Attachment 1

Final Project Report
Upper Des Plaines Structure Inventory and Nonresidential Surveys

Prepared By:

URS Group, Inc.
200 Orchard Ridge Drive, Suite 101
Gaithersburg, MD 20878

Prepared For:

U.S. Army Corps of Engineers
Chicago District

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UPPER DES PLAINES RIVER FEASIBILITY PHASE II STUDY
BASELINE ECONOMIC ANALYSIS REPORT

RESIDENTIAL INVENTORY ANALYSIS AND NONRESIDENTIAL FLOOD DAMAGE SURVEY

June 2009

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Chicago District, is conducting the Upper Des Plaines River Feasibility Phase II Study. As part of that baseline economic analysis, URS Group, Inc. (URS) conducted the field collection and analysis of government-identified structures, which consisted of four tasks:

1. Assign depreciated replacement values to a specified sample of residential structures and develop a relationship to county tax assessed structure values
2. Collect field information through site reconnaissance for each identified nonresidential structure
3. Develop and facilitate Office of Management and Budget (OMB) approval of a survey instrument to estimate potential flood damages at nonresidential structures
4. Collect flood damage information through onsite interviews for selected nonresidential structures

The study area consisted of the 100-year floodplain along the Upper Des Plaines River and several tributaries within Lake and Cook Counties, IL.

Data collected from the structure inventory and nonresidential surveys are to be incorporated into the overall economic analysis. The methodology and a summary of the collected data are contained in this report.

2.0 STRUCTURE INVENTORY

The purpose of the structure inventory was to collect data on selected residential and nonresidential structures in the Des Plaines watershed. The structure inventory was conducted using the Institute of Water Resources (IWR), IWR-GeoFIT program, which is a USACE-developed geographic information system (GIS)-based floodplain inventory tool that allows characteristic information for structures to be entered and recorded in a database.

The Chicago District identified the structures to be inventoried and provided four databases of the selected structures to URS. The government-furnished items were based on tax assessor data obtained from Lake and Cook Counties. There were two databases from each county, as the residential and nonresidential structures are assessed differently and, therefore, stored in different tax databases. The government-furnished items were compiled and formatted in order to be consistent with IWR-GeoFIT requirements.

An inventory of all structures in the study area was not completed for this effort due to the size of the Des Plaines watershed and the number of structures within the floodplain for the 1-percent-annual-chance event (100-year floodplain). Instead, a random sample of structures was selected by the Chicago District to be inventoried. The inventoried structures were used to create adjustment factors to apply to the remaining structures in the study area. Further details on the steps taken to calculate these factors are provided in this section.

2.1 Data Collection

A two-person team performed the data collection. The team was equipped with a laptop computer and a digital camera. All structure information was collected from outside the structure and recorded in the IWR-GeoFIT program. A letter of introduction containing a project description and contact information was available for property owners upon request.

The characteristics collected for each structure were based on fields used in the Marshall & Swift (M&S) Residential and Commercial Estimator Programs to calculate depreciated replacement value and new replacement value.

The following information was collected for each residential structure:

- Address
- Photograph of structure
- Characteristics
  - Type of structure (e.g., single family)
  - Type of foundation
  - Floor area
  - Effective age
  - Quality of construction
  - Condition of structure
  - Style of structure (e.g., one story)

- Type of exterior wall (e.g., siding)
- Type of roofing
- Presence of garage
- Presence of other outbuildings
- Presence of fireplaces

URS estimated the finished floor area of each structure utilizing an aerial photograph and tracing tool provided by IWR-GeoFIT, and using the data provided by the Chicago District. The effective age of each structure was estimated from a combination of factors: the style in which the structure was built, the appearance, and any improvements done to the original structure. The effective age takes into account renovations to a structure since the original construction. The construction quality of the building was determined by looking at the workmanship in relation to the materials used. The appearance and condition of the structure in relation to the effective age determined the physical condition of the buildings.

During the inventory, if a nonresidential structure contained multiple businesses (e.g., a strip mall), each business was considered a separate structure and entered individually. The following information was collected for each nonresidential structure:

- Name of business
- Address
- Photograph of structure
- Characteristics
  - General use of structure (occupancy code)
  - Effective age
  - Total floor area
  - Construction class (e.g., masonry bearing walls)
  - Story height
  - Quality of construction
  - Number of stories
  - Perimeter shape

The survey team used maps to locate the selected residential or nonresidential structures. Structures that no longer existed were deleted from the database. Additional structures that were clearly on the same property as the identified structure were added to the database. For example, if one warehouse from a self-storage facility was selected by the Chicago District for inventory, the other warehouses associated with that facility were added to the database.

2.2 Marshall & Swift

URS exported the data into the M&S Residential Estimator and Commercial Estimator programs from the IWR-GeoFIT software. The M&S programs were used to calculate depreciated

replacement values for each nonresidential and residential structure based on the concepts of effective age, quality, condition, and other structural parameters. The depreciated replacement values were based on a 2008 price level.

To more accurately estimate the depreciated replacement value, the surveyor assigned an M&S 3-digit occupancy code to each structure based on its use (Table 1). Use was determined by the activities conducted in the building as observed during the field survey and by company name. The predominant use of, or activity performed in, a structure determines both the type of construction and quality of materials used. For example, the construction design and the materials used for a fast food restaurant are very different than those used for a warehouse or a small office.

Table 1: List of 3-Digit Occupancy Codes Used

Occupancy Code	Definition	Occupancy Code	Definition
133	Storage Shed, Pre-fabricated	418	Health Club
181	Secure Storage Shed, Pre-abricated	419	Convenience Market
300	Apartment	426	Day Care Center
304	Bank	432	Restroom Building
309	Church	436	Car Wash, Automatic
313	Convalescent Hospital	442	Bar/Tavern
322	Fire Station, Staffed	444	Dental/Office Clinic
326	Storage Garage	446	Supermarket
331	Hospital	453	Industrial Flex Building
336	Laundromat	455	Auto Dealership, Complete
341	Medical Office	471	Light Commercial Utility Building
344	Office Building	484	Entire High School
349	Fast Food Restaurant	494	Industrial Light Manufacturing
350	Restaurant, Table Service	499	Dry Cleaners/Laundry
353	Retail Store	514	Community Center
365	Entire Elementary School	519	Greenhouse Shade Shelter
377	Entire College	528	Service Repair Garage
381	Veterinary Hospital	532	Florist Shop
384	Barber Shop	552	Recreational Enclosure
392	Industrial Engineering Building	582	Post Office, Branch
406	Storage Warehouse	594	Hotel, Full Service
407	Distribution Warehouse		

Because the survey team did not enter the interior of any structures, a number of factors that are normally entered into the M&S programs—such as the method of heating and cooling, plumbing, and the type of interior floor covering—could not be recorded. Default values were used for characteristics that could not be determined during the structure inventory.

2.3 County Adjustment Factor

Because only a representative sample of residential structures was inventoried, adjustment factors (average percent difference) were calculated to describe the differences between the M&S depreciated replacement values and the county tax assessor values. Because counties do

not assess residential structures in the same manner, separate adjustment factors were calculated for Cook and Lake Counties.

County tax databases typically record multiple values for each property, such as land value, improvement value, and total value. Since improvement value captures the value of any structures built on the land, it was used as the tax assessor structure value to calculate the adjustment factors for each county. Cook County also calculates an equalized value[1], but Lake County does not. Consequently, the un-equalized value was used for Cook County.

URS calculated the percent difference between the M&S value (treated as the experimental value) and the tax assessor value (treated as the actual value) for each inventoried residential structure. The average percent difference was then calculated for each county and used as the adjustment factor. The adjustment factor for Cook County was 607 percent and the adjustment factor for Lake County was 103 percent.

A comparison between the tax assessor data and field data was performed on major structure characteristics to determine the presence of inconsistencies or trends in either set of data. The square footage data field is present in both sets of residential tax assessor data and is a major factor in structure value. The square footages recorded in the tax assessor data were not an exact match to the square footage estimates using field data, but the values were close. The tax assessor data generally records to the nearest whole square foot. Field-collected square footage data were estimated from outside of the structures using aerial photographs. These estimates were rounded to the nearest 100 square feet.

Square footage was estimated in the field in case the tax assessor data was incorrect or outdated (e.g., typos or new additions since last tax assessment). Generally, the differences between the tax assessor and field-collected square footages can be attributed to rounding. For example, the tax assessor data may have a house listed at 1,094 square feet, and the field data may have the same house listed as 1,100 square feet.

No major inconsistencies were found between the tax assessor data and field-collected data. However, Cook County only records 16 percent of the structure value in their tax database. Because M&S provides a depreciated replacement value based on the total value, this practice greatly affects the Cook County adjustment factor.

2.4 Results

A total of 698 residential and nonresidential structures were inventoried during the field work (Table 2). All of the structures provided in the USACE database were identified. Some of the structures identified by USACE were deleted from the database because the structures had been demolished. This total also includes all structures added to the database while in the field.

[1] The equalized value is the total assessed value equalized by the State Department of Revenue equalization factor to bring values to the statutory level of 0.333 percent of the Markey value (if applicable).

Table 2: Number of Structures Inventoried

Structure Type	Number Inventoried
Residential	
One-Story, No Basement	44
One-Story, With Basement	154
Two-Story, No Basement	24
Two-Story, With Basement	152
Split-Level, No Basement	4
Split-Level, With Basement	6
Bi-Level, No Basement	6
Total Residential	**390**
Nonresidential	
Commercial	240
Industrial	46
Public	22
Total Nonresidential	**308**

Table 3 provides descriptive statistics about the residential structures inventoried.

Table 3: Descriptive Statistics for Residential Structures

Category	Average	Maximum	Minimum	Standard Deviation
One-Story, No Basement				
Square feet	1,493	4,000	1,000	680.4
Effective age	19	25	10	3.5
Depreciated replacement value	$126,889	$346,104	$74,072	$54,540.3
One-Story, With Basement				
Square feet	1,442	3,600	1,000	484.6
Effective age	19	25	10	3.7
Depreciated replacement value	$124,123	$294,493	$63,977	$37,328.7
Two-Story, No Basement				
Square feet	2,313	4,400	1,200	970.1
Effective age	17	20	10	3.5
Depreciated replacement value	$171,021	$277,879	$63,340	$69,901.4
Two-Story, With Basement				
Square feet	2,407	7,800	1,200	1,121.1
Effective age	15	25	10	4.6
Depreciated replacement value	$186,611	$453,264	$79,053	$79,444.1
Split-Level, No Basement				
Square feet	2,000	3,300	1,300	890.7
Effective age	19	20	15	2.5
Depreciated replacement value	$174,312	$221,645	$142,713	$34,551.5
Split-Level, With Basement				
Square feet	1,500	2,200	1,200	395.0
Effective age	18	20	15	2.6
Depreciated replacement value	$140,331	$202,893	$100,878	$39,631.0
Bi-Level, No Basement				
Square feet	1,350	1,900	1,100	327.1
Effective age	16	20	15	2.0
Depreciated replacement value	$121,913	$181,056	$89,462	$40,486.6

Table 4 provides descriptive statistics about the nonresidential structures collected during the inventory.

Table 4: Descriptive Statistics for Nonresidential Structures

Category	Average	Maximum	Minimum	Standard Deviation
Commercial (General)				
Square Feet	15,248	220,400	400	31,292
Effective Age	19	25	10	3.5
Depreciated replacement value	$1,869,417	$29,783,517	$1,382	$4,265,952
Industrial				
Square Feet	52,050	363,400	400	85,200
Effective Age	19	25	10	3.7
Depreciated replacement value	$2,644,440	$20,118,481	$4,799	$4,425,867
Public				
Square Feet	52,868	395,200	1,000	98,603
Effective Age	17	20	10	3.5
Depreciated replacement value	$7,304,159	$55,859,717	$54,931	$14,330,000

Each nonresidential structure inventoried was assigned two depth-damage functions (DDFs): one to represent the structure and the other to represent the contents. The DDFs were based on generic categories provided by USACE. An Expert Elicitation Opinion Panel created the generic DDFs[2] in 2008 to provide USACE Districts with results that can be used on a nationwide basis. An independent technical review (ITR) of the DDFs was conducted by USACE. The final report is expected to be released in the summer of 2009. The DDF assigned to the structure was based on the construction type of the structure, while the DDF assigned to the contents was based on the type of business/activities conducted in the structure (Table 5).

[2] DDFs are often categorized as "indirect" or "direct". Indirect DDFs estimate the monetary damage to a structure based on a percentage of the structure's value. The estimated percent of damage to a structure for a particular level of inundation is multiplied by the value of the structure to estimate the monetary damages (e.g., if one foot of water is estimate to cause 12 percent damage to a $100,000 structure, the estimated damages would be $12,000). The generic DDFs referred to in this report are indirect DDFs. Direct DDFs estimate the monetary damages to a structure are based solely on the level of inundation (e.g., one foot of water is estimated to cause $12,000 in damages).

Table 5. Summary Count of the Assigned Nonresidential DDFs

Depth-Damage Curve	Count
Apartment Engineered	8
Apartment Pre-Engineered	3
Retail Clothing Engineered	10
Retail Clothing Pre-Engineered	5
Convenience Engineered	9
Retail Electronic Engineered	7
Retail Electronic Pre-Engineered	1
Fast Food Restaurant Engineered	16
Retail Furniture Engineered	4
Retail Furniture Pre-Engineered	2
Grocery Engineered	2
Hospital Engineered	0
Hotel Engineered	1
Light Manufacturing Engineered	7
Light Manufacturing Pre-Engineered	4
Medical Office Engineered	9
Office Engineered	101
Office Pre-Engineered	1
Recreation Engineered	9
Restaurant Engineered	15
Restaurant Pre-Engineered	3
Religious Facilities Engineered	8
School Engineered	7
Service Engineered	25
Service Pre-Engineered	2
Warehouse Engineered	8
Warehouse Pre-Engineered	14
Direct Depth-Damage Function (from surveys)[3]	27
Total	**308**

The resulting data was delivered to the Chicago District in several formats. Data relevant to the economic analysis was provided in the Hydrologic Engineering Center – Flood Damage Assessment (HEC-FDA) program format. However, the first floor elevation and station number of each structure were not included in the HEC-FDA file. These fields will be populated by USACE at a later time. Backup data was provided on a compact disc, including the IWR-GeoFIT database containing the information collected during the inventory, and a spreadsheet showing the factors used to adjust the county data to the current M&S depreciated replacement values.

[3] The source of the direct depth-damage functions were nonresidential surveys explained in Chapter 3.

3.0 NONRESIDENTIAL SURVEYS

Most nonresidential structures can be categorized into one of the generic DDFs discussed previously. However, some structures are unique and not represented well by the generic DDFs or have subterranean levels that are not accounted for with the generic DDFs.. The purpose of the nonresidential surveys was to obtain data to more accurately estimate potential flood damages of the contents of unique structures than can be estimated by the generic DDFs. Data were collected at selected facilities and used to calculate DDFs for the contents of each structure at the facility, cleanup costs, and other valuable items on the property (e.g., equipment stored in a maintenance yard). The resulting DDFs replaced the generic DDFs originally assigned to the structure. To collect the data, URS worked with the Chicago District to develop a survey instrument that asked respondents to provide information on historical flood damages and to estimate damages for different levels of flooding. The surveys were completed through interviews conducted with representatives of the selected facilities.

3.1 Survey Instrument

A survey instrument was developed based on surveys that had been conducted previously for other studies. Prior to conducting any interviews, OMB approval of the survey instrument was required. URS prepared an information package containing basic information on the purpose of the survey, the selection of facilities, and the basis from which the survey instrument was derived. The information package was submitted to OMB through the USACE Great Lakes and Ohio River Division in August 2008.

OMB denied the approval of the survey instrument based on concerns that the questions asked respondents to provide information on hypothetical flood situations. Revisions were subsequently made to the survey instrument based on comments received from, and discussions with, OMB. The revised survey instrument was approved by OMB for use in October 2008 (Appendix A). The After Action Report created upon receiving OMB approval is provided in Appendix B.

The revised survey instrument steps respondents through the process of identifying the placement and value of contents within each structure at a facility. Respondents were asked to separate the contents into three categories (equipment, furniture, and inventory/products), and indicate the placement and value for each category. Respondents were then asked to estimate the amount of damage that would occur if the structure flooded. For the amount of damage, respondents were asked to provide a low, most likely, and high value to account for uncertainty. In addition to the contents in the structures, respondents were asked to identify cleanup costs (if the facility had been flooded previously) and other items of value that may be located on the facility grounds.

3.2 Selection of Facilities to Interview

In addition to collecting structure information, a separate goal of the inventory was to determine which nonresidential structures warranted an interview. Selection focused on industrial-type facilities that appeared to contain unique or expensive contents. In addition, since the generic

DDFs do not account for subterranean levels (basements), a few large, multi-story buildings (e.g., hotels, office high-rises) were also selected for interviews.

The selection of facilities to survey was finalized in a meeting with the Chicago District on August 21, 2008. The forty facilities identified in Table 6 were selected. Table 7 provides a summary of the survey status.

Table 6: Facilities Selected for Interviews

Company	Survey Status
1040 W. Higgins	Vacant
1060 W. Higgins	Vacant
10701 W. Belmont	Vacant
1700 Higgins Centre	Completed
Acco, Inc.	No Response
Advocate Children's Hospital	Completed
Advocate Medical Group	Completed
Ajax Tool Works	Completed
Alberto Culver Company (three buildings interconnected)	Completed
Allied Die Casting Co.	No Response
Autorad, Inc.	Declined
Bank of America	Completed
Bodycote Thermal Proc. (two buildings)	Declined
Charter One Bank	No Response
Chase Bank	No Response
Coaster Co. of America	Completed
Cortina	Completed
Delta Tech Products	Completed
General Produce Distr.	Declined
Holiday Inn Express	Completed
Illinois Brick	No Response
Kenny Construction Company	Vacant
Lutheran General Hospital (two buildings)	Completed
Marvel Engineering	Declined

Company	Survey Status
Meyer Material Company	No Response
Mid-States Recycling, Inc.	Completed
Motorcoach Industries	Completed
Partner Logistics, Inc.	Completed
Patten Industries Inc.	Declined
Precision Instruments (two buildings)	Declined
Ruby North Partnership	No Response
Seasons Hospice, Inc.	Completed
Sheraton Gateway Suites	Completed
Star Creations/Universal Const. Testing/Precision Zone/Masonry Co. Inc. (four businesses in one building)	Completed/Completed/No Response/Declined
Sunrise Assisted Living	Completed
Systems Material Handling	Completed
Temperature Equipment Corp.	Completed
Temperature Equipment Corp. (two buildings)	Completed
U.S. Postal Office	Completed
Village of Grayslake Department of Public Works	Completed
Wharton (two buildings)	No Response

Table 7. Summary Count of Survey Status

Survey Status	Summary Count
Completed	24
Declined	7
No Response	9
Vacant	4
Total	44

3.3 Contact and Interview Process

During the contact and interview process, the survey team visited all the selected facilities at least once to obtain contact information. In addition, the Chicago District sent letters of introduction to 28 of the facilities to garner support for the interviews. Efforts were made to obtain the contact information for the persons deemed best suited to participate in the interview, such as business owners, office managers, or facilities engineers. Multiple follow-up phone calls and e-mails were exchanged with the selected facilities to ensure as many responses as possible (a record of the contacts and attempts was kept) were obtained. However, many facilities were not interviewed due to the respondents either declining interviews or simply not answering inquiries. A few of the structures were vacant and thus no interview was possible. To improve the success rate, the Chicago District sent letters to three of the respondents who declined to be interviewed. The letters contained an explanation of the need for the data and a map showing the location of the facility in the floodplain. However, no responses were received from these facilities.

During the interviews process, some respondents had difficulty estimating the damages to their facilities. Business owners and facilities managers were better able to address the questions on the survey. However, office managers were not as familiar with the value of the contents and often had difficulty answering the questions. Some respondents who had reported previous flooding of their facility were not located at that particular structure at the time of flooding and did not have relevant records. Twenty-four surveys were completed, resulting in information being collected for 27 structures.

3.4 Analysis of Survey Data

Direct DDFs for contents were calculated for the structures at facilities where interviews were conducted. The direct DDFs were calculated by multiplying the total value of the contents for each category by the percent damage at each level of inundation. The estimated damages for the three categories (equipment, furniture, and inventory/products) were aggregated by depth to estimate the total damage at each increment of flooding. These calculations were conducted for each of the uncertainty values (low, most likely, and high). The resulting flood levels, which were unique to each structure, ranged anywhere from -8 to 6 feet.

In addition to estimating the potential damages to contents, respondents were also asked to provide information on clean-up costs (only if the respondent had been flooded previously), valuable property on the grounds, and potential flood damage reduction measure they would undertake if flooding was imminent. When respondents provided this information, separate DDFs were created and provided to the Chicago District as separate entries[4]. The DDFs started at -2 feet, with the assumption that emergency preparedness plans would begin to be implemented when the elevation of the water was within two feet of the elevation of the structure.

Data obtained from the surveys were provided to the Chicago District in a HEC-FDA program compatible format. However, this information is not presented in this report to maintain confidentiality.

[4] Separate DDFs and entries (with unique identifiers) were provided so as not to conflict with the low water entry point assigned to each structure by the Chicago District.

4.0 SUMMARY

To evaluate flood damage reduction alternatives as part of the Upper Des Plaines River Feasibility Phase II Study, data were collected to perform a large economic analysis. The data consisted of two components: a structure inventory and nonresidential survey. The structure inventory provides a representative account of selected structures located in the flood plain for the 1-percent-annual-chance event (100-year floodplain) along the Upper Des Plaines River and several tributaries within Lake and Cook Counties, IL. The data gathered for residential and nonresidential structures was used to determine the depreciated replacement values. The survey included interviews conducted at selected nonresidential facilities to develop unique DDFs for content damages and emergency preparedness costs.

The resulting data from the structural inventory and nonresidential interviews were compiled into the HEC-FDA format and referenced to a unique identifier supplied by USACE to ensure the URS database (including all IWR-GeoFIT and interview data) and original government furnished database could be accurately matched.

APPENDIX A

NONRESIDENTIAL INTERVIEW SURVEY FORM

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY

(Personal Interview)

OMB Control Number: 0710-0001

Expires: 30-Sep-2009

The public report burden for this information collection is estimated to average 40 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this data collection, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters Services, Executive Services Directorate, Information Management Division, and the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503, Attn.: Desk Officer for U.S. Army Corps of Engineers. Respondents should be aware that notwithstanding any other provision of law, an agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Please DO NOT RETURN your completed form to either of these offices.

***Be sure to notify each person to be interviewed that responding to questions is voluntary.**

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY
PRIMARY SURVEY FORM

OMB#: 0710-0001
Expires: 30-Sep-09

Attach Business Card Here

Firm Name: _____

This survey is focused on damages that could occur to the contents of structures at your facility in the event of future flooding. Contents are defined as items that would be relocated in the event that the facility moves to another location, such as furniture, equipment, products, and raw materials. For this survey contents were divided in three categories:

- **Equipment**: Physical items that are used for the production process or the operation of the facility (e.g., generators, machinery, production tables, paint booths, robotics, racks, conveyors, floor scrubbers, computers/servers, etc.). These items would most likely be removed if the business relocates to another facility.
- **Furniture**: Physical items necessary for the conduct of business or delivery of a product (e.g., desks, chairs, bookcases, artwork, etc.). As with equipment, this category is focused on free-standing and attached furniture that would be removed in the event of relocation.
- **Inventory/Products**: Items that are used in the production process or result from the production process, or consumables used as part of the business activities. Items include raw materials, finished products, replacement parts, medical consumables, cleaning products, food, pharmaceuticals, software, building materials, office supplies, etc.

Business Information

Address_____
Contact Name _____
Contact's Title _____ Telephone # _____
Interviewer_____ Date_____ Time _____

1. Type of business _____
2. Total number of buildings on site _____
3. Number of years business has been at this location _____

Flood History and Mitigation

4. Has your facility been flooded in the past? Yes No

If "Yes," please complete Questions 5 and 6. If "No," skip to Question 7.

5. Please estimate the damages to your business from past flooding events. Please give a single set of combined damages for all floors in all buildings.

Date of the flooding event:		Date of the flooding event:	
Water depth above first floor:		Water depth above first floor:	
Contents damage estimate ($):		Contents damage estimate ($):	
Structure damage estimate ($):		Structure damage estimate ($):	
Number of lost business days:		Number of lost business days:	
Amount of lost net income ($):		Amount of lost net income ($):	
Cost of cleanup ($):		Cost of cleanup ($):	

6. Briefly describe any permanent flood mitigation measures that have been implemented to reduce potential flood damage. _____
_____
_____
_____
_____

Building Information

*(Questions 7-17 are to be answered for your **primary building only**. If there are multiple buildings at the facility, a supplemental sheet is provided that asks for similar information.)*

7. Building #: _____
8. Brief description of function of the building and its contents: _____
_____
_____
_____
9. Year building was constructed: _____
10. Building Construction Type (e.g. brick): _____
11. Number of floors (including basement, if any): _____
12. Building footprint: _____ feet by _____ feet = _____square feet
13. Does the building have a basement? Yes No If yes: _____ square feet finished area
_____ square feet unfinished area
14. Is there a seasonal variation in the value of inventory in this building? Yes No
If yes, what is the average value of your inventory during the following time periods:
January – March $_____ April – June $_____
July – September $_____ October – December $_____

15. Relative to the 1st floor elevation of the building, what is the current value of the contents and where are they located vertically? (up through 1st floor only)

Height (ft)	Equipment ($)	Furniture ($)	Inventory/products ($)
0.0 ft			
1.0 ft			
3.0 ft			
6.0 ft			
Total			

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Susceptibility to Flood Damage

The amount of damage due to flooding can vary considerably depending on conditions (e.g., quality of water, duration of flood). When completing the following section, you will be asked to provide a range for potential damages. In addition to the most likely damage amount due to flooding, you will also be asked to provide a low and high estimate. Please use the following definitions:

- *"Most Likely" – reasonable amount of damage expected to occur during an average flood.*
- *"Low" – reasonable low estimate of damages assuming that the flood conditions are less than a typical flood (e.g., short duration, relatively clean floodwaters) or the contents were less impacted than typically estimated (e.g., motors were sealed well).*
- *"High" – reasonable high estimate of damages assuming that the flood conditions are worse than a typical flood (e.g., long duration, highly contaminated floodwaters) or the contents were more impacted than typically estimated (e.g., motors need total replacement).*

16. At what elevation, relative to the 1st floor of the building, does flood damage to **contents** begin? (+ or – ; will only be negative if there is a subterranean level) _____ feet
17. Please estimate damage to contents corresponding with water depths above/below the building's 1st floor elevation. (Express damage in either **$ or % of total value**.)

Flood Depth	Equipment			Furniture			Inventory/products		
	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
0.0 ft									
0.5 ft									
1.0 ft									
3.0 ft									
6.0 ft									

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Other Information

18. Other than the principal structures, are there any other valuable items on your property that flood waters could damage?
    - Not readily movable (landscaping, electrical equipment, pipes, trailers on blocks, etc.)

Type	Current Value ($)	Height Above Ground (ft.)

- Movable (cars, trucks, trailers, etc.)

Type	Current Value ($)

19. Emergency Measures/Plans:

a. What emergency measures/plans, if any, would you take to reduce damage if eminent flooding was forewarned? _____
_____
_____
_____

b. What is the estimated cost to implement these emergency measures? $_____

c. How much time is required to implement these emergency measures? _____ hours

COMMERCIAL AND INDUSTRIAL FLOOD DAMAGE SURVEY
SUPPLEMENTAL SURVEY FORM

OMB#: 0710-0001
Expires: 30-Sep-09

Firm Name: _____

This supplemental survey form is to be used for each additional building at your facility. Information for each building is needed to estimate damages that could occur to the contents of all structures at your facility in the event of future flooding.

1. Building #: _____
2. Brief description of function of the building and its contents: _____
_____
_____
_____
_____
_____
_____
_____
_____
_____
3. Year building was constructed: _____
4. Building Construction Type (e.g. brick): _____
5. Number of floors (including basement, if any): _____
6. Building footprint: _____ feet by _____ feet = _____square feet
7. Does the building have a basement? Yes No If yes: _____ square feet finished area
_____ square feet unfinished area
8. Is there a seasonal variation in the value of inventory in this building? Yes No
If yes, what is the average value of your inventory during the following time periods:
January – March $_____ April – June $_____
July – September $_____ October – December $_____
9. Relative to the 1st floor elevation of the building, what is the current value of the contents and where are they located vertically? (up through 1st floor only)

Height (ft)	Equipment ($)	Furniture ($)	Inventory/products ($)
0.0 ft			
1.0 ft			
3.0 ft			
6.0 ft			
Total			

Notes to interviewer:
- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

Susceptibility to Flood Damage

10. At what elevation, relative to the 1st floor of the building, does flood damage to **contents** begin? (+ or – ; will only be negative if there is a subterranean level) _____ feet

11. Please estimate damage to contents corresponding with water depths above/below the building's 1st floor elevation. (Express damage in either **$ or % of total value**.)

Flood Depth	**Equipment**			**Furniture**			**Inventory/products**		
	Low	Most Likely	High	Low	Most Likely	High	Low	Most Likely	High
0.0 ft									
0.5 ft									
1.0 ft									
3.0 ft									
6.0 ft									

Notes to interviewer:

- Shaded areas are for buildings with a subterranean level only. Please fill in appropriate values for the depth (e.g., -1.0 ft, -3.0 ft, -6.0 ft). Leave shaded areas blank if no subterranean level exists.
- The values in the columns should be a cumulative total, starting from the lowest level of the structure.

APPENDIX B

AFTER ACTION REPORT FOR OMB APPROVAL PROCESS

Upper Des Plaines River Feasibility Phase II Study

OMB Approval of Non-Residential Flood Damage Survey

AFTER ACTION REPORT

US Army Corps of Engineers ®
Chicago District

Date: October 2008

As part of the Upper Des Plaines River Feasibility Phase II Study a survey of flood damages to structures located within the floodplain is needed to complete a baseline economic evaluation. The Chicago District along with their consultant URS determined through field reconnaissance 40 unique non-residential structures that did not fit generic depth-damage relations, thus requiring individual flood damage surveys. After reviewing the list of OMB approved questionnaires located on the IWR website, the study team determined that none of those surveys fulfilled all the necessary requirements, therefore revisions were made to the survey instrument.

Using the "Commercial and Industrial Flood Damage Survey", OMB 0710-0001, as a starting point the survey instrument was revised to include more detailed damage estimates from previous flood events, more detailed estimates of content values and estimates of the susceptibility of content damage with depth. A submittal package was prepared and sent to LRD to include a formal request memo that laid out the purpose, location, population size, methodology, and consistency with approved questionnaires; a survey cover letter; and the survey questionnaire. The package was forwarded to OMB for approval on 27-Aug-08. After two weeks without an answer, follow-up contact was made of the status.

On 22-Sep-08, the OMB/OIRA Desk Officer for USACE responded with a rejection to the submitted questionnaire citing the following reasons:

- Primary concern is with asking questions that are beyond the respondent's area of expertise. For example a facilities manager would know the value of their equipment, but without prior flood experience they would most likely not know the cost of clean-up or the amount of downtime. Questions outside of a respondent's area of expertise would be speculative at best.
- Concerned that information collected from hypothetical questions would be speculative if the respondent has not experienced prior flooding (e.g., clean-up costs).
- The current approved survey was constructed with careful consideration and close coordination with Corps representatives.

Two conference calls were held with representatives from LRC, LRD, IWR, and HQ to discuss the concerns of OMB and potential revisions to the survey. Conclusions from these discussions centered on ways to revise the survey so that responses are less speculative and geared towards the individual respondent's expertise.

LRC submitted a revised submittal package to LRD that included a substantially revised survey questionnaire for OMB approval. The package was forwarded to OMB for approval on 23-Oct-08. Areas of the survey instrument that were substantially revised include:

- All speculative questions were removed. (i.e. survey now asks for estimated clean-up costs only when previous flooding occurred)
- Content value questions were condensed to a single schedule that mirrors the flood susceptibility questions for clarity and consistency purposes.
- Flood susceptibility questions were condensed to a single table for clarity and ease.
- Detailed terminology, descriptions, examples, and notes to interviewer were included to reduce survey response errors.

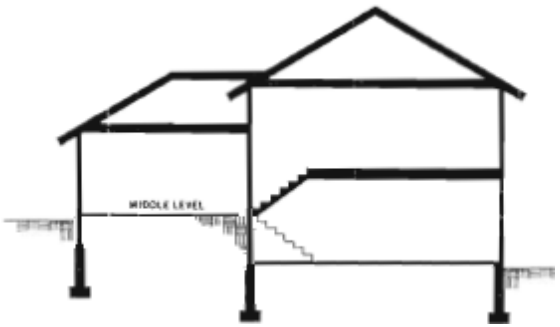
On 28-Oct-08, the OMB/OIRA Desk Officer for USACE approved the revised survey questionnaire subject to the terms and conditions of OMB control number 0710-0001. Attached is the approved survey to be used in conducting non-residential flood damage surveys for the Upper Des Plaines River Feasibility Phase II Study. On-site individual surveys are planned to begin the first week of November 2008 and last for two weeks.

Contacts:

Mr. David Bucaro, P.E., Lead Planner, U.S. Army Corps of Engineers, Chicago District, 312-846-5583 or david.f.bucaro@usace.army.mil.

Attachment 2

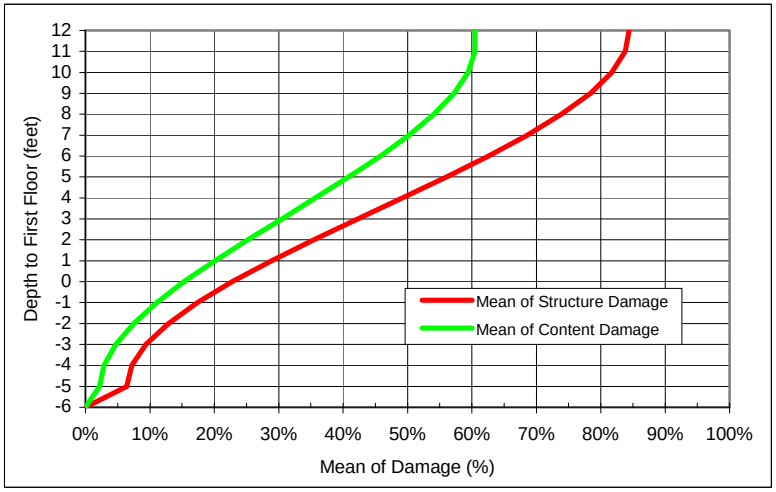
US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: TLNB – Tri-Level No Basement**	CHECKED BY:	DATE:	



This type of residence has three levels of living area, one at grade level, one about 4 feet above grade and one stacked above the grade level area. All levels serve as living areas and have full ceiling heights. Many times the middle level is placed on an artificial earth fill. The entry is located on the middle level about 4 feet above grade.

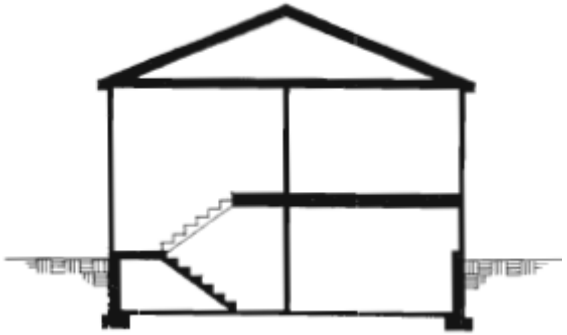
TLNB – Tri-Level No Basement

	Structure		Contents	
Depth	Mean of Damage	Standard Deviation	Mean of Damage	Standard Deviation
12	84.4%	8.7%	60.5%	6.0%
11	83.8%	8.3%	60.5%	5.7%
10	81.7%	7.9%	59.4%	5.4%
9	78.4%	7.4%	57.2%	5.0%
8	73.9%	6.7%	54.1%	4.6%
7	68.6%	6.0%	50.2%	4.1%
6	62.6%	5.3%	45.8%	3.5%
5	56.1%	4.5%	40.9%	3.0%
4	49.2%	3.8%	35.7%	2.5%
3	42.3%	3.2%	30.5%	2.1%
2	35.5%	2.7%	25.2%	1.8%
1	28.9%	2.4%	20.1%	1.6%
0	22.8%	2.2%	15.3%	1.5%
-1	17.4%	2.0%	11.1%	1.4%
-2	12.9%	1.9%	7.5%	1.3%
-3	9.4%	1.9%	4.7%	1.2%
-4	7.2%	2.1%	2.9%	1.5%
-5	6.4%	2.9%	2.2%	2.2%
-6	0.0%	0.0%	0.0%	0.0%



Notes: Depth-damage functions were derived by taking the split-level no basement relationship directly from EGM 04-01 and simply raising the vertical axis by 4-feet to account for elevated entry.

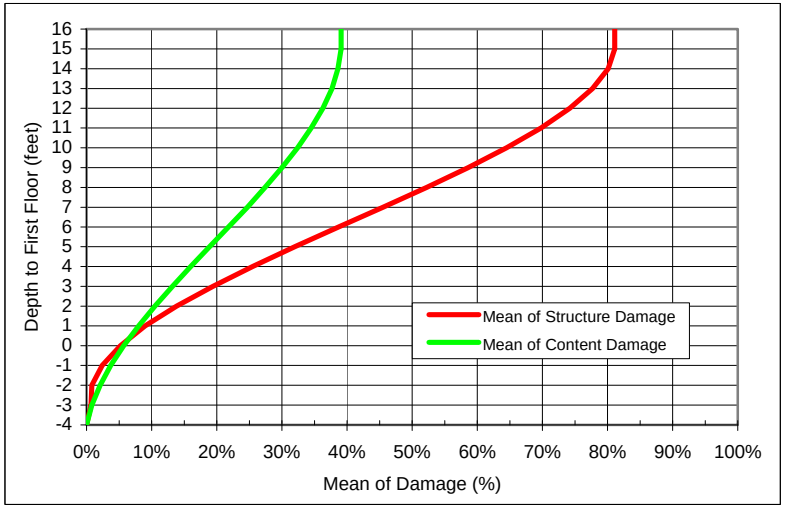
US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: BLWB – Bi-Level With Basement**	CHECKED BY:	DATE:	



This type of residence has two living areas, one above the other. One area is about 4 feet below grade and the second is about 4 feet above grade. Both areas are equal in size and used as living space. The entry is at grade.

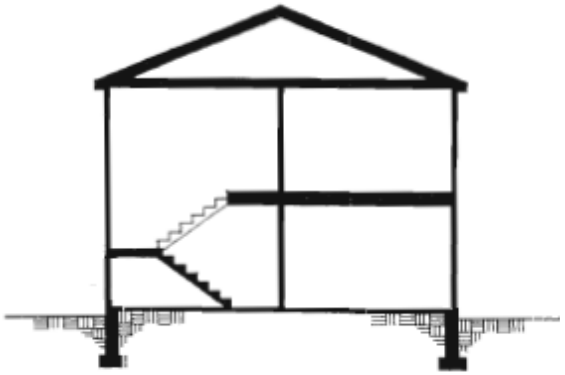
BLWB – Bi-Level With Basement

Depth	Structure		Contents	
	Mean of Damage	Standard Deviation	Mean of Damage	Standard Deviation
16	81.1%	2.9%	39.1%	2.5%
15	81.1%	2.9%	39.1%	2.5%
14	80.1%	2.8%	38.6%	2.4%
13	77.7%	2.7%	37.7%	2.3%
12	74.2%	2.5%	36.3%	2.1%
11	69.8%	2.4%	34.5%	2.0%
10	64.5%	2.1%	32.4%	1.8%
9	58.6%	1.9%	30.0%	1.6%
8	52.2%	1.6%	27.4%	1.4%
7	45.5%	1.4%	24.7%	1.2%
6	38.7%	1.1%	21.8%	1.0%
5	32.0%	1.0%	18.9%	0.8%
4	25.5%	0.9%	16.0%	0.7%
3	19.4%	0.8%	13.2%	0.7%
2	13.8%	0.9%	10.5%	0.7%
1	9.0%	0.9%	8.0%	0.8%
0	5.2%	0.9%	5.7%	0.8%
-1	2.4%	0.9%	3.7%	0.8%
-2	0.8%	1.1%	2.1%	0.9%
-3	0.7%	1.3%	0.8%	1.2%
-4	0.0%	0.0%	0.0%	0.0%



Notes: Depth-damage functions were derived by taking the one-story with basement (1SWB) relationship directly from EGM 04-01 and simply raising the vertical axis by 4-feet to account for elevated entry.

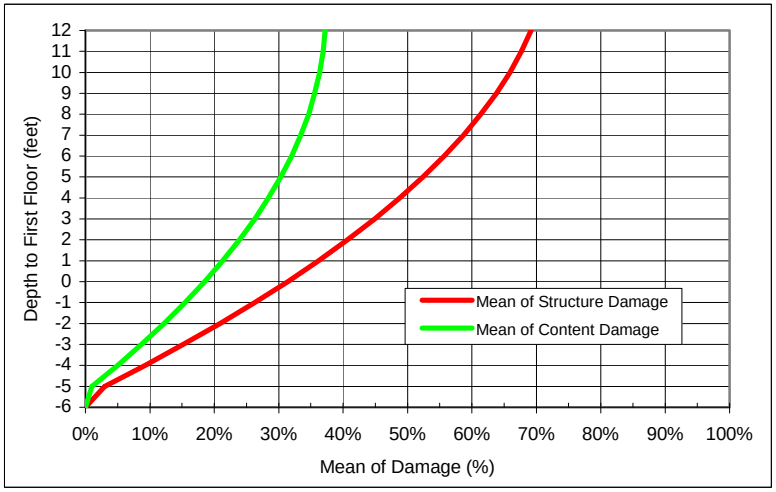
US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: BLNB – Bi-Level No Basement**	CHECKED BY:	DATE:	



This type of residence has two living areas, one above the other. Both areas are equal in size and used as living space. The entry is elevated about 4 feet above grade. Many times an artificial earth berm is placed along portions of the lower level for esthetic purposes.

BLNB – Bi-Level No Basement

Depth	Structure: Mean of Damage	Structure: Standard Deviation	Contents: Mean of Damage	Contents: Standard Deviation
12	69.2%	5.0%	37.2%	4.2%
11	67.7%	4.6%	36.9%	3.8%
10	65.9%	4.3%	36.4%	3.6%
9	63.8%	4.2%	35.6%	3.5%
8	61.4%	4.2%	34.7%	3.5%
7	58.7%	4.2%	33.4%	3.5%
6	55.7%	4.2%	32.0%	3.5%
5	52.4%	4.1%	30.3%	3.5%
4	48.8%	4.0%	28.4%	3.4%
3	44.9%	3.9%	26.3%	3.3%
2	40.7%	3.7%	23.9%	3.2%
1	36.2%	3.4%	21.3%	3.0%
0	31.4%	3.2%	18.5%	2.7%
-1	26.3%	2.9%	15.5%	2.5%
-2	20.9%	2.8%	12.2%	2.5%
-3	15.2%	3.0%	8.7%	2.6%
-4	9.3%	3.4%	5.0%	2.9%
-5	3.0%	4.1%	1.0%	3.5%
-6	0.0%	0.0%	0.0%	0.0%

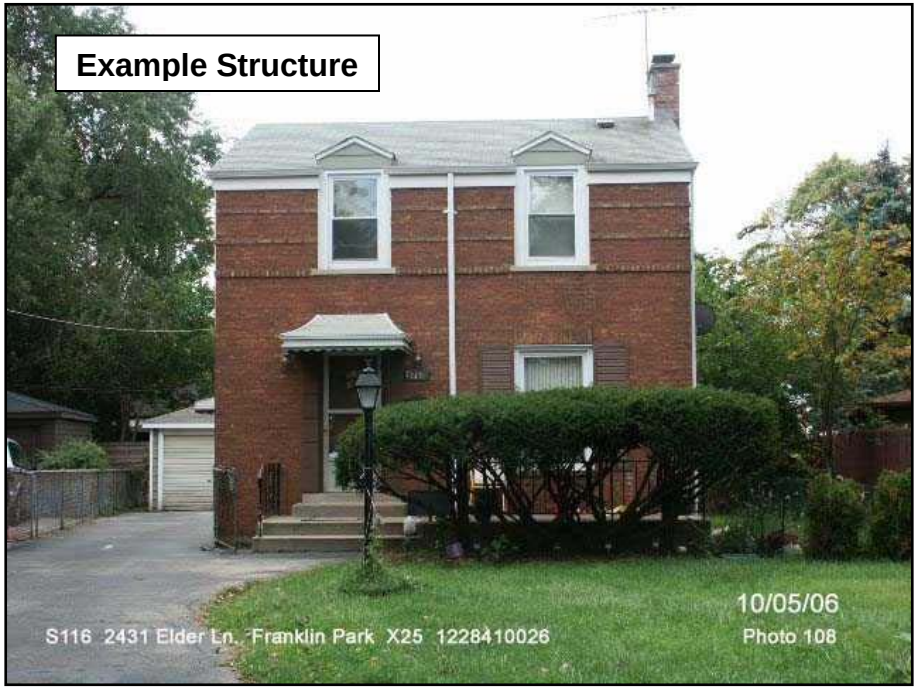


Notes: Depth-damage functions were derived by taking the two-story no basement (2SNB) relationship directly from EGM 04-01 and simply raising the vertical axis by 4-feet to account for elevated entry.

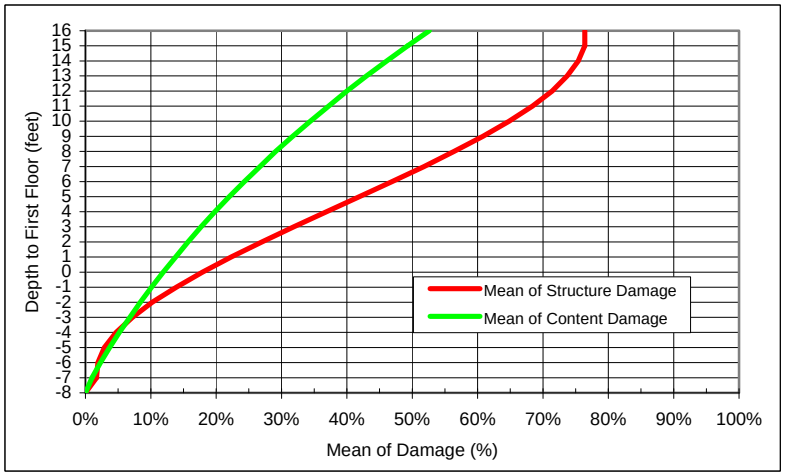
US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: 2SWB – Two Story With Basement**	CHECKED BY:	DATE:	

This type of residence has a second floor or upper level area which is equal or nearly equal to the ground floor area. The first floor and entry are typically elevated about 4 feet above grade.

2SWB – Two Story With Basement

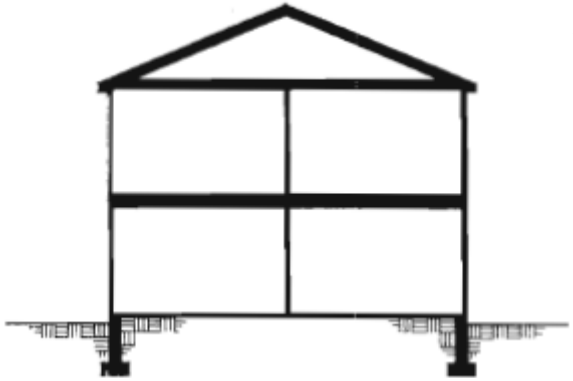


Depth	Structure		Contents	
	Mean of Damage	Standard Deviation	Mean of Damage	Standard Deviation
16	76.4%	12.4%	52.6%	10.2%
15	76.4%	9.8%	49.3%	8.1%
14	75.4%	7.8%	46.1%	6.4%
13	73.7%	6.2%	43.0%	5.1%
12	71.4%	5.0%	40.0%	4.1%
11	68.4%	4.2%	37.2%	3.5%
10	64.8%	3.7%	34.4%	3.0%
9	60.8%	3.4%	31.7%	2.8%
8	56.4%	3.1%	29.1%	2.6%
7	51.8%	2.9%	26.7%	2.4%
6	46.9%	2.6%	24.3%	2.2%
5	41.9%	2.3%	22.0%	1.9%
4	36.9%	2.0%	19.8%	1.7%
3	31.9%	1.8%	17.7%	1.4%
2	27.0%	1.5%	15.7%	1.2%
1	22.3%	1.4%	13.8%	1.1%
0	17.9%	1.3%	11.9%	1.1%
-1	13.9%	1.4%	10.1%	1.1%
-2	10.2%	1.5%	8.4%	1.2%
-3	7.2%	1.6%	6.8%	1.3%
-4	4.7%	1.7%	5.2%	1.4%
-5	2.9%	1.8%	3.7%	1.5%
-6	1.9%	2.1%	2.3%	1.8%
-7	1.7%	2.7%	1.0%	2.3%
-8	0.0%	0.0%	0.0%	0.0%



Notes: Depth-damage functions taken directly from EGM 04-01.

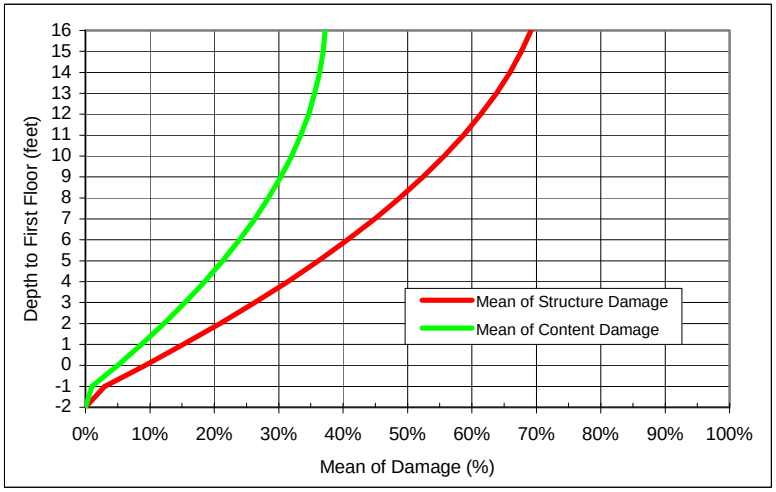
US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: 2SNB – Two Story No Basement**	CHECKED BY:	DATE:	



This type of residence has a second floor or upper level area which is equal or nearly equal to the ground floor area. The first floor and entry are typically at grade.

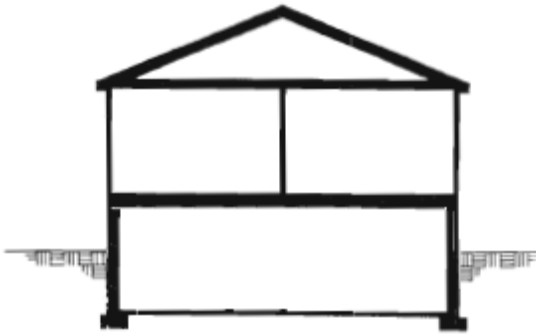
2SNB – Two Story No Basement

Depth	Structure: Mean of Damage	Structure: Standard Deviation	Contents: Mean of Damage	Contents: Standard Deviation
16	69.2%	5.0%	37.2%	4.2%
15	67.7%	4.6%	36.9%	3.8%
14	65.9%	4.3%	36.4%	3.6%
13	63.8%	4.2%	35.6%	3.5%
12	61.4%	4.2%	34.7%	3.5%
11	58.7%	4.2%	33.4%	3.5%
10	55.7%	4.2%	32.0%	3.5%
9	52.4%	4.1%	30.3%	3.5%
8	48.8%	4.0%	28.4%	3.4%
7	44.9%	3.9%	26.3%	3.3%
6	40.7%	3.7%	23.9%	3.2%
5	36.2%	3.4%	21.3%	3.0%
4	31.4%	3.2%	18.5%	2.7%
3	26.3%	2.9%	15.5%	2.5%
2	20.9%	2.8%	12.2%	2.5%
1	15.2%	3.0%	8.7%	2.6%
0	9.3%	3.4%	5.0%	2.9%
-1	3.0%	4.1%	1.0%	3.5%
-2	0.0%	0.0%	0.0%	0.0%



Notes: Depth-damage functions taken directly from EGM 04-01.

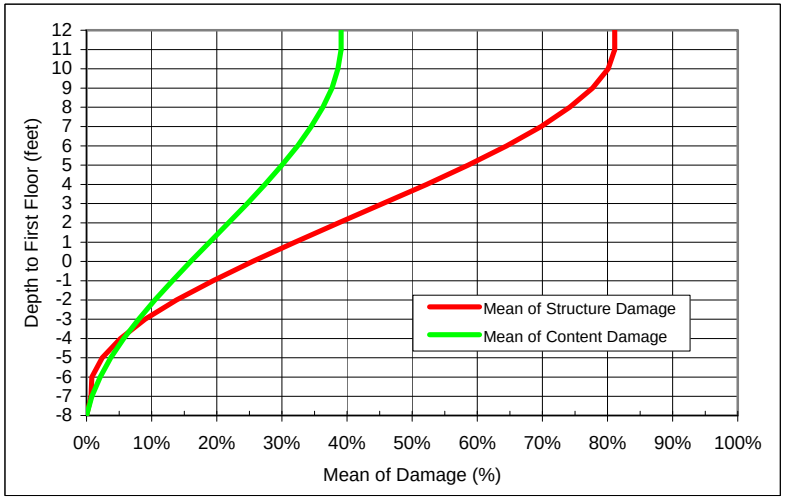
US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: 1SWB – One Story With Basement**	CHECKED BY:	DATE:	



The living area of this type of residence is confined to the ground floor and basement. The headroom in the attic is usually too low for use as living area and is used for storage. The first floor and entry are typically elevated about 4 feet above grade.

1SWB – One Story With Basement

Depth	Structure		Contents	
	Mean of Damage	Standard Deviation	Mean of Damage	Standard Deviation
12	81.1%	2.9%	39.1%	2.5%
11	81.1%	2.9%	39.1%	2.5%
10	80.1%	2.8%	38.6%	2.4%
9	77.7%	2.7%	37.7%	2.3%
8	74.2%	2.5%	36.3%	2.1%
7	69.8%	2.4%	34.5%	2.0%
6	64.5%	2.1%	32.4%	1.8%
5	58.6%	1.9%	30.0%	1.6%
4	52.2%	1.6%	27.4%	1.4%
3	45.5%	1.4%	24.7%	1.2%
2	38.7%	1.1%	21.8%	1.0%
1	32.0%	1.0%	18.9%	0.8%
0	25.5%	0.9%	16.0%	0.7%
-1	19.4%	0.8%	13.2%	0.7%
-2	13.8%	0.9%	10.5%	0.7%
-3	9.0%	0.9%	8.0%	0.8%
-4	5.2%	0.9%	5.7%	0.8%
-5	2.4%	0.9%	3.7%	0.8%
-6	0.8%	1.1%	2.1%	0.9%
-7	0.7%	1.3%	0.8%	1.2%
-8	0.0%	0.0%	0.0%	0.0%

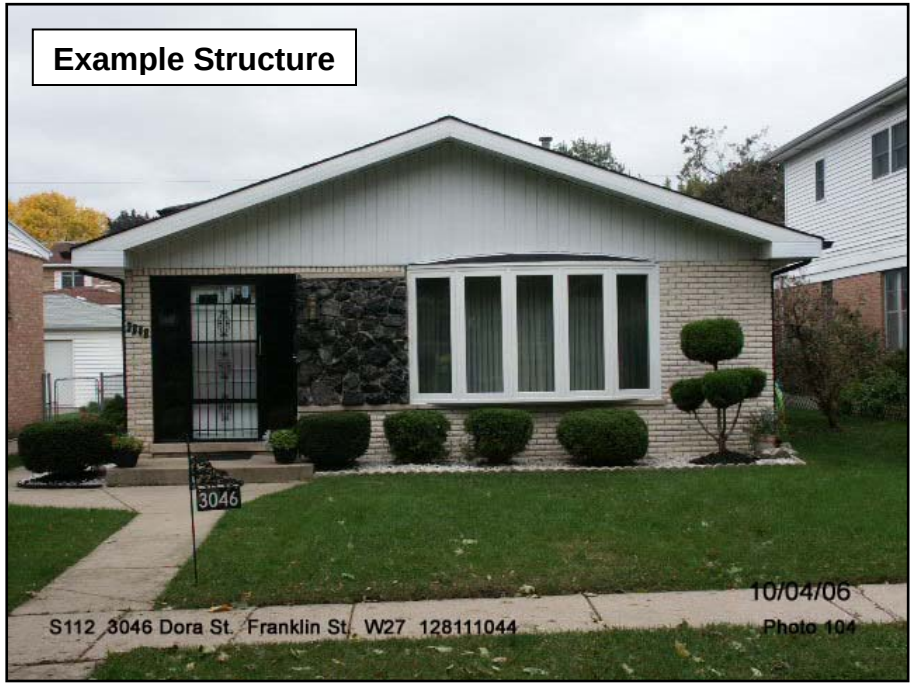


Notes: Depth-damage functions taken directly from EGM 04-01.

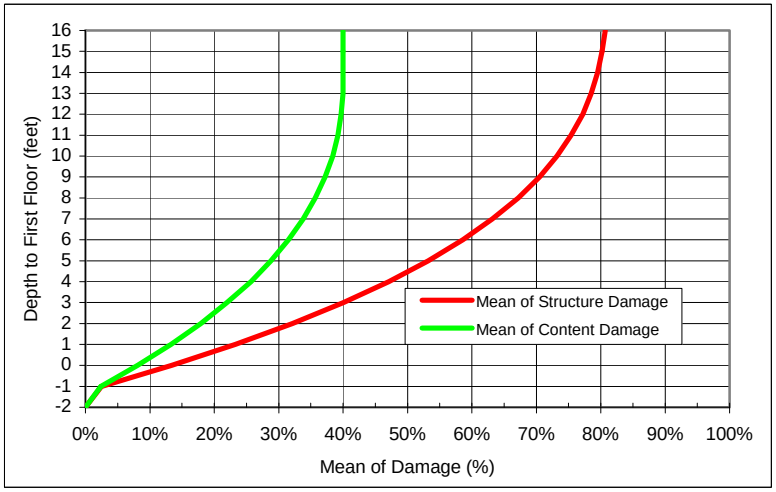
US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: 1SNB – One Story No Basement**	CHECKED BY:	DATE:	

The living area of this type of residence is confined to the ground floor. The headroom in the attic is usually too low for use as living area and is used for storage. The first floor and entry are typically at grade.

1SNB – One Story No Basement

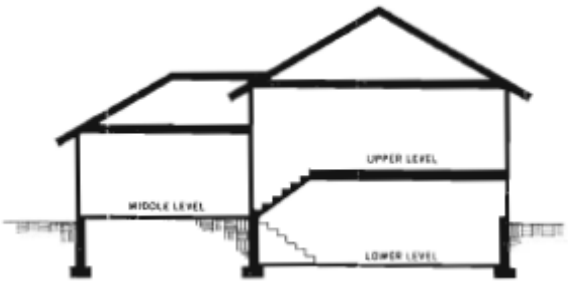


	Structure		Contents	
Depth	Mean of Damage	Standard Deviation	Mean of Damage	Standard Deviation
16	80.7%	4.9%	40.0%	3.8%
15	80.2%	4.5%	40.0%	3.5%
14	79.5%	4.1%	40.0%	3.2%
13	78.5%	3.7%	40.0%	2.9%
12	77.2%	3.3%	39.7%	2.6%
11	75.4%	3.0%	39.2%	2.3%
10	73.2%	2.7%	38.4%	2.1%
9	70.5%	2.4%	37.2%	1.9%
8	67.2%	2.3%	35.7%	1.8%
7	63.2%	2.2%	33.8%	1.7%
6	58.6%	2.1%	31.5%	1.6%
5	53.2%	2.0%	28.8%	1.6%
4	47.1%	1.9%	25.7%	1.5%
3	40.1%	1.8%	22.0%	1.4%
2	32.1%	1.6%	17.9%	1.2%
1	23.3%	1.6%	13.3%	1.2%
0	13.4%	2.0%	8.1%	1.5%
-1	2.5%	2.7%	2.4%	2.1%
-2	0.0%	0.0%	0.0%	0.0%



Notes: Depth-damage functions taken directly from EGM 04-01.

US Army Corps of Engineers® Chicago District	PROJECT TITLE: **Upper Des Plaines Phase II Study – Baseline Economic Analysis**	COMPUTED BY: **DFB**	DATE: **15Jan09**	SHEET:
	COMPUTATION TITLE: **Residential Damage Categories: TLWB – Tri-Level With Basement**	CHECKED BY:	DATE:	

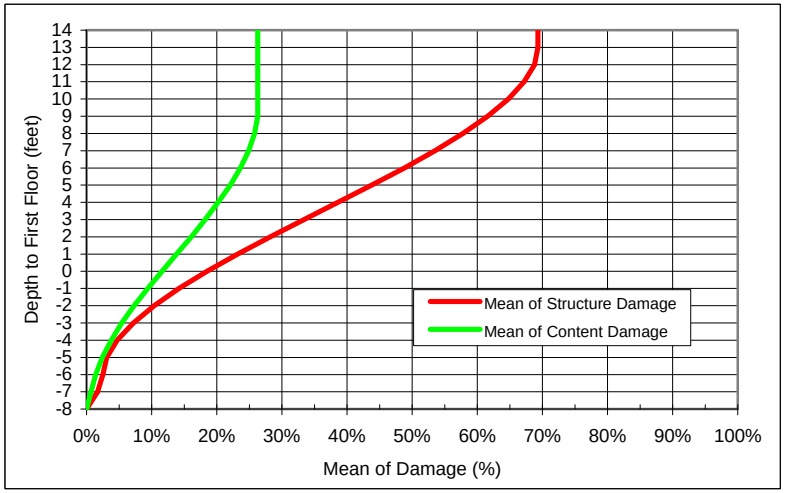


This type of residence has three levels of living area, one at grade level, one about 4 feet below grade and one about 4 feet above grade. All levels serve as living areas and have full ceiling heights. The entry is located on the middle level at grade.

TLWB – Tri-Level With Basement

Example Structure

Depth	Structure		Contents	
	Mean of Damage	Standard Deviation	Mean of Damage	Standard Deviation
14	69.3%	5.7%	26.3%	2.4%
13	69.3%	5.7%	26.3%	2.4%
12	68.8%	4.8%	26.3%	2.4%
11	67.2%	4.2%	26.3%	2.4%
10	64.8%	3.9%	26.3%	2.4%
9	61.6%	3.6%	26.3%	2.4%
8	57.8%	3.4%	25.8%	2.3%
7	53.5%	3.2%	24.9%	2.1%
6	48.8%	2.9%	23.6%	2.0%
5	43.8%	2.6%	22.1%	1.8%
4	38.6%	2.4%	20.2%	1.6%
3	33.4%	2.1%	18.2%	1.4%
2	28.2%	1.9%	16.1%	1.2%
1	23.2%	1.7%	13.8%	1.1%
0	18.5%	1.6%	11.6%	1.1%
-1	14.2%	1.6%	9.4%	1.0%
-2	10.4%	1.6%	7.3%	1.0%
-3	7.2%	1.6%	5.4%	1.0%
-4	4.7%	1.5%	3.8%	1.0%
-5	3.1%	1.6%	2.4%	1.0%
-6	2.5%	1.8%	1.4%	1.1%
-7	1.7%	2.7%	0.7%	1.5%
-8	0.0%	0.0%	0.0%	0.0%



Notes: Depth-damage functions were taken directly from the split-level with basement category in EGM 04-01.

Attachment 3

Upper Des Plaines River Watershed Estimated Flood-Induced Traffic Impacts

Baseline Analysis

June 2009

prepared by:

Northwestern University

Laurence Audenaerd, Ph.D. candidate
Joseph Schofer, Ph.D.

Vista Transport Group

Curtis Barrett
Thomas Vick, AICP
Thanasis Ziliaskopoulos, Ph.D.

prepared for:

United States Army Corps of Engineers

Chicago District
Planning Branch

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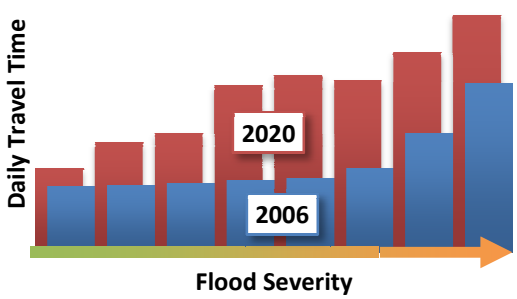
1 Executive Summary

In this project, we have analyzed the traffic impacts of flooding of the Des Plaines Watershed by the Des Plaines River and associated tributaries. This analysis required the use of hydrologic and hydraulic data and a traffic model. The scenarios tested included a number of flood severities for both a current and future model year, as well as a sensitivity analysis of flood start times for the current year model. This work was accomplished in support of the Chicago District of the United States Army Corps of Engineers (USACE) program to prepare a baseline economic analysis for the Upper Des Plaines River Feasibility Phase II Study in northeastern Illinois and southeastern Wisconsin.

The hydrologic and hydraulic models used by the United States Army Corps of Engineers (USACE) determined the flood-driven rise and fall of water levels at all major river crossings in the watershed resulting from various flood frequency analyses. This provided a set of start times at which floods were expected to occur, as well as flood durations. A start time defines both the time of day, and the day of the flood event, on which a flood starts.

These data were used to prepare time-varying road closures to be modeled using the Visual Interactive System for Transportation Algorithms (VISTA) traffic operations modeling software. (1) Flooded roadway closures were combined with traffic demand and network data provided by the Chicago Metropolitan Agency for Planning (CMAP). Traffic impact effects were modeled to produce measures of effect (travel delay) by comparing without-flood conditions to flood conditions for the years 2006 and 2020.

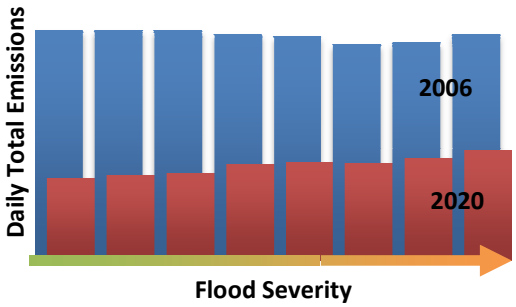
The scenarios tested included varying the start times of floods, varying the duration of the storm, and varying the model year (2006 or 2020) for both the traffic network and demand. This report discusses the methodology used to prepare these scenarios and the results. A discussion of various modeling issues is included. Detailed results for all scenarios are provided in the appendices.



Travel time was found to increase with flood severity in both model years. Delays changed across the sensitivity scenarios tested, but did not exhibit any consistent trend among the time offsets and flood severities. Travel time savings were to be relatively constant for all scenarios in both model years. The increasing proportion of traffic experiencing delays correlated very strongly with the decreasing proportion of traffic experiencing no time change as flood severity increased.

Mileage increased for the less severe flood events in the 2006 model year, then decreased in the most severe flood events. Mileage decreased with flood severity in the 2020 model year. These decreases were due to the availability of shorter alternate routes around flooded roads and significant traffic congestion caused by the more severe flood events, resulting in some vehicles not able to finish their trips. These partial trips are of a group which would potentially exhibit different travel behavior in the

real world, such as delaying or canceling the trip. Modeling these behaviors were outside the scope of this project.



Estimated emissions were found to vary by vehicle classification and the type of pollutant across the 2006 model year scenarios, with and without time offsets. Correlations between travel measures and emissions in these scenarios did not yield conclusive trends. Some pollutants correlated strongly with delay, some with mileage, and others with nothing. The 2020 model year yielded significantly smaller estimated emissions than the 2006 model year due to the expectation of tougher fuel standards and more modern vehicle fleets in that year. All pollutants trended consistently upwards in the 2020 model year.

The delay effects estimated in this project were attributed to the flooded roadways. These roadway effects were weighted according to flood frequencies and traffic volumes to produce rankings of roads contributing most significantly to the total delay within the study region. The largest contributions for both model years and all sensitivity scenarios were attributed to nearly identical sets of roads.

2 Glossary

This report contains a variety of terms and acronyms which may not be familiar to all readers. We have defined the most important of these in this section.

CMAP, Chicago Metropolitan Agency for Planning

The metropolitan planning organization for the city of Chicago and the surrounding suburbs.

Commercial Vehicle

Any truck used for a commercial purpose, from delivery vans to container trucks.

Delay

The travel time difference of a vehicle between a flood condition and a without-flood condition.

Dynamic

Used to describe data which changes over time, or processes which account for dynamic data.

Flood Duration

The length of time during which an individual road segment is closed by a flood. Not to be confused with the total length of a flood event.

DTA, Dynamic Traffic Assignment

A modeling tool which assigns origin-to-destination vehicle traffic to a given road network based on some minimization criteria, while accounting for temporal variations in both the demand for travel (the times people wish to travel) and in the travel times on the network that result from time-specific traffic conditions.

DUE, Dynamic User Equilibrium Assignment

A user equilibrium assignment which accounts for time-varying travel costs.

Mileage

Travel distance as measured in miles.

NWU, Northwestern University

A private research university located in Evanston, Illinois. Primary contractor on this project.

Passenger Vehicle

Any vehicle used for transporting people, such as cars and some small trucks as defined by CMAP. Transit vehicles are not included in this definition.

Offset

A time offset added to the start time of a flood. A flood normally starting at 6 a.m. would start at 9 a.m. with a 3-hour offset.

Road Segment

A road between two intersections.

SIBA, System Impacts-Based Aggregation

A methodology for ascribing regional traffic impacts to individual flood crossings. Developed by Mr. Dennis Giba for USACE as discussed in Section 3.4.4.

Storm

A storm event with significant rainfall, leading to flooding. In this project, both a 24-hour and 10-day storm were considered.

Severity

The significance of a flood event, in terms of the duration of closures.

Traffic Assignment

A method to assign trips to a traffic network using a travel cost function to choose routes.

Traffic Simulation

A method to model the behavior of vehicles traveling in a traffic network.

Trip

An origin-destination pair and the number of vehicles traveling between the two.

Trip Table

A set of trips for a specific trip purpose and/or vehicle type.

USACE, United States Army Corps of Engineers

The federal agency responsible for investigating, developing and managing the nation's water and related environmental resources. Sponsor of this project.

User Equilibrium Assignment

A traffic assignment in which no vehicle can move to a shorter route. See Section 3.1.

VISTA, Visual Interactive System for Transportation Algorithms

A traffic modeling software package tailored towards planning and operations projects.

VTG, Vista Transport Group

A traffic software and consulting company located in Evanston, Illinois. Subcontractor on this project.

3 Methodology

This section discusses the steps taken in preparing, executing, and analyzing the flood scenarios for this project. The data were obtained from CMAP and USACE. The without-flood conditions and flood scenarios were prepared in VISTA using this data, the results of which were processed to provide the needed analysis.

VISTA was chosen for this analysis because it is capable of scaling to large regions, because it can achieve a dynamic user equilibrium assignment, and because it can simulate the queuing and rerouting effects of traffic during a major network event.

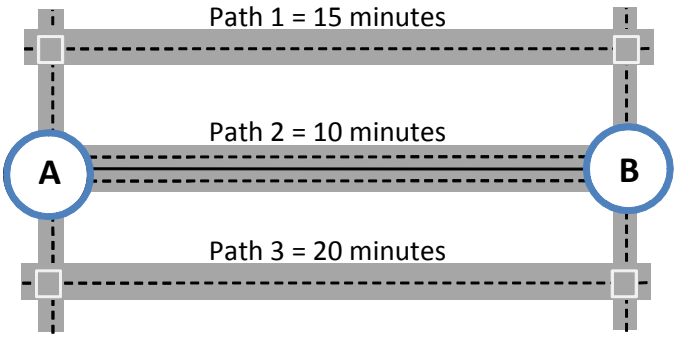
VISTA was developed with the intent to model large regional traffic networks. VISTA can operate on regions the size of the Chicago regional planning network, and larger. The complete traffic network for this project spans seventeen counties in three states, a testament to the ability of VISTA to be applied to large problems.

A unique vehicle assignment process is used within the Dynamic Traffic Assignment (DTA) module of VISTA, allowing a true dynamic user equilibrium (DUE) assignment to be found. A DUE assignment guarantees that no driver can choose a faster route than the one to which that driver is already assigned. This type of assignment is the closest approximation to real traveler behavior possible using the data available from most regional planning data sets.

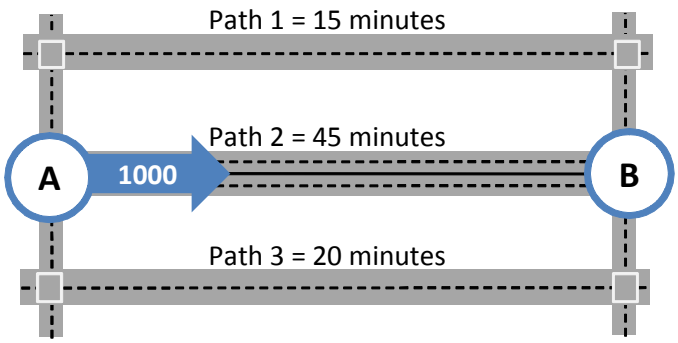
3.1 Traffic Assignment

A traffic assignment model approximates route choice behavior by assigning vehicles to network routes until travel times between origins and destinations are in equilibrium. The underlying assumption is that drivers of vehicles have enough knowledge about both the traffic network and typical traffic conditions to choose the quickest route available to them. Equilibrium is the condition in which assigned traffic volumes on each link are consistent with the estimated travel time on that link, and no driver can find a quicker path to get to her or his destination. In the example below, we assume a demand of 1000 vehicles from intersection A, the origin, to intersection B, the destination.

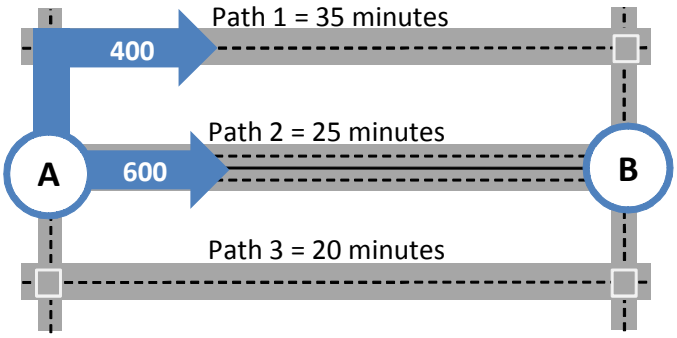
Without any traffic assigned to the network, the three available paths have these travel times.



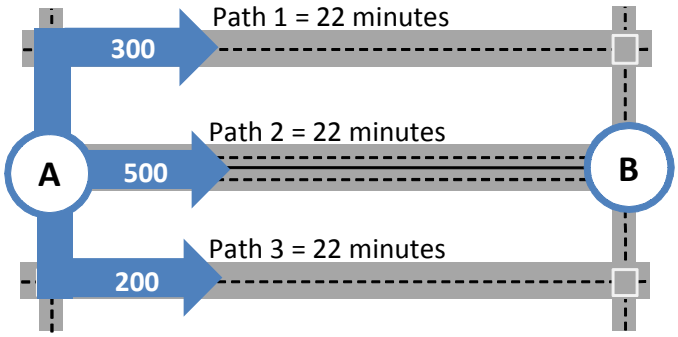
Vehicles are first assigned to the quickest path, which is Path 2 with a travel time of 10 minutes. The travel time increases on Path 2 as the vehicles using this path create congestion.



The algorithm reassigns a portion of the vehicles to the next shortest path, Path 1 with a travel time of 15 minutes. The travel time on Path 1 increases with the additional traffic while travel time on Path 2 decreases.



This process continues reassigning vehicles and recomputing travel times until no additional shifts in vehicles to other paths would improve travel times. This is condition is called user equilibrium.



In a larger traffic network, most road segments carry traffic for paths between multiple (sometimes many) origins and destinations. That is, using the example above, vehicles traveling from A to B would experience not only delays due to congestion of traffic going from A to B, but traffic between other origins and destinations. In applications, the model cycles all origin-destination pairs through the equilibration process subsequently, affecting other origin-destination pairs.

Dynamic Traffic Assignment (DTA) is an extension of traffic assignment which accounts for the variation in network performance and travel demand over a given time period. These variations cannot be accounted for by static traffic assignment, the typical approach used by large traffic planning models.

Travel patterns change over the course of a given day in any city or region, with morning trips predominantly consisting of travel from homes to employment centers, and afternoon trips going the

reverse. Additional trips for purposes of shopping, recreation, commercial shipping, and other activities also vary during the day. These differences necessitate the use of time-varying travel demand data. While individual static assignments can be performed for large time periods over the course of a day, this method of analysis suffers from boundary effects at the edges of these time periods. Trips departing late in a time period would be assigned based on travel costs associated only with that time period, even though those trips may not arrive at their destinations until the next time period.

DTA solves this disparity by using the time-varying travel times over the entire day. Routes are chosen based on travel times accumulated as if the route were actually traveled. The travel time of an individual road segment in a route is dependent on the departure time of the trip for which the route is being created, and the travel times of all prior road segments in the route. These travel times allow the assignment to choose routes which best fit the changing travel times of the traffic network during the day.

3.2 Data

CMAP made available its modeled 2006 and 2020 regional traffic networks and travel demand data for this project. These data sets each included a traffic network, traffic analysis zones, and trip tables (zone to zone trips) for ten different combinations of vehicle type and trip purpose. The CMAP data were provided as a number of files in plain text. These were processed and imported into VISTA databases, one each for the 2006 and 2020 data sets.

USACE prepared the flood schedule data for both the 2006 and 2020 analysis years. These data were provided as spreadsheets and shapefiles, including the location and scheduling information for each flooded river crossing.

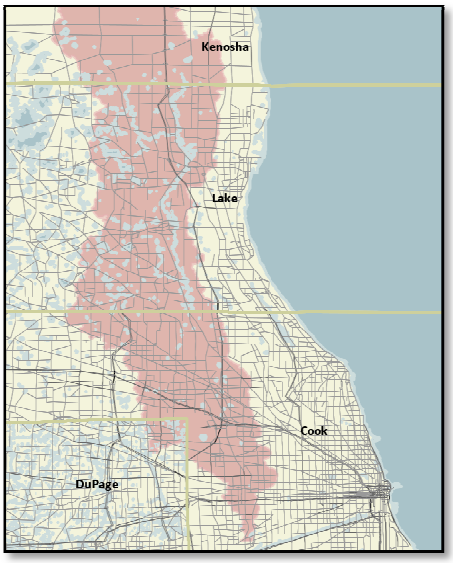


Figure 1: 2006 Study Region Traffic Network

3.2.1 Traffic Network

The CMAP regional traffic network spans three states and seventeen counties, from southeastern Wisconsin, through northeastern Illinois, and into northwestern Indiana. The network includes the Des Plaines River Watershed in its entirety, making it suitable for use in this project. However, the large size of this network, in relation to the flood-affected area, made it impractical for running the numerous multi-day flood scenarios required by this project.

Reducing the size of the network benefited both the analysis of results and the computational time required to produce those results. The impacts of the floods are ultimately diluted over the study region. A smaller study region would demonstrate more substantial regional effects than the full study region. A smaller study region would also run through the traffic simulator and analysis procedures more quickly than the full region.

The network was cropped to a sub-region including the Des Plaines River Watershed and a buffer zone of at least five miles on all sides. This cropped network is large enough to capture all of the likely vehicle rerouting spillover effects of flooding in the Des Plaines Watershed.

3.2.2 Trip Tables

CMAP developed the regional trip tables using its method of trip generation, trip distribution, and mode split models. These models compromise the first three steps of the standard four-step traffic planning model. Trip generation takes socioeconomic data (household size, vehicle ownership, employment, etc.) and generates person trips leaving and entering each analysis zones across the modeled region. Trip distribution takes the generated trips by zone and allocates them to specific zone-to-zone flows across the model region. Finally, the mode split model predicts which of these trips use transit and which take personal vehicles, the latter being the trips important to this study. CMAP uses both census data(2) and household travel surveys(3) to support the demand modeling process. The travel data used in this project was collected in 2006.

The CMAP travel demand matrices (also called trip tables) include ten different trip types, covering both passenger vehicles and trucks and a variety of trip purposes. These trip types were aggregated by vehicle classification and trip purpose for reporting the results of this project. The CMAP trip types, used in both the 2006 and 2020 trip tables, are listed in Table 1.

CMAP Trip Type	Vehicles	Purposes
Home to Work	Passenger Cars and Trucks	Work
Home to Other	Passenger Cars and Trucks	Shop, Other
Non-Home to Non-Work	Passenger Cars and Trucks	Work, Shop, Other
B-Plate Truck	Passenger Trucks	Commercial
Light Truck	Commercial Trucks	Commercial
Medium Truck	Commercial Trucks	Commercial
Heavy Truck	Container Trucks	Commercial
External Auto	Passenger Cars	Other
External Truck	Container Trucks	Commercial
Airport	Passenger Cars	Other

Table 1: CMAP Trip Types

USACE requested the breakdown of vehicles by trip purpose in the results of this project. While CMAP does categorize trip purpose into Work, Shop, and Other purposes, this data was not immediately usable in this project. The more detailed categorization by trip purpose is done earlier in the CMAP travel demand modeling process, before generation of the trip tables used in this project.

As is the standard practice in regional transportation planning, the CMAP trip tables are only produced only for weekday vehicle trips. CMAP does not prepare trip tables for either weekend travel demand or for travel during major network events, such as a flooding. Because of this, all flood scenario days were run with the weekday trip table. Project flood scenarios extended beyond five days, therefore, travel over weekend days was assumed to exhibit the same patterns as weekday travel. This introduces errors

because urban travel is reduced on weekends in northeastern Illinois(4). The use of only weekday trip data created a modest over-estimation of predicted impacts in the flood scenario results.

All ten CMAP trip types were used in the VISTA traffic model and in the preparation of the results reported here. Only in the finalized results, both in this report and in summary spreadsheets, were these vehicle types aggregated into the categories *Car* or *Truck* for economic modeling purposes. This mapping is detailed in Section 3.4.1.

A secondary mapping was prepared between the CMAP trip types and the vehicle categories defined by MOBILE6, an emissions modeling software package used in this project. This mapping is detailed in Section 3.4.7.

The trip table used in the scenarios was reduced from the full regional demand by the cropping of the regional traffic network to the study region used by this project. First, an initial assignment was prepared using the full CMAP regional model. The routes used in this assignment were tested against the study region. Those which did not intersect the study region were dropped. Those contained partially within the study region were clipped to just the portions within the study region. Those routes which were contained entirely within the study region were kept as is. The vehicles using the latter two types of routes were assigned to the revised set of routes in the same proportions. The reduced travel demand included just over a third of the trips for the full CMAP regional model, including all trips affected by the floods.

3.2.3 Traffic Counts

We obtained traffic count data for major expressways from Illinois Department of Transportation (IDOT). These traffic counts were used to calibrate and refine the assignment of the trip tables to the traffic network, to assure that the results were realistically representative of observed traffic flows. These traffic counts were obtained by CMAP from the IRIS database maintained by IDOT. The counts used to calibrate the 2006 model were collected between 2003 and 2005.

Obviously, no traffic counts are available for the 2020 model. No such calibration could be performed for this network.

3.2.4 Flood Scenarios

Flood schedule and location data were provided by USACE. The traffic modeling team were given these flood schedules (flood start times and durations) for every river crossing in the traffic network. Start times and durations were further broken down by flood severity and model year.

A key modeling decision made in this project was the determination of which storm event to use to obtain the most severe traffic impacts. USACE required the most severe impacts for use in their baseline economic analysis, to best justify planning of flood mitigation projects. USACE prepared flooding data for both a 24-hour and a 10-day storm, the length of each storm defining the amount of time over which rain falls and collects in the watershed. The flood schedules for both storm events were remarkably similar. While differences in the given start times for both storm events were numerous, the amount of road inundation under both storm events was very similar. The USACE hydrologic model determined

that the floods would start at different times under these conditions, but would take similar durations to recede.

The traffic modeling team performed a number of scenario runs on both the 24-hour and 10-day storms, for a number of different flood year scenarios. The 24-hour storm caused slightly larger impacts in most of the scenarios tested. While these results leaned towards the use of the 24-hour storm event, the differences were not substantial enough to be considered conclusive.

An analysis of the flooding schedules themselves yielded a better answer to the question of which storm duration to use in this project. Given that peak periods represent the highest levels of traffic volume and congestion in the study region, the amount of flooding which takes place during those periods should provide an indication or measure of the overall level of traffic impact of a particular flood event.

The first step in this process was to accumulate the closure duration of individual flood locations which overlapped with the morning and afternoon peak periods. This involved overlaying the flood schedules with daily peak period schedules an adding up the intersection of the two. This process was performed for start time offsets between zero and twenty three hours, inclusive.

Figure 2 gives an example of how a two-day flood schedule overlaps with peak periods during those two days. Flooded Road A closes at 4 a.m. on the first day and reopens at 8 p.m. that same day. This overlaps with the morning and afternoon peak periods on this first day, contributing four hours of flooding during peak periods. Flooded Road B overlaps with the afternoon peak period on the first day, and both peak periods on the second day, contributing six hours of peak period flooding. Flooded Road C overlaps no peak periods, and therefore does not contribute to the peak period flood duration. Flooded Road D overlaps both peak periods on the second day, contributing another four hours.

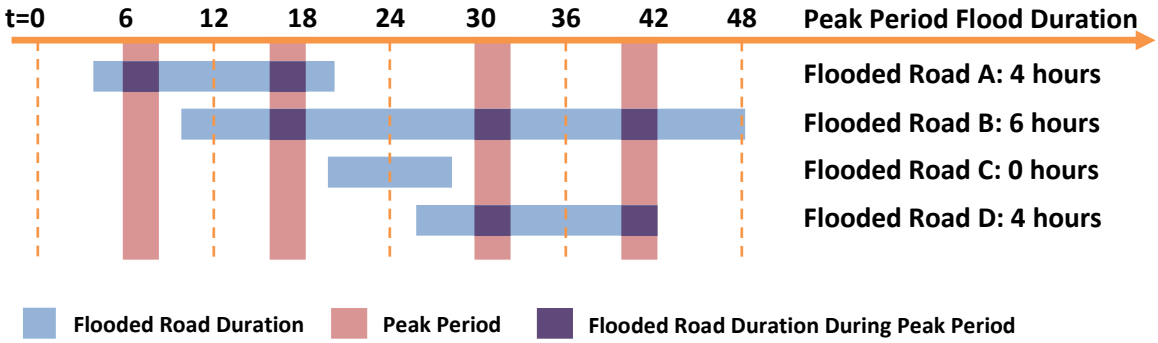


Figure 2: Example Peak Period Flood Durations

This example simplifies the input data used for this analysis. The analysis performed for this project did not round the start or end times, so only the time which a flood was actually active is considered for each peak period. A flood starting halfway through a peak period contributes only half of the duration of that peak period, not the entire period.

A series of graphs was produced to contrast these durations against the start time. These graphs demonstrated that 24-hour storm events contributed more flooding during peak periods than 10-day storm events. See **Error! Reference source not found.** for an example of this. The 500-year flood for the

24-hour storm demonstrates a significant peak with a 3-hour start time offset, as well as a significant trough with a 13-hour start time offset.

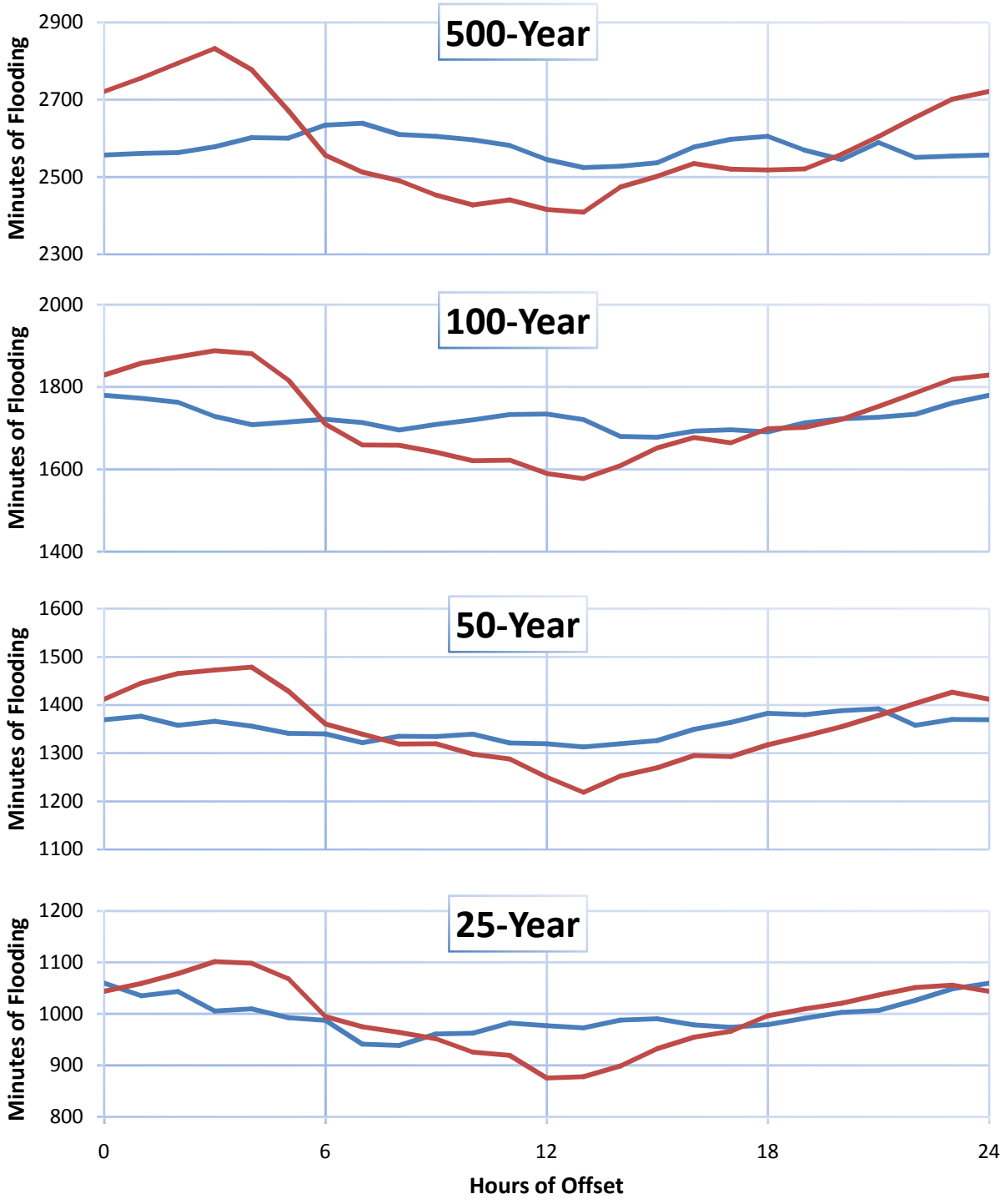


Figure 3: 25 through 500-Year Peak Period Flood Durations by Start Time Offset

The 24-hour storm demonstrated slightly more serious delays in the flood scenario runs performed for both storm events, yielding a slight preference for the 24-hour storm. This storm also displayed a more

variable overlap with the highest levels of traffic volume during the typical day, giving a much more diverse set of input possibilities for the sensitivity analysis portion of this project. The traffic modeling team presented these findings and our recommendation to use the 24-hour storm to USACE, which accepted and approved the recommendation. The 24-hour storm schedules were used for all scenarios.

The procedure used to choose the storm event also assisted in choosing the time offsets used for sensitivity analysis. A sensitivity analysis was performed for this project because it is not possible to predict the actual start time of a flood. While the flood schedules provided by USACE assumed a certain set of start times, such a flood in the real world could start much later, or much sooner, during the day. To test the effects of such start time changes on travel, a sensitivity analysis was performed for four different start time offsets and flood severities.

Error! Reference source not found. demonstrates the variability of the peak period flood duration for the 24-hour storm at a 500-year severity. The peak and trough of this graph (at three and thirteen hours, respectively) provided a good basis for two of the four start time offsets chosen for the sensitivity analysis. The former would overlay the most flooding on the most traffic in hopes of netting a more significant impact than other start time offsets. The latter would overlay the least flooding with the most traffic, which should minimize the impact relative to other start time offsets. The other two start time offsets (eight and eighteen hours) were chosen to give a more complete representation of the range of peak period flooding.

3.3 Modeling

The modeling process involved applying the USACE flooding data to the VISTA software using CMAP data to produce estimates of travel time delay for use by USACE in its flood damage determination economic model.

3.3.1 Flood Locations

The traffic modeling team was given flood location data including a latitude-longitude and a street name. The latitude-longitude were used to match each flood location with the nearest road segment in the CMAP traffic network so that the road closures caused by flooding can be correctly simulated by VISTA. The resulting mapping was then checked manually for all flood locations.

The generated link mappings and flood location coordinates were validated against several sources, including Google Maps™, physical maps, and personal experience. The process consisted of determining the VISTA mapped flood link's location on the physical maps and Google Maps™. If the mapped location was either on or very close to a VISTA link, the Google Maps™ satellite imagery was used to verify the existence of the Des Plains River or a tributary. Otherwise, location was marked for further investigation and discussion between the traffic modeling team and USACE. Examples of these ambiguous mapping locations included: mappings to closest, but incorrect links (Figure 4); mapping locations incorrectly onto the CMAP network (Figure 5); and mapping coordinate locations far from mapped links (Figure 6). Less important verifications were also performed, such as road name inconsistencies and spelling mistakes.

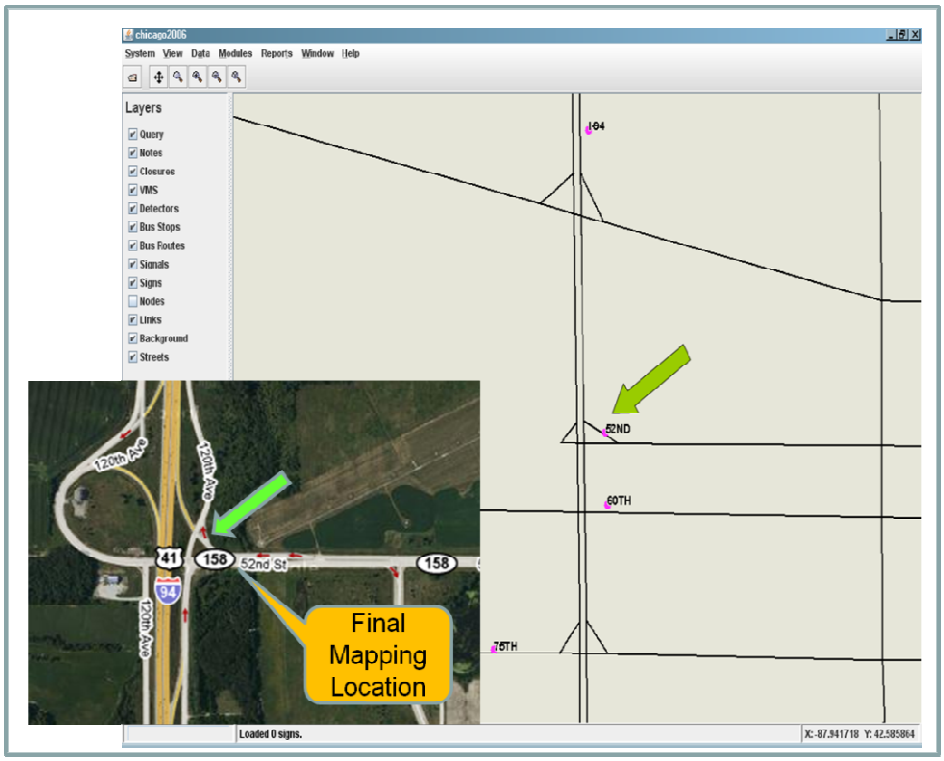


Figure 4: A Flood Location on the Incorrect Road Segment

Incorrectly mapped locations were mapped to the correct location on the network by checking the sources mentioned above for the road name given with the flood location data from USACE. In Figure 4, a closure on 52nd street was moved from the automatically chosen location of an on-ramp to I-94 to the section of 52nd street east of that ramp.

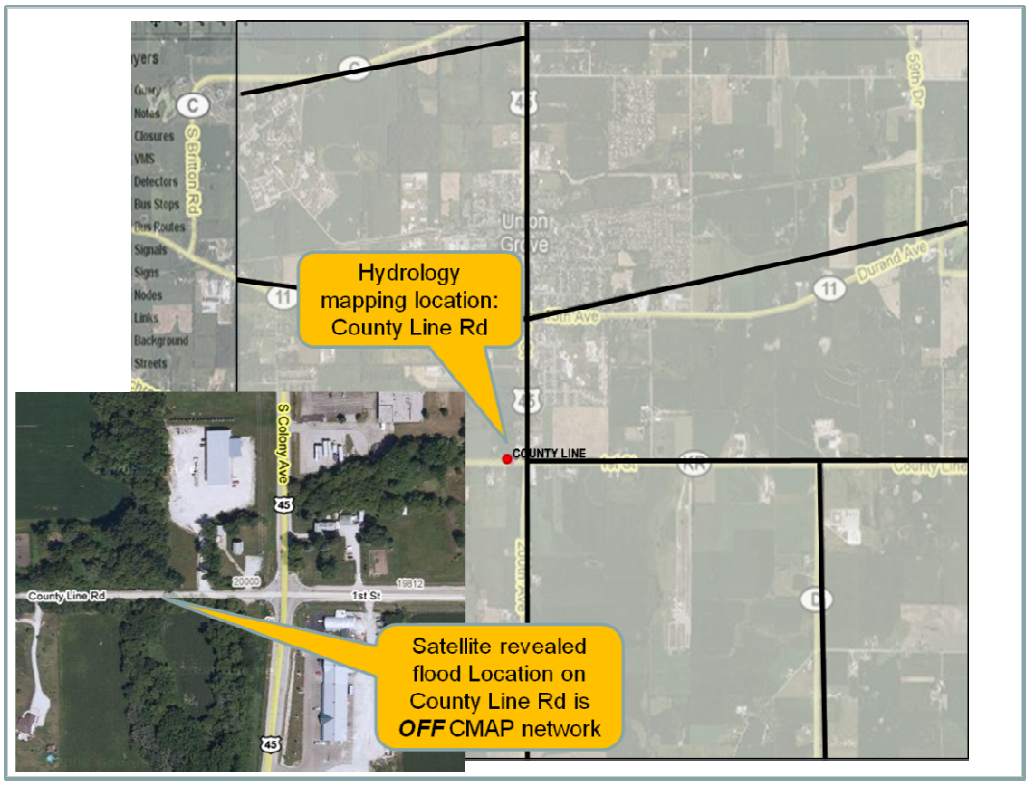


Figure 5: A Flood Location Not in the CMAP Traffic Network

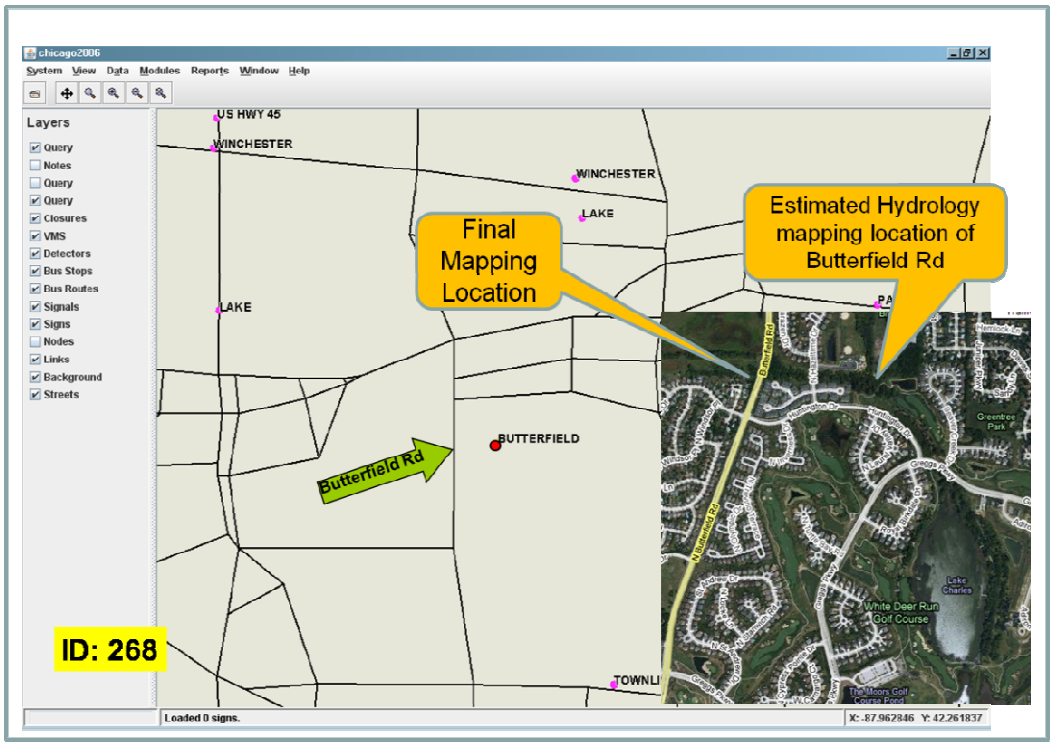


Figure 6: A Flood Location Not Directly on the CMAP Traffic Network

After a discussion between the traffic modeling team and the USACE to clarify the flood location anomalies, the final locations were prepared for the traffic simulation model. Each affected road segment was assumed to be closed in both directions.

3.3.2 Flood Schedules

The flood schedule data provided by USACE included different schedules for both the 2006 and 2020 model years. Unique durations and start times were given for every storm severity for both of the model years. The 2020 model year included longer flood durations for all storms. A summary of the total duration of all closures for every model year and storm severity can be found in Table 2.

Severity	2006 Model Year		2020 Model Year	
1-year	29 hours	2 roads	30 hours	2 roads
2-year	156 hours	7 roads	233 hours	8 roads
5-year	1,436 hours	25 roads	1,824 hours	33 roads
10-year	3,205 hours	42 roads	3,772 hours	44 roads
25-year	5,529 hours	71 roads	6,248 hours	73 roads
50-year	7,609 hours	83 roads	8,206 hours	87 roads
100-year	9,523 hours	112 roads	10,225 hours	116 roads
500-year	14,286 hours	165 roads	15,503 hours	173 roads

Table 2: Flood Closure Durations and Counts

The provided flood schedules spanned multiple days. Because the sensitivity analysis scenarios offset the start times of flooding, many of those scenarios differed in the number of days during which flooding occurs. This information was necessary to correctly compare with-flood results to without-flood conditions. The lengths of each flood event for each model year and sensitivity analysis time offset are shown in Table 3. Sensitivity scenarios were run only for the 10-, 25-, 50-, 100-, and 500-year flood severities.

Model Year Offset	2006 0 hours	2006 3 hours	2006 8 hours	2006 13 hours	2006 18 hours	2020 0 hours
1-year	3 days	*n/a*	*n/a*	*n/a*	*n/a*	3 days
2-year	7 days	*n/a*	*n/a*	*n/a*	*n/a*	8 days
5-year	12 days	*n/a*	*n/a*	*n/a*	*n/a*	13 days
10-year	15 days	15 days	16 days	15 days	15 days	16 days
25-year	19 days	19 days	19 days	20 days	19 days	19 days
50-year	21 days	21 days	21 days	21 days	20 days	21 days
100-year	21 days	22 days	22 days	22 days	21 days	22 days
500-year	25 days	25 days	25 days	25 days	26 days	25 days

Table 3: Flood Event Length

The flood schedules were divided up into individual schedules for each day of flooding for each with-flood scenario. These schedules ran from midnight to midnight the next day, closing roads at the specified start times on the days on which individual locations flooded. Locations which flood longer

than 24 hours are closed again at midnight on each subsequent day they should be closed, and staying closed past midnight if they are not intended to reopen on any given day.

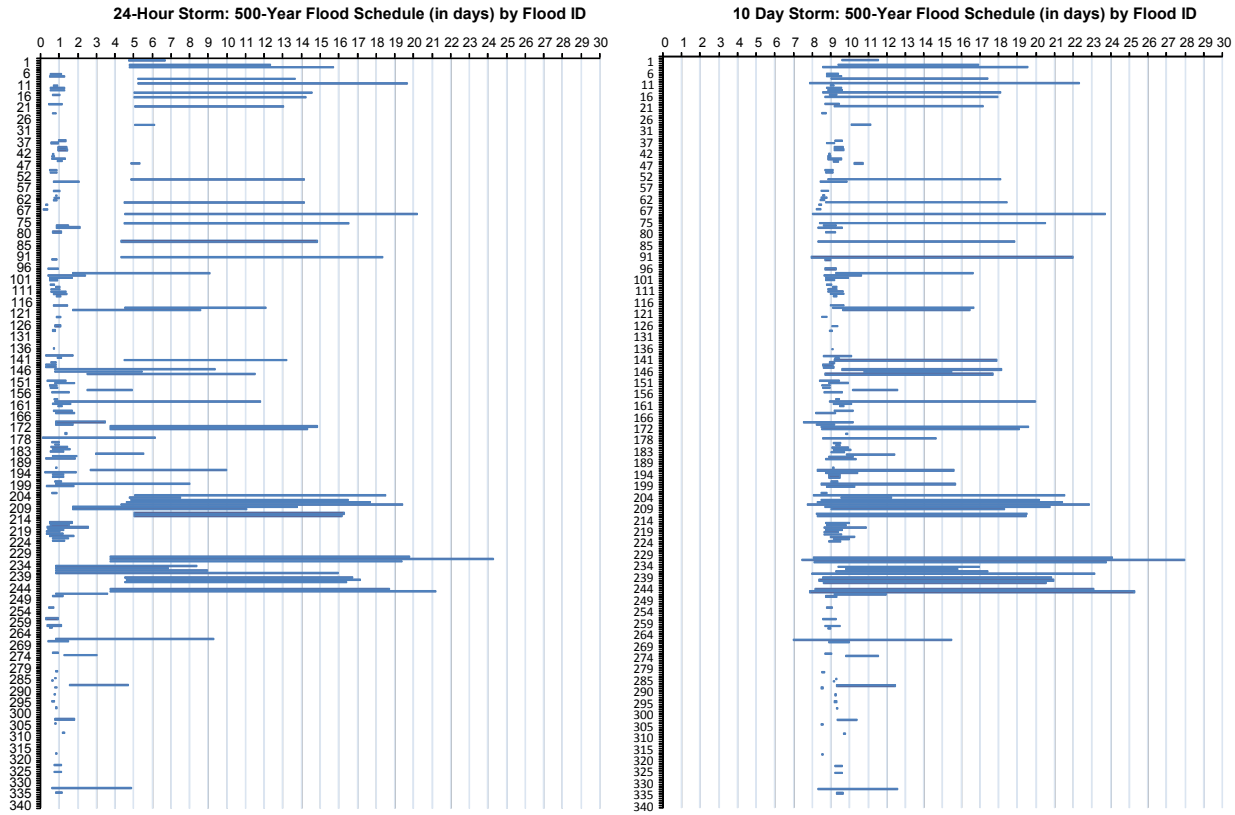


Figure 7: 500-year Flood Schedules for Both Storm Events

The schedules were prepared as Gantt charts to verify with USACE that the correct flood schedule inputs were used for the VISTA traffic simulation. These are shown in Figure 7. The horizontal axis is measured in days from the beginning of the storm event. The vertical axis lists flood locations by their ID numbers, partially ordered from south to north. In the 24-hour storm, many of the tributaries flood close to the precipitation event, illustrated by the shorter lines at the left of the 24-hour schedule chart. These affect the main stem days later, illustrated by the longer lines beginning on or after the third. In the 10-day storm, the effects of the precipitation event are realized later on all flood locations. The total aggregate flood duration for either storm event at the 500-year severity is almost 300 days. As stated earlier, only the 24-hour storm schedules were used in preparation of scenarios.

3.3.3 Without-Flood Condition Preparation

The traffic modeling team used VISTA to prepare dynamic traffic assignments for both the 2006 and 2020 datasets. The Dynamic Traffic Assignment algorithm iterates between identifying origin-to-destination routes, assigning vehicle to those routes, and simulating the performance of the roads in the network with the assigned volumes. The simulation step produces travel times which are used iteratively to redefine routes and reassign vehicle trips to them.

The key to a DTA model is the use of time-varying cost metrics, in this case travel time. The travel time of every road segment is recorded for every time step of simulation. These travel times can then be used by a least-cost routing algorithm(5) to generate the least-cost routes for all vehicle trips, for the specific departure times of those trips. This latter point is key – a static routing model produces routes independent of departure time. A vehicle departing in the early morning will likely have a different least-cost route from a vehicle making the same trip later in the day.

A least-cost routing algorithm operates on some metric, called *cost*, related to travel through the traffic network. For this project, the metric used is travel time. Other measures of *cost* could also be used, including mileage, road classification preferences, tolls, and so on. For a setting such as the Des Plaines River basin, and based on behavioral research, travel time is the most important variable affecting driver choice of routes. The VISTA routing algorithm attempts to find the lowest travel time from the origin to the destination for each driver.

The DTA algorithm used in VISTA is capable of finding a dynamic user equilibrium assignment. For a network and demand of the size used in this project, it is impractical to achieve true dynamic user equilibrium because of the substantial computational requirements involved. As a reasonable compromise, the without-flood conditions were prepared to within 10% of true equilibrium. This means that the average vehicle traveling in the system experienced a travel time 10% higher than could be obtained by switching routes. For a network and demand of this size, based on our modeling experience, and given the other uncertainties in the data, this is an acceptable trade-off.

3.3.4 With-Flood Condition Preparation

For this project, as with some previous flood impact analysis projects, a decision was made to perform each flood scenario using simulation only instead of dynamic traffic assignment. With simulation only, the traffic has very limited means to respond to changes in network capacity while DTA enables traffic to respond to events prior to their occurrence. This approach to modeling traffic impacts of flooding is acceptable for a number of reasons.

3.3.4.1 Computational Time

The diversity and length of the flood scenarios yielded 659 distinct days of floods to be tested. The simulation and statistical analysis for each flood day takes between three and four hours, depending on the severity of the flood.

Dynamic Traffic Assignment (DTA) is an algorithm which conducts many simulations, dozens, even hundreds in some cases, in a search for near equilibrium conditions. For example, the without-flood conditions used in this project required between 50 and 60 simulations within DTA to reach convergence. These individual model runs can take weeks. To perform the same computation for 659 days of flooding would take years on the computer hardware available for this work.

The high run times would also slow down debugging of modeling issues discovered during the analysis process. A mistake in the preparation of a flood scenario could set back the entire project months, instead of days.

3.3.4.2 Driver Knowledge

See Table 4 for a summary of driver knowledge within DTA and simulation. In all cases, the driver is assumed to have perfect knowledge of the network topology.

In the early stages of a flood, drivers do not know when or where in their route a road may be flooded. This is something they will typically find out only when they arrive at the flooded road itself. This is best modeled with simulation alone because the traffic condition knowledge assumed by the VISTA simulator does not extend much beyond what drivers can see in front of them. All drivers are assumed by the VISTA simulator to have adequate knowledge of the traffic network to choose an alternate route to their destination, but not knowledge of the travel times or traffic volumes elsewhere on the network.

DTA assumes perfect knowledge of traffic conditions, each driver clairvoyant to the current condition of the network and prescient about the future condition of the network. This knowledge enables the dynamic user equilibrium solutions used in the VISTA DTA module and reflects, to a certain degree, the knowledge drivers have about their traffic network on an average day. In a DTA model, drivers know what to expect when they choose from a number of different routes available to them.

Knowledge	Assignment	Simulation
Network Topology	Perfect	Perfect
Network Availability	Perfect	Limited
Network Performance	Perfect	Limited

Table 4: Driver Knowledge

Given that DTA assumes far more knowledge than a driver has about traffic conditions, it is not the best choice for scenario analysis needing realistic reactions to unexpected capacity changes.

This modeling approach was entirely reasonable for our past flood impact analysis projects for USACE, in which floods were relatively short, none lasting past a few days.

In this project, some floods lasted as long as twenty days. This is a sufficiently long period for drivers to accumulate knowledge about these flooded roads and test various alternative routes around these locations. The later days of this behavior would be better modeled by a mixture of DTA and the simulation rerouting. The earlier days of this behavior could be modeled using the simulation rerouting with a stochastic variation in route choice.

The modeling approach used by this project is expected to produce a net overestimate of delay. Drivers who would otherwise have foreknowledge of flooded roads instead travel to those roads before diverting, rather than using an alternate route when departing their origin.

The more severe flood schedules given to us by the USACE included closures extending up to twenty five days past the start of the flood event. These long flood durations covered a longer time span than had ever been simulated within VISTA.

In past flood impact analysis projects, the traffic modeling team had evaluated continuous multi-day analysis procedures and determined that the long run times were a hindrance, particularly in cases where runs needed to be performed again because of input data issues which affected only a small

duration of the overall flood schedule.(6) Performing multi-day model runs forced us to simulate the flood scenarios serially, such that later days could not be completed before earlier days.

3.3.5 With-Flood Simulation

For the Chicago region, as with most regions, traffic volumes drop off significantly in the few hours after midnight. In analyzing these trends in past projects, it was determined that the continuity errors introduced by breaking a long multi-day analysis into multiple single-day analyses were insignificant. This procedure was used to the satisfaction of USACE in past projects, and was used again in this project after coordination with USACE.

Each flood scenario included a schedule which we first broke into multiple 24-hour periods representing each day of the flood. These floods were coded as dynamic road closures (a road which can close and reopen at any time during a simulation) within VISTA. The VISTA traffic simulation module was run for each day of each flood for each flood event and start time offset and model year.

The VISTA traffic simulation module moves traffic according to a modified version of the cell-transmission model.(7) This model approximates vehicle motion by dividing road segments into individual *cells*. Vehicles move between these cells according to a set of constraints on the size and throughput of these cells. This modeling approach is computationally more efficient than traditional microsimulation, allowing large regional traffic networks to be modeled, as in this study. This approach also allows the queuing and discharge effects of traffic congestion to be captured, something not possible with typical volume-delay functions used in typical large-scale models.

These simulations were performed using a rerouting model built in to the VISTA simulation module. This rerouting model accounts for driver behavior under sudden reductions in network capacity, e.g. encountering a newly-flooded road. Finding the road ahead blocked, the driver chooses a diversion route around the flooded road, to the driver's destination. Drivers are assumed to have knowledge of the topology and performance of the traffic network under uncongested conditions. The route search is performed without the flooded road, allowing the driver to find the shortest (based on the driver's knowledge) path to the driver's destination. This functionality enables drivers to divert around flooded roads much as they would in the real world, though it is still possible for a driver to encounter a different flooded road on the new route.

Upon completion of each simulation day, vehicle paths and travel times were processed to provide aggregate statistics by vehicle type, delay, and other strata. These values were stored in a separate database for each scenario for later analysis alongside all days comprising each scenario.

3.3.6 Delayed and Cancelled Trips

One major concern among members of the traffic modeling team related to the quantity of trips traveling during the flood scenario conditions. Logic and experience suggest that individual travelers will change their travel behavior in response to conditions such as those experienced during a flood, particularly a long-duration flood. Some individuals will delay their trips while others may cancel their trips altogether.

We conducted a literature review to find any research done on this phenomenon. This review identified a number of studies describing travel demand changes under adverse conditions. The research confirmed that travel demand reductions do occur during a major network disruption, such as a flood. None of the reviewed studies investigated the alteration of departure times in such a situation.

The magnitude of vehicle trip demand reduction averaged 20% during "natural disasters, structural failures, or some engineering necessity," including shifts in travel mode from passenger vehicles to transit. (8) During very severe storms, with visibility less than a quarter mile and winds as high as 80 miles per hour, "traffic levels were reduced by 80 percent," while "commercial vehicles became a higher percentage of the traffic stream," because truck traffic persisted even under difficult conditions. (9) Demand reductions were found to be most severe on Saturday, less severe on Sunday, and least severe on weekdays.(10)

None of the research, however, dealt with the issue of a long-term reduction in network capacity, nor did it provide a formulation for estimating demand reduction. Without a defensible approach to reducing demand, no reduction of demand was performed in the preparation of the results for this project. Ignoring trips deferred or cancelled in this study led to an over-estimate of delay. Trips are taken because of the value produced, and a cancelled or deferred trip represents a loss in value to the traveler. These two errors work in opposite directions, so the decision not to account for effects of flood closures on the magnitude of travel is not unreasonable in this project.

3.4 Result Preparation

The primary output of any scenario with a capacity reduction is delay, both in terms of increased travel time and mileage. These two metrics are the inputs needed for the USACE baseline economic analysis and were produced in the most detail.

For this project, delay was defined as the difference in travel time between a vehicle traveling during a flooding scenario and the same travel time that vehicle experienced in the without-flood condition. This comparison was also used to analyze mileage differences.

3.4.1 Vehicle Categories

To meet the requirements of the USACE baseline economic analysis, the trip types defined in the CMAP travel demand matrices were carried through the scenario simulations and aggregated into the categories listed below:

CMAP Trip Type	Analysis Category
Home to Work Home to Other Non-Home to Non-Work External Auto Airport	Passenger Vehicle
B-Plate Truck Light Truck Medium Truck	Commercial Vehicle

Heavy Truck
External Truck

Table 5: Analysis Vehicle Categories

3.4.2 Vehicle Analysis

Simulated vehicles were aggregated by flood day and CMAP trip type to be stored and analyzed later. For each of these groupings, the following statistics were calculated:

- the number of vehicles
- the cumulative and standard deviation travel time
- the cumulative and standard deviation delay
- the cumulative free-flow travel time
- the cumulative and standard deviation mileage

3.4.3 Delay Analysis

Simulated vehicles were also aggregated by flood day and delay category.

Greater Than or Equal to	Less Than
-	-1 hour
-1 hour	-30 minutes
-30 minutes	-15 minutes
-15 minutes	-5 minutes
-5 minutes	0 seconds
Equal To	
0 seconds	
Greater Than	**Less than or Equal To**
1 second	5 minutes
5 minutes	15 minutes
15 minutes	30 minutes
30 minutes	1 hour
1 hour	1.5 hours
1.5 hours	2 hours
2 hours	2.5 hours
2.5 hours	3 hours
3 hours	3.5 hours
3.5 hours	4 hours
4 hours	4.5 hours
4.5 hours	5 hours
5 hours	-

Table 6: Delay Categories

A negative delay represents a time savings, e.g. a vehicle experiencing a faster travel time in the scenario than in the without-flood condition.

For each flood day and each of the above categories, the following statistics were calculated:

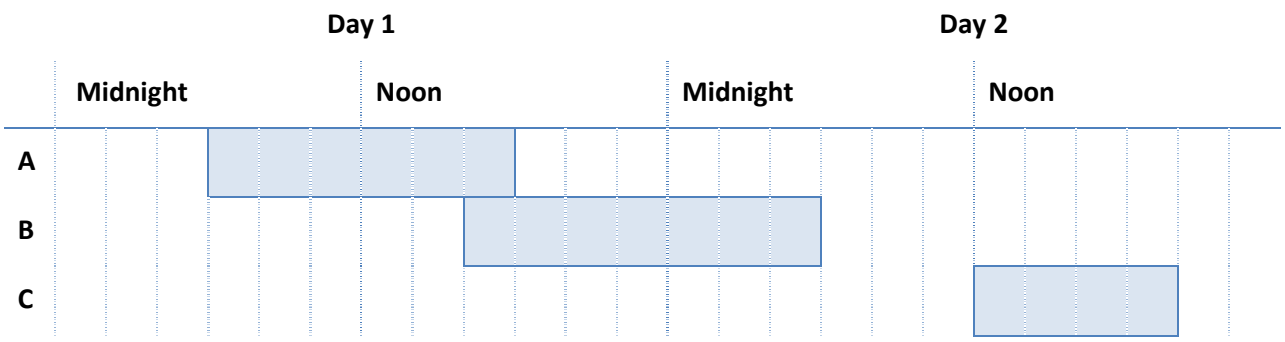
- the number of vehicles
- the cumulative and standard deviation of the travel time change

3.4.4 Flooded Crossing Impact Analysis

The traffic modeling team explored various methods to allocate portions of the total delay to specific flood locations. The System Impacts-Based Aggregation (SIBA) method, developed by Mr. Dennis Giba of USACE, was chosen after thorough discussion with the traffic modeling team and sponsors. Discussion of the methods can be found in Section 12.

The SIBA method involves developing a set of weights used to distribute the delay experienced by vehicles traveling in the traffic network while floods are active. These weights were derived from traffic volumes on the roads which flooded. For each flooded road, the traffic volume in the without-flood condition was obtained for every hour of the day. These volumes were combined with the flood durations to provide traffic volumes for every flooded road during every day of every scenario. These traffic volumes provided the weight of the delay contribution for each flooded road on that day. These weights were apportioned among the total delay for each day, aggregated over all delays by flood location, and then prepared as subtotals and proportions of total scenario delay. This procedure is described below.

In this example, we assume a two-day flood scenario with three flood locations A, B and C. These calculations will use a two-hour aggregation. The flood schedule is as follows, shaded areas indicating closure:



The two-hour without-flood condition volumes for these locations are as follows:

	Midnight						Noon					
A	100	200	400	700	900	600	400	600	700	600	400	300
B	800	900	1300	1700	1600	1400	1500	1700	1800	1600	1300	1100
C	500	800	1700	2100	1900	1400	1200	1500	1900	1400	900	700

The volumes above are considered to be the same for both Day 1 and Day 2.

The closure periods are highlighted in the above volume table. Using these data, the traffic volumes for each flood location are calculated by summing the volumes overlapping the closure periods. For example, the volume for location B on day 2 would be 800 + 900 + 1300, over 3000 vehicles.

	Day 1	Day 2
A	4,000 vehicles	
B	6,000 vehicles	3,000 vehicles
C		6,000 vehicles
Total	10,000 vehicles	9,000 vehicles

This establishes the proportions of the delay which will be ascribed to each flood location for each day.

After running a simulation of this flood scenario, the total network delays are obtained for each day:

	Day 1	Day 2	Total
Delay	25 hours	15 hours	40 hours

The delay contribution for each location for each day is the product of the total delay for that day and the proportion of the traffic volume for that location.

	Day 1	Day 2	Total
A	$\frac{4000\times25}{10000} = 10$ hours	$\frac{0\times15}{9000} = 0$ hours	10 hours
B	$\frac{6000\times25}{10000} = 15$ hours	$\frac{3000\times15}{9000} = 5$ hours	20 hours
C	$\frac{0\times25}{10000} = 0$ hours	$\frac{6000\times15}{9000} = 10$ hours	10 hours

Applying the method determines the total delay contribution of each flood location. Flood locations A and C both account for 25% of the total delay due to the flood event, while location B accounts for 50% of the total delay.

The SIBA method was chosen for two reasons. First, the process accounted for full network delay while some other suggested processes captured only the primary effects (delays experienced by vehicles intending to use flooded roads) of vehicle diversions. Secondary effects (delays experienced by vehicles interacting with vehicles diverted around flooded roads) can be captured using this method. Second, the process correlated well with results obtained by application of a similar process used in past flood impact analysis projects.

This method may overestimate the actual delay caused by a closure due to the startup time required for a closure to begin affecting the traffic network. The process may also underestimate the actual delay as congestion will take some time to clear even after a closure has ended. The traffic modeling team determined that these potential (and possibly offsetting) errors were not significant factors in affecting

the results, as many closures extended for multiple days. The impact of such long closures would not be significantly changed by addition or removal of a small amount of traffic volume from the calculation.

3.4.5 Time Savings

One interesting result of any capacity reduction analysis is that some vehicles experience improved travel times during flood conditions. This has been observed in prior flood impact and traffic operations analysis projects in addition to this project. The amount of traffic experiencing time savings is usually significantly less than the traffic experiencing time delays.

This improvement is a result of increased capacity elsewhere in the traffic network. As the flood-induced bottlenecks create traffic congestion within the traffic network, vehicles delayed by these floods take longer than they normally would to progress through the network. Because these vehicles are delayed getting to their normal routes, the vehicles not affected by the floods experience less congestion when they use those same routes, saving travel time.

For example, a vehicle normally contributing to peak period congestion by taking a ramp on to an expressway at 7:45 a.m. might be delayed by a flood and arrive 15 minutes later. This gradual shift of flood-affected vehicles to later arrival times at congested infrastructure is responsible for the improvement in travel time on unaffected vehicles using that same infrastructure.

In some cases, the diversion route a vehicle takes may bypass some portion of the congested infrastructure, using a ramp further south from the normal one, for example. This would also reduce congestion on the infrastructure north of the ramp now being used.

3.4.6 Mileage Savings

In some cases, the diversion route chosen by a vehicle may be geographically shorter than the route to which the vehicle is assigned in the without-flood condition. Speed limits vary between expressways and arterials, for example. A long, fast expressway route, normally the fastest route from origin to destination, may be unavailable due to a flood. This forces drivers to use shorter, but slower, arterial routes. Within the simulation algorithm, a slow arterial route is always preferable to a route in which a vehicle sits, waiting for flood waters to recede.

3.4.7 Air Quality Analysis

An air quality analysis was performed using the Environmental Protection Agency's MOBILE emissions modeling software. (11) This software takes aggregate traffic performance measures and vehicle classification distributions as inputs, and produces estimates of emissions. These estimates can be further refined by specifying weather conditions, the season, time of day, the calendar year, and other data. The most recently available version of MOBILE, version 6.2, was used to perform this analysis.

This analysis assumed that the flooding in question would occur during the late spring. The model year from the travel demand data was used as the modeling year for input into MOBILE. The default temperature distribution provided by MOBILE was also used.

To translate vehicle classes from the taxonomy used by CMAP data to the vehicle classes handled by MOBILE, the following categorization was made:

CMAP Trip Type	Emissions Category
Home to Work Home to Other Non-Home to Non-Work B-Plate Truck External Auto Airport	Light-Duty
Light Truck	Class 3 Heavy-Duty
Medium Truck	Class 7 Heavy-Duty
Heavy Truck External Truck	Class 8A Heavy-Duty

Table 7: MOBILE Vehicle Categories

MOBILE gives as output pollutant generation rates in grams per mile. For this study, HC (hydrocarbons) and NOx (oxides of nitrogen), the two regulated ozone precursors in the Chicago region, were reported, as well as CO (Carbon Monoxide).

In all cases possible, this study used the same data and emissions modeling assumptions as the 2007 conformity analysis report produced by CMAP, including the vehicle age and maintenance profiles. Further discussion of these assumptions can be found in the air quality analysis report produced by CMAP (12).

4 Results

NOTE: THE 2020 MODEL YEAR RESULTS ARE BEING REVISED AS OF THE RELEASE OF THIS DRAFT. A NEW DRAFT WILL BE PREPARED WHEN THE NEW RESULTS ARE COMPLETE.

This following section summarizes the results of all without-flood and with-flood scenarios. These results are aggregated and presented in different groupings for comparative purposes. All with-flood scenario results are compared to the two without-flood scenarios. Table 8 shows inputs to and results of the without-flood DTA runs.

Network	2006 Model Year	2020 Model Year	Difference	
Intersections	6,231	6,352	+121	+1.9%
Road Segments	19,321	19,549	+228	+1.2%
Road Lane-Miles	15,567	16,144	+577	+3.7%
Demand	2006 Model Year	2020 Model Year		
Car Trips	8,147,245	8,790,106	+642,861	+7.9%
Truck Trips	734,060	873,980	+139,920	+19.1%
Total Trips	8,881,305	9,664,086	+782,781	+8.8%

Travel Time	Total *hours*	Average *minutes*	Total *hours*	Average *minutes*	Total *hours*	Total *percent*
Cars	1,431,737	10.54	1,697,422	11.58	+265,685	+18.6%
Trucks	123,033	10.12	195,821	13.44	+72,788	+59.2%
All	1,554,770	10.50	1,893,243	11.75	+338,473	+21.8%

Mileage	Total *miles*	Average *miles*	Total *miles*	Average *miles*	Total *miles*	Total *percent*
Cars	54,465,055	6.68	45,846,573	5.21	-8,618,482	-15.8%
Trucks	5,337,763	7.27	5,586,258	6.39	+248,495	+4.7%
All	59,802,818	6.73	51,432,831	5.32	-8,369,987	-14.0%

Table 8: Without-Flood Condition Summary

The without-flood results illustrate the differences in behavior between today's drivers and the drivers expected to be on the road over a decade from now. As with most future travel demand models, CMAP

is expecting an increase in both infrastructure and travel. The distribution of trips among the trip purposes modeled by CMAP does not change between 2006 and 2020.

Trip Purpose	Cars	Trucks
Work Trips	25%	100%
Shop Trips	22%	-
Other Trips	53%	-

Table 9: CMAP Trip Purpose Factors

The traffic network gains 577 new lane-miles of roadway in the 2020 model year. While some of these additions represent new construction, the majority are existing roads which will be widened to become significant travel corridors.

The travel demand increases by almost a million vehicles in the study region. These additional trips will add to traffic congestion even without floods or other events in the network. The increase in travel time for cars, and the much larger increase in travel time for trucks, both reflect the impact of these additional trips.

The mileage decreases. This could be caused by a number of factors. First, additional infrastructure and capacity are available in the future traffic network. This gives drivers new routing options, some shorter in distance. Demographic and economic shifts between the 2006 and 2020 models also contribute to the reduced mileage. Demand for travel may exceed the supply of roadway lane miles, increasing the friction of travel. This friction results in individuals minimizing mileage, which is reflected in CMAP land use assumptions. Change in mileage is substantially a product of the assumptions which CMAP made when developing the 2020 regional traffic network and trip tables.

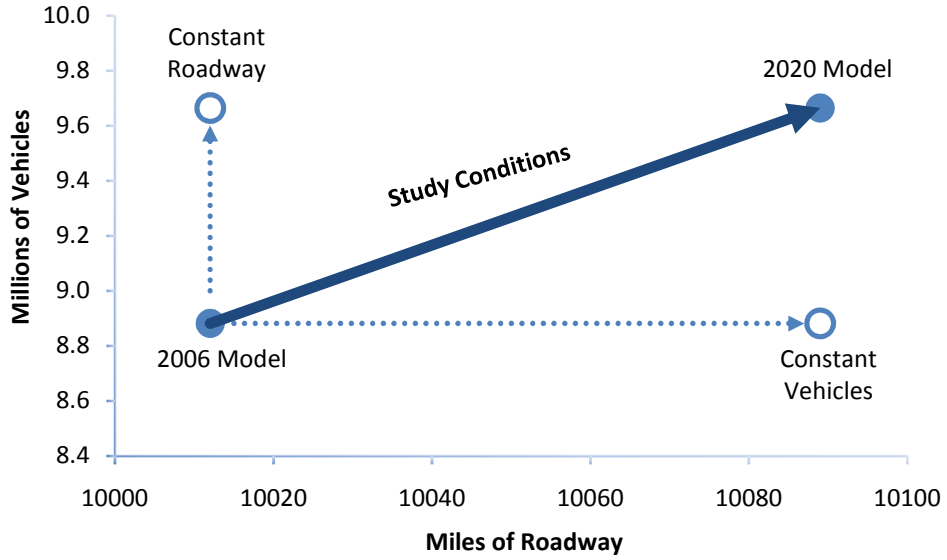


Figure 8: Data Comparison Between the 2006 and 2020 Model Years

The 2006 and 2020 models are difficult to compare because of the data differences between the two, shown in Figure 8. Each network is varied in both the trips and roadway modeled. The 2006 model year is based on existing travel data, while the 2020 model is a product of assumptions made by CMAP about

changes in land use, travel patterns, and other factors. Direct comparison of the results from these two model years is not done, except to analyze changes in trends.

In the following sections, 2006 model year results are presented first without start time offsets, followed by the 2020 model year results, then finally the 2006 model year sensitivity results with start time offsets.

4.1 Travel Time Effects

The majority of vehicles in the study region were not found to be affected by flooding. However, travel time in the study region did increase with flood severity, as expected. The proportion of vehicles affected by flooding also increased with flood severity. These effects were seen for most flood scenarios, start time offsets, and model years.

4.1.1 2006 Model Year

In the 2006 model year scenarios, travel time increased with severity for passenger vehicles. For commercial vehicles, a slight decrease was found in the 1-year flood event.

	Passenger Vehicles		Commercial Vehicles	
	Thousands of Hours	% Change	Thousands of Hours	% Change
Without Flood	1,431.74	n/a	123.03	n/a
1-Year Flood	1,431.74	0.00%	122.94	-0.08%
2-Year Flood	1,446.41	1.03%	123.29	0.21%
5-Year Flood	1,492.21	4.22%	126.11	2.50%
10-Year Flood	1,559.22	8.90%	129.66	5.39%
25-Year Flood	1,613.31	12.68%	132.62	7.79%
50-Year Flood	1,821.71	27.24%	140.06	13.84%
100-Year Flood	2,575.59	79.89%	183.52	49.16%
500-Year Flood	3,674.85	156.67%	239.53	94.69%

Table 10: Daily Average Travel Times per Flood Severity - 2006 Model Year

The decrease in travel time for commercial vehicles in the 1-year flood event could be caused by the nature of commercial trips. Many commercial vehicles make long-distance trips using the expressways, while passenger vehicles use arterial roads more heavily. With floods only occurring on the arterials in all but the most severe events, expressway-using commercial vehicles could only benefit by other traffic being delayed in getting to the expressways.

Delay accounted for the increase in travel time and then some. Delays were offset by time savings, such as those found for commercial vehicles in the 1-year flood event

		Time Savings						No Change	Time Delays					
		> 15 minutes		5 to 15 minutes		0 to 5 minutes		0 min	0 to 5 minutes		5 to 15 minutes		> 15 minutes	
Flood Severity	Vehicle Type	Vehicle Count	Average Minutes	Vehicle Count	Average Minutes	Vehicle Count	Average Minutes	Vehicle Count	Vehicle Count	Average Minutes	Vehicle Count	Average Minutes	Vehicle Count	Average Minutes
1-year	Cars	30,441	29.9	37,644	8.9	230,926	0.6	23,838,870	257,038	0.7	27,528	8.8	19,288	49.7
	Trucks	1,164	26.6	1,521	8.5	19,351	0.5	2,153,969	24,932	0.5	876	8.6	367	48.8
2-year	Cars	69,988	29.7	76,332	9.0	569,105	0.6	55,468,736	712,544	0.9	74,691	9.0	59,319	134.8
	Trucks	2,734	26.5	3,500	8.5	49,130	0.5	5,010,509	68,390	0.6	2,667	9.0	1,490	114.3
5-year	Cars	126,272	31.0	116,133	9.1	1,085,869	0.6	94,227,783	1,754,402	1.4	233,719	9.0	222,762	200.5
	Trucks	5,552	29.3	6,391	8.7	91,769	0.5	8,484,067	189,265	1.4	17,212	8.5	14,464	143.4
10-year	Cars	142,328	31.1	130,087	9.1	1,461,321	0.6	116,956,428	2,700,635	1.5	415,593	8.9	402,283	282.0
	Trucks	6,508	29.4	7,739	8.7	118,756	0.5	10,533,476	279,165	1.5	35,649	8.5	29,607	187.8
25-year	Cars	185,267	31.3	162,869	9.1	1,865,867	0.6	147,123,936	3,845,779	1.7	691,473	8.6	922,464	220.2
	Trucks	8,821	30.2	10,095	8.8	152,336	0.5	13,263,505	397,335	1.7	58,061	8.3	56,987	179.2
50-year	Cars	199,776	31.6	163,452	9.2	2,079,013	0.6	160,829,268	4,617,895	1.7	955,034	8.4	2,247,707	215.6
	Trucks	9,415	30.9	10,780	8.8	168,808	0.5	14,550,806	473,693	1.7	87,885	8.3	113,873	179.0
100-year	Cars	194,501	31.8	156,960	9.1	2,091,251	0.6	158,259,939	4,837,327	1.7	1,067,781	8.3	4,484,386	319.5
	Trucks	9,115	31.1	10,570	8.8	171,338	0.5	14,407,332	502,489	1.7	98,497	8.2	215,919	347.3
500-year	Cars	232,932	30.7	221,171	9.0	2,408,623	0.6	184,332,381	5,854,986	1.8	1,436,924	8.3	9,194,108	364.7
	Trucks	10,813	30.5	13,130	8.7	205,061	0.5	16,947,204	615,151	1.8	134,591	8.1	425,550	406.8

Table 11: Delays by Flood Severity and Vehicle Type - 2006 Model Year

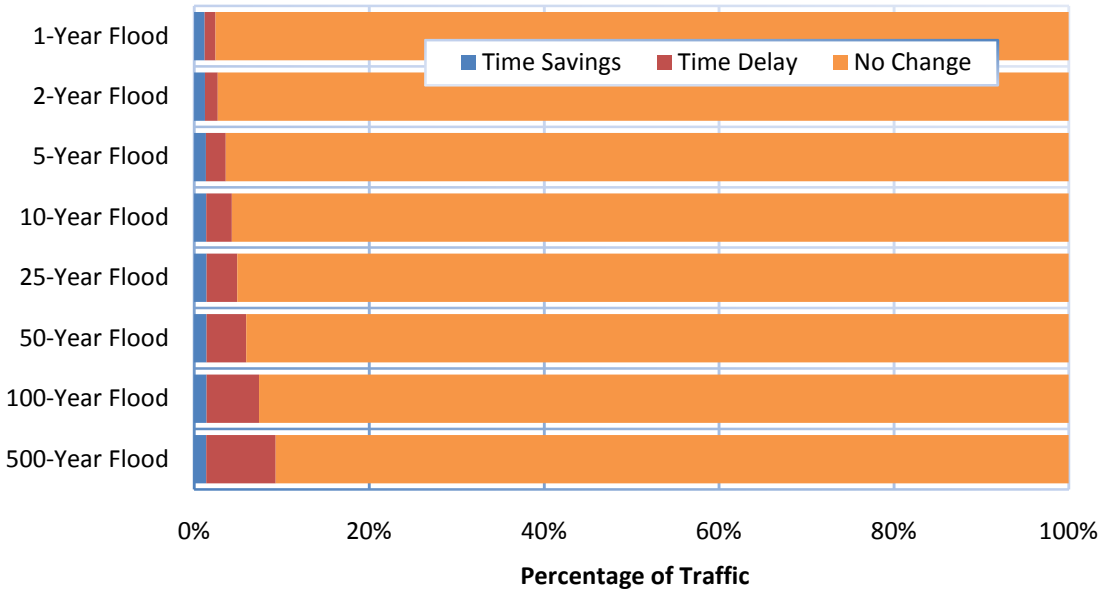


Figure 9: Vehicle Distribution by Travel Time Change and Flood Severity - 2006 Model Year

While the proportion of vehicles delayed increased steadily with flood severity, the proportion experiencing time savings remained relatively stable. Traffic which experienced travel time savings never exceeds 2%, instead hovering around 1.4% from the 10-year through the 500-year flood severities.

Traffic experiencing delays peaks at 8% of total in the 500-year flood event. The delayed and not-changed vehicle proportions were found to have a correlation coefficient of -0.99967, indicating a very strong inverse relationship, as seen in Figure 9.

For the 500-year flood event, a 9% of the total vehicles experience some change in travel time, with only 5% of the total vehicles experiencing a change in travel time greater than five minutes. The numbers for less severe flood events are less, of course, but the amount of delay which accumulates in these scenarios can be very large, as seen in the travel times in Table 10.

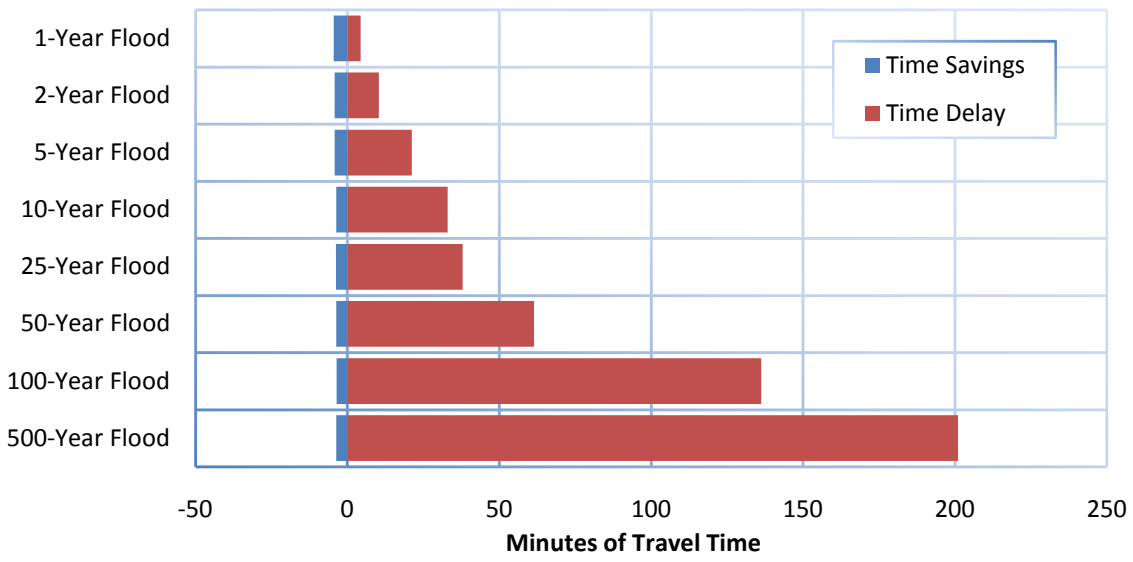


Figure 10: Average Time Changes for All Vehicles by Flood Severity - 2006 Model Year

Individual vehicles which experienced delays were more heavily delayed by the more severe flood events. Figure 10 shows the massive increase in average delay, from 4.3 minutes in the 1-year flood event to 201.0 minutes in the 500-year flood event. By contrast, time savings decreases from 4.5 minutes to 3.6 minutes. So, while a minority of traffic was affected by the flood, the effect was very significant for those vehicles.

4.1.2 2020 Model Year

Examining the results for the 2020 model year scenarios gives a very similar set of trends and effects. Travel time increases with flood severity, as in the 2006 model year, but to a much greater degree than in the 2006 model year.

	Passenger Vehicles		Commercial Vehicles	
	Thousands of Hours	% Change	Thousands of Hours	% Change
Without Flood	1,697.42	n/a	195.82	n/a
1-Year Flood	1,811.25	6.71%	207.64	6.03%
2-Year Flood	2,379.98	40.21%	263.20	34.41%
5-Year Flood	2,583.90	52.23%	285.25	45.67%
10-Year Flood	3,614.12	112.92%	392.29	100.33%
25-Year Flood	3,846.28	126.60%	418.65	113.79%
50-Year Flood	3,732.25	119.88%	408.02	108.36%
100-Year Flood	4,337.33	155.52%	469.15	139.58%
500-Year Flood	5,148.41	203.31%	550.13	180.94%

Table 12: Daily Travel Times per Flood Severity - 2020 Model Year

Compared to the 2006 model year results, the 2020 model gave much larger increases in travel time due to flooding. Commercial vehicles in the 500-year flood event experienced twice the travel time increase in 2020 as they did in 2006. These changes could be the result of the increased amount of trips modeled in the 2020 scenarios. With these extra trips, the already higher level of congestion (see Table 8) is compounded with the effects of the floods for much more severe overall changes.

The proportions of vehicles experiencing travel time savings and delays turned out to be remarkably similar to the proportions found for the 2006 model year.

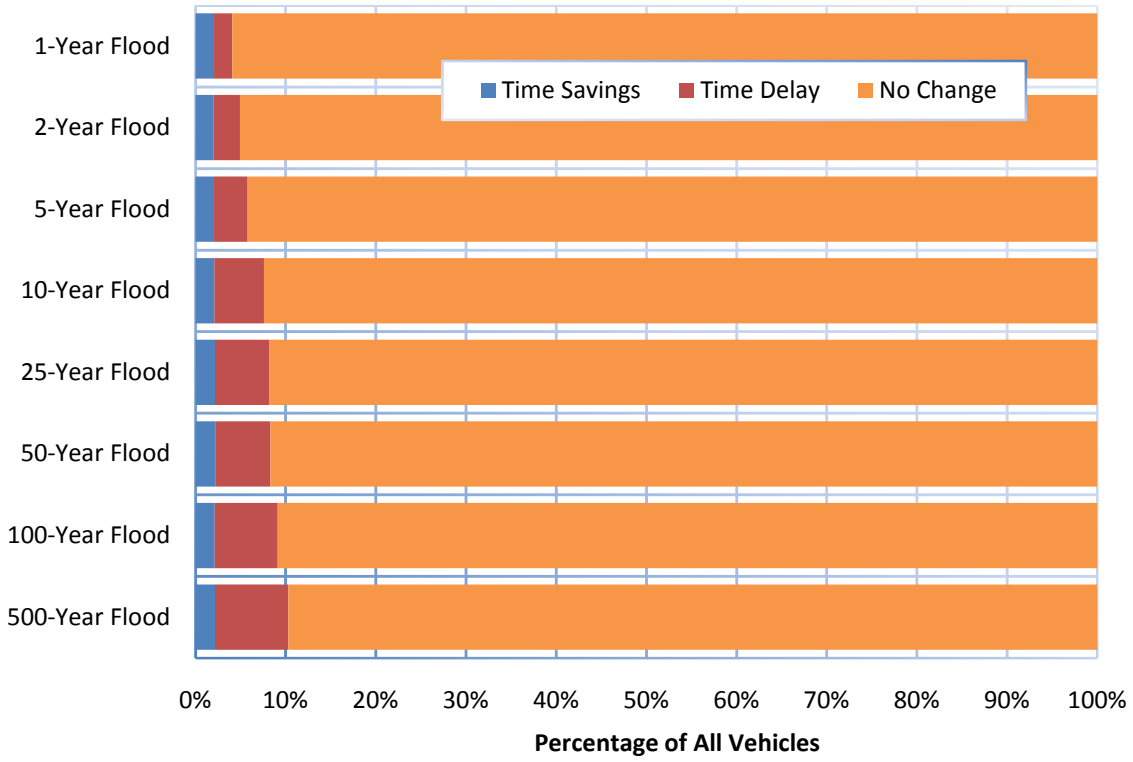


Figure 11: Vehicle Travel Time Changes by Flood Severity - 2020 Model Year

Between 2.0% and 2.2% of all vehicles in the 2020 model year scenarios experienced time savings, with slightly more variability than in the 2006 model year.

Like the 2006 model year results, 8% of vehicles experienced time delays during the 500-year flood event in the 2020 model year. Time delays increase with flood severity, beginning with 2% for the 1-year flood event. The comparison of the proportion of delayed vehicles to vehicles not experiencing travel time changes yielded a correlation coefficient of 0.99988, indicating a strong inverse relationship between the two groups of vehicles.

The biggest difference found between the trends observed in the 2006 and 2020 model year scenarios has to do with time savings.

		Time Savings						No Change	Time Delays					
		> 15 minutes		5 to 15 minutes		0 to 5 minutes		0 min	0 to 5 minutes		5 to 15 minutes		> 15 minutes	
Flood Severity	**Vehicle Type**	**Vehicle Count**	**Average Minutes**	**Vehicle Count**	**Average Minutes**	**Vehicle Count**	**Average Minutes**	**Vehicle Count**	**Vehicle Count**	**Average Minutes**	**Vehicle Count**	**Average Minutes**	**Vehicle Count**	**Average Minutes**
1-year	**Cars**	146,334	66.0	85,940	9.7	292,090	1.0	25,313,491	233,914	1.1	100,705	9.2	197,844	152.1
	Trucks	16,933	69.0	9,922	10.3	42,887	0.8	2,496,431	27,939	0.9	8,865	9.4	18,963	175.3
2-year	**Cars**	375,711	86.3	225,658	9.5	759,351	1.0	66,890,967	683,867	1.2	253,753	9.4	1,131,541	318.0
	Trucks	44,282	87.1	25,842	10.0	110,304	0.8	6,601,952	82,783	1.0	21,524	9.5	105,153	344.9
5-year	**Cars**	622,338	100.5	363,057	9.3	1,305,586	1.0	107,771,016	1,574,413	1.5	433,563	9.1	2,201,405	341.8
	Trucks	73,758	105.3	47,063	9.3	176,409	0.9	10,600,570	193,807	1.4	44,001	9.0	226,132	342.5
10-year	**Cars**	899,025	112.2	400,441	9.3	1,586,777	1.0	130,085,545	2,258,892	1.7	610,707	9.1	4,800,309	403.5
	Trucks	110,364	121.8	55,046	9.3	209,285	0.9	12,789,761	272,727	1.6	63,558	8.9	482,939	417.8
25-year	**Cars**	1,076,702	116.0	499,579	9.3	1,932,562	0.9	153,554,150	2,883,121	1.8	956,773	8.7	6,109,127	420.3
	Trucks	131,212	124.8	62,257	9.1	251,301	0.9	15,093,086	352,577	1.7	100,784	8.4	614,403	439.1
50-year	**Cars**	1,224,449	118.8	542,583	9.4	2,160,574	1.0	169,451,719	3,421,470	1.8	1,129,048	8.6	6,662,383	405.4
	Trucks	148,764	129.6	70,757	9.1	284,099	0.9	16,641,797	410,769	1.7	120,992	8.4	676,402	422.6
100-year	**Cars**	1,284,554	120.6	546,372	9.3	2,180,756	0.9	175,923,038	3,725,910	1.8	1,253,896	8.5	8,467,806	428.6
	Trucks	160,368	127.3	70,375	9.1	289,250	0.9	17,281,600	441,750	1.7	133,806	8.4	850,411	447.1
500-year	**Cars**	1,512,628	122.7	617,972	9.3	2,496,813	1.0	197,368,380	4,397,977	1.9	1,599,155	8.4	11,759,725	454.8
	Trucks	192,442	128.5	80,521	9.1	329,346	1.0	19,397,245	520,703	1.7	173,497	8.3	1,155,746	480.1

Table 13: Delays by Flood Severity and Vehicle Type - 2020 Model Year

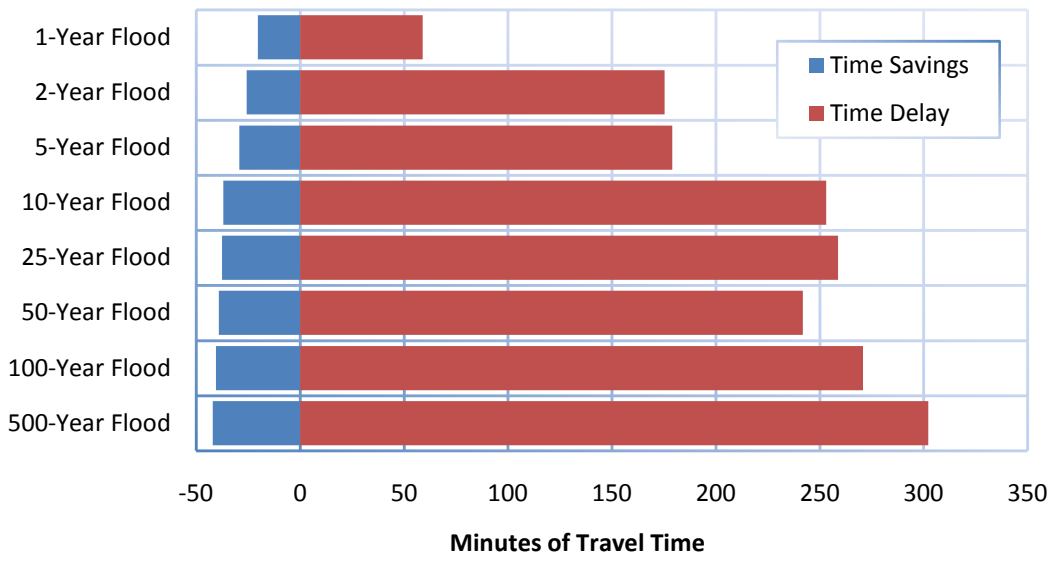


Figure 12: Average Time Changes for All Vehicles by Flood Severity - 2020 Model Year

The average travel time saved by vehicles experiencing time savings increased with flood severity, peaking at 42 minutes for the 500-year flood event. This increase may be due to congestion concentrating in certain parts of the study region, allowing other vehicles to move much more freely. While shown for all vehicles in Figure 12, this trend is consistent for both passenger and commercial vehicles.

Travel time delays showed a mostly consistent increasing trend, the notable exception being the 50-year flood event.

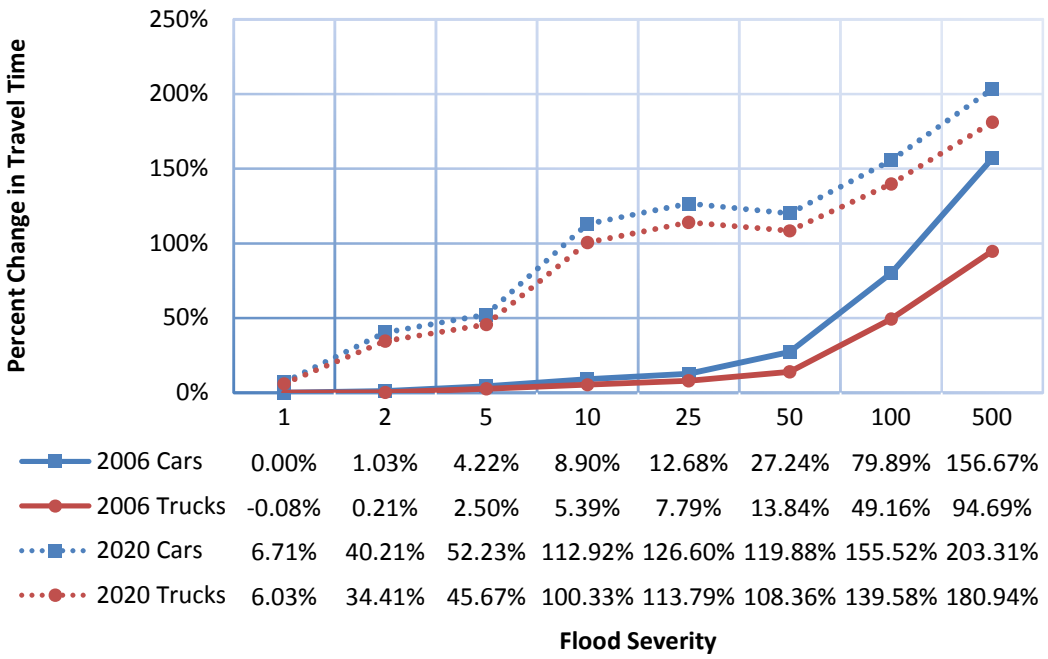


Figure 13: Comparison of Travel Time Changes

4.1.3 Sensitivity Analysis

Some variability in travel time was observed for the travel time offsets evaluated. While travel time continued to increase with flood severity, no consistent trend was found across the start time offsets.

	No Offset	3 Hours	8 Hours	13 Hours	18 Hours	Range
10-Year Flood	8.63%	8.96%	8.22%	8.76%	8.95%	0.74%
25-Year Flood	12.29%	11.89%	18.18%	14.63%	19.57%	7.68%
50-Year Flood	26.18%	24.68%	26.38%	32.78%	32.53%	8.10%
100-Year Flood	77.46%	61.62%	59.02%	62.69%	78.96%	19.94%
500-Year Flood	151.77%	148.47%	154.64%	161.36%	158.45%	12.89%

Table 14: Travel Time Increase by Start Time Offset - 2006 Model Year

The range of variation within each flood severity exhibited a mostly linear increase. The 100-year flood ranged 19.9% from highest to lowest increase in travel time. The other flood severities ranged consistently upwards, from 0.7% at the 10-year flood event to 12.9% at the 500-year flood event.

The largest travel time increases were observed with the 13- and 18-hour start time offsets for all but the 10-year flood event. The smallest travel time increases were observed with the 3- and 8-hour start time offsets for all flood events.

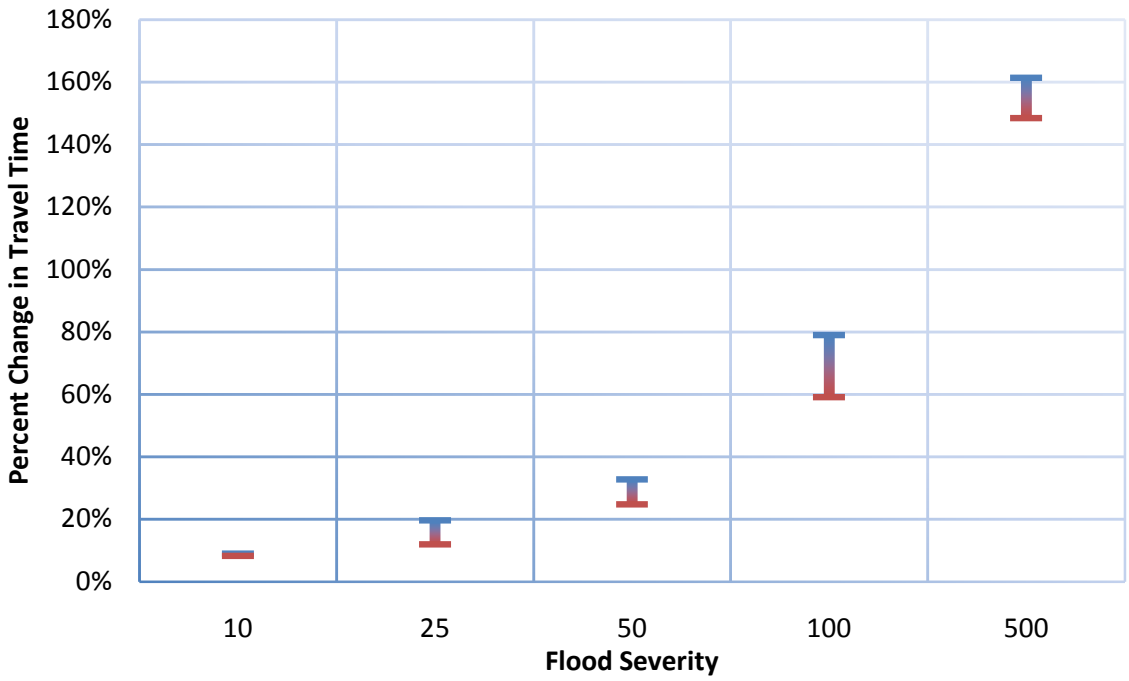


Figure 14: Range of Travel Time Change for All Vehicles - Sensitivity Analysis

Travel time was found to be somewhat sensitive to flood severity in the more severe storm events. Increasing flood severity yields an increasing sensitivity to flood start time, though no fully consistent trend was found regarding the range of travel time changes or the start time offsets yielding the minimum and maximum travel time changes. The anticipated effects on travel time of varying start time

were not observed as expected (see Section 3.2.4), indicating that the impact of a flood on a traffic system cannot be adequately estimated using the flood schedule alone.

4.2 Mileage Effects

Mileage was recorded for all simulated vehicles in all without-flood and with-flood scenarios. Mileage for vehicles in with-flood scenarios were compared to the mileages for the same vehicles in the corresponding without-flood scenario to produce difference measures.

For many of the more severe flood events, mileages were found to decrease from the without-flood conditions. These decreases are the result of extreme congestion preventing some vehicles from reaching their destinations by the end of the simulation period. As discussed in section 3.3.5, simulations were performed on individual days.

Figure 15 gives an example of how traffic network density can affect mileage. Vehicles from origin A to destination B are routed by *First St* for the waterway crossing during non-flooded conditions. When the crossing is lost to flooding conditions as depicted, the alternative would be to re-route using *Second St*. In a denser traffic network, *Second St* still remains a detour option, but with the addition of *New Rd*, the shortest detour option may now be using New Road, shortening the mileage. The capacity for *Second St* and *New Rd* may be significantly less than the original route, yielding higher travel times even while mileage is reduced for the flooded condition.

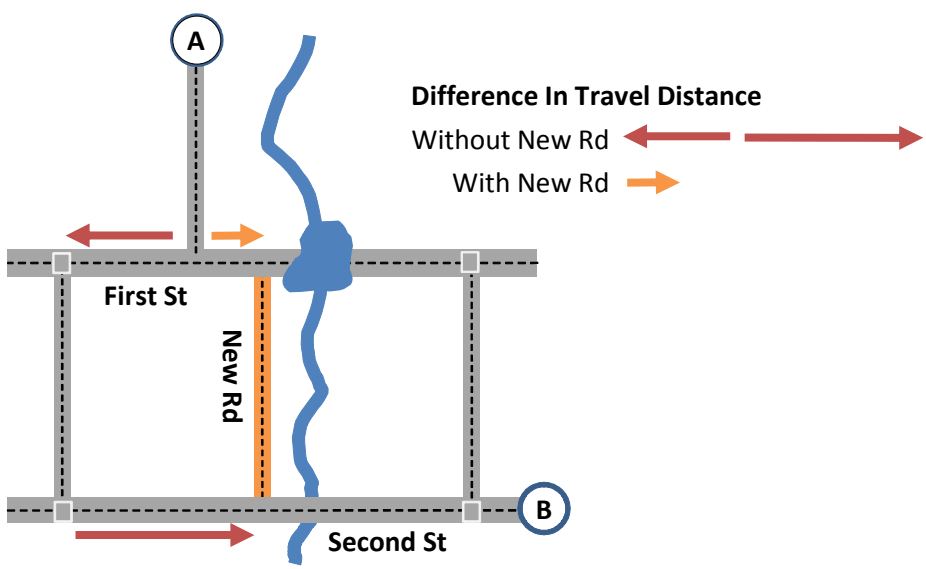


Figure 15: Effect of Network Density on Detour Distance

While the illustrative example discussed above is an overly simplistic interpretation of the results, determining a specific example from the model results would require an exhaustive search, which is not within the scope of this project.

4.2.1 2006 Model Year

The 2006 model year with-flood results yielded a variable relationship between flood severity and change in mileage. The aggregate mileage for passenger vehicles decreased for the less severe floods,

increased for the moderately severe floods, then decreased again for the most severe floods, as seen in Table 15.

	Passenger Vehicle		Commercial Vehicle	
	Millions of Miles	% Change	Millions of Miles	% Change
Without Flood	54.477	*n/a*	5.338	*n/a*
1-Year Flood	54.465	-0.022%	5.338	0.001%
2-Year Flood	54.462	-0.028%	5.338	0.004%
5-Year Flood	54.492	0.027%	5.343	0.099%
10-Year Flood	54.495	0.033%	5.346	0.165%
25-Year Flood	54.522	0.082%	5.350	0.224%
50-Year Flood	54.448	-0.054%	5.352	0.265%
100-Year Flood	53.626	-1.562%	5.294	-0.814%
500-Year Flood	52.571	-3.499%	5.241	-1.819%

Table 15: Daily Mileage Results - 2006 Model Year

Commercial vehicles experienced a different trend, mileage increasing for most flood severities, with only the most severe floods yielding declines in mileage. The decline begins in the 100-year flood severity for commercial vehicles, instead of the 50-year severity for passenger vehicles.

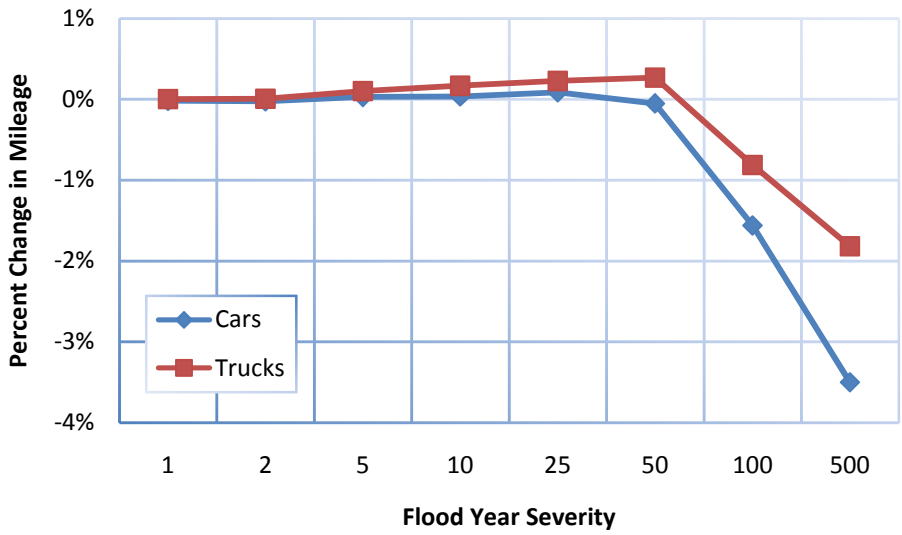


Figure 16: Percentage Mileage Changes - 2006 Model Year

Many commercial vehicles in this region make long-haul trips up and down the expressways, reducing their exposure to the flooded arterials. Passenger vehicles, by contrast, use arterials very heavily. These usage patterns could account for the smaller decline in mileage for commercial vehicles within the study region, which includes several major expressways.

4.2.2 2020 Model Year

Unlike the 2006 model year, the 2020 model year results yielded only declines in mileage. With the exception of the 50-year flood event, the trend is consistently downward.

	Passenger Vehicle		Commercial Vehicle	
	Millions of Miles	% Change	Millions of Miles	% Change
Without Flood	45.847	*n/a*	5.586	*n/a*
1-Year Flood	45.816	-0.068%	5.581	-0.099%
2-Year Flood	45.622	-0.490%	5.563	-0.417%
5-Year Flood	45.595	-0.548%	5.565	-0.373%
10-Year Flood	45.247	-1.309%	5.535	-0.909%
25-Year Flood	45.196	-1.419%	5.531	-0.980%
50-Year Flood	45.260	-1.280%	5.538	-0.862%
100-Year Flood	45.095	-1.639%	5.523	-1.134%
500-Year Flood	44.716	-2.467%	5.487	-1.772%

Table 16: Daily Mileage Results - 2020 Model Year

This decline could be a product of the increased congestion present in the 2020 model itself. As seen in Table 8, the number of vehicles traveling in the 2020 model year is larger than in the 2006 model year. This increase, coupled with the combination of an increase in average travel time and a decrease in average mileage, indicate an increase in traffic congestion. The capacity reductions caused by flooding could therefore have a greater impact than on a less-congested traffic network, such as the 2006 model.

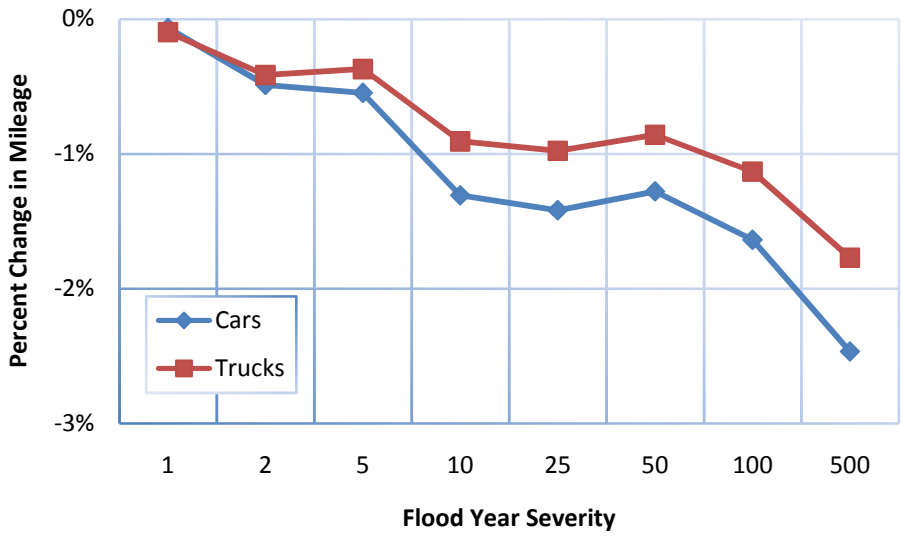


Figure 17: Percent Change in Mileage by Flood Severity - 2020 Model Year

While the 2020 model year experienced declines under all flood severities, the magnitude of the largest decline (passenger vehicles in the 500-year flood event) was a percentage point lower than the largest decline in the 2006 model (also passenger vehicles in the 500-year flood event).

The magnitude of the decline in less severe flood events is always greater in the 2020 model year. This could be an effect of the increased demand and congestion in the 2020 model, as discussed above.

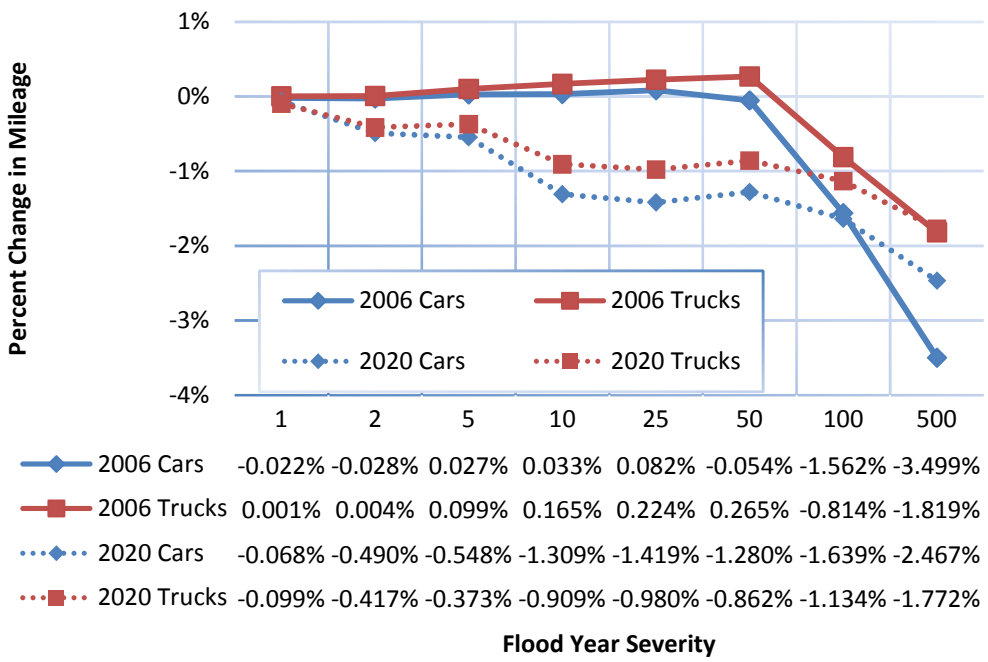


Figure 18: Comparison of Mileage Changes

4.2.3 Sensitivity Analysis

Varying start time offset in the sensitivity scenarios yielded mileage changes very similar to those observed without a start time offset. The range of the mileage changes can be seen in Figure 19. The maximum and minimum changes from all start time offsets are indicated by the horizontal blue and red bars, respectively, for each flood year. These ranges include all the start time offsets, as well as the 2006 model year scenarios without a start time offset.

	No Offset	3 Hours	8 Hours	13 Hours	18 Hours
10-Year Flood	0.045%	0.047%	0.040%	0.049%	0.052%
25-Year Flood	0.095%	0.103%	-0.123%	-0.030%	-0.148%
50-Year Flood	-0.026%	-0.019%	-0.113%	-0.246%	-0.196%
100-Year Flood	-1.495%	-1.017%	-1.017%	-1.074%	-1.523%
500-Year Flood	-3.349%	-3.279%	-3.346%	-3.612%	-3.528%

Table 17: Mileage Changes by Flood Year Severity and Start Time Offset

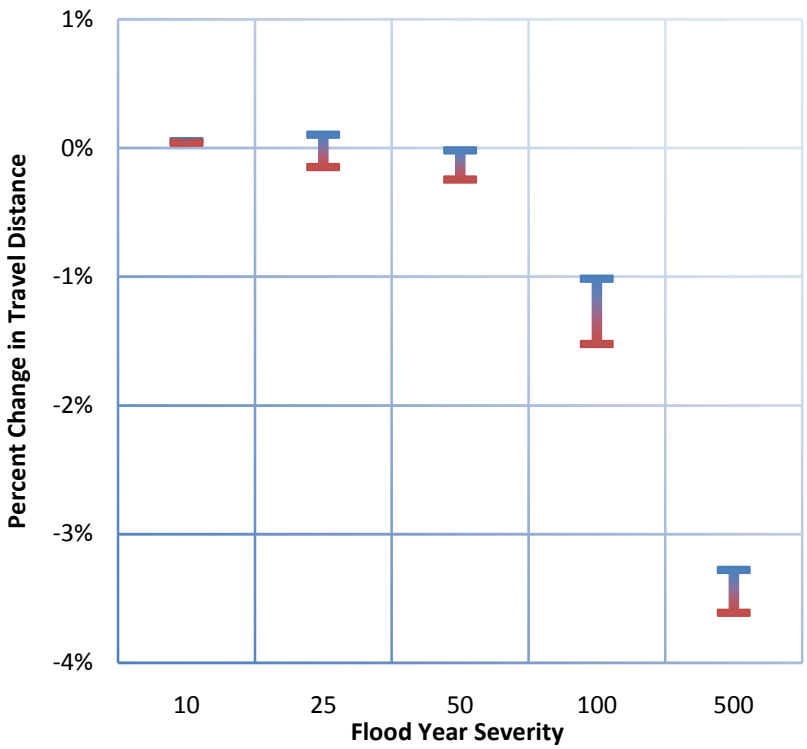


Figure 19: Range of Percent Change in Mileage for All Vehicles – Sensitivity Scenarios

The distance changes found in the sensitivity scenarios trend in the same way as the changes for the 2006 model year scenarios without a start time offset. The range between minimum and maximum change is at most half a percent, for the 100-year scenarios. This indicates that start time had a relatively small influence on the change in mileage. The largest increase in mileage was found for the 25-year flood event with a three-hour offset, the largest decrease for the 500-year flood event with a thirteen-hour offset.

4.3 Air Quality Effects

Pollutant generation was estimated for Carbon Monoxide (CO), Nitrous Oxide (NOX), and Volatile Organic Compounds (VOC) using MOBILE 6.

4.3.1 2006 Model Year Emissions

The estimated emissions for the 2006 model year yield a mixture of trends across vehicle classification and pollutant. The estimated volume of CO produced by passenger vehicles dwarfs the combined emissions of commercial vehicles and the other two pollutants estimated for passenger vehicles. Passenger vehicles, being mostly gasoline-fueled, will generate CO at much higher rates than NOX or VOC. Commercial vehicles are mostly diesel-fueled and will generate NOX at higher rates than CO or VOC under current fuel standards.

	Passenger Vehicle			Commercial Vehicle		
	CO	NOX	VOC	CO	NOX	VOC
Without Flood	534.6	37.8	37.8	14.0	38.4	3.4
1-Year Flood	534.5	37.9	37.8	14.1	38.4	3.4
2-Year Flood	534.5	37.9	37.8	14.1	38.4	3.4
5-Year Flood	533.5	37.8	37.8	14.0	38.2	3.4
10-Year Flood	526.5	37.7	38.1	13.9	36.6	3.4
25-Year Flood	518.9	37.6	38.3	13.8	35.2	3.5
50-Year Flood	498.3	37.3	39.2	14.0	33.1	3.6
100-Year Flood	495.7	38.5	42.2	16.2	33.3	4.1
500-Year Flood	507.4	40.5	46.9	19.2	34.2	4.6

Table 18: Daily Metric Tons of Pollutants - 2006 Model Year

The changes in delay and mileage between the various flood severities resulted in corresponding changes to the estimated production of pollutants. The results obtained for travel time and distance gave the impression that some pollutants related more strongly to one of those two measures than the other.

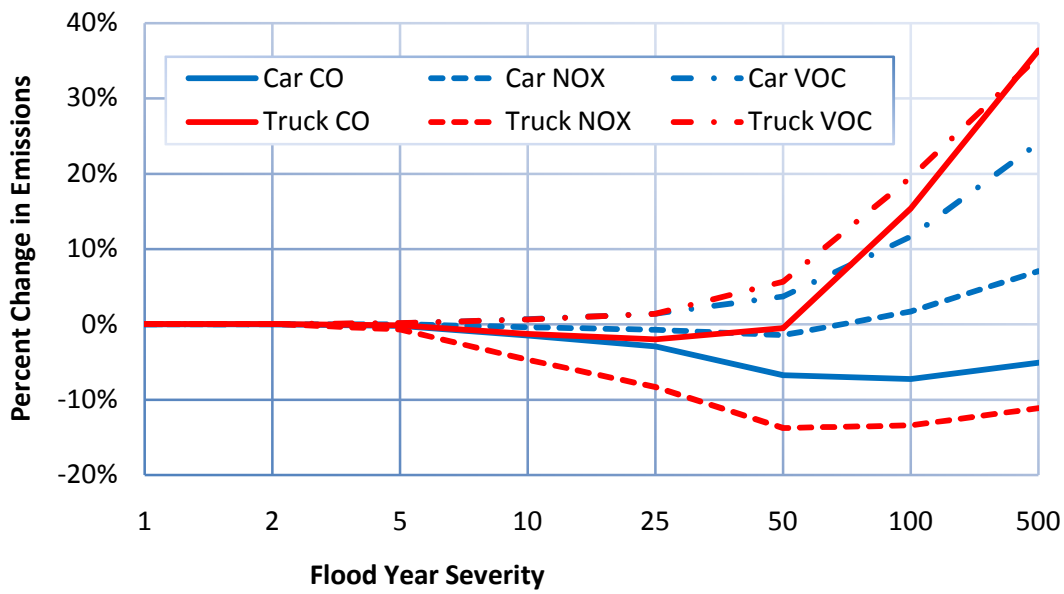


Figure 20: Percent Change in Emissions - 2006 Model Year

Figure 20 demonstrates that both Car (passenger vehicle) and Truck (commercial vehicle) emissions are sensitive to increases in traffic congestion. The pollutants mostly trend in similar ways for both vehicle classifications. CO is the most obvious exception, with passenger vehicles swinging to a positive increase much more sharply than commercial vehicles during the 100 and 500 year floods.

Correlation coefficients were calculated between travel time and mileage results and estimated emissions for the 2006 model year scenarios without a start time offset.

	Travel Time		Mileage	
	Passenger Vehicles	Commercial Vehicles	Passenger Vehicles	Commercial Vehicles
CO	-0.639	0.984	0.522	-0.994
NOX	0.926	-0.621	-0.970	0.417
VOC	0.999	0.998	-0.991	-0.968

Table 19: Correlation Coefficients between With-Flood Results and Emissions - 2006 Model Year

Travel time trended consistently upwards with flood severity for these scenarios. Of the three pollutants estimated, only VOC was found to also trend consistently upwards. The correlation coefficients for both vehicle classifications for Travel Time and VOC are therefore very high. Travel time is a good predictor of hydrocarbon generation for these scenarios.

Figure 20 demonstrates the variability of NOX and CO. Both pollutants exhibited substantial increases at higher storm severities and decreases at lower storm severities. This variability makes travel time an uncertain predictor for these pollutants.

Because of the rise and fall in mileage through increasing storm severities, pollutant generation for these scenarios cannot be considered to have a strong causal relationship with mileage. A strong negative correlation implies that any increase mileage will always yield a reduction in estimated pollutant, an unreasonable conclusion.

4.3.2 2020 Model Year Emissions

The estimated emissions for the 2020 model year yielded a substantial decrease from the 2006 model year. MOBILE assumes more strict emissions requirements to be in force in future years, which accounts for the reduction in estimated emissions despite increased travel.

Estimated emissions were reduced by 65% on average from the 2006 to the 2020 model year. The most drastic reduction, estimated NOX for commercial vehicles, averaged 89% over all flood severities.

	Passenger Vehicle			Commercial Vehicle		
	CO	NOX	VOC	CO	NOX	VOC
Without Flood	207.0	10.0	12.2	4.8	3.4	1.0
1-Year Flood	203.8	10.1	12.5	4.9	3.4	1.1
2-Year Flood	212.7	10.7	13.6	5.7	3.6	1.2
5-Year Flood	217.1	10.9	14.1	6.0	3.7	1.3
10-Year Flood	235.1	12.1	16.2	7.5	4.0	1.6
25-Year Flood	242.1	12.4	16.8	7.7	4.1	1.6
50-Year Flood	239.4	12.3	16.5	7.6	4.1	1.6
100-Year Flood	251.1	12.9	17.9	8.3	4.2	1.7
500-Year Flood	269.1	13.6	20.0	8.9	4.3	1.8

Table 20: Daily Metric Tons of Pollutants - 2020 Model Year

Unlike the 2006 model year, the 2020 estimated emissions show a nearly consistent upward trend with flood severity. The only exception to this trend is the decline in estimated emissions between the 25-year and 50-year flood severities. All pollutants and vehicle classifications exhibited the same contour, as can be seen in Figure 21.

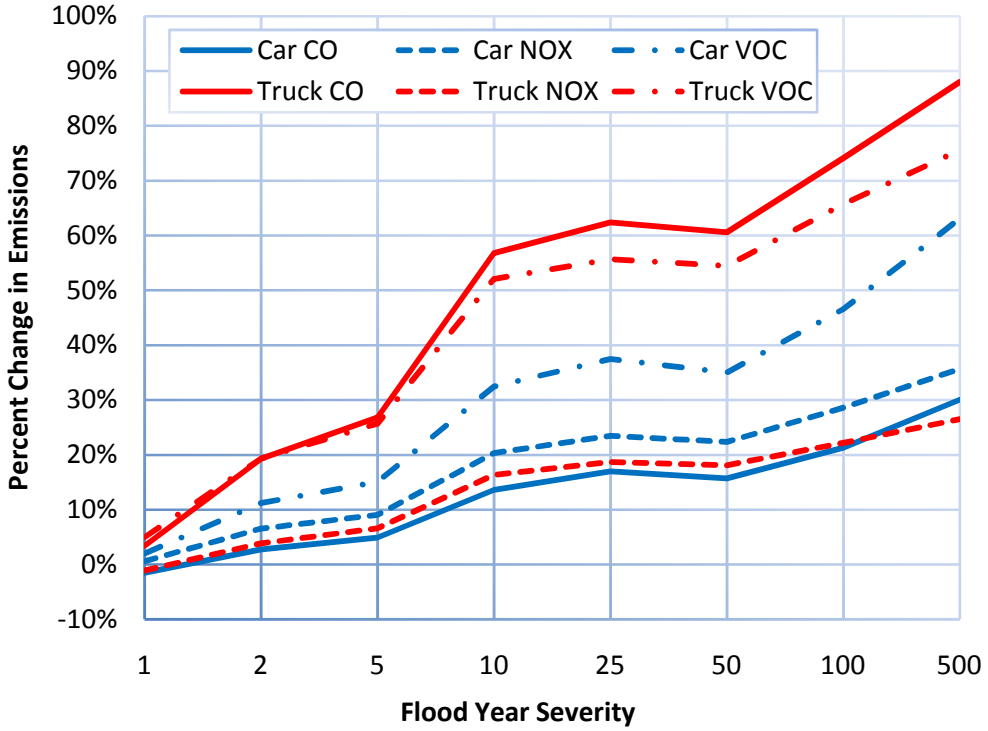


Figure 21: Percent Change in Emissions - 2020 Model Year

Correlation coefficients were calculated between the travel time and mileage results and the estimated emissions for the 2020 model year. These coefficients yielded a much different picture than the same comparisons for the 2006 model year.

	Travel Time		Mileage	
	Passenger Vehicles	Commercial Vehicles	Passenger Vehicles	Commercial Vehicles
CO	0.995	0.997	-0.994	-0.962
NOX	0.999	0.995	-0.987	-0.956
VOC	0.996	0.994	-0.996	-0.954

Table 21: Correlation Coefficients between With-Flood Results and Emissions - 2020 Model Year

A very strong positive linear relationship was found between travel time and emissions. Emissions trended upwards with flood severity, as does travel time, making it very likely that travel time is a good predictor of pollutant generation.

A very strong negative linear relationship was found between mileage and emissions. The downward trend in mileage over the 2020 model year flood scenarios could be responsible for this. The estimated emissions trended upwards with flood severity, so mileage is a poor predictor of emissions for these scenarios.

4.3.3 Sensitivity Analysis

The estimated emissions were also analyzed across the sensitivity analysis scenarios. In this section, estimated emissions are combined for the sake of brevity.

	No Offset	3 Hours	8 Hours	13 Hours	18 Hours
10-Year Flood	-1.511%	-1.647%	-1.475%	-1.704%	-1.792%
25-Year Flood	-2.848%	-2.705%	-3.739%	-3.388%	-3.759%
50-Year Flood	-6.103%	-5.441%	-5.953%	-6.053%	-6.550%
100-Year Flood	-5.445%	-4.521%	-4.925%	-4.486%	-4.140%
500-Year Flood	-2.027%	-3.079%	-1.398%	-0.929%	-1.167%

Figure 22: Total Emissions Changes by Flood Severity and Start Time Offset

These changes are largely driven by passenger-vehicle CO, as mentioned in section 4.3.1. The general trend of the combined emissions in Figure 22 parallels the passenger vehicle CO trend seen in Figure 20, with a gradual decrease through the 50-year flood event, followed by an increase in the 100 and 500-year flood events.

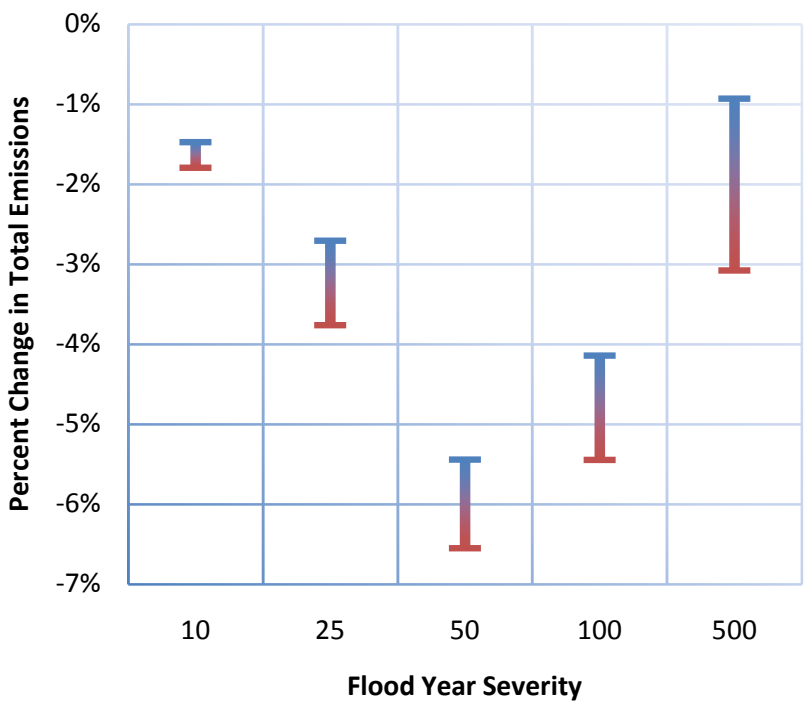


Figure 23: Range of Emissions Changes by Flood Severity - Sensitivity Scenarios

Predictably, the range of variation for the sensitivity scenarios increased with flood severity. The 10-year flood events ranged 0.318% while the 500-year flood events had a range of 2.150%. The 50-year results yielded the most consistently large reduction in estimated emissions.

4.4 Delay Distribution

Using the SIBA method described in Section 3.4.4, travel time delay contributions at every flooded road were prepared for each flood event. These delay contributions were weighted by flood severity to

produce a potential delay contribution for a given year. Delays from the 1-year flood event were used as-is. Delays from the 5-year flood event were divided by five, since a 5-year flood event is expected to occur only once every five years.

These weighted delays were summed across all flood severities to obtain a total estimated annual delay contribution per flood location for a given model year.

All flood locations listed in the following results are in Illinois.

4.4.1 2006 Model Year

Most of the large delay contributions were found to be from flood locations along the Des Plaines River.

For the 2006 model year, the top 25 flood locations account for 89% of the total delay. Five each of the top 25 roads contributing the most delay were found in Gurnee and Des Plaines.

Rank	Flood ID	Road Name	Municipality	Watercourse	Delay Contribution per Flood Event								Total Delay *hours*	
					1	2	5	10	25	50	100	500		
1	17	1st Ave	River Grove	Des Plaines River		63.4%	18.2%	20.5%	13.4%	10.2%	6.9%	6.2%	163,674	14.98%
2	238	Old Grand Ave	Gurnee	Des Plaines River		31.4%	15.9%	10.1%	6.9%	5.0%	3.5%	3.1%	92,287	8.45%
3	98	Milwaukee Ave	Prospect Heights	Des Plaines River			17.3%	11.0%	7.6%	5.9%	4.2%	3.7%	84,566	7.74%
4	252	US Highway 41	Gurnee	Des Plaines River			10.3%	7.1%	5.9%	4.6%	3.2%	2.8%	57,947	5.30%
5	213	River Road	Des Plaines	Des Plaines River			3.8%	8.6%	6.3%	5.0%	3.7%	3.3%	54,011	4.94%
6	210	River Road	Schiller Park	Des Plaines River			5.9%	8.3%	5.8%	4.5%	3.2%	2.9%	53,235	4.87%
7	78	Golf Road	Des Plaines	Des Plaines River			10.6%	6.9%	4.6%	3.4%	2.4%	2.1%	50,940	4.66%
8	214	River Road	Prospect Heights	Des Plaines River			9.3%	5.9%	4.0%	3.0%	2.1%	1.8%	44,020	4.03%
9	215	River Road	Buffalo Grove	Des Plaines River				0.2%	5.7%	5.7%	5.7%	5.7%	39,526	3.62%
10	179	Grand Ave	Gurnee	Des Plaines River				1.1%	4.0%	4.4%	4.7%	4.7%	32,992	3.02%
11	70	Rand Road	Des Plaines	Des Plaines River					1.8%	6.2%	5.1%	4.8%	31,746	2.91%
12	82	River Road	Glenview	Feehanville Ditch			0.9%	4.5%	3.8%	3.3%	2.5%	2.3%	30,402	2.78%
13	219	River Road	River Grove	Des Plaines River				2.3%	1.9%	4.3%	3.2%	3.0%	26,262	2.40%
14	218	River Road	River Grove	Des Plaines River				1.9%	3.5%	3.6%	2.7%	2.5%	24,739	2.26%
15	239	IL Route 132	Gurnee	Des Plaines River			3.5%	2.6%	2.4%	2.1%	1.6%	1.5%	23,686	2.17%
16	246	Miner Street	Des Plaines	Des Plaines River			0.3%	3.5%	2.7%	2.3%	1.7%	1.6%	21,857	2.00%
17	212	River Road	Des Plaines	Des Plaines River				1.0%	3.1%	2.8%	2.1%	1.9%	18,627	1.70%
18	91	Milwaukee Ave	Prospect Heights	Des Plaines River				0.2%	3.0%	2.9%	2.3%	2.2%	18,277	1.67%
19	216	River Road	Buffalo Grove	Des Plaines River					0.1%	1.5%	4.1%	3.6%	17,309	1.58%
20	180	US Highway 41	Gurnee	Des Plaines River				0.0%	2.2%	2.2%	2.6%	2.6%	16,546	1.51%
21	166	IL Route 120	Grayslake	Des Plaines River					1.2%	2.0%	3.0%	3.0%	16,266	1.49%
22	148	IL Route 60	Long Grove	Des Plaines River					0.5%	1.9%	2.8%	3.0%	14,564	1.33%
23	10	Chicago Ave	River Forest	Des Plaines River				1.0%	1.0%	2.4%	1.9%	1.8%	14,462	1.32%
24	125	Milwaukee Ave	Long Grove	Aptakisic Creek							3.4%	4.4%	13,679	1.25%
25	21	Grand Ave	River Grove	Des Plaines River					0.7%	1.2%	2.7%	2.6%	12,985	1.19%

Table 22: Top 25 Flooded Roads by Delay - 2006 Model Year

4.4.2 2020 Model Year

The 2020 model year results included significantly higher travel delays than in the 2006 model year, yielding a somewhat different distribution of delays among flooded roads. Most of the flooded roads in the 2006 model year top 25 were also present in the 2020 model year top 25.

For the 2020 model year, 98% of the delay was attributed to the top 25 flooded roads. This is a higher proportion than in the 2006 model year. As in the 2006 model year, all but a few roads were located along the Des Plaines River. Gurnee contained six of the top 25 flooded roads, while Des Plaines had four.

The 2020 model year represents a traffic network with significant additional lane mileage for carrying traffic. This increase in network capacity could account for the smaller proportions of delay among the top 25 roads as compared to the 2006 model year. The economic and demographic shifts assumed by CMAP in preparation of the 2020 regional trip tables could also account for the different trends between the two model years.

Rank	Flood ID	Road Name	Municipality	Watercourse	Delay Contribution per Flood Event								Total Delay *hours*	
					1	2	5	10	25	50	100	500		
1	17	1st Ave	River Grove	Des Plaines River		29.2%	23.1%	24.1%	19.3%	14.4%	17.4%	11.5%	3,816,069	23.81%
2	238	River Road	Prospect Heights	Des Plaines River		38.4%	14.3%	10.5%	8.0%	8.0%	7.0%	5.4%	3,354,826	20.93%
3	98	Old Grand Ave	Gurnee	Des Plaines River		27.8%	5.2%	5.0%	3.9%	2.8%	3.4%	2.2%	2,133,588	13.31%
4	252	Milwaukee Ave	Prospect Heights	Des Plaines River			18.5%	11.8%	8.3%	8.4%	7.0%	6.0%	1,154,840	7.20%
5	213	River Road	Schiller Park	Des Plaines River			9.9%	12.0%	8.9%	8.3%	7.2%	6.2%	955,173	5.96%
6	210	Golf Road	Des Plaines	Des Plaines River		4.7%	8.5%	7.4%	6.2%	4.6%	5.7%	3.7%	949,089	5.92%
7	78	River Road	Des Plaines	Des Plaines River			2.1%	8.1%	5.9%	5.5%	4.5%	3.8%	521,709	3.25%
8	214	US Highway 41	Gurnee	Des Plaines River			6.7%	4.1%	3.8%	4.1%	3.9%	3.3%	449,768	2.81%
9	215	Hutchins Road	Grandwood Park	Mill Creek	100.0%		2.2%	0.0%	0.0%	0.0%	0.0%	0.1%	434,880	2.71%
10	179	River Road	River Grove	Des Plaines River			2.5%	2.0%	6.1%	6.0%	4.8%	4.4%	337,686	2.11%
11	70	River Road	Glenview	Feehanville Ditch			0.1%	4.3%	3.4%	3.2%	2.5%	2.5%	260,183	1.62%
12	82	River Road	Buffalo Grove	Des Plaines River				1.9%	3.7%	4.7%	4.1%	4.9%	211,018	1.32%
13	219	Rand Road	Des Plaines	Des Plaines River					5.8%	6.4%	5.0%	5.3%	206,809	1.29%
14	218	River Road	River Grove	Des Plaines River			1.5%	1.2%	3.5%	3.6%	2.8%	2.6%	196,876	1.23%
15	239	River Road	Des Plaines	Des Plaines River			1.1%	0.9%	3.4%	3.3%	2.5%	2.3%	171,230	1.07%
16	246	Milwaukee Ave	Prospect Heights	Des Plaines River				1.8%	2.0%	1.9%	1.5%	1.6%	126,432	0.79%
17	212	Miner Street	Des Plaines	Des Plaines River			0.0%	1.7%	1.2%	1.2%	0.9%	0.9%	98,829	0.62%
18	91	IL Route 132	Gurnee	Des Plaines River			1.0%	0.9%	0.9%	1.0%	0.8%	1.0%	88,718	0.55%
19	216	Milwaukee Ave	Gurnee	Des Plaines River			0.7%	0.5%	0.6%	0.7%	0.6%	0.7%	58,255	0.36%
20	180	Chicago Ave	River Forest	Des Plaines River			0.3%	0.6%	0.5%	1.2%	1.0%	0.9%	58,122	0.36%
21	166	Grand Ave	Gurnee	Des Plaines River				0.2%	1.1%	1.2%	1.2%	1.6%	48,003	0.30%
22	148	IL Route 60	Long Grove	Des Plaines River					0.8%	1.7%	1.8%	3.1%	47,577	0.30%
23	10	Grand Ave	River Grove	Des Plaines River					0.8%	0.9%	2.5%	2.7%	44,464	0.28%
24	125	Kilbourne Road	Gurnee	Des Plaines River			0.5%	0.3%	0.3%	0.4%	0.3%	0.4%	36,733	0.23%
25	21	River Road	Buffalo Grove	Des Plaines River		29.2%	23.1%	24.1%	19.3%	14.4%	17.4%	11.5%	35,229	0.22%

Table 23: Top 25 Flooded Roads by Delay - 2020 Model Year

4.4.3 Sensitivity Analysis

Numerous changes in the rankings of flooded roads took place in the sensitivity analysis scenarios. The most severely affected flood location, 1st in River Grove, was consistent across all scenarios. Other flooded roads in the top 24 moved up and down the rankings in different ways, and to different levels, for the four start time offsets.

					Rank and Change by Hours of Offset							
Rank	**Flood ID**	**Road**	**Municipality**	**Watercourse**	**3**		**8**		**13**		**18**	
1	17	1st Ave	River Grove	Des Plaines River	1		1		1		1	
2	238	Old Grand Ave	Gurnee	Des Plaines River	3	*-1*	3	*-1*	3	*-1*	3	*-1*
3	98	Milwaukee Ave	Prospect Heights	Des Plaines River	2	*+1*	2	*+1*	2	*+1*	4	*-1*
4	252	US Highway 41	Gurnee	Des Plaines River	7	*-3*	9	*-5*	9	*-5*	9	*-5*
5	213	River Rd	Des Plaines	Des Plaines River	4	*+1*	5		6	*-1*	7	*-2*
6	210	River Rd	Schiller Park	Des Plaines River	5	*+1*	7	*-1*	8	*-2*	8	*-2*
7	78	Golf Rd	Des Plaines	Des Plaines River	8	*-1*	10	*-3*	10	*-3*	10	*-3*
8	214	River Rd	Prospect Heights	Des Plaines River	11	*-3*	13	*-5*	11	*-3*	11	*-3*
9	215	River Rd	Buffalo Grove	Des Plaines River	6	*+3*	4	*+5*	5	*+4*	5	*+4*
10	179	Grand Ave	Gurnee	Des Plaines River	10		12	*-2*	12	*-2*	12	*-2*
11	70	Rand Rd	Des Plaines	Des Plaines River	9	*+2*	11		13	*-2*	13	*-2*
12	82	River Rd	Glenview	Feehanville Ditch	12		14	*-2*	14	*-2*	15	*-3*
13	219	River Rd	River Grove	Des Plaines River	13		15	*-2*	16	*-3*	16	*-3*
14	218	River Rd	River Grove	Des Plaines River	14		17	*-3*	17	*-3*	17	*-3*
15	239	IL Route 132	Gurnee	Des Plaines River	19	*-4*	20	*-5*	20	*-5*	20	*-5*
16	246	Miner St	Des Plaines	Des Plaines River	15	*+1*	18	*-2*	18	*-2*	18	*-2*
17	212	River Rd	Des Plaines	Des Plaines River	16	*+1*	19	*-2*	19	*-2*	19	*-2*
18	91	Milwaukee Ave	Prospect Heights	Des Plaines River	18		21	*-3*	21	*-3*	21	*-3*
19	216	River Rd	Buffalo Grove	Des Plaines River	17	*+2*	16	*+3*	15	*+4*	14	*+5*
20	180	US Highway 41	Gurnee	Des Plaines River	21	*-1*	22	*-2*	22	*-2*	22	*-2*
21	166	IL Route 120	Grayslake	Des Plaines River	20	*+1*	8	*+13*	7	*+14*	6	*+15*
22	148	IL Route 60	Long Grove	Des Plaines River	24	*-2*	*n/a*		25	*-3*	25	*-3*
23	10	Chicago Ave	River Forest	Des Plaines River	23		24	*-1*	24	*-1*	23	
24	125	Milwaukee Ave	Long Grove	Aptakisic Creek	22	*+2*	23	*+1*	23	*+1*	*n/a*	
25	21	Grand Ave	River Grove	Des Plaines River	25		25		*n/a*		24	*+1*

Table 24: Flooded Road Ranking Changes by Start Time Offset

Among the start time offsets, the 3-hour yielded the fewest changes in ranking. IL Route 120 made the largest changes, dropping 13, 14 and 15 ranks in the 8-, 13-, and 18-hour start time offset scenarios, respectively. IL Route 60, Milwaukee in Long Grove, and Grand in River Grove each fell off the top 25 ranking in one start time offset. In all three of these cases, the flooded section of I-94 in Pleasant Prairie (Flood ID 339) was newly included in the ranking.

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6 Appendix A: 2006 Model Year Results

This appendix details the results for the current year condition under each of the various flood severities.

6.1 1-Year Flood

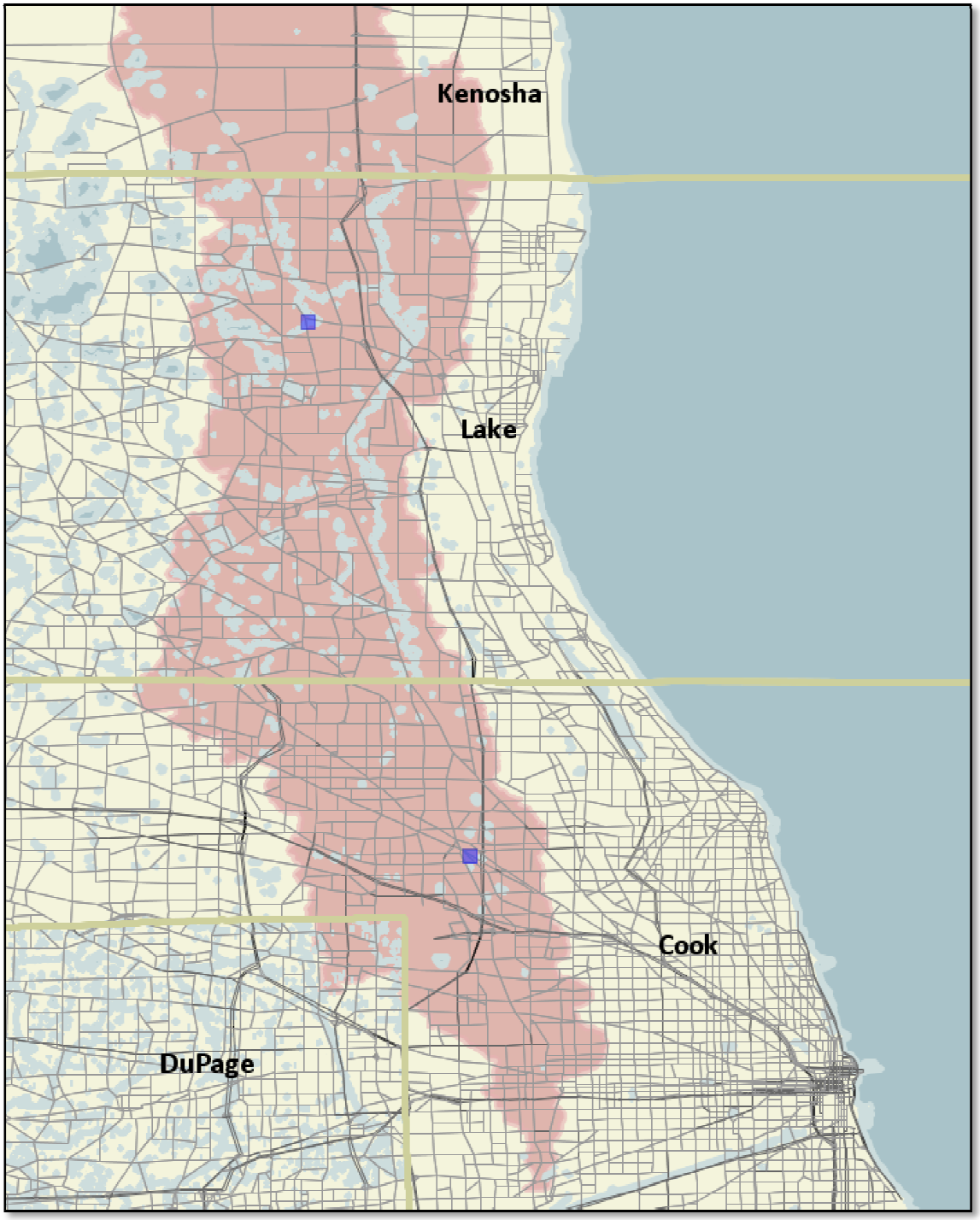


Figure 24: 1-Year Flood Locations – 2006 Model Year

6.1.1 Flood Location and Schedules

2006 Case: 1-yr Flood Schedule			
Flood ID	**Location**	**Start Time**	**End Time**
61	CHICAGO AVE	Day: 1, Hour: 17:00	Day: 1, Hour: 22:38
184	HUTCHINS RD	Day: 2, Hour: 9:00	Day: 3, Hour: 8:31

6.1.2 Travel Time Effects

2006 Case: 1-yr Flood Severity, 0-hr Offset

	Vehicles	**Total Savings**	**Average Savings**	**Percentage**
greater than		*hours*	*minutes*	
60 minutes	1,206	2,297	114.29	0.005%
30 minutes	8,925	5,634	37.87	0.033%
15 minutes	21,474	7,748	21.65	0.081%
5 minutes	39,165	5,804	8.89	0.147%
0 minutes	250,277	2,588	0.62	0.939%
no change	25992839			97.556%

	Vehicles	**Total Delay**	**Average Delay**	**Percentage**
greater than		*hours*	*minutes*	
0 minutes	281,970	3,344	0.71	1.058%
5 minutes	28,404	4,174	8.82	0.107%
15 minutes	8,505	2,976	20.99	0.032%
30 minutes	7,187	5,056	42.21	0.027%
60 minutes	3,214	3,912	73.03	0.012%
90 minutes	43	74	102.67	0.000%
120 minutes	27	61	135.58	0.000%
150 minutes	46	127	166.27	0.000%
180 minutes	47	154	196.27	0.000%
210 minutes	63	237	225.64	0.000%
240 minutes	55	232	253.34	0.000%
270 minutes	81	384	284.49	0.000%
300 minutes	387	3,074	476.54	0.001%

6.2 2-Year Flood

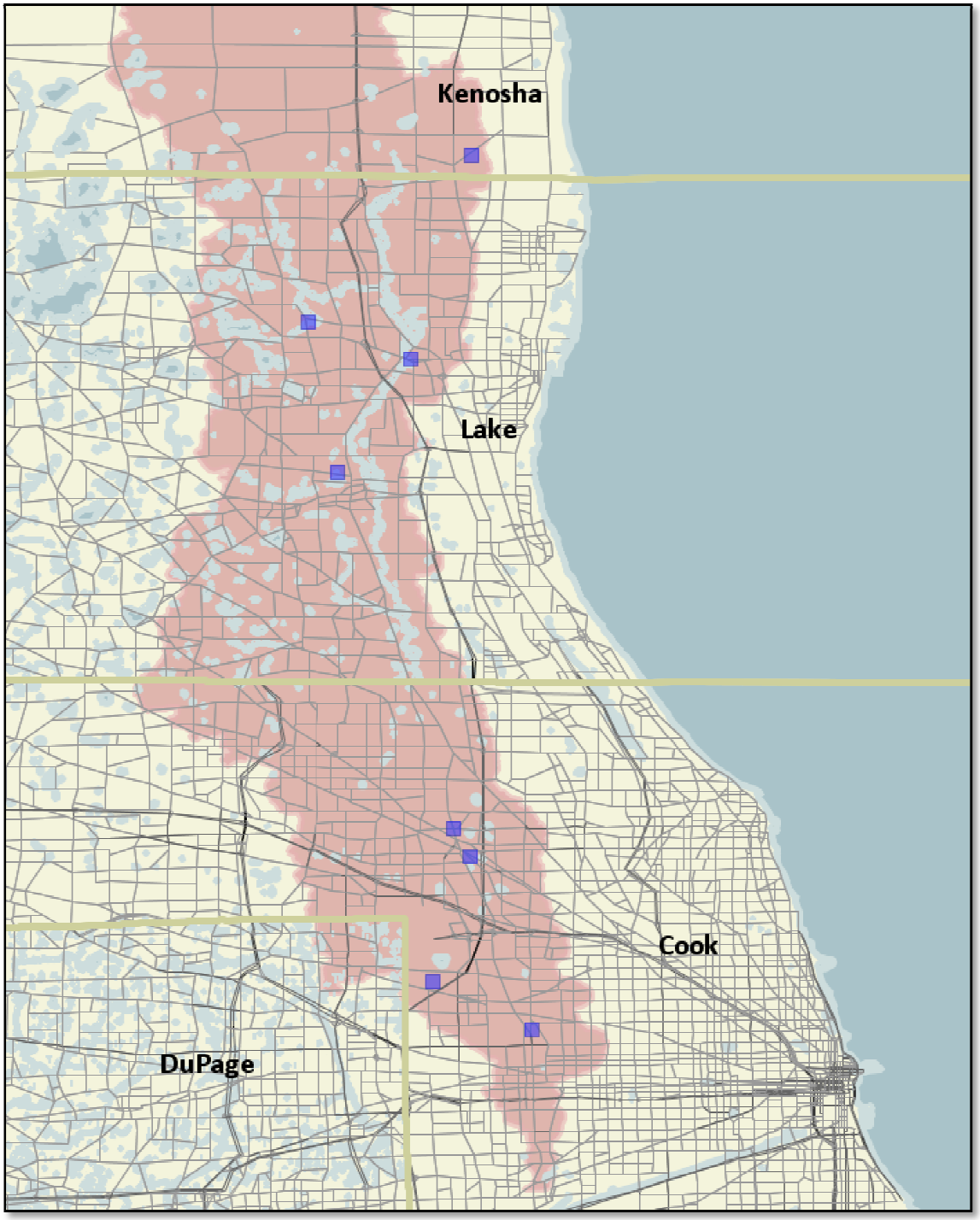


Figure 25: 2-Year Flood Locations – 2006 Model Year

6.2.1 Flood Location and Schedules

2006 Case: 2-yr Flood Schedule			
Flood ID	**Location**	**Start Time**	**End Time**
17	1ST AVE	Day: 6, Hour: 5:00	Day: 7, Hour: 5:02
26	IRVING PARK RD	Day: 1, Hour: 17:00	Day: 1, Hour: 21:40
61	CHICAGO AVE	Day: 1, Hour: 17:00	Day: 2, Hour: 0:18
78	GOLF RD	Day: 5, Hour: 12:00	Day: 5, Hour: 17:45
157	WINCHESTER RD	Day: 1, Hour: 14:00	Day: 1, Hour: 16:58
184	HUTCHINS RD	Day: 2, Hour: 4:00	Day: 4, Hour: 0:16
238	OLD GRAND	Day: 4, Hour: 18:00	Day: 7, Hour: 13:30

6.2.2 Travel Time Effects

2006 Case: 2-yr Flood Severity, 0-hr Offset

	Vehicles	**Total Savings**	**Average Savings**	**Percentage**
greater than		*hours*	*minutes*	
60 minutes	2,792	5,312	114.15	0.004%
30 minutes	20,061	12,566	37.58	0.032%
15 minutes	49,869	18,027	21.69	0.080%
5 minutes	79,832	11,938	8.97	0.128%
0 minutes	618,235	6,356	0.62	0.994%

no change	60479245			97.282%

	Vehicles	**Total Delay**	**Average Delay**	**Percentage**
greater than		*hours*	*minutes*	
0 minutes	780,934	11,013	0.85	1.256%
5 minutes	77,358	11,596	8.99	0.124%
15 minutes	27,563	9,233	20.10	0.044%
30 minutes	16,444	11,645	42.49	0.026%
60 minutes	6,380	7,633	71.78	0.010%
90 minutes	220	383	104.58	0.000%
120 minutes	247	557	135.30	0.000%
150 minutes	243	673	166.25	0.000%
180 minutes	251	816	195.13	0.000%
210 minutes	294	1,106	225.75	0.000%
240 minutes	320	1,360	255.07	0.001%
270 minutes	310	1,463	283.19	0.000%
300 minutes	8,537	101,249	711.60	0.014%

6.3 5-Year Flood

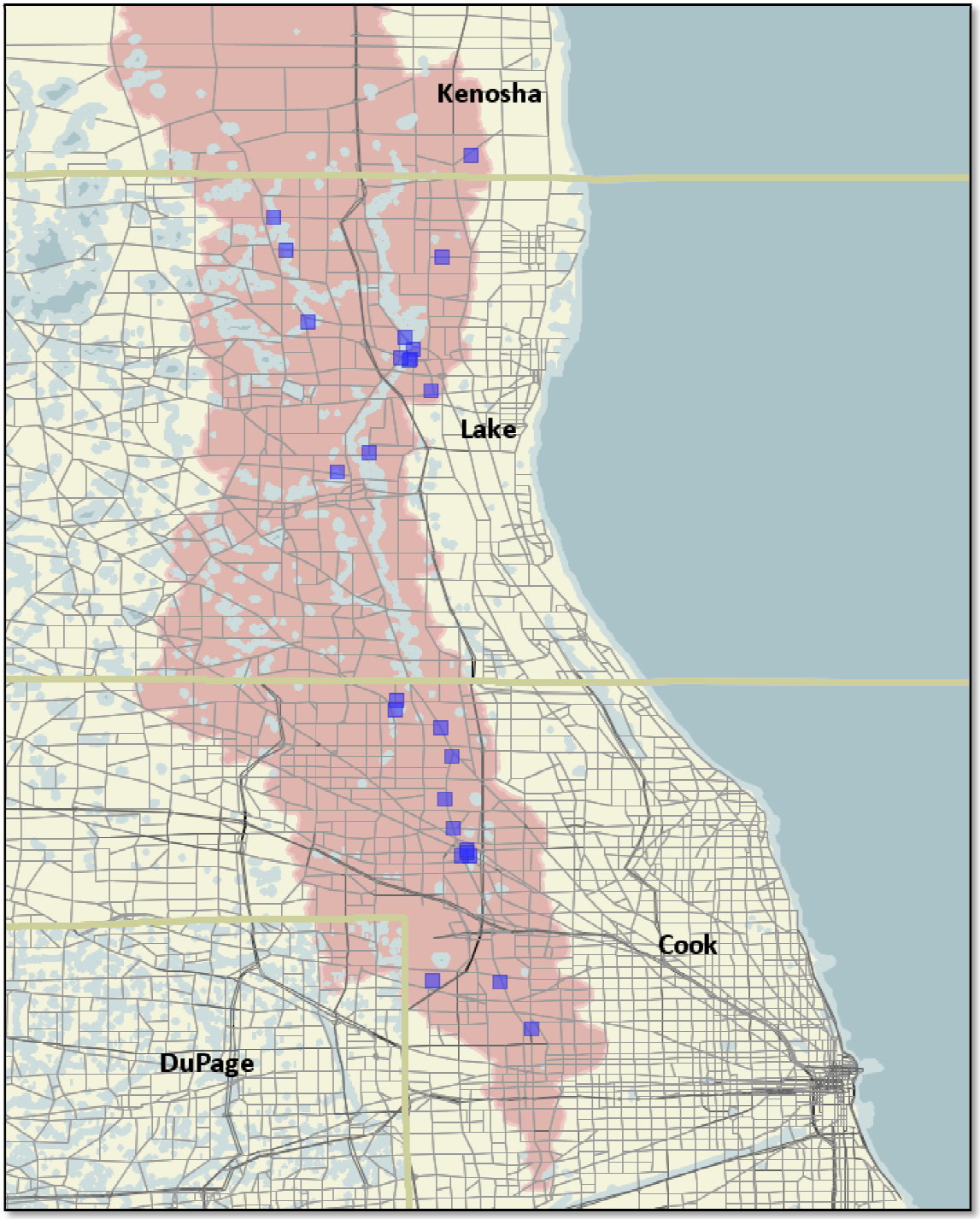


Figure 26: 5-Year Flood Locations – 2006 Model Year

6.3.1 Flood Location and Schedules

2006 Case: 5-yr Flood Schedule			
Flood ID	**Location**	**Start Time**	**End Time**
17	1ST AVE	Day: 6, Hour: 5:00	Day: 8, Hour: 22:44
26	IRVING PARK RD	Day: 1, Hour: 15:00	Day: 1, Hour: 23:53
61	CHICAGO AVE	Day: 1, Hour: 17:00	Day: 2, Hour: 2:53
78	GOLF RD	Day: 5, Hour: 12:00	Day: 12, Hour: 13:05
82	RIVER RD	Day: 5, Hour: 11:00	Day: 5, Hour: 18:12
98	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 10, Hour: 21:02
111	NORTHGATE PKWY	Day: 1, Hour: 15:00	Day: 1, Hour: 20:12
157	WINCHESTER RD	Day: 1, Hour: 13:00	Day: 1, Hour: 18:14
184	HUTCHINS RD	Day: 1, Hour: 14:00	Day: 4, Hour: 14:04
193	ADAMS RD	Day: 1, Hour: 20:00	Day: 2, Hour: 1:00
194	KELLEY RD	Day: 1, Hour: 21:00	Day: 1, Hour: 21:15
200	IL-173	Day: 1, Hour: 18:00	Day: 2, Hour: 0:01
210	RIVER RD	Day: 6, Hour: 1:00	Day: 8, Hour: 4:52
213	RIVER RD	Day: 5, Hour: 14:00	Day: 6, Hour: 17:13
214	RIVER RD	Day: 5, Hour: 7:00	Day: 12, Hour: 5:37
224	WHEELING	Day: 1, Hour: 14:00	Day: 1, Hour: 20:07
237	KILBOURNE	Day: 4, Hour: 18:00	Day: 8, Hour: 3:16
238	OLD GRAND	Day: 4, Hour: 18:00	Day: 12, Hour: 14:54
239	IL ROUTE 132	Day: 4, Hour: 18:00	Day: 7, Hour: 19:02
244	RIVER RD	Day: 1, Hour: 19:00	Day: 7, Hour: 12:00
246	MINER	Day: 5, Hour: 12:00	Day: 5, Hour: 15:51
247	BUSSE	Day: 5, Hour: 14:00	Day: 6, Hour: 12:36
251	MILWAUKEE AVE	Day: 4, Hour: 18:00	Day: 6, Hour: 22:22
252	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 9, Hour: 12:59
273	GREENLEAF	Day: 1, Hour: 19:00	Day: 2, Hour: 17:23

6.3.2 Travel Time Effects

2006 Case: 5-yr Flood Severity, 0-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	7,181	12,570	105.03	0.007%
30 minutes	40,338	25,452	37.86	0.038%
15 minutes	84,305	29,949	21.31	0.079%
5 minutes	122,524	18,513	9.07	0.115%
0 minutes	1,177,638	12,057	0.61	1.105%

no change	102711850			96.375%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	1,943,667	44,742	1.38	1.824%
5 minutes	250,931	37,466	8.96	0.235%
15 minutes	109,954	37,618	20.53	0.103%
30 minutes	42,891	30,162	42.19	0.040%
60 minutes	12,860	15,319	71.47	0.012%
90 minutes	3,064	5,355	104.87	0.003%
120 minutes	3,500	7,921	135.80	0.003%
150 minutes	4,461	12,231	164.51	0.004%
180 minutes	2,235	7,033	188.80	0.002%
210 minutes	1,002	3,768	225.61	0.001%
240 minutes	1,102	4,702	256.03	0.001%
270 minutes	1,244	5,915	285.31	0.001%
300 minutes	54,913	648,888	709.00	0.052%

6.4 10-Year Flood

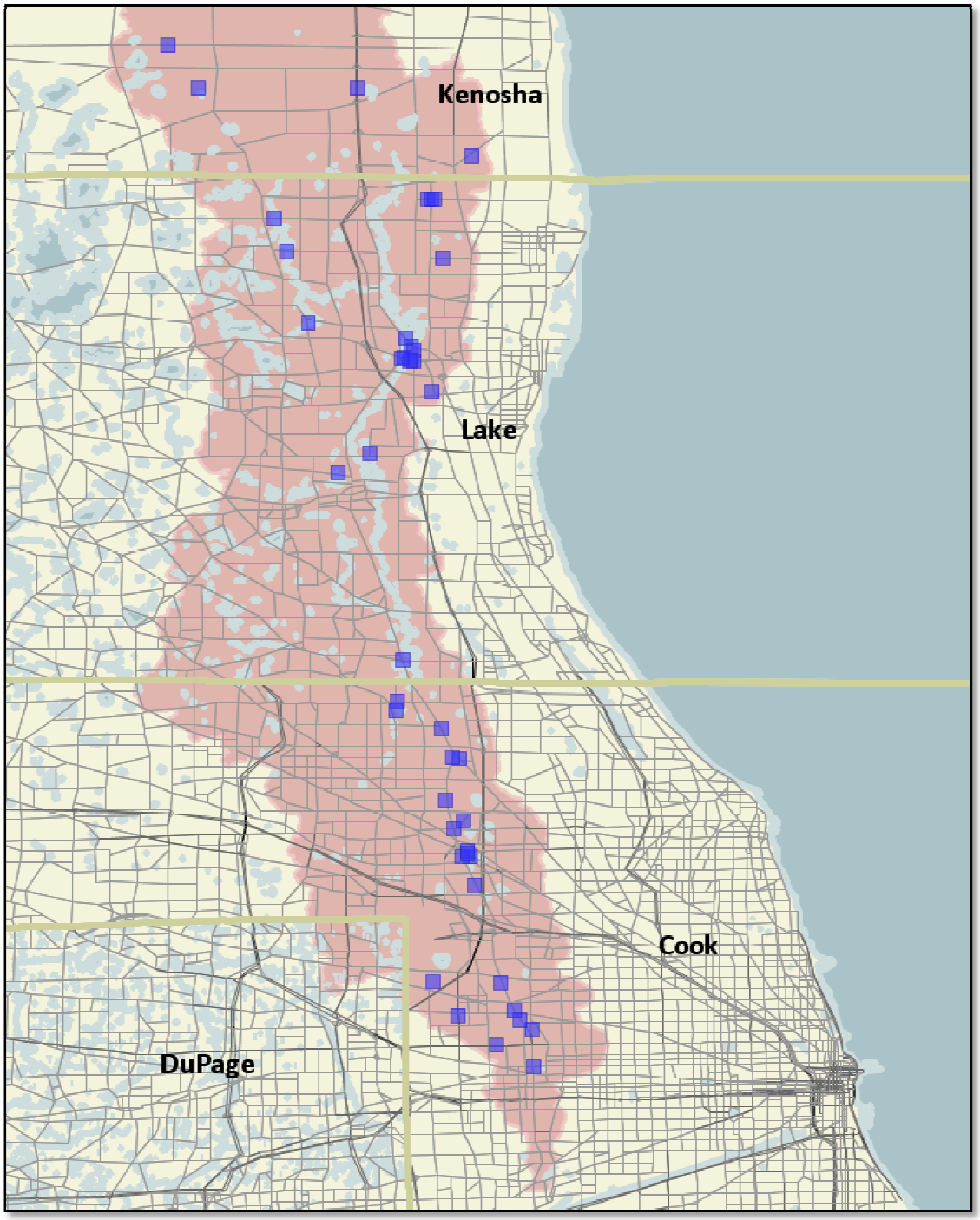


Figure 27: 10-Year Flood Locations – 2006 Model Year

6.4.1 Flood Location and Schedules

2006 Case: 10-yr Flood Schedule			
Flood ID	**Location**	**Start Time**	**End Time**
10	CHICAGO AVE	Day: 5, Hour: 18:00	Day: 7, Hour: 12:27
14	NORTH AVE	Day: 1, Hour: 14:00	Day: 1, Hour: 16:43
17	1ST AVE	Day: 6, Hour: 5:00	Day: 13, Hour: 22:22
19	MANNHEIM RD	Day: 1, Hour: 16:00	Day: 1, Hour: 17:01
26	IRVING PARK RD	Day: 1, Hour: 14:00	Day: 2, Hour: 0:57
61	CHICAGO AVE	Day: 1, Hour: 16:00	Day: 2, Hour: 4:07
78	GOLF RD	Day: 5, Hour: 12:00	Day: 14, Hour: 4:01
82	RIVER RD	Day: 5, Hour: 11:00	Day: 10, Hour: 14:19
91	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 5, Hour: 12:22
98	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 12, Hour: 20:08
111	NORTHGATE PKWY	Day: 1, Hour: 13:00	Day: 1, Hour: 22:04
157	WINCHESTER RD	Day: 1, Hour: 12:00	Day: 1, Hour: 19:45
177	OPLAINE RD	Day: 1, Hour: 19:00	Day: 2, Hour: 14:02
179	GRAND AVE	Day: 4, Hour: 18:00	Day: 6, Hour: 1:22
180	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 5, Hour: 1:33
184	HUTCHINS RD	Day: 1, Hour: 12:00	Day: 4, Hour: 21:54
193	ADAMS RD	Day: 1, Hour: 17:00	Day: 2, Hour: 5:28
194	KELLEY RD	Day: 1, Hour: 16:00	Day: 2, Hour: 2:11
200	IL-173	Day: 1, Hour: 15:00	Day: 2, Hour: 3:09
201	DELANEY RD	Day: 1, Hour: 19:00	Day: 1, Hour: 20:49
202	9TH ST	Day: 1, Hour: 19:00	Day: 1, Hour: 21:22
210	RIVER RD	Day: 6, Hour: 1:00	Day: 12, Hour: 20:11
212	RIVER RD	Day: 5, Hour: 20:00	Day: 7, Hour: 9:20
213	RIVER RD	Day: 5, Hour: 14:00	Day: 12, Hour: 4:53
214	RIVER RD	Day: 5, Hour: 7:00	Day: 13, Hour: 19:47
215	RIVER RD	Day: 2, Hour: 17:00	Day: 4, Hour: 5:50
218	RIVER	Day: 6, Hour: 0:00	Day: 7, Hour: 22:04
219	RIVER	Day: 6, Hour: 0:00	Day: 7, Hour: 20:16
224	WHEELING	Day: 1, Hour: 13:00	Day: 1, Hour: 22:43
230	9TH	Day: 1, Hour: 18:00	Day: 1, Hour: 23:36
237	KILBOURNE	Day: 4, Hour: 18:00	Day: 10, Hour: 12:07
238	OLD GRAND	Day: 4, Hour: 18:00	Day: 15, Hour: 19:01
239	IL ROUTE 132	Day: 4, Hour: 18:00	Day: 10, Hour: 4:43
244	RIVER	Day: 1, Hour: 19:00	Day: 11, Hour: 0:55
246	MINER	Day: 5, Hour: 12:00	Day: 11, Hour: 7:31
247	BUSSE	Day: 5, Hour: 14:00	Day: 11, Hour: 12:32
248	COLLEGE CIRCLE	Day: 5, Hour: 12:00	Day: 10, Hour: 19:24
251	MILWAUKEE AVE	Day: 4, Hour: 18:00	Day: 9, Hour: 16:00
252	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 12, Hour: 5:08
273	GREENLEAF	Day: 1, Hour: 19:00	Day: 2, Hour: 21:28
301	60TH ST	Day: 1, Hour: 15:00	Day: 1, Hour: 15:30
339	I-94	Day: 2, Hour: 5:00	Day: 3, Hour: 22:45

6.4.2 Travel Time Effects

2006 Case: 10-yr Flood Severity, 0-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	7,500	12,884	103.07	0.006%
30 minutes	49,056	30,960	37.87	0.037%
15 minutes	92,280	33,145	21.55	0.069%
5 minutes	137,826	20,884	9.09	0.103%
0 minutes	1,580,077	16,389	0.62	1.186%

no change	127489904			95.699%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	2,979,800	76,221	1.53	2.237%
5 minutes	451,242	66,352	8.82	0.339%
15 minutes	178,922	59,905	20.09	0.134%
30 minutes	58,499	40,520	41.56	0.044%
60 minutes	18,978	22,805	72.10	0.014%
90 minutes	7,740	13,570	105.19	0.006%
120 minutes	9,783	22,243	136.42	0.007%
150 minutes	6,620	18,193	164.89	0.005%
180 minutes	4,724	15,155	192.48	0.004%
210 minutes	2,187	8,176	224.32	0.002%
240 minutes	1,963	8,365	255.69	0.001%
270 minutes	2,419	11,475	284.63	0.002%
300 minutes	140,055	1,762,942	755.25	0.105%

6.5 25-Year Flood

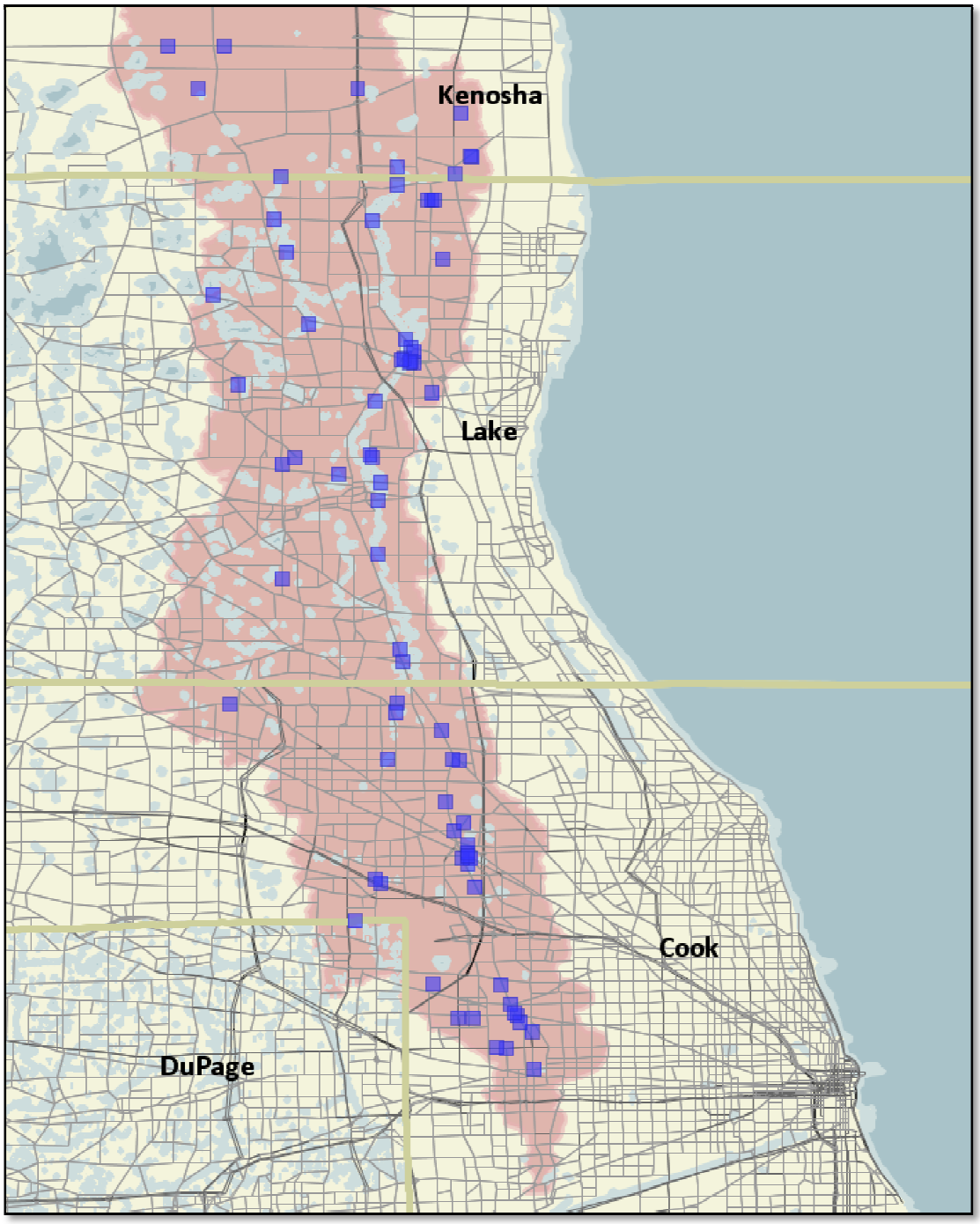


Figure 28: 25-Year Flood Locations – 2006 Model Year

6.5.1 Flood Location and Schedules

2006 Case: 25yr Flood Schedule			
Flood ID	**Location**	**Start Time**	**End Time**
10	CHICAGO AVE	Day: 5, Hour: 18:00	Day: 8, Hour: 13:36
13	15TH AVE	Day: 1, Hour: 14:00	Day: 1, Hour: 16:51
14	NORTH AVE	Day: 1, Hour: 13:00	Day: 2, Hour: 1:54
17	1ST AVE	Day: 6, Hour: 5:00	Day: 15, Hour: 18:51
19	MANNHEIM RD	Day: 1, Hour: 14:00	Day: 2, Hour: 2:23
20	SCOTT ST	Day: 1, Hour: 22:00	Day: 2, Hour: 2:33
21	GRAND AVE	Day: 6, Hour: 0:00	Day: 7, Hour: 5:37
23	BELMONT AVE	Day: 6, Hour: 0:00	Day: 6, Hour: 4:47
26	IRVING PARK RD	Day: 1, Hour: 13:00	Day: 2, Hour: 2:04
44	DEVON AVE	Day: 1, Hour: 15:00	Day: 1, Hour: 18:14
56	WILLE RD	Day: 1, Hour: 14:00	Day: 1, Hour: 16:46
57	ELMHURST RD	Day: 1, Hour: 15:00	Day: 1, Hour: 15:42
60	ALGONQUIN RD	Day: 5, Hour: 20:00	Day: 6, Hour: 19:57
61	CHICAGO AVE	Day: 1, Hour: 16:00	Day: 2, Hour: 8:23
70	RAND RD	Day: 5, Hour: 11:00	Day: 6, Hour: 17:55
78	GOLF RD	Day: 5, Hour: 12:00	Day: 16, Hour: 0:58
82	RIVER RD	Day: 5, Hour: 11:00	Day: 13, Hour: 1:03
91	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 11, Hour: 12:51
98	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 14, Hour: 14:18
106	DUNDEE RD	Day: 1, Hour: 12:00	Day: 1, Hour: 17:00
111	NORTHGATE PKWY	Day: 1, Hour: 12:00	Day: 2, Hour: 14:19
146	DIAMOND LAKE RD	Day: 1, Hour: 10:00	Day: 1, Hour: 15:11
148	IL ROUTE 60	Day: 5, Hour: 11:00	Day: 5, Hour: 23:59
152	ROCKLAND RD	Day: 1, Hour: 18:00	Day: 3, Hour: 3:05
154	OAK SPRING RD	Day: 3, Hour: 12:00	Day: 5, Hour: 16:17
157	WINCHESTER RD	Day: 1, Hour: 12:00	Day: 1, Hour: 21:53
159	US HWY 45	Day: 1, Hour: 14:00	Day: 1, Hour: 18:08
160	PETERSON RD	Day: 1, Hour: 14:00	Day: 1, Hour: 17:23
166	IL ROUTE 120	Day: 1, Hour: 18:00	Day: 6, Hour: 4:10
177	OPLAINE RD	Day: 1, Hour: 19:00	Day: 2, Hour: 19:41
179	GRAND AVE	Day: 4, Hour: 18:00	Day: 9, Hour: 7:49
180	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 8, Hour: 23:09
184	HUTCHINS RD	Day: 1, Hour: 10:00	Day: 5, Hour: 11:01
193	ADAMS RD	Day: 1, Hour: 16:00	Day: 2, Hour: 12:59
194	KELLEY RD	Day: 1, Hour: 13:00	Day: 2, Hour: 6:21
199	IL ROUTE 173	Day: 3, Hour: 16:00	Day: 5, Hour: 15:03
200	IL-173	Day: 1, Hour: 13:00	Day: 2, Hour: 8:06
201	DELANEY RD	Day: 1, Hour: 17:00	Day: 2, Hour: 0:24
202	9TH ST	Day: 1, Hour: 17:00	Day: 2, Hour: 0:39
205	RUSSELL RD	Day: 1, Hour: 19:00	Day: 3, Hour: 20:28
206	128TH ST	Day: 1, Hour: 14:00	Day: 2, Hour: 3:02
210	RIVER RD	Day: 6, Hour: 1:00	Day: 14, Hour: 21:23
212	RIVER RD	Day: 5, Hour: 20:00	Day: 13, Hour: 0:19
213	RIVER RD	Day: 5, Hour: 14:00	Day: 14, Hour: 2:18

2006 Case: 25yr Flood Schedule (Continued)			
Flood ID	**Location**	**Start Time**	**End Time**
214	RIVER RD	Day: 5, Hour: 7:00	Day: 15, Hour: 17:27
215	RIVER RD	Day: 2, Hour: 17:00	Day: 9, Hour: 14:48
216	RIVER RD	Day: 2, Hour: 17:00	Day: 4, Hour: 2:31
218	RIVER	Day: 6, Hour: 0:00	Day: 12, Hour: 1:04
219	RIVER	Day: 6, Hour: 0:00	Day: 8, Hour: 19:13
224	WHEELING	Day: 1, Hour: 12:00	Day: 2, Hour: 15:25
228	BARRON	Day: 1, Hour: 20:00	Day: 2, Hour: 3:58
230	9TH	Day: 1, Hour: 16:00	Day: 2, Hour: 1:23
237	KILBOURNE	Day: 4, Hour: 18:00	Day: 13, Hour: 8:31
238	OLD GRAND	Day: 4, Hour: 18:00	Day: 19, Hour: 11:13
239	IL ROUTE 132	Day: 4, Hour: 18:00	Day: 12, Hour: 23:47
243	BUCKLEY	Day: 1, Hour: 19:00	Day: 2, Hour: 11:03
244	RIVER	Day: 1, Hour: 19:00	Day: 14, Hour: 0:00
246	MINER	Day: 5, Hour: 12:00	Day: 13, Hour: 8:03
247	BUSSE	Day: 5, Hour: 14:00	Day: 13, Hour: 14:21
248	COLLEGE CIRCLE	Day: 5, Hour: 12:00	Day: 13, Hour: 0:55
251	MILWAUKEE AVE	Day: 4, Hour: 18:00	Day: 12, Hour: 7:43
252	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 15, Hour: 4:57
254	WILLOW RD	Day: 1, Hour: 19:00	Day: 1, Hour: 20:26
273	GREENLEAF	Day: 1, Hour: 19:00	Day: 3, Hour: 5:54
274	GRAND	Day: 1, Hour: 15:00	Day: 1, Hour: 23:40
294	122ND	Day: 3, Hour: 1:00	Day: 4, Hour: 4:15
295	GREEN BAY RD	Day: 1, Hour: 19:00	Day: 1, Hour: 19:15
301	60TH ST	Day: 1, Hour: 15:00	Day: 1, Hour: 16:30
309	60TH ST	Day: 1, Hour: 23:00	Day: 2, Hour: 4:30
311	SPRINGBROOK RD	Day: 1, Hour: 18:00	Day: 1, Hour: 18:30
339	I-94	Day: 2, Hour: 0:00	Day: 4, Hour: 8:00

6.5.2 Travel Time Effects

2006 Case: 25-yr Flood Severity, 0-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	10,845	17,865	98.84	0.006%
30 minutes	64,630	40,815	37.89	0.038%
15 minutes	118,613	42,525	21.51	0.070%
5 minutes	172,964	26,235	9.10	0.103%
0 minutes	2,018,203	21,057	0.63	1.196%

no change	160387441			95.047%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	4,243,114	117,693	1.66	2.515%
5 minutes	749,534	107,190	8.58	0.444%
15 minutes	319,686	109,827	20.61	0.189%
30 minutes	167,222	119,625	42.92	0.099%
60 minutes	88,483	108,956	73.88	0.052%
90 minutes	60,273	105,104	104.63	0.036%
120 minutes	50,488	113,182	134.51	0.030%
150 minutes	29,877	81,871	164.42	0.018%
180 minutes	22,878	73,972	194.00	0.014%
210 minutes	13,710	51,066	223.48	0.008%
240 minutes	6,303	26,615	253.35	0.004%
270 minutes	4,553	21,575	284.32	0.003%
300 minutes	215,978	2,743,813	762.25	0.128%

6.6 50-Year Flood

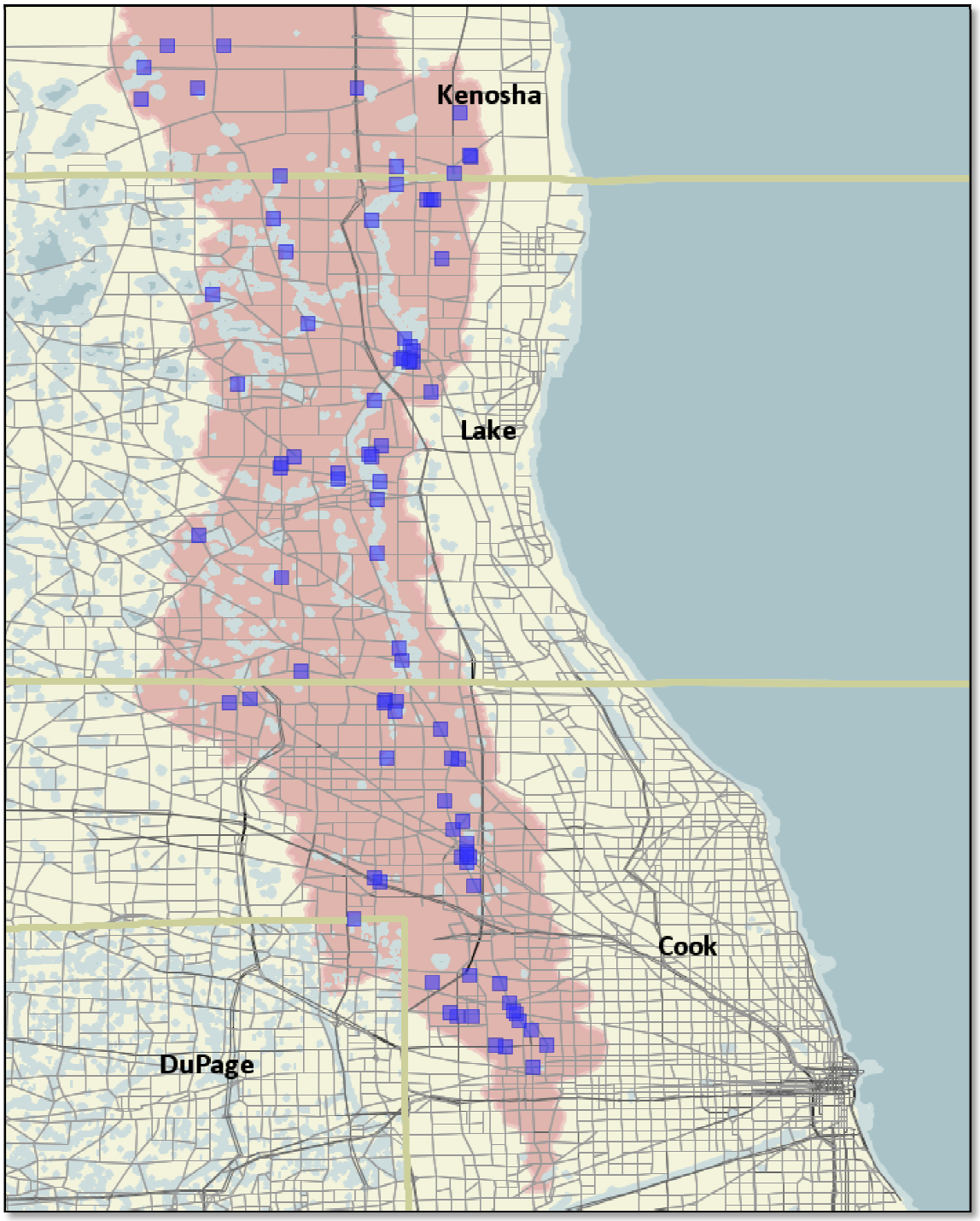


Figure 29: 50-Year Flood Locations – 2006 Model Year

6.6.1 Flood Location and Schedules

2006 Case: 50-yr Flood Schedule			
Flood ID	**Location**	**Start Time**	**End Time**
10	CHICAGO AVE	Day: 5, Hour: 18:00	Day: 13, Hour: 7:56
13	15TH AVE	Day: 1, Hour: 13:00	Day: 2, Hour: 0:15
14	NORTH AVE	Day: 1, Hour: 12:00	Day: 2, Hour: 3:35
15	NORTH AVE	Day: 6, Hour: 5:00	Day: 6, Hour: 22:03
17	1ST AVE	Day: 6, Hour: 5:00	Day: 17, Hour: 1:28
19	MANNHEIM RD	Day: 1, Hour: 13:00	Day: 2, Hour: 4:11
20	SCOTT ST	Day: 1, Hour: 14:00	Day: 2, Hour: 4:22
21	GRAND AVE	Day: 6, Hour: 0:00	Day: 8, Hour: 7:13
22	GRAND AVE	Day: 1, Hour: 20:00	Day: 1, Hour: 21:10
23	BELMONT AVE	Day: 6, Hour: 0:00	Day: 8, Hour: 0:00
26	IRVING PARK RD	Day: 1, Hour: 12:00	Day: 2, Hour: 2:42
44	DEVON AVE	Day: 1, Hour: 14:00	Day: 1, Hour: 19:23
56	WILLE RD	Day: 1, Hour: 13:00	Day: 1, Hour: 17:33
57	ELMHURST RD	Day: 1, Hour: 14:00	Day: 1, Hour: 17:18
60	ALGONQUIN RD	Day: 5, Hour: 20:00	Day: 11, Hour: 17:07
61	CHICAGO AVE	Day: 1, Hour: 16:00	Day: 2, Hour: 13:03
70	RAND RD	Day: 5, Hour: 11:00	Day: 12, Hour: 7:23
78	GOLF RD	Day: 5, Hour: 12:00	Day: 17, Hour: 12:56
82	RIVER RD	Day: 5, Hour: 11:00	Day: 14, Hour: 9:28
91	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 12, Hour: 21:51
98	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 15, Hour: 23:05
106	DUNDEE RD	Day: 1, Hour: 12:00	Day: 1, Hour: 19:42
111	NORTHGATE PKWY	Day: 1, Hour: 11:00	Day: 2, Hour: 16:59
112	MCHENRY RD	Day: 1, Hour: 13:00	Day: 2, Hour: 6:44
113	RAND RD	Day: 1, Hour: 14:00	Day: 1, Hour: 14:30
124	CHECKER RD	Day: 1, Hour: 22:00	Day: 2, Hour: 4:36
146	DIAMOND LAKE RD	Day: 1, Hour: 9:00	Day: 1, Hour: 20:04
148	IL ROUTE 60	Day: 5, Hour: 11:00	Day: 8, Hour: 23:19
150	GILMER RD	Day: 1, Hour: 10:00	Day: 1, Hour: 11:09
152	ROCKLAND RD	Day: 1, Hour: 18:00	Day: 5, Hour: 14:09
154	OAK SPRING RD	Day: 3, Hour: 12:00	Day: 7, Hour: 14:26
155	LAKE ST	Day: 2, Hour: 0:00	Day: 2, Hour: 10:14
157	WINCHESTER RD	Day: 1, Hour: 11:00	Day: 1, Hour: 22:33
158	WINCHESTER RD	Day: 2, Hour: 0:00	Day: 2, Hour: 11:28
159	US HWY 45	Day: 1, Hour: 13:00	Day: 1, Hour: 18:37
160	PETERSON RD	Day: 1, Hour: 13:00	Day: 1, Hour: 18:02
166	IL ROUTE 120	Day: 1, Hour: 18:00	Day: 7, Hour: 17:53
177	OPLAINE RD	Day: 1, Hour: 19:00	Day: 2, Hour: 22:00
179	GRAND AVE	Day: 4, Hour: 18:00	Day: 10, Hour: 19:28
180	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 10, Hour: 9:31
184	HUTCHINS RD	Day: 1, Hour: 9:00	Day: 5, Hour: 20:54
193	ADAMS RD	Day: 1, Hour: 16:00	Day: 2, Hour: 15:16
194	KELLEY RD	Day: 1, Hour: 12:00	Day: 2, Hour: 9:58
199	IL ROUTE 173	Day: 3, Hour: 16:00	Day: 6, Hour: 22:54

2006 Case: 50-yr Flood Schedule (Continued)			
Flood ID	**Location**	**Start Time**	**End Time**
200	IL-173	Day: 1, Hour: 12:00	Day: 2, Hour: 11:42
201	DELANEY RD	Day: 1, Hour: 16:00	Day: 2, Hour: 1:30
202	9TH ST	Day: 1, Hour: 16:00	Day: 2, Hour: 1:45
205	RUSSELL RD	Day: 1, Hour: 19:00	Day: 4, Hour: 23:10
206	128TH ST	Day: 1, Hour: 12:00	Day: 2, Hour: 6:23
209	IRVING PARK RD	Day: 1, Hour: 16:00	Day: 1, Hour: 17:43
210	RIVER RD	Day: 6, Hour: 1:00	Day: 16, Hour: 3:25
212	RIVER RD	Day: 5, Hour: 20:00	Day: 14, Hour: 9:53
213	RIVER RD	Day: 5, Hour: 14:00	Day: 15, Hour: 8:41
214	RIVER RD	Day: 5, Hour: 7:00	Day: 17, Hour: 4:58
215	RIVER RD	Day: 2, Hour: 17:00	Day: 11, Hour: 0:02
216	RIVER RD	Day: 2, Hour: 17:00	Day: 6, Hour: 16:01
218	RIVER	Day: 6, Hour: 0:00	Day: 14, Hour: 5:03
219	RIVER	Day: 6, Hour: 0:00	Day: 14, Hour: 2:56
222	DUNDEE RD	Day: 1, Hour: 13:00	Day: 2, Hour: 7:18
224	WHEELING	Day: 1, Hour: 11:00	Day: 2, Hour: 18:04
228	BARRON	Day: 1, Hour: 17:00	Day: 2, Hour: 11:07
230	9TH	Day: 1, Hour: 16:00	Day: 2, Hour: 3:28
237	KILBOURNE	Day: 4, Hour: 18:00	Day: 15, Hour: 8:33
238	OLD GRAND	Day: 4, Hour: 18:00	Day: 21, Hour: 1:55
239	IL ROUTE 132	Day: 4, Hour: 18:00	Day: 14, Hour: 23:25
241	GUERIN	Day: 1, Hour: 19:00	Day: 4, Hour: 16:47
243	BUCKLEY	Day: 1, Hour: 19:00	Day: 5, Hour: 6:58
244	RIVER	Day: 1, Hour: 19:00	Day: 15, Hour: 16:28
246	MINER	Day: 5, Hour: 12:00	Day: 14, Hour: 13:39
247	BUSSE	Day: 5, Hour: 14:00	Day: 14, Hour: 21:04
248	COLLEGE CIRCLE	Day: 5, Hour: 12:00	Day: 14, Hour: 6:51
251	MILWAUKEE AVE	Day: 4, Hour: 18:00	Day: 14, Hour: 6:19
252	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 17, Hour: 4:06
254	WILLOW RD	Day: 1, Hour: 16:00	Day: 1, Hour: 23:31
273	GREENLEAF	Day: 1, Hour: 19:00	Day: 3, Hour: 12:55
274	GRAND	Day: 1, Hour: 14:00	Day: 2, Hour: 2:53
292	75TH ST	Day: 1, Hour: 15:00	Day: 1, Hour: 15:30
294	122ND	Day: 2, Hour: 21:00	Day: 4, Hour: 16:15
295	GREEN BAY RD	Day: 1, Hour: 19:00	Day: 1, Hour: 19:45
301	60TH ST	Day: 1, Hour: 14:00	Day: 1, Hour: 15:45
309	60TH ST	Day: 1, Hour: 21:00	Day: 2, Hour: 8:45
311	SPRINGBROOK RD	Day: 1, Hour: 18:00	Day: 1, Hour: 18:45
339	I-94	Day: 1, Hour: 19:00	Day: 4, Hour: 10:15

6.6.2 Travel Time Effects

2006 Case: 50-yr Flood Severity, 0-hr Offset

	Vehicles	**Total Savings**	**Average Savings**	**Percentage**
greater than		*hours*	*minutes*	
60 minutes	11,247	18,688	99.69	0.006%
30 minutes	74,518	47,111	37.93	0.040%
15 minutes	123,426	44,191	21.48	0.066%
5 minutes	174,232	26,547	9.14	0.093%
0 minutes	2,247,821	23,224	0.62	1.205%
no change	175380074			94.034%

	Vehicles	**Total Delay**	**Average Delay**	**Percentage**
greater than		*hours*	*minutes*	
0 minutes	5,091,588	143,244	1.69	2.730%
5 minutes	1,042,919	145,965	8.40	0.559%
15 minutes	444,768	156,519	21.11	0.238%
30 minutes	316,811	226,346	42.87	0.170%
60 minutes	196,219	243,139	74.35	0.105%
90 minutes	179,967	316,606	105.55	0.096%
120 minutes	174,339	391,258	134.65	0.093%
150 minutes	144,317	395,220	164.31	0.077%
180 minutes	119,350	387,290	194.70	0.064%
210 minutes	94,009	350,705	223.83	0.050%
240 minutes	66,302	281,665	254.89	0.036%
270 minutes	57,658	273,513	284.62	0.031%
300 minutes	567,840	5,395,149	570.07	0.304%

6.7 100-Year Flood

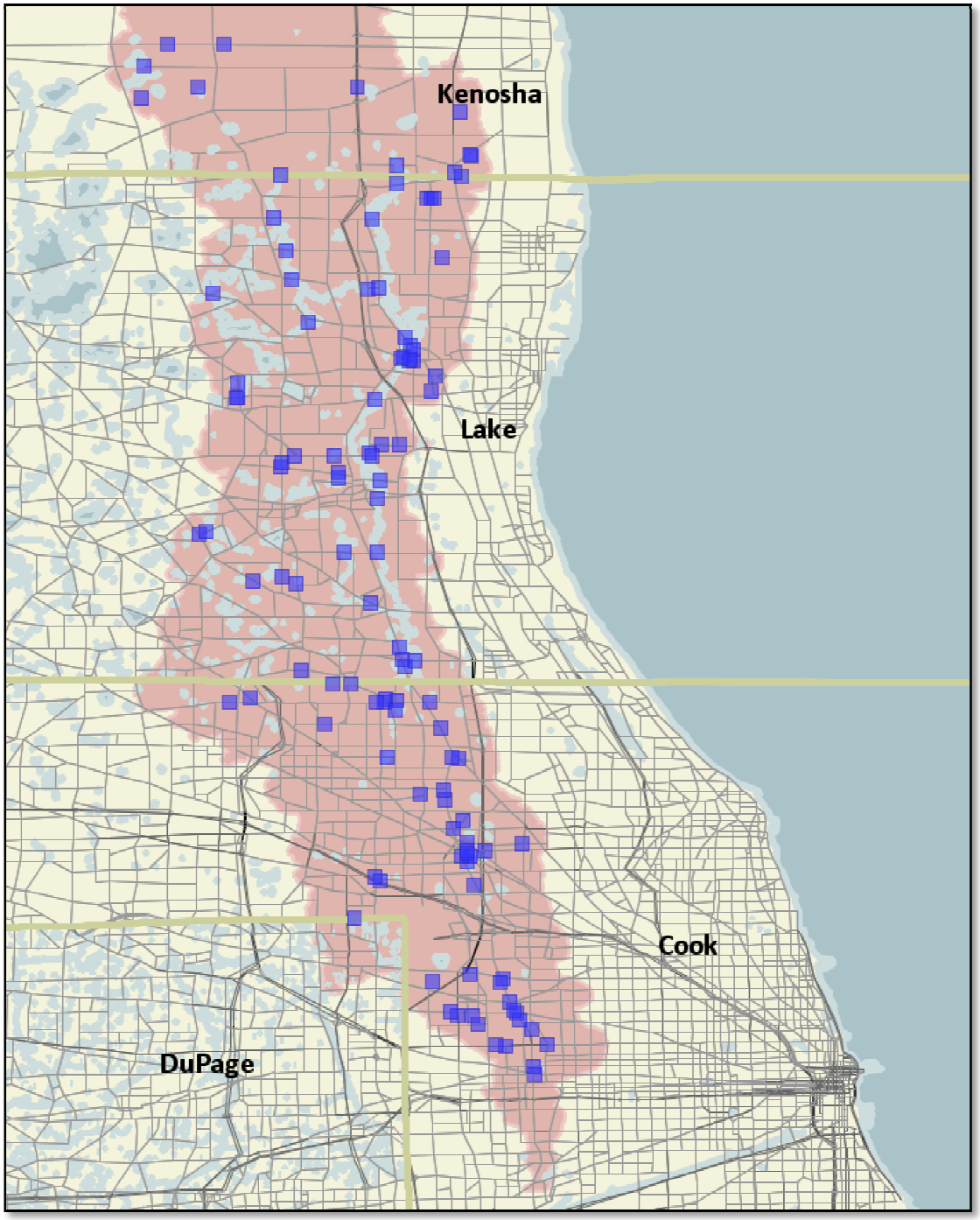


Figure 30: 100-Year Flood Locations – 2006 Model Year

6.7.1 Flood Location and Schedules

2006 Case: 100-yr Flood Schedule (Part 1 of 3)			
Flood ID	**Location**	**Start Time**	**End Time**
9	LAKE ST	Day: 5, Hour: 18:00	Day: 7, Hour: 4:27
10	CHICAGO AVE	Day: 5, Hour: 18:00	Day: 14, Hour: 15:52
13	15TH AVE	Day: 1, Hour: 13:00	Day: 2, Hour: 1:27
14	NORTH AVE	Day: 1, Hour: 12:00	Day: 2, Hour: 4:52
15	NORTH AVE	Day: 6, Hour: 5:00	Day: 8, Hour: 7:16
17	1ST AVE	Day: 6, Hour: 5:00	Day: 18, Hour: 5:20
18	FULLERTON AVE	Day: 1, Hour: 18:00	Day: 1, Hour: 19:47
19	MANNHEIM RD	Day: 1, Hour: 13:00	Day: 2, Hour: 5:21
20	SCOTT ST	Day: 1, Hour: 13:00	Day: 2, Hour: 4:55
21	GRAND AVE	Day: 6, Hour: 0:00	Day: 12, Hour: 22:23
22	GRAND AVE	Day: 1, Hour: 18:00	Day: 1, Hour: 22:24
23	BELMONT AVE	Day: 6, Hour: 0:00	Day: 8, Hour: 17:20
26	IRVING PARK RD	Day: 1, Hour: 11:00	Day: 2, Hour: 2:45
27	IRVING PARK RD	Day: 6, Hour: 1:00	Day: 7, Hour: 12:32
44	DEVON AVE	Day: 1, Hour: 14:00	Day: 1, Hour: 20:58
56	WILLE RD	Day: 1, Hour: 13:00	Day: 1, Hour: 19:04
57	ELMHURST RD	Day: 1, Hour: 13:00	Day: 1, Hour: 17:54
60	ALGONQUIN RD	Day: 5, Hour: 20:00	Day: 13, Hour: 3:41
61	CHICAGO AVE	Day: 1, Hour: 16:00	Day: 2, Hour: 17:34
65	MINER/DEMSTER ST	Day: 1, Hour: 18:00	Day: 1, Hour: 19:00
69	BALLARD RD	Day: 1, Hour: 17:00	Day: 1, Hour: 17:58
70	RAND RD	Day: 5, Hour: 11:00	Day: 13, Hour: 7:29
78	GOLF RD	Day: 5, Hour: 12:00	Day: 18, Hour: 17:47
82	RIVER RD	Day: 5, Hour: 11:00	Day: 15, Hour: 9:16
84	FEEHANVILLE DR	Day: 1, Hour: 20:00	Day: 2, Hour: 5:29
86	KENSINGTON RD	Day: 1, Hour: 17:00	Day: 1, Hour: 21:14
91	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 13, Hour: 19:58
98	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 17, Hour: 1:54
99	HINTZ RD	Day: 1, Hour: 15:00	Day: 1, Hour: 18:24
106	DUNDEE RD	Day: 1, Hour: 11:00	Day: 1, Hour: 20:57
110	DUNDEE RD	Day: 2, Hour: 17:00	Day: 5, Hour: 10:02
111	NORTHGATE PKWY	Day: 1, Hour: 11:00	Day: 2, Hour: 20:09
112	MCHENRY RD	Day: 1, Hour: 13:00	Day: 2, Hour: 11:00
113	RAND RD	Day: 1, Hour: 12:00	Day: 1, Hour: 17:05
118	APTAKISIC RD	Day: 2, Hour: 0:00	Day: 2, Hour: 3:51
119	LAKE COOK RD	Day: 1, Hour: 22:00	Day: 2, Hour: 4:44
124	CHECKER RD	Day: 1, Hour: 20:00	Day: 2, Hour: 6:09
125	MILWAUKEE AVE	Day: 5, Hour: 12:00	Day: 8, Hour: 9:31
126	DEERFIELD RD	Day: 2, Hour: 17:00	Day: 5, Hour: 4:36
146	DIAMOND LAKE RD	Day: 1, Hour: 7:00	Day: 2, Hour: 2:56
148	IL ROUTE 60	Day: 5, Hour: 11:00	Day: 10, Hour: 8:31
150	GILMER RD	Day: 1, Hour: 8:00	Day: 1, Hour: 14:46
151	CHEVY CHASE RD	Day: 1, Hour: 9:00	Day: 1, Hour: 12:37
152	ROCKLAND RD	Day: 1, Hour: 18:00	Day: 6, Hour: 22:08

2006 Case: 100-yr Flood Schedule (Part 2 of 3)			
Flood ID	**Location**	**Start Time**	**End Time**
154	OAK SPRING RD	Day: 3, Hour: 12:00	Day: 8, Hour: 21:52
155	LAKE ST	Day: 1, Hour: 22:00	Day: 2, Hour: 13:48
157	WINCHESTER RD	Day: 1, Hour: 10:00	Day: 1, Hour: 23:16
158	WINCHESTER RD	Day: 1, Hour: 21:00	Day: 2, Hour: 13:45
159	US HWY 45	Day: 1, Hour: 12:00	Day: 1, Hour: 18:51
160	PETERSON RD	Day: 1, Hour: 13:00	Day: 1, Hour: 19:18
162	PETERSON RD	Day: 1, Hour: 23:00	Day: 2, Hour: 5:02
166	IL ROUTE 120	Day: 1, Hour: 18:00	Day: 9, Hour: 6:56
167	IL ROUTE 83	Day: 1, Hour: 20:00	Day: 2, Hour: 3:50
172	WASHINGTON ST	Day: 1, Hour: 19:00	Day: 2, Hour: 4:19
177	OPLAINE RD	Day: 1, Hour: 19:00	Day: 3, Hour: 3:31
179	GRAND AVE	Day: 4, Hour: 18:00	Day: 12, Hour: 7:05
180	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 11, Hour: 19:38
184	HUTCHINS RD	Day: 1, Hour: 7:00	Day: 6, Hour: 8:03
189	DILLEYS RD	Day: 1, Hour: 17:00	Day: 2, Hour: 1:03
190	US HIGHWAY 41	Day: 1, Hour: 19:00	Day: 2, Hour: 3:37
191	MILLBURN RD	Day: 1, Hour: 17:00	Day: 1, Hour: 23:02
193	ADAMS RD	Day: 1, Hour: 15:00	Day: 2, Hour: 15:48
194	KELLEY RD	Day: 1, Hour: 10:00	Day: 2, Hour: 13:12
199	IL ROUTE 173	Day: 3, Hour: 16:00	Day: 7, Hour: 23:55
200	IL-173	Day: 1, Hour: 10:00	Day: 2, Hour: 15:08
201	DELANEY RD	Day: 1, Hour: 15:00	Day: 2, Hour: 2:30
202	9TH ST	Day: 1, Hour: 15:00	Day: 2, Hour: 2:45
205	RUSSELL RD	Day: 1, Hour: 19:00	Day: 5, Hour: 23:59
206	128TH ST	Day: 1, Hour: 11:00	Day: 2, Hour: 11:03
209	IRVING PARK RD	Day: 1, Hour: 15:00	Day: 1, Hour: 18:39
210	RIVER RD	Day: 6, Hour: 1:00	Day: 17, Hour: 5:18
212	RIVER RD	Day: 5, Hour: 20:00	Day: 15, Hour: 9:56
213	RIVER RD	Day: 5, Hour: 14:00	Day: 16, Hour: 10:31
214	RIVER RD	Day: 5, Hour: 7:00	Day: 18, Hour: 10:06
215	RIVER RD	Day: 2, Hour: 17:00	Day: 12, Hour: 4:12
216	RIVER RD	Day: 2, Hour: 17:00	Day: 9, Hour: 17:06
218	RIVER	Day: 6, Hour: 0:00	Day: 15, Hour: 6:25
219	RIVER	Day: 6, Hour: 0:00	Day: 15, Hour: 4:27
222	DUNDEE RD	Day: 1, Hour: 12:00	Day: 2, Hour: 10:15
223	DUNDEE RD	Day: 1, Hour: 15:00	Day: 2, Hour: 7:14
224	WHEELING	Day: 1, Hour: 11:00	Day: 2, Hour: 21:24
225	US HIGHWAY 45	Day: 1, Hour: 14:00	Day: 1, Hour: 21:26
227	IL ROUTE 83	Day: 1, Hour: 9:00	Day: 1, Hour: 16:48
228	BARRON	Day: 1, Hour: 14:00	Day: 2, Hour: 10:29
229	CENTER	Day: 1, Hour: 21:00	Day: 1, Hour: 21:14
230	9TH	Day: 1, Hour: 15:00	Day: 2, Hour: 4:16
237	KILBOURNE	Day: 4, Hour: 18:00	Day: 17, Hour: 2:59

2006 Case: 100-yr Flood Schedule (Part 3 of 3)			
Flood ID	**Location**	**Start Time**	**End Time**
238	OLD GRAND	Day: 4, Hour: 18:00	Day: 21, Hour: 23:18
239	IL ROUTE 132	Day: 4, Hour: 18:00	Day: 16, Hour: 17:55
241	GUERIN	Day: 1, Hour: 19:00	Day: 6, Hour: 4:50
242	GUERIN	Day: 1, Hour: 19:00	Day: 5, Hour: 0:49
243	BUCKLEY	Day: 1, Hour: 19:00	Day: 6, Hour: 15:22
244	RIVER	Day: 1, Hour: 19:00	Day: 16, Hour: 21:57
246	MINER	Day: 5, Hour: 12:00	Day: 15, Hour: 13:54
247	BUSSE	Day: 5, Hour: 14:00	Day: 15, Hour: 22:23
248	COLLEGE CIRCLE	Day: 5, Hour: 12:00	Day: 15, Hour: 6:39
251	MILWAUKEE AVE	Day: 4, Hour: 18:00	Day: 16, Hour: 0:41
252	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 18, Hour: 18:28
254	WILLOW RD	Day: 1, Hour: 16:00	Day: 2, Hour: 2:06
264	GILMER	Day: 1, Hour: 8:00	Day: 1, Hour: 17:12
267	TOWNLINE RD	Day: 1, Hour: 11:00	Day: 1, Hour: 21:03
273	GREENLEAF	Day: 1, Hour: 19:00	Day: 5, Hour: 2:27
274	GRAND	Day: 1, Hour: 12:00	Day: 2, Hour: 5:15
292	75TH ST	Day: 1, Hour: 14:00	Day: 1, Hour: 14:45
294	122ND	Day: 2, Hour: 18:00	Day: 5, Hour: 0:15
295	GREEN BAY RD	Day: 1, Hour: 18:00	Day: 1, Hour: 19:15
298	I-94	Day: 1, Hour: 17:00	Day: 1, Hour: 17:15
301	60TH ST	Day: 1, Hour: 14:00	Day: 1, Hour: 16:15
309	60TH ST	Day: 1, Hour: 20:00	Day: 2, Hour: 12:30
311	SPRINGBROOK RD	Day: 1, Hour: 18:00	Day: 1, Hour: 18:45
339	I-94	Day: 1, Hour: 18:00	Day: 4, Hour: 16:00
341	12TH ST	Day: 1, Hour: 22:00	Day: 2, Hour: 0:00

6.7.2 Travel Time Effects

2006 Case: 100-yr Flood Severity, 0-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	12,266	20,162	98.62	0.007%
30 minutes	70,100	44,231	37.86	0.038%
15 minutes	121,250	43,335	21.44	0.065%
5 minutes	167,530	25,458	9.12	0.090%
0 minutes	2,262,589	23,480	0.62	1.213%

no change	172667271			92.579%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	5,339,816	154,846	1.74	2.863%
5 minutes	1,166,278	161,717	8.32	0.625%
15 minutes	496,463	175,861	21.25	0.266%
30 minutes	380,030	272,118	42.96	0.204%
60 minutes	224,928	279,159	74.47	0.121%
90 minutes	189,686	333,986	105.64	0.102%
120 minutes	209,545	469,734	134.50	0.112%
150 minutes	169,786	465,652	164.55	0.091%
180 minutes	144,140	467,477	194.59	0.077%
210 minutes	132,039	495,201	225.02	0.071%
240 minutes	136,602	581,124	255.25	0.073%
270 minutes	145,868	693,698	285.34	0.078%
300 minutes	2,471,218	20,897,155	507.37	1.325%

6.8 500-Year Flood

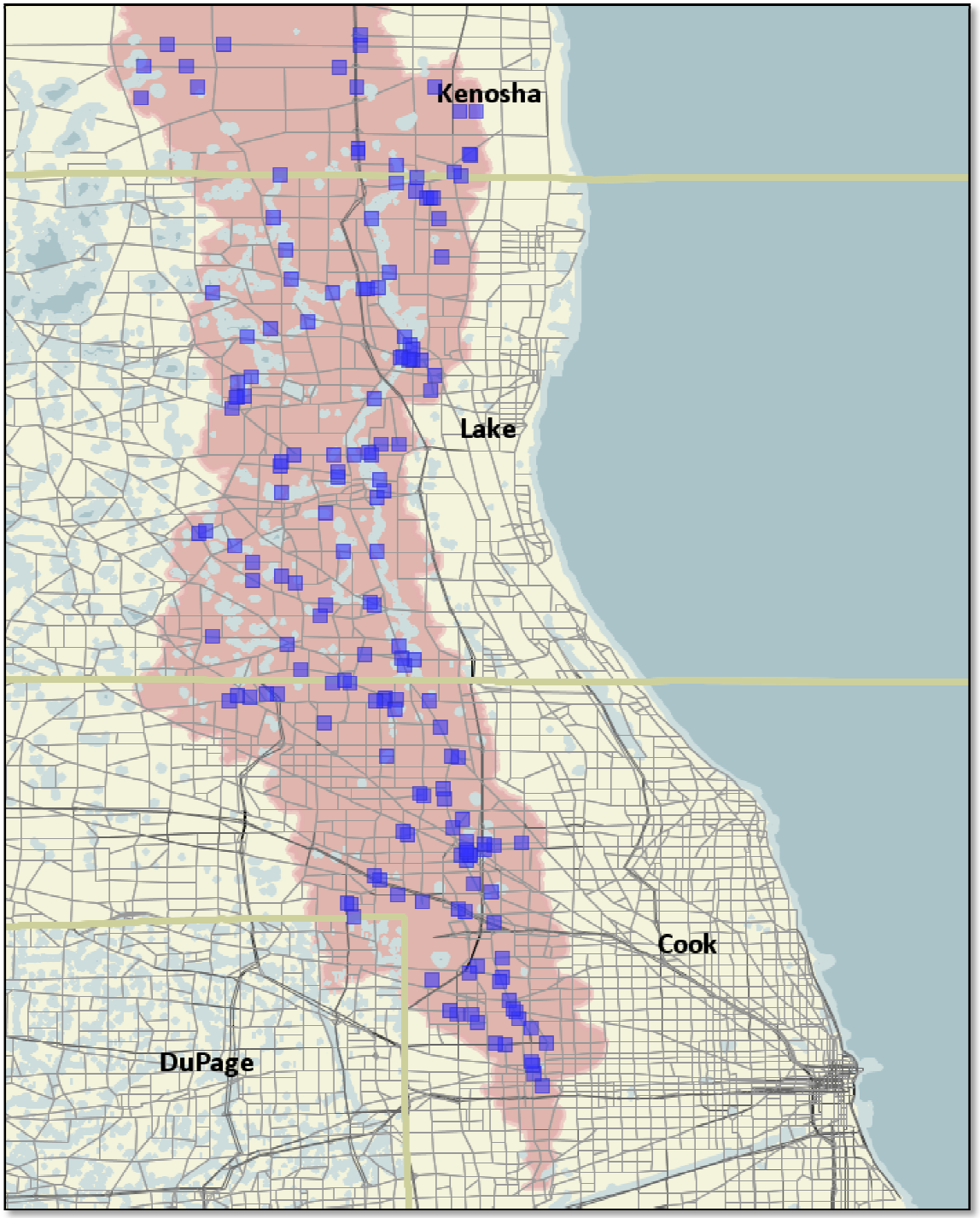


Figure 31: 500-Year Flood Locations – 2006 Model Year

6.8.1 Flood Location and Schedules

2006 Case: 500-yr Flood Schedule (Part 1 of 4)			
Flood ID	**Location**	**Start Time**	**End Time**
7	MADISON ST	Day: 5, Hour: 17:00	Day: 7, Hour: 16:08
9	LAKE ST	Day: 5, Hour: 18:00	Day: 13, Hour: 6:57
10	CHICAGO AVE	Day: 5, Hour: 18:00	Day: 16, Hour: 16:36
13	15TH AVE	Day: 1, Hour: 12:00	Day: 2, Hour: 2:18
14	NORTH AVE	Day: 1, Hour: 11:00	Day: 2, Hour: 5:48
15	NORTH AVE	Day: 6, Hour: 5:00	Day: 14, Hour: 14:59
17	1ST AVE	Day: 6, Hour: 5:00	Day: 20, Hour: 15:01
18	FULLERTON AVE	Day: 1, Hour: 16:00	Day: 1, Hour: 20:52
19	MANNHEIM RD	Day: 1, Hour: 12:00	Day: 2, Hour: 6:20
20	SCOTT ST	Day: 1, Hour: 12:00	Day: 2, Hour: 6:00
21	GRAND AVE	Day: 6, Hour: 0:00	Day: 15, Hour: 12:20
22	GRAND AVE	Day: 1, Hour: 15:00	Day: 2, Hour: 0:10
23	BELMONT AVE	Day: 6, Hour: 0:00	Day: 15, Hour: 5:18
26	IRVING PARK RD	Day: 1, Hour: 10:00	Day: 2, Hour: 3:39
27	IRVING PARK RD	Day: 6, Hour: 1:00	Day: 14, Hour: 0:35
30	25TH AVE	Day: 1, Hour: 15:00	Day: 1, Hour: 19:36
36	LAWRENCE AVE	Day: 6, Hour: 1:00	Day: 7, Hour: 1:35
43	RIVER RD	Day: 1, Hour: 23:00	Day: 2, Hour: 7:54
44	DEVON AVE	Day: 1, Hour: 13:00	Day: 1, Hour: 22:28
46	HIGGINS RD	Day: 1, Hour: 22:00	Day: 2, Hour: 9:17
47	MANNHEIM RD	Day: 1, Hour: 22:00	Day: 2, Hour: 9:59
49	LUNT AVE	Day: 1, Hour: 15:00	Day: 1, Hour: 16:38
50	BUSSE RD	Day: 1, Hour: 14:00	Day: 1, Hour: 17:39
51	WOLF RD	Day: 1, Hour: 14:00	Day: 2, Hour: 7:02
52	TOUHY AVE	Day: 1, Hour: 21:00	Day: 2, Hour: 3:12
53	TOUHY AVE	Day: 5, Hour: 20:00	Day: 6, Hour: 7:14
56	WILLE RD	Day: 1, Hour: 11:00	Day: 1, Hour: 20:03
57	ELMHURST RD	Day: 1, Hour: 12:00	Day: 1, Hour: 19:59
60	ALGONQUIN RD	Day: 5, Hour: 20:00	Day: 15, Hour: 2:41
61	CHICAGO AVE	Day: 1, Hour: 16:00	Day: 3, Hour: 1:11
62	BUSSE HWY	Day: 1, Hour: 18:00	Day: 1, Hour: 22:46
65	MINER/DEMSTER ST	Day: 1, Hour: 16:00	Day: 2, Hour: 0:26
67	POTTER RD	Day: 1, Hour: 19:00	Day: 1, Hour: 20:23
68	BALLARD RD	Day: 1, Hour: 17:00	Day: 1, Hour: 23:13
69	BALLARD RD	Day: 1, Hour: 16:00	Day: 1, Hour: 20:09
70	RAND RD	Day: 5, Hour: 11:00	Day: 15, Hour: 3:14
74	GOLF RD	Day: 1, Hour: 6:00	Day: 1, Hour: 8:09
76	MOUNT PROSPECT RD	Day: 1, Hour: 3:00	Day: 1, Hour: 7:56
78	GOLF RD	Day: 5, Hour: 12:00	Day: 21, Hour: 4:24
82	RIVER RD	Day: 5, Hour: 11:00	Day: 17, Hour: 12:24
83	WOLF RD	Day: 1, Hour: 20:00	Day: 2, Hour: 11:04
84	FEEHANVILLE DR	Day: 1, Hour: 20:00	Day: 3, Hour: 2:04
86	KENSINGTON RD	Day: 1, Hour: 15:00	Day: 2, Hour: 1:58
91	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 15, Hour: 19:12

2006 Case: 500-yr Flood Schedule (Part 2 of 4)			
Flood ID	**Location**	**Start Time**	**End Time**
98	MILWAUKEE AVE	Day: 5, Hour: 7:00	Day: 19, Hour: 7:44
99	HINTZ RD	Day: 1, Hour: 14:00	Day: 1, Hour: 20:32
106	DUNDEE RD	Day: 1, Hour: 9:00	Day: 1, Hour: 22:40
110	DUNDEE RD	Day: 2, Hour: 17:00	Day: 10, Hour: 1:34
111	NORTHGATE PKWY	Day: 1, Hour: 9:00	Day: 3, Hour: 8:24
112	MCHENRY RD	Day: 1, Hour: 11:00	Day: 2, Hour: 15:38
113	RAND RD	Day: 1, Hour: 11:00	Day: 1, Hour: 21:30
115	HICKS RD	Day: 1, Hour: 12:00	Day: 1, Hour: 17:33
116	STATE HWY 53	Day: 1, Hour: 19:00	Day: 2, Hour: 0:10
117	BALDWIN RD	Day: 1, Hour: 13:00	Day: 2, Hour: 0:13
118	APTAKISIC RD	Day: 1, Hour: 13:00	Day: 2, Hour: 8:38
119	LAKE COOK RD	Day: 1, Hour: 16:00	Day: 2, Hour: 9:34
120	BUFFALO GROVE RD	Day: 1, Hour: 20:00	Day: 2, Hour: 0:48
124	CHECKER RD	Day: 1, Hour: 16:00	Day: 2, Hour: 9:47
125	MILWAUKEE AVE	Day: 5, Hour: 12:00	Day: 13, Hour: 1:47
126	DEERFIELD RD	Day: 2, Hour: 17:00	Day: 9, Hour: 12:48
129	DEERFIELD PKWY	Day: 1, Hour: 20:00	Day: 2, Hour: 1:35
133	ROBERT PARKER COFFIN RD	Day: 1, Hour: 18:00	Day: 2, Hour: 1:33
135	CUBA RD	Day: 1, Hour: 15:00	Day: 1, Hour: 18:00
143	PORT CLINTON RD	Day: 1, Hour: 16:00	Day: 1, Hour: 17:00
146	DIAMOND LAKE RD	Day: 1, Hour: 6:00	Day: 2, Hour: 17:08
147	INDIAN CREEK RD	Day: 1, Hour: 21:00	Day: 2, Hour: 2:35
148	IL ROUTE 60	Day: 5, Hour: 11:00	Day: 14, Hour: 4:14
149	MIDLOTHIAN RD	Day: 1, Hour: 13:00	Day: 1, Hour: 19:12
150	GILMER RD	Day: 1, Hour: 6:00	Day: 1, Hour: 18:53
151	CHEVY CHASE RD	Day: 1, Hour: 6:00	Day: 1, Hour: 18:53
152	ROCKLAND RD	Day: 1, Hour: 18:00	Day: 10, Hour: 7:51
153	PARK AVE	Day: 1, Hour: 18:00	Day: 6, Hour: 9:36
154	OAK SPRING RD	Day: 3, Hour: 12:00	Day: 12, Hour: 11:31
155	LAKE ST	Day: 1, Hour: 19:00	Day: 2, Hour: 19:11
157	WINCHESTER RD	Day: 1, Hour: 8:00	Day: 2, Hour: 7:56
158	WINCHESTER RD	Day: 1, Hour: 18:00	Day: 2, Hour: 19:15
159	US HWY 45	Day: 1, Hour: 11:00	Day: 1, Hour: 20:26
160	PETERSON RD	Day: 1, Hour: 12:00	Day: 1, Hour: 20:49
161	BUCKLEY RD	Day: 3, Hour: 12:00	Day: 5, Hour: 21:33
162	PETERSON RD	Day: 1, Hour: 14:00	Day: 2, Hour: 11:53
165	BELVIDERE RD	Day: 1, Hour: 17:00	Day: 1, Hour: 21:04
166	IL ROUTE 120	Day: 1, Hour: 18:00	Day: 12, Hour: 18:46
167	IL ROUTE 83	Day: 1, Hour: 15:00	Day: 2, Hour: 13:58
168	CENTER ST	Day: 1, Hour: 22:00	Day: 2, Hour: 3:17
171	ATKINSON RD	Day: 1, Hour: 16:00	Day: 2, Hour: 15:51
172	WASHINGTON ST	Day: 1, Hour: 19:00	Day: 2, Hour: 19:15
177	OPLAINE RD	Day: 1, Hour: 19:00	Day: 4, Hour: 10:21

2006 Case: 500-yr Flood Schedule (Part 3 of 4)			
Flood ID	**Location**	**Start Time**	**End Time**
178	IL ROUTE 132	Day: 1, Hour: 19:00	Day: 2, Hour: 17:24
179	GRAND AVE	Day: 4, Hour: 18:00	Day: 15, Hour: 19:46
180	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 15, Hour: 6:48
182	ROLLINS RD	Day: 2, Hour: 7:00	Day: 2, Hour: 9:28
184	HUTCHINS RD	Day: 1, Hour: 2:00	Day: 7, Hour: 2:45
187	HUNT CLUB RD	Day: 1, Hour: 14:00	Day: 1, Hour: 23:24
188	I 94	Day: 1, Hour: 18:00	Day: 1, Hour: 23:17
189	DILLEYS RD	Day: 1, Hour: 13:00	Day: 2, Hour: 10:37
190	US HIGHWAY 41	Day: 1, Hour: 15:00	Day: 2, Hour: 13:10
191	MILLBURN RD	Day: 1, Hour: 12:00	Day: 2, Hour: 4:50
192	WADSWORTH RD	Day: 3, Hour: 23:00	Day: 6, Hour: 12:34
193	ADAMS RD	Day: 1, Hour: 15:00	Day: 2, Hour: 22:05
194	KELLEY RD	Day: 1, Hour: 6:00	Day: 2, Hour: 20:15
198	IL ROUTE 173	Day: 1, Hour: 19:00	Day: 1, Hour: 20:04
199	IL ROUTE 173	Day: 3, Hour: 16:00	Day: 10, Hour: 22:31
200	IL-173	Day: 1, Hour: 5:00	Day: 2, Hour: 21:17
201	DELANEY RD	Day: 1, Hour: 15:00	Day: 2, Hour: 5:04
202	9TH ST	Day: 1, Hour: 15:00	Day: 2, Hour: 5:17
204	KILBOURNE RD	Day: 1, Hour: 18:00	Day: 2, Hour: 2:09
205	RUSSELL RD	Day: 1, Hour: 19:00	Day: 8, Hour: 23:19
206	128TH ST	Day: 1, Hour: 7:00	Day: 2, Hour: 18:09
209	IRVING PARK RD	Day: 1, Hour: 14:00	Day: 1, Hour: 20:33
210	RIVER RD	Day: 6, Hour: 1:00	Day: 19, Hour: 12:01
211	RIVER RD	Day: 5, Hour: 18:00	Day: 8, Hour: 11:06
212	RIVER RD	Day: 5, Hour: 20:00	Day: 17, Hour: 11:36
213	RIVER RD	Day: 5, Hour: 14:00	Day: 18, Hour: 16:09
214	RIVER RD	Day: 5, Hour: 7:00	Day: 20, Hour: 9:10
215	RIVER RD	Day: 2, Hour: 17:00	Day: 14, Hour: 17:42
216	RIVER RD	Day: 2, Hour: 17:00	Day: 12, Hour: 0:39
218	RIVER	Day: 6, Hour: 0:00	Day: 17, Hour: 5:51
219	RIVER	Day: 6, Hour: 0:00	Day: 17, Hour: 3:44
222	DUNDEE RD	Day: 1, Hour: 11:00	Day: 2, Hour: 15:54
223	DUNDEE RD	Day: 1, Hour: 12:00	Day: 2, Hour: 11:54
224	WHEELING	Day: 1, Hour: 8:00	Day: 3, Hour: 12:45
225	US HIGHWAY 45	Day: 1, Hour: 9:00	Day: 2, Hour: 5:36
226	PORT CLINTON	Day: 1, Hour: 7:00	Day: 1, Hour: 23:59
227	IL ROUTE 83	Day: 1, Hour: 7:00	Day: 2, Hour: 4:37
228	BARRON	Day: 1, Hour: 11:00	Day: 2, Hour: 17:54
229	CENTER	Day: 1, Hour: 15:00	Day: 2, Hour: 10:45
230	9TH	Day: 1, Hour: 15:00	Day: 2, Hour: 6:32

2006 Case: 500-yr Flood Schedule (Part 3 of 4)			
Flood ID	**Location**	**Start Time**	**End Time**
237	KILBOURNE	Day: 4, Hour: 18:00	Day: 20, Hour: 18:10
238	OLD GRAND	Day: 4, Hour: 18:00	Day: 25, Hour: 6:11
239	IL ROUTE 132	Day: 4, Hour: 18:00	Day: 20, Hour: 8:54
241	GUERIN	Day: 1, Hour: 19:00	Day: 9, Hour: 8:24
242	GUERIN	Day: 1, Hour: 19:00	Day: 7, Hour: 19:23
243	BUCKLEY	Day: 1, Hour: 19:00	Day: 9, Hour: 22:07
244	RIVER	Day: 1, Hour: 19:00	Day: 16, Hour: 21:57
246	MINER	Day: 5, Hour: 12:00	Day: 17, Hour: 17:29
247	BUSSE	Day: 5, Hour: 14:00	Day: 18, Hour: 3:21
248	COLLEGE CIRCLE	Day: 5, Hour: 12:00	Day: 17, Hour: 9:37
251	MILWAUKEE AVE	Day: 4, Hour: 18:00	Day: 19, Hour: 16:23
252	US HIGHWAY 41	Day: 4, Hour: 18:00	Day: 22, Hour: 4:10
253	KILBOURNE	Day: 1, Hour: 19:00	Day: 4, Hour: 13:55
254	WILLOW RD	Day: 1, Hour: 15:00	Day: 2, Hour: 3:54
259	HALF DAY	Day: 1, Hour: 10:00	Day: 1, Hour: 16:12
264	GILMER	Day: 1, Hour: 6:00	Day: 1, Hour: 22:36
267	TOWNLINE RD	Day: 1, Hour: 8:00	Day: 2, Hour: 2:16
268	BUTTERFIELD	Day: 1, Hour: 11:00	Day: 1, Hour: 14:05
273	GREENLEAF	Day: 1, Hour: 19:00	Day: 10, Hour: 6:27
274	GRAND	Day: 1, Hour: 9:00	Day: 2, Hour: 10:52
279	LAKE	Day: 1, Hour: 15:00	Day: 1, Hour: 22:08
281	GRAND	Day: 2, Hour: 6:00	Day: 4, Hour: 0:05
288	I-94	Day: 1, Hour: 19:00	Day: 1, Hour: 21:15
291	75TH ST	Day: 1, Hour: 18:00	Day: 1, Hour: 18:15
292	75TH ST	Day: 1, Hour: 14:00	Day: 1, Hour: 15:15
294	122ND	Day: 2, Hour: 13:00	Day: 5, Hour: 16:45
295	GREEN BAY RD	Day: 1, Hour: 18:00	Day: 1, Hour: 20:00
298	I-94	Day: 1, Hour: 17:00	Day: 1, Hour: 18:15
301	60TH ST	Day: 1, Hour: 14:00	Day: 1, Hour: 17:15
304	75TH ST	Day: 1, Hour: 19:00	Day: 1, Hour: 19:15
309	60TH ST	Day: 1, Hour: 18:00	Day: 2, Hour: 19:00
311	SPRINGBROOK RD	Day: 1, Hour: 18:00	Day: 1, Hour: 19:15
315	248TH AVE	Day: 2, Hour: 4:00	Day: 2, Hour: 6:30
324	I-94	Day: 1, Hour: 19:00	Day: 1, Hour: 19:45
329	60TH ST	Day: 1, Hour: 17:00	Day: 2, Hour: 2:00
332	52ND ST	Day: 1, Hour: 17:00	Day: 2, Hour: 2:30
339	I-94	Day: 1, Hour: 14:00	Day: 5, Hour: 20:00
341	12TH ST	Day: 1, Hour: 19:00	Day: 2, Hour: 3:00

6.8.2 Travel Time Effects

2006 Case: 500-yr Flood Severity, 0-hr Offset

	Vehicles	**Total Savings**	**Average Savings**	**Percentage**
greater than		*hours*	*minutes*	
60 minutes	12,210	19,589	96.26	0.005%
30 minutes	82,437	51,961	37.82	0.037%
15 minutes	149,098	53,063	21.35	0.067%
5 minutes	234,301	35,197	9.01	0.106%
0 minutes	2,613,684	27,277	0.63	1.177%
no change	201279585			90.653%

	Vehicles	**Total Delay**	**Average Delay**	**Percentage**
greater than		*hours*	*minutes*	
0 minutes	6,470,137	193,056	1.79	2.914%
5 minutes	1,571,515	215,835	8.24	0.708%
15 minutes	591,208	210,666	21.38	0.266%
30 minutes	453,212	322,744	42.73	0.204%
60 minutes	243,401	299,911	73.93	0.110%
90 minutes	224,033	399,559	107.01	0.101%
120 minutes	313,709	705,490	134.93	0.141%
150 minutes	293,190	806,438	165.03	0.132%
180 minutes	281,339	913,935	194.91	0.127%
210 minutes	294,072	1,104,737	225.40	0.132%
240 minutes	324,401	1,380,156	255.27	0.146%
270 minutes	363,887	1,731,590	285.52	0.164%
300 minutes	6,237,206	50,893,165	489.58	2.809%

7 Appendix B: 2020 Model Year Results

The results in this appendix are presented without maps because the flood locations are identical to those in Appendix A.

7.1 1-Year Flood

2020 Case: 1-yr Flood Severity, 0-hr Offset

greater than	Vehicles	Total Savings *hours*	Average Savings *minutes*	Percentage
60 minutes	41,557	126,094	182.05	0.143%
30 minutes	31,414	21,705	41.46	0.108%
15 minutes	90,296	32,595	21.66	0.311%
5 minutes	95,862	15,563	9.74	0.331%
0 minutes	334,977	5,584	1.00	1.155%
no change	27,809,922	0	0	95.922%

greater than	Vehicles	Total Delay *hours*	Average Delay *minutes*	Percentage
0 minutes	261,853	4,668	1.07	0.903%
5 minutes	109,570	16,831	9.22	0.378%
15 minutes	54,171	18,338	20.31	0.187%
30 minutes	56,830	38,540	40.69	0.196%
60 minutes	16,940	21,102	74.74	0.058%
90 minutes	16,277	28,802	106.17	0.056%
120 minutes	11,799	26,101	132.73	0.041%
150 minutes	6,434	17,733	165.37	0.022%
180 minutes	3,387	10,699	189.53	0.012%
210 minutes	1,348	5,042	224.44	0.005%
240 minutes	1,568	6,583	251.89	0.005%
270 minutes	1,025	4,868	284.97	0.004%
300 minutes	47,028	379,178	483.77	0.162%

7.2 2-Year Flood

2020 Case: 2-yr Flood Severity, 0-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	139,348	492,084	211.88	0.180%
30 minutes	103,178	71,372	41.50	0.133%
15 minutes	102,316	36,715	21.53	0.132%
5 minutes	153,829	24,121	9.41	0.199%
0 minutes	573,167	9,520	1.00	0.741%
no change	73,478,766	0	0	95.041%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	531,785	10,410	1.17	0.688%
5 minutes	152,640	23,829	9.37	0.197%
15 minutes	115,298	40,923	21.30	0.149%
30 minutes	135,241	95,332	42.29	0.175%
60 minutes	64,826	80,306	74.33	0.084%
90 minutes	52,243	90,866	104.36	0.068%
120 minutes	48,398	108,693	134.75	0.063%
150 minutes	50,085	137,840	165.13	0.065%
180 minutes	53,519	174,557	195.70	0.069%
210 minutes	61,392	230,976	225.74	0.079%
240 minutes	68,539	291,706	255.36	0.089%
270 minutes	77,502	368,598	285.36	0.100%
300 minutes	1,350,616	11,291,741	501.63	1.747%

7.3 5-Year Flood

2020 Case: 5-yr Flood Severity, 0-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	296,969	978,042	197.60	0.236%
30 minutes	147,995	105,441	42.75	0.118%
15 minutes	251,132	88,593	21.17	0.200%
5 minutes	410,120	63,347	9.27	0.326%
0 minutes	1,481,995	24,803	1.00	1.180%
no change	118,371,586	0	0	94.220%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	1,768,220	44,518	1.51	1.407%
5 minutes	477,564	72,213	9.07	0.380%
15 minutes	325,622	116,538	21.47	0.259%
30 minutes	300,476	208,285	41.59	0.239%
60 minutes	104,022	126,206	72.80	0.083%
90 minutes	133,888	237,693	106.52	0.107%
120 minutes	100,395	221,710	132.50	0.080%
150 minutes	42,029	114,680	163.72	0.033%
180 minutes	30,740	99,572	194.35	0.024%
210 minutes	26,409	99,182	225.34	0.021%
240 minutes	32,338	137,808	255.69	0.026%
270 minutes	35,840	170,364	285.21	0.029%
300 minutes	1,295,778	12,298,255	569.46	1.031%

7.4 10-Year Flood

2020 Case: 10-yr Flood Severity, 0-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	502,670	1,654,584	197.50	0.325%
30 minutes	197,063	139,806	42.57	0.127%
15 minutes	309,656	110,639	21.44	0.200%
5 minutes	455,487	70,940	9.34	0.295%
0 minutes	1,796,062	29,192	0.98	1.162%
no change	142,875,306	0	0	92.401%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	2,531,619	72,152	1.71	1.637%
5 minutes	674,265	102,517	9.12	0.436%
15 minutes	501,226	182,383	21.83	0.324%
30 minutes	475,625	334,474	42.19	0.308%
60 minutes	214,389	266,105	74.47	0.139%
90 minutes	160,633	282,421	105.49	0.104%
120 minutes	146,949	331,213	135.24	0.095%
150 minutes	85,671	233,756	163.71	0.055%
180 minutes	69,275	224,540	194.48	0.045%
210 minutes	58,780	220,587	225.17	0.038%
240 minutes	61,290	260,719	255.23	0.040%
270 minutes	68,206	324,138	285.14	0.044%
300 minutes	3,441,204	32,980,882	575.05	2.226%

7.5 25-Year Flood

2020 Case: 25-yr Flood Severity, 0-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	620,153	2,064,760	199.77	0.338%
30 minutes	225,006	160,938	42.92	0.123%
15 minutes	362,755	128,622	21.27	0.198%
5 minutes	561,836	87,039	9.30	0.306%
0 minutes	2,183,863	34,173	0.94	1.189%
no change	168,647,236	0	0	91.847%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	3,235,698	94,799	1.76	1.762%
5 minutes	1,057,557	153,494	8.71	0.576%
15 minutes	648,190	235,395	21.79	0.353%
30 minutes	543,858	381,900	42.13	0.296%
60 minutes	229,033	280,852	73.58	0.125%
90 minutes	168,516	295,038	105.05	0.092%
120 minutes	171,739	382,345	133.58	0.094%
150 minutes	101,816	279,184	164.52	0.055%
180 minutes	75,100	243,446	194.50	0.041%
210 minutes	69,884	262,206	225.12	0.038%
240 minutes	72,618	309,177	255.45	0.040%
270 minutes	83,960	399,325	285.37	0.046%
300 minutes	4,558,816	44,220,366	582.00	2.483%

7.6 50-Year Flood

2020 Case: 50-yr Flood Severity, 0-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	736,412	2,428,375	197.85	0.363%
30 minutes	258,204	184,225	42.81	0.127%
15 minutes	378,597	133,644	21.18	0.187%
5 minutes	613,340	96,063	9.40	0.302%
0 minutes	2,444,673	38,656	0.95	1.205%
no change	186,093,516	0	0	91.696%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	3,832,239	111,912	1.75	1.888%
5 minutes	1,250,040	178,332	8.56	0.616%
15 minutes	758,632	271,949	21.51	0.374%
30 minutes	664,701	474,899	42.87	0.328%
60 minutes	290,763	354,339	73.12	0.143%
90 minutes	216,122	379,091	105.24	0.106%
120 minutes	194,734	430,975	132.79	0.096%
150 minutes	113,847	312,160	164.52	0.056%
180 minutes	84,705	274,900	194.72	0.042%
210 minutes	76,613	287,161	224.89	0.038%
240 minutes	80,005	340,535	255.39	0.039%
270 minutes	100,450	478,113	285.58	0.049%
300 minutes	4,758,213	46,174,251	582.25	2.345%

7.7 100-Year Flood

2020 Case: 100-yr Flood Severity, 0-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	779,211	2,587,872	199.27	0.366%
30 minutes	269,948	192,722	42.84	0.127%
15 minutes	395,763	141,755	21.49	0.186%
5 minutes	616,747	95,449	9.29	0.290%
0 minutes	2,470,006	38,624	0.94	1.162%
no change	193,204,638	0	0	90.873%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	4,167,660	124,115	1.79	1.960%
5 minutes	1,387,702	195,762	8.46	0.653%
15 minutes	781,773	283,401	21.75	0.368%
30 minutes	698,262	496,952	42.70	0.328%
60 minutes	328,494	402,681	73.55	0.155%
90 minutes	240,159	420,960	105.17	0.113%
120 minutes	212,820	474,208	133.69	0.100%
150 minutes	129,338	354,422	164.42	0.061%
180 minutes	109,366	354,352	194.40	0.051%
210 minutes	113,319	426,723	225.94	0.053%
240 minutes	114,625	487,099	254.97	0.054%
270 minutes	125,410	596,446	285.36	0.059%
300 minutes	6,464,651	62,530,590	580.36	3.041%

7.8 500-Year Flood

2020 Case: 500-yr Flood Severity, 0-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	936,407	3,115,884	199.65	0.388%
30 minutes	321,466	229,889	42.91	0.133%
15 minutes	447,197	160,423	21.52	0.185%
5 minutes	698,493	107,563	9.24	0.289%
0 minutes	2,826,159	45,243	0.96	1.170%
no change	216,765,625	0	0	89.720%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	4,918,680	152,203	1.86	2.036%
5 minutes	1,772,652	248,364	8.41	0.734%
15 minutes	926,385	334,217	21.65	0.383%
30 minutes	799,297	566,305	42.51	0.331%
60 minutes	367,394	450,954	73.65	0.152%
90 minutes	253,873	446,026	105.41	0.105%
120 minutes	244,438	544,252	133.59	0.101%
150 minutes	163,470	448,370	164.57	0.068%
180 minutes	144,926	470,935	194.97	0.060%
210 minutes	145,791	545,963	224.69	0.060%
240 minutes	149,610	637,454	255.65	0.062%
270 minutes	176,164	837,869	285.37	0.073%
300 minutes	9,544,123	93,108,603	585.34	3.950%

8 Appendix C: 2006 Model Year 3-Hour Sensitivity Analysis Results

The results in this appendix are presented without maps because the flood locations are identical to those in Appendix A. There are no results shown here for the 1-Year, 2-Year, and 5-Year Floods because no simulations were run for these sensitivity cases.

8.1 10-Year Flood

2006 Case: 10-yr Flood Severity, 3-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	7,969	13,511	101.73	0.006%
30 minutes	54,075	34,362	38.13	0.041%
15 minutes	88,659	31,896	21.59	0.067%
5 minutes	134,432	20,319	9.07	0.101%
0 minutes	1,594,807	16,415	0.62	1.197%
no change	127,384,938	0	0	95.620%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	2,978,898	75,553	1.52	2.236%
5 minutes	486,675	72,352	8.92	0.365%
15 minutes	200,148	67,805	20.33	0.150%
30 minutes	70,553	49,250	41.88	0.053%
60 minutes	22,923	27,468	71.90	0.017%
90 minutes	10,923	19,181	105.36	0.008%
120 minutes	14,092	32,002	136.26	0.011%
150 minutes	13,013	35,734	164.76	0.010%
180 minutes	7,485	24,132	193.44	0.006%
210 minutes	7,208	26,597	221.39	0.005%
240 minutes	1,684	7,185	256.00	0.001%
270 minutes	2,176	10,334	284.95	0.002%
300 minutes	138,917	1,757,695	759.17	0.104%

8.2 25-Year Flood

2006 Case: 25-yr Flood Severity, 3-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	12,469	20,706	99.64	0.007%
30 minutes	70,300	44,682	38.14	0.042%
15 minutes	113,959	40,926	21.55	0.068%
5 minutes	181,476	27,720	9.16	0.108%
0 minutes	2,008,277	20,981	0.63	1.190%
no change	160,464,773	0	0	95.093%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	4,242,948	117,443	1.66	2.514%
5 minutes	745,110	106,928	8.61	0.442%
15 minutes	313,747	108,109	20.67	0.186%
30 minutes	141,197	100,076	42.53	0.084%
60 minutes	65,974	80,928	73.60	0.039%
90 minutes	49,338	86,188	104.81	0.029%
120 minutes	47,662	107,024	134.73	0.028%
150 minutes	28,968	79,300	164.25	0.017%
180 minutes	19,983	64,705	194.28	0.012%
210 minutes	15,384	57,043	222.48	0.009%
240 minutes	4,862	20,538	253.45	0.003%
270 minutes	3,750	17,805	284.88	0.002%
300 minutes	214,618	2,719,836	760.37	0.127%

8.3 50-Year Flood

2006 Case: 50-yr Flood Severity, 3-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	10,253	16,872	98.73	0.005%
30 minutes	72,077	45,532	37.90	0.039%
15 minutes	115,937	41,760	21.61	0.062%
5 minutes	167,842	25,330	9.06	0.090%
0 minutes	2,251,022	23,653	0.63	1.207%
no change	175,584,460	0	0	94.143%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	5,065,324	143,127	1.70	2.716%
5 minutes	1,029,060	143,128	8.35	0.552%
15 minutes	429,096	151,074	21.12	0.230%
30 minutes	307,461	220,030	42.94	0.165%
60 minutes	185,373	229,682	74.34	0.099%
90 minutes	168,655	296,611	105.52	0.090%
120 minutes	164,698	368,718	134.33	0.088%
150 minutes	126,334	345,662	164.17	0.068%
180 minutes	103,302	335,432	194.83	0.055%
210 minutes	77,215	287,474	223.38	0.041%
240 minutes	56,072	238,426	255.13	0.030%
270 minutes	47,745	226,657	284.83	0.026%
300 minutes	545,479	5,226,020	574.84	0.292%

8.4 100-Year Flood

2006 Case: 100-yr Flood Severity, 3-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	13,705	22,961	100.52	0.007%
30 minutes	79,179	50,108	37.97	0.041%
15 minutes	129,566	46,309	21.45	0.066%
5 minutes	186,792	28,434	9.13	0.096%
0 minutes	2,306,127	23,317	0.61	1.180%
no change	181,872,563	0	0	93.082%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	5,484,584	156,444	1.71	2.807%
5 minutes	1,247,215	172,371	8.29	0.638%
15 minutes	504,998	178,615	21.22	0.258%
30 minutes	363,488	259,090	42.77	0.186%
60 minutes	207,857	258,137	74.51	0.106%
90 minutes	165,742	291,423	105.50	0.085%
120 minutes	172,811	387,885	134.67	0.088%
150 minutes	150,771	414,211	164.84	0.077%
180 minutes	131,269	426,310	194.86	0.067%
210 minutes	116,633	437,210	224.92	0.060%
240 minutes	114,176	485,562	255.17	0.058%
270 minutes	123,741	588,664	285.43	0.063%
300 minutes	2,017,493	17,192,966	511.32	1.033%

8.5 500-Year Flood

2006 Case: 500-yr Flood Severity, 3-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	13,769	22,205	96.76	0.006%
30 minutes	87,808	55,797	38.13	0.040%
15 minutes	140,506	50,173	21.43	0.063%
5 minutes	217,890	32,713	9.01	0.098%
0 minutes	2,616,510	26,921	0.62	1.178%
no change	201,463,634	0	0	90.736%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	6,405,131	190,812	1.79	2.885%
5 minutes	1,638,455	224,684	8.23	0.738%
15 minutes	622,029	221,639	21.38	0.280%
30 minutes	462,188	329,467	42.77	0.208%
60 minutes	245,269	301,440	73.74	0.110%
90 minutes	231,036	411,693	106.92	0.104%
120 minutes	303,672	682,374	134.82	0.137%
150 minutes	277,711	762,856	164.82	0.125%
180 minutes	264,377	859,201	194.99	0.119%
210 minutes	267,998	1,006,290	225.29	0.121%
240 minutes	303,801	1,292,870	255.34	0.137%
270 minutes	344,692	1,640,447	285.55	0.155%
300 minutes	6,126,149	49,974,736	489.46	2.759%

9 Appendix D: 2006 Model Year 8-Hour Sensitivity Analysis Results

The results in this appendix are presented without maps because the flood locations are identical to those in Appendix A. There are no results shown here for the 1-Year, 2-Year, and 5-Year Floods because no simulations were run for these sensitivity cases.

9.1 10-Year Flood

2006 Case: 10-yr Flood Severity, 8-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	9,868	17,000	103.36	0.007%
30 minutes	59,263	37,637	38.10	0.042%
15 minutes	102,107	36,836	21.65	0.072%
5 minutes	157,525	24,004	9.14	0.111%
0 minutes	1,633,311	16,462	0.60	1.149%
no change	136,028,323	0	0	95.727%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	3,086,717	77,185	1.50	2.172%
5 minutes	502,228	74,782	8.93	0.353%
15 minutes	217,078	74,285	20.53	0.153%
30 minutes	90,562	62,805	41.61	0.064%
60 minutes	28,373	33,940	71.77	0.020%
90 minutes	13,558	23,840	105.50	0.010%
120 minutes	12,245	27,818	136.31	0.009%
150 minutes	10,125	27,789	164.68	0.007%
180 minutes	5,367	17,174	192.00	0.004%
210 minutes	4,584	16,994	222.43	0.003%
240 minutes	1,714	7,311	255.93	0.001%
270 minutes	2,124	10,083	284.83	0.001%
300 minutes	135,808	1,721,974	760.77	0.096%

9.2 25-Year Flood

2006 Case: 25-yr Flood Severity, 8-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	12,179	20,041	98.73	0.007%
30 minutes	73,673	47,022	38.30	0.044%
15 minutes	109,102	39,295	21.61	0.065%
5 minutes	175,707	26,610	9.09	0.104%
0 minutes	2,014,140	21,203	0.63	1.194%
no change	160,274,610	0	0	94.980%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	4,200,204	116,086	1.66	2.489%
5 minutes	731,312	105,618	8.67	0.433%
15 minutes	300,968	103,744	20.68	0.178%
30 minutes	137,892	96,611	42.04	0.082%
60 minutes	56,194	68,645	73.29	0.033%
90 minutes	46,416	81,834	105.78	0.028%
120 minutes	57,354	129,030	134.98	0.034%
150 minutes	39,783	108,654	163.87	0.024%
180 minutes	27,769	90,002	194.46	0.016%
210 minutes	23,271	86,951	224.19	0.014%
240 minutes	16,749	71,207	255.09	0.010%
270 minutes	17,870	84,912	285.10	0.011%
300 minutes	429,602	4,380,029	611.73	0.255%

9.3 50-Year Flood

2006 Case: 50-yr Flood Severity, 8-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	11,046	18,185	98.78	0.006%
30 minutes	76,936	48,789	38.05	0.041%
15 minutes	121,054	43,451	21.54	0.065%
5 minutes	187,889	28,239	9.02	0.101%
0 minutes	2,243,531	24,053	0.64	1.203%
no change	175,545,537	0	0	94.123%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	5,032,689	141,879	1.69	2.698%
5 minutes	1,022,353	143,152	8.40	0.548%
15 minutes	432,885	152,905	21.19	0.232%
30 minutes	316,656	226,174	42.86	0.170%
60 minutes	194,345	241,314	74.50	0.104%
90 minutes	172,744	302,699	105.14	0.093%
120 minutes	168,636	378,320	134.60	0.090%
150 minutes	127,248	348,259	164.21	0.068%
180 minutes	94,051	304,230	194.08	0.050%
210 minutes	67,436	251,652	223.90	0.036%
240 minutes	45,238	192,051	254.72	0.024%
270 minutes	41,021	194,817	284.95	0.022%
300 minutes	606,110	5,899,037	583.96	0.325%

9.4 100-Year Flood

2006 Case: 100-yr Flood Severity, 8-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	10,784	17,967	99.97	0.006%
30 minutes	78,288	49,520	37.95	0.040%
15 minutes	130,302	46,851	21.57	0.067%
5 minutes	204,410	30,700	9.01	0.105%
0 minutes	2,344,805	24,351	0.62	1.200%
no change	182,025,779	0	0	93.161%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	5,489,017	157,609	1.72	2.809%
5 minutes	1,217,882	169,532	8.35	0.623%
15 minutes	493,724	174,800	21.24	0.253%
30 minutes	389,587	279,048	42.98	0.199%
60 minutes	231,437	287,194	74.46	0.118%
90 minutes	176,108	308,530	105.12	0.090%
120 minutes	171,701	384,613	134.40	0.088%
150 minutes	133,851	367,286	164.64	0.069%
180 minutes	111,522	361,630	194.56	0.057%
210 minutes	91,514	342,455	224.53	0.047%
240 minutes	86,741	368,788	255.10	0.044%
270 minutes	94,688	450,592	285.52	0.048%
300 minutes	1,906,570	16,705,081	525.71	0.976%

9.5 500-Year Flood

2006 Case: 500-yr Flood Severity, 8-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	15,409	25,498	99.29	0.007%
30 minutes	89,867	57,228	38.21	0.040%
15 minutes	138,134	49,637	21.56	0.062%
5 minutes	225,041	33,734	8.99	0.101%
0 minutes	2,563,019	25,798	0.60	1.154%
no change	201,296,366	0	0	90.661%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	6,406,328	190,787	1.79	2.885%
5 minutes	1,659,815	227,859	8.24	0.748%
15 minutes	594,612	211,564	21.35	0.268%
30 minutes	429,841	305,081	42.59	0.194%
60 minutes	215,134	264,966	73.90	0.097%
90 minutes	211,241	377,879	107.33	0.095%
120 minutes	308,432	693,929	134.99	0.139%
150 minutes	281,753	774,209	164.87	0.127%
180 minutes	271,134	881,963	195.17	0.122%
210 minutes	284,373	1,068,138	225.37	0.128%
240 minutes	316,876	1,348,232	255.29	0.143%
270 minutes	355,171	1,690,225	285.53	0.160%
300 minutes	6,370,079	52,263,683	492.27	2.869%

10 Appendix E: 2006 Model Year 13-Hour Sensitivity Analysis Results

The results in this appendix are presented without maps because the flood locations are identical to those in Appendix A. There are no results shown here for the 1-Year, 2-Year, and 5-Year Floods because no simulations were run for these sensitivity cases.

10.1 10-Year Flood

2006 Case: 10-yr Flood Severity, 13-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	10,846	18,099	100.12	0.008%
30 minutes	61,822	39,446	38.28	0.046%
15 minutes	96,410	34,534	21.49	0.072%
5 minutes	142,234	21,984	9.27	0.107%
0 minutes	1,558,135	15,277	0.59	1.170%
no change	127,314,170	0	0	95.567%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	2,980,237	76,110	1.53	2.237%
5 minutes	515,047	75,780	8.83	0.387%
15 minutes	238,899	82,255	20.66	0.179%
30 minutes	87,909	61,056	41.67	0.066%
60 minutes	26,901	32,220	71.86	0.020%
90 minutes	11,704	20,468	104.93	0.009%
120 minutes	13,896	31,494	135.99	0.010%
150 minutes	12,414	34,187	165.23	0.009%
180 minutes	5,495	17,594	192.11	0.004%
210 minutes	4,873	18,087	222.70	0.004%
240 minutes	1,881	8,022	255.90	0.001%
270 minutes	2,332	11,063	284.64	0.002%
300 minutes	134,370	1,705,046	761.35	0.101%

10.2 25-Year Flood

2006 Case: 25-yr Flood Severity, 13-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	12,752	21,098	99.27	0.007%
30 minutes	76,081	48,177	37.99	0.043%
15 minutes	125,130	45,015	21.58	0.070%
5 minutes	201,606	30,333	9.03	0.114%
0 minutes	2,062,684	21,410	0.62	1.161%
no change	168,942,355	0	0	95.111%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	4,384,974	120,114	1.64	2.469%
5 minutes	770,246	110,384	8.60	0.434%
15 minutes	328,674	113,521	20.72	0.185%
30 minutes	152,237	106,544	41.99	0.086%
60 minutes	67,022	82,073	73.47	0.038%
90 minutes	39,779	69,288	104.51	0.022%
120 minutes	38,977	87,976	135.43	0.022%
150 minutes	27,289	75,003	164.91	0.015%
180 minutes	18,383	59,457	194.06	0.010%
210 minutes	13,774	51,176	222.92	0.008%
240 minutes	8,840	37,611	255.28	0.005%
270 minutes	9,979	47,450	285.30	0.006%
300 minutes	345,318	3,755,084	652.46	0.194%

10.3 50-Year Flood

2006 Case: 50-yr Flood Severity, 13-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	10,705	17,686	99.13	0.006%
30 minutes	77,208	48,992	38.07	0.041%
15 minutes	120,152	43,227	21.59	0.064%
5 minutes	179,292	26,846	8.98	0.096%
0 minutes	2,231,320	23,380	0.63	1.196%
no change	175,076,618	0	0	93.871%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	5,106,772	144,725	1.70	2.738%
5 minutes	1,061,723	150,412	8.50	0.569%
15 minutes	455,628	160,424	21.13	0.244%
30 minutes	341,089	243,679	42.86	0.183%
60 minutes	204,860	253,905	74.36	0.110%
90 minutes	192,297	338,594	105.65	0.103%
120 minutes	186,752	418,906	134.59	0.100%
150 minutes	152,350	416,850	164.17	0.082%
180 minutes	109,995	356,691	194.57	0.059%
210 minutes	82,009	305,152	223.26	0.044%
240 minutes	59,336	252,147	254.97	0.032%
270 minutes	54,675	259,780	285.08	0.029%
300 minutes	804,624	7,560,833	563.80	0.431%

10.4 100-Year Flood

2006 Case: 100-yr Flood Severity, 13-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	10,988	18,363	100.27	0.006%
30 minutes	77,308	48,839	37.90	0.040%
15 minutes	127,992	45,806	21.47	0.066%
5 minutes	192,979	29,358	9.13	0.099%
0 minutes	2,349,330	24,483	0.63	1.202%
no change	181,789,344	0	0	93.040%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	5,540,957	158,948	1.72	2.836%
5 minutes	1,202,890	167,826	8.37	0.616%
15 minutes	508,355	180,203	21.27	0.260%
30 minutes	415,379	299,210	43.22	0.213%
60 minutes	252,751	313,601	74.45	0.129%
90 minutes	200,857	352,146	105.19	0.103%
120 minutes	196,730	440,596	134.38	0.101%
150 minutes	151,474	415,792	164.70	0.078%
180 minutes	117,158	379,163	194.18	0.060%
210 minutes	94,324	352,580	224.28	0.048%
240 minutes	87,116	370,875	255.44	0.045%
270 minutes	96,750	459,905	285.21	0.050%
300 minutes	1,976,028	17,719,512	538.03	1.011%

10.5 500-Year Flood

2006 Case: 500-yr Flood Severity, 13-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	16,469	27,129	98.84	0.007%
30 minutes	95,379	60,721	38.20	0.043%
15 minutes	148,792	53,185	21.45	0.067%
5 minutes	226,464	34,222	9.07	0.102%
0 minutes	2,580,897	25,854	0.60	1.162%
no change	200,943,141	0	0	90.502%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	6,410,634	190,656	1.78	2.887%
5 minutes	1,647,828	226,375	8.24	0.742%
15 minutes	624,705	222,116	21.33	0.281%
30 minutes	441,606	311,853	42.37	0.199%
60 minutes	208,093	256,388	73.93	0.094%
90 minutes	208,912	373,603	107.30	0.094%
120 minutes	301,527	678,430	135.00	0.136%
150 minutes	279,118	766,687	164.81	0.126%
180 minutes	274,551	893,024	195.16	0.124%
210 minutes	285,186	1,071,723	225.48	0.128%
240 minutes	323,950	1,378,196	255.26	0.146%
270 minutes	363,561	1,730,455	285.58	0.164%
300 minutes	6,651,812	54,819,497	494.48	2.996%

11 Appendix F: 2006 Model Year 18-Hour Sensitivity Analysis Results

The results in this appendix are presented without maps because the flood locations are identical to those in Appendix A. There are no results shown here for the 1-Year, 2-Year, and 5-Year Floods because no simulations were run for these sensitivity cases.

11.1 10-Year Flood

2006 Case: 10-yr Flood Severity, 18-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	9,654	16,226	100.84	0.007%
30 minutes	57,415	36,469	38.11	0.043%
15 minutes	99,971	35,205	21.13	0.075%
5 minutes	145,653	22,524	9.28	0.109%
0 minutes	1,583,453	15,949	0.60	1.189%
no change	127,288,728	0	0	95.548%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	3,015,026	76,792	1.53	2.263%
5 minutes	491,875	73,282	8.94	0.369%
15 minutes	221,716	75,443	20.42	0.166%
30 minutes	78,879	54,994	41.83	0.059%
60 minutes	27,272	33,025	72.66	0.020%
90 minutes	14,547	25,456	104.99	0.011%
120 minutes	17,189	39,091	136.45	0.013%
150 minutes	12,829	35,136	164.33	0.010%
180 minutes	7,725	24,798	192.61	0.006%
210 minutes	6,153	22,812	222.44	0.005%
240 minutes	2,385	10,122	254.64	0.002%
270 minutes	2,274	10,801	284.99	0.002%
300 minutes	136,831	1,730,830	758.96	0.103%

11.2 25-Year Flood

2006 Case: 25-yr Flood Severity, 18-hr Offset

	Vehicles	Total Savings	Average Savings	Percentage
greater than		*hours*	*minutes*	
60 minutes	10,380	17,295	99.97	0.006%
30 minutes	69,042	43,733	38.01	0.041%
15 minutes	116,347	41,345	21.32	0.069%
5 minutes	179,341	27,346	9.15	0.106%
0 minutes	2,031,092	21,485	0.63	1.204%
no change	160,098,883	0	0	94.876%

	Vehicles	Total Delay	Average Delay	Percentage
greater than		*hours*	*minutes*	
0 minutes	4,299,200	118,081	1.65	2.548%
5 minutes	741,012	105,878	8.57	0.439%
15 minutes	297,081	102,090	20.62	0.176%
30 minutes	140,522	99,050	42.29	0.083%
60 minutes	64,886	79,324	73.35	0.038%
90 minutes	49,401	86,613	105.20	0.029%
120 minutes	54,187	122,008	135.10	0.032%
150 minutes	40,797	112,185	164.99	0.024%
180 minutes	29,661	96,003	194.20	0.018%
210 minutes	25,977	96,779	223.53	0.015%
240 minutes	16,447	69,795	254.62	0.010%
270 minutes	17,070	81,078	284.99	0.010%
300 minutes	463,469	4,763,041	616.62	0.275%

11.3 50-Year Flood

2006 Case: 50-yr Flood Severity, 18-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	9,580	15,650	98.02	0.005%
30 minutes	69,243	43,630	37.81	0.039%
15 minutes	114,113	40,635	21.37	0.064%
5 minutes	163,117	24,756	9.11	0.092%
0 minutes	2,187,983	23,023	0.63	1.232%
no change	166,443,623	0	0	93.704%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	5,046,610	143,734	1.71	2.841%
5 minutes	1,039,746	145,332	8.39	0.585%
15 minutes	454,243	159,964	21.13	0.256%
30 minutes	332,316	238,507	43.06	0.187%
60 minutes	211,386	262,642	74.55	0.119%
90 minutes	185,165	325,201	105.38	0.104%
120 minutes	186,491	419,069	134.83	0.105%
150 minutes	152,735	417,858	164.15	0.086%
180 minutes	111,572	361,920	194.63	0.063%
210 minutes	82,060	305,699	223.52	0.046%
240 minutes	58,845	249,637	254.54	0.033%
270 minutes	51,929	246,489	284.80	0.029%
300 minutes	725,343	6,985,507	577.84	0.408%

11.4 100-Year Flood

2006 Case: 100-yr Flood Severity, 18-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	10,149	16,323	96.50	0.005%
30 minutes	73,231	46,158	37.82	0.039%
15 minutes	117,786	41,955	21.37	0.063%
5 minutes	179,764	27,036	9.02	0.096%
0 minutes	2,283,024	24,600	0.65	1.224%
no change	172,766,464	0	0	92.632%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	5,407,622	156,323	1.73	2.899%
5 minutes	1,162,537	161,093	8.31	0.623%
15 minutes	479,076	169,680	21.25	0.257%
30 minutes	363,741	259,056	42.73	0.195%
60 minutes	210,571	261,174	74.42	0.113%
90 minutes	179,570	316,647	105.80	0.096%
120 minutes	199,022	445,602	134.34	0.107%
150 minutes	158,929	436,315	164.72	0.085%
180 minutes	124,633	403,579	194.29	0.067%
210 minutes	107,930	404,094	224.64	0.058%
240 minutes	104,344	443,978	255.30	0.056%
270 minutes	117,047	556,660	285.35	0.063%
300 minutes	2,461,965	21,921,587	534.25	1.320%

11.5 500-Year Flood

2006 Case: 500-yr Flood Severity, 18-hr Offset

greater than	**Vehicles**	**Total Savings** *hours*	**Average Savings** *minutes*	**Percentage**
60 minutes	13,746	21,722	94.82	0.006%
30 minutes	92,559	58,795	38.11	0.040%
15 minutes	147,699	52,949	21.51	0.064%
5 minutes	255,582	37,894	8.90	0.111%
0 minutes	2,677,416	27,791	0.62	1.159%
no change	209,387,268	0	0	90.678%

greater than	**Vehicles**	**Total Delay** *hours*	**Average Delay** *minutes*	**Percentage**
0 minutes	6,500,814	192,577	1.78	2.815%
5 minutes	1,624,997	223,577	8.26	0.704%
15 minutes	622,404	221,897	21.39	0.270%
30 minutes	460,554	326,281	42.51	0.199%
60 minutes	240,687	296,799	73.99	0.104%
90 minutes	232,764	415,506	107.11	0.101%
120 minutes	318,169	714,593	134.76	0.138%
150 minutes	284,970	783,008	164.86	0.123%
180 minutes	274,823	893,086	194.98	0.119%
210 minutes	283,735	1,066,141	225.45	0.123%
240 minutes	325,923	1,386,931	255.32	0.141%
270 minutes	372,963	1,775,121	285.57	0.162%
300 minutes	6,796,857	55,956,563	493.96	2.943%

12 Appendix G: Isolating Traffic Impacts of Flooding

In a highway network when road segments are disrupted or closed, such as during a flood, drivers will reroute around congested or inaccessible infrastructure when there are alternate paths available (and known to them). These reroutings create additional congestion on roadways not otherwise impacted by this traffic. That is, the disruption of one road segment affects others, perhaps many others, and sometimes others far from the scene of the disruption. It is for this reason that a simulation model is necessary to estimate those rerouting impacts of a disruption.

In the case of a flood disruption, the typical circumstances is that several, perhaps many road segments are affected simultaneously as water rises.

The United States Army Corps of Engineers (USACE) requested that ranking and evaluation criteria be developed for a flooding study of the Des Plaines River Basin to estimate the relative impacts of closures of particular road segments, presumably to provide a basis for allocating resources to protect certain road segments, or collections of road segments from flood disruptions. The exact request was:

> *Evaluate individual road segments in terms of their contribution to impacts on the rest of the system. Joint … determination of criteria to facilitate ranking.*

This request presented a unique challenge to any traffic model. It is not possible to distinguish the traffic effects of one closure when, in the case of flooding, there are multiple, simultaneous closures, even when those closures may be geographically distant. This is the case in flooding because rising water will not normally force the closure of single road segments at one time – clusters of road segments, perhaps whole sections of roadways, not necessarily in close proximity, can be expected to be inundated with flood water simultaneously. Because vehicles diverted from one closure can be diverted to road segments used by vehicles diverted from other closures, the causal road segment between rising congestion on a road segment and the “sending” (closed) road segment cannot be sorted out. This interaction makes the identification of a particular closure's contribution to delay, miles traveled, or other performance metrics, impossible to isolate. This characteristic is not due to the modeling system, but to the actual process of travel over networks. Thus, the choice of a different model will not solve this problem.

There are several options that might be used to produce the desired, incremental evaluation. These are presented below along with advantages and disadvantages of each, and the relative effort required to implement each solution.

12.1 Perform a Scenario Analysis for each Road Segment

This is the most basic, brute force approach, and it produces the most basic and least defensible results.

In this case a scenario is run in the modeling system treating each closed road segment as an individual scenario, with all other road segments operating without any capacity reduction. In the simulation model, the drivers impacted by the closed road segment will reroute around the road segment, introducing some amount of delay spread across the remaining road segments on the network, as well as extra travel distance.

The primary advantage of this approach is simplicity. It requires little effort beyond preparing the scenarios to be run. This can even be automated to a degree.

The primary disadvantage of this approach is that it cannot correctly capture the real secondary effects of the flood scenarios. In reality, road segments will not be closed one at a time, and so each isolated closure scenario would underestimate the actual impact of the closed road segment on the network. In addition, this would add a very substantial number of simulation runs to isolate hundreds of potential road segments closures for eight flooding recurrences (magnitudes). This greatly increased number of simulation runs is simply not feasible, and given the unrealistic assumptions, it is not productive. We do not believe this solution to be adequate to address the needs of the USACE.

12.2 Perform an Inverted Scenario Analysis for each Road Segment

Much like the previous approach, this approach is fairly basic, but is more defensible. Instead of running scenarios with a single road segment closed, scenarios will be run with the full closures for each flood intensity, while keeping one affect road segment open. Trips that would be affected only by the still-open road segment will travel normally. All other traffic will be rerouting around other closures.

This approach is as simple to prepare as the previous approach, and like the previous, the preparation of these scenarios could be automated.

Use of this approach will yield impacts comparable to having completed a flood mitigation project for each road segment evaluated in this way. The results of this approach will still only be an approximation of the individual impact of a road segment, because the availability of each individual road segment affects they way drivers using that road segment affect the rest of the network. A simple subtraction can yield the delay and distance changes requested.

Unfortunately, this approach also requires just as many runs as the previous. The number of scenarios could number in the thousands, which is simply not feasible. Because of the unrealistic assumptions underlying this approach, as well as the quantity of scenarios to be tested involved, we do not believe this approach meets the needs of the USACE.

12.3 Perform a Cluster Evaluation

This method involves identifying geographic clusters of flood closures, groups of road segments, all of which are expected to be closed simultaneously under a particular flooding scenario. Of course for a particular scenario we would expect to identify a number of clusters, each of which would be tested separately. This provides a test of the value of protecting one subset of road segments compared with other subsets, as well as all other affected road segments under a particular scenario. Instead of attempting to isolate impacts of individual road segments, impacts at the (logical) cluster level are evaluated.

This approach would require additional scenario runs to evaluate individual clusters of closures.

This suffers from the same shortcoming as attempting to look at individual road segments, as traffic may be affected by two or more neighboring clusters. But, if the clusters are larger and more logically

defined in terms of feasible and separable pieces of flood control work, the results should be more useful than those of the other two options.

This would require some manual inspection of each flood year to determine how closures may be clustered, a process requiring a collaboration between the Northwestern-Vista team and USACE. Analysis of the results will need to be aggregated in terms of these clusters, requiring some extra effort.

The viability of this approach is dependent on the geographic distribution of the flood closures.

12.4 Perform a Vehicle Routing Comparison

This method involves identifying vehicles in the base cases which travel through road segments to be closed in scenario cases. Vehicles in our modeling software have unique identifiers which remain consistent between scenarios, so the routes chosen in the base case and the diversion routes chosen in the scenarios can be directly compared. The travel time and distance attributed to these vehicles can be aggregated to the flooded road segments based on the base case route choice. A comparison between the base case and scenario results at this level will yield metrics reflecting the impact of each closure.

This method will not require any extra simulation runs for any scenario, as the results can be obtained directly from the work already planned. This method of analysis has been used in past flood impact studies, and should be appropriate for this and future studies.

One drawback of this method is that impacts may be "double-counted," meaning that the delay experienced by one vehicle which passed through multiple road segments in the base case which were flooded in a scenario case. The increase in travel time will be attributed to each of these flooded road segments.

Other impacts will be under-counted, as vehicles delay by diverted vehicles will not be taken in to consideration in the calculation.

12.5 Perform a Distribution of Delays by Volume

This method involves distributing the delay experienced by traffic according to the volumes present on flooded crossings when no flooding occurs. The without-flood condition hourly traffic volumes are used as the basis for these calculations. The total delay for each day of flooding is apportioned according to these volumes while roads are flooded. The volumes for individual flooded road segments are taken against the total volume of all the flooded road segments to produce the factors used to distribute the delay.

This method will not require additional simulation runs for any scenario. The calculatios can be obtained directly from the work already planned. The entire delay will be captured, unlike other methods discussed above.

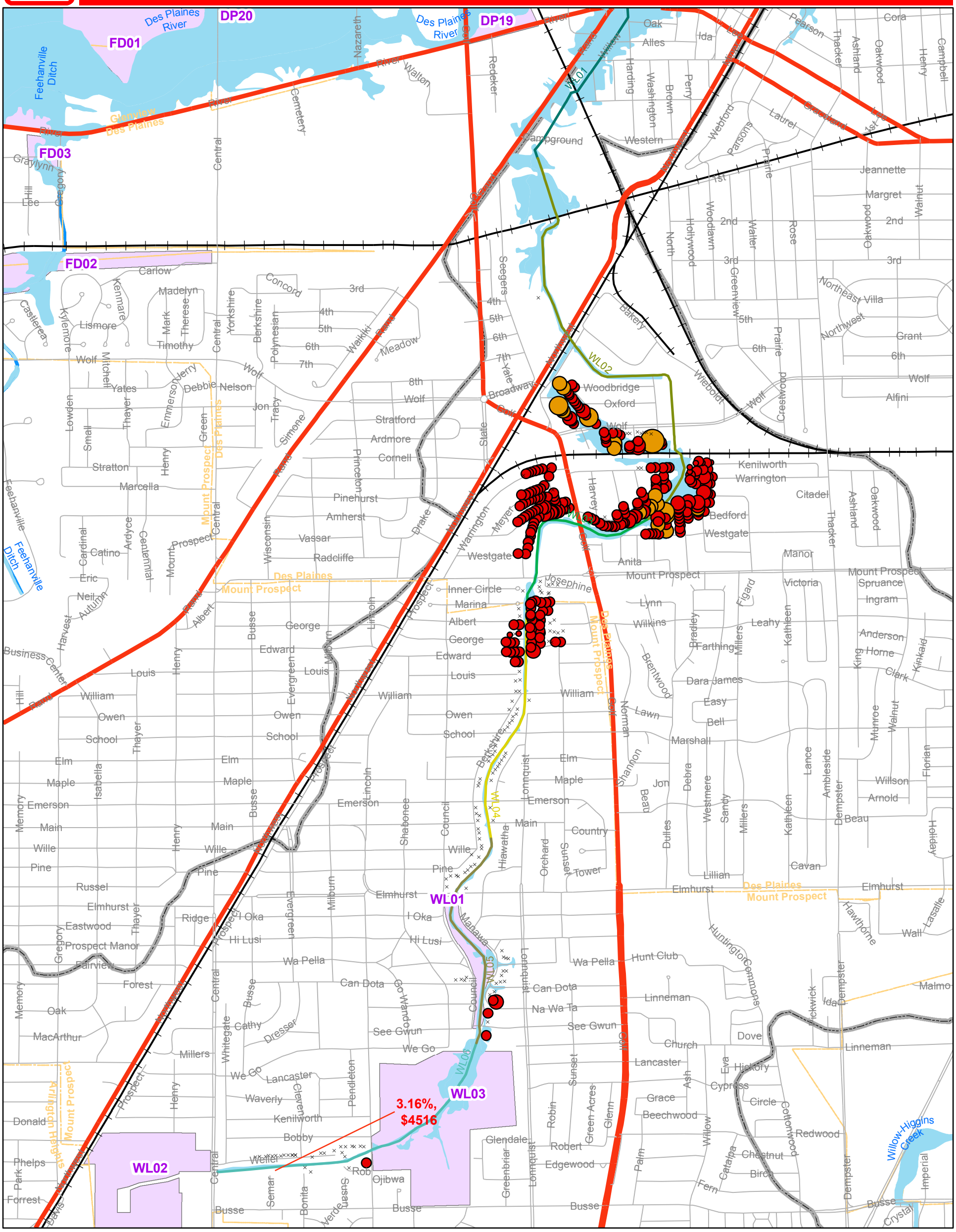
This method has issues with lag, since the effects of any capacity reduction or restoration will lag the event itself. A road flooding at 2 p.m. may not affect any vehicles until minutes later, possibly a very long time on a low-volume road. The magnitude of these imperfections are most certainly dwarfed by the use of one-hour analysis intervals, making them less than relevant.

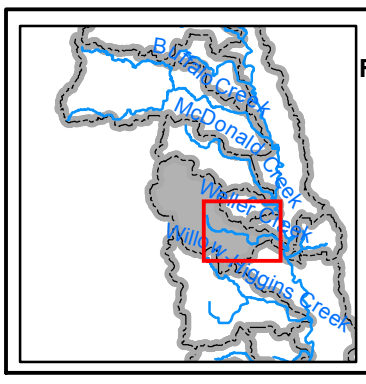
After multiple discussions of this and the above analysis options, the Army Corps of Engineers has deemed this approach acceptable. As such, it will be used to fulfill the delay attribution analysis for the current flood impact study.

Attachment 4

Weller Creek Structure Damage

U.S. Army Corps of Engineers
Chicago District





Legend

Frequency

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

WL01, WL02, WL03, WL04, WL05, WL06

Roads, Highways, RailRoads, Streams

Counties, Municipality, Floodplain, Subwatersheds, Vehicle Damages, FDR Potential Reservoir Sites

0 490 980 1,960 Feet

EAD Contribution

'GIS Report$'.PRCT_EAD

- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

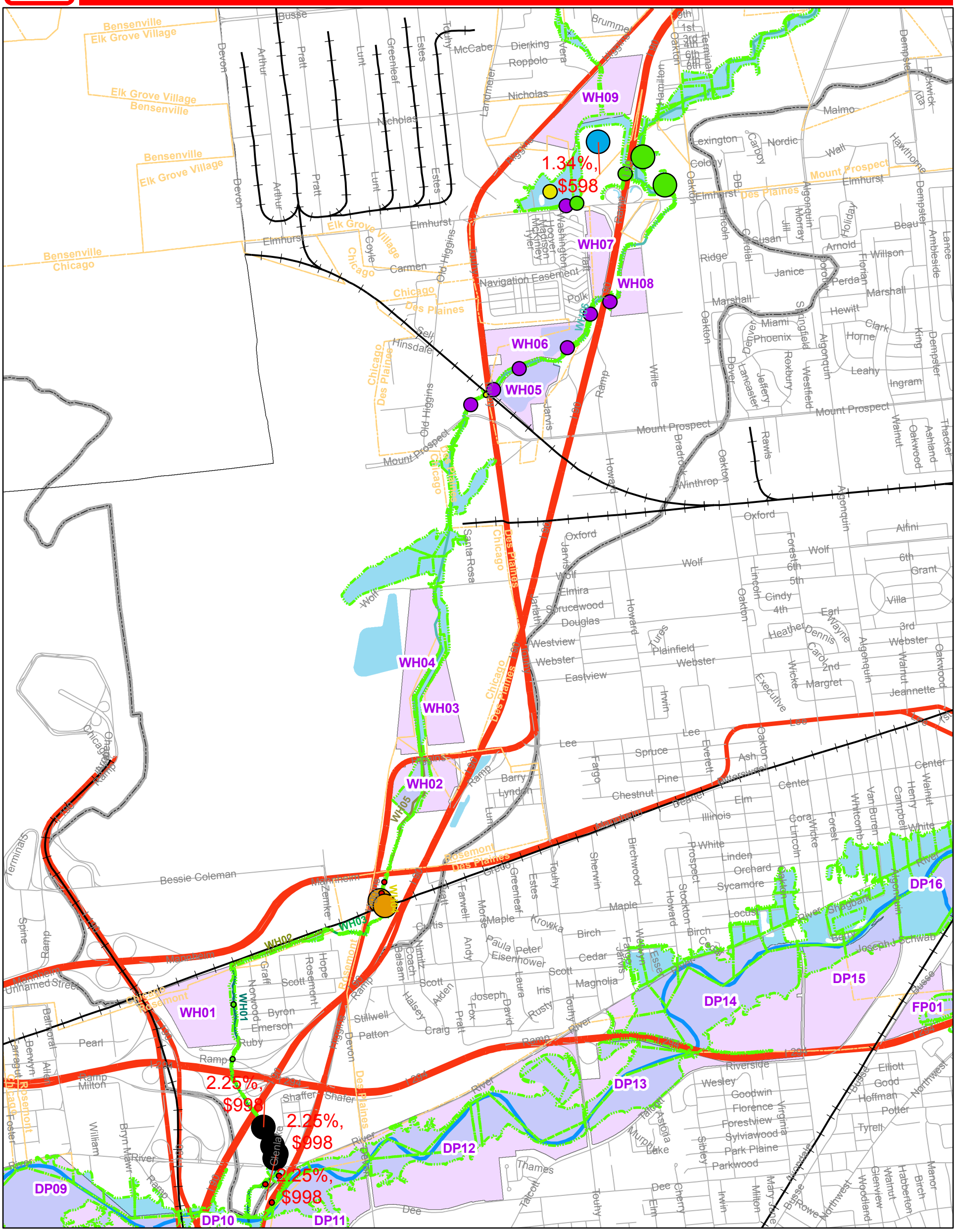
N E S W

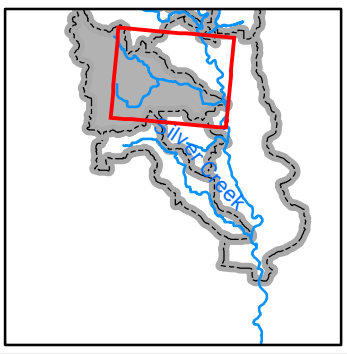
Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

Thursday, May 7, 2009 N:\01 New N Drive Structure\Planning Missions\Flood Risk Management Center\DesPlaines II\Economics\HEC-FDA\GIS Sundries\Silver Creek.mxd

Willow-Higgins Creek Vehicle Damages

U.S. Army Corps of Engineers
Chicago District





Frequency

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

Reach

- WH01
- WH02
- WH03
- WH04
- WH05
- WH06

- RailRoads
- Roads
- Highways
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

0 800 1,600 3,200
Feet

EAD Contribution

Deviation from Mean

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.

Source: Floodplains - FEMA DFIRM Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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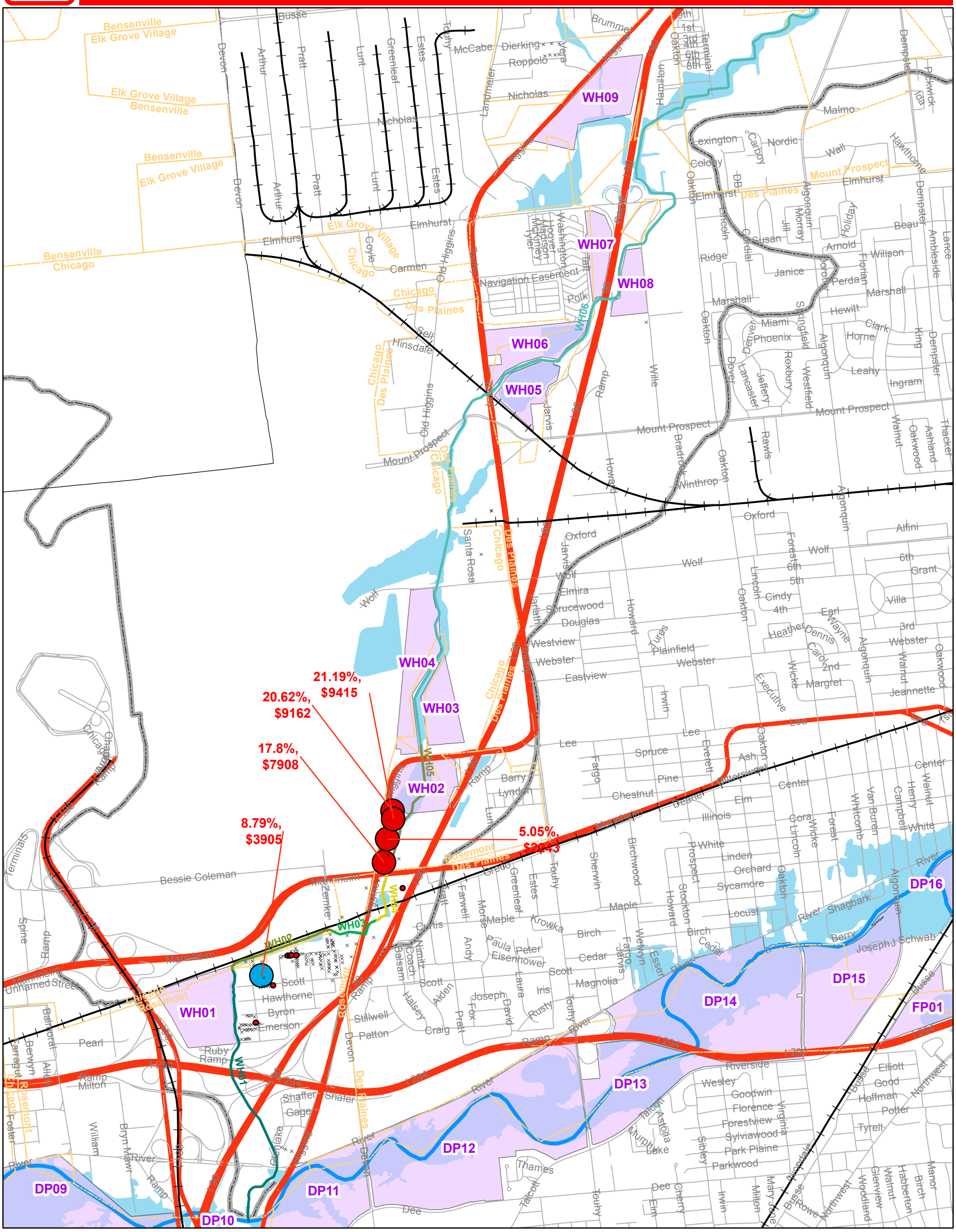
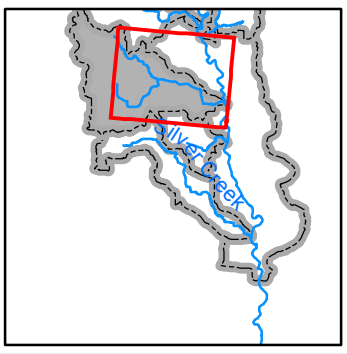
Willow-Higgins Creek Structure Damages

U.S. Army Corps of Engineers
Chicago District





Frequency

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

Reach

- WH01
- WH02
- WH03
- WH04
- WH05
- WH06

- RailRoads
- Roads
- Highways
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

0 800 1,600 3,200
Feet

EAD Contribution

Deviation from Mean

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.

Source: Floodplains - FEMA DFIRM Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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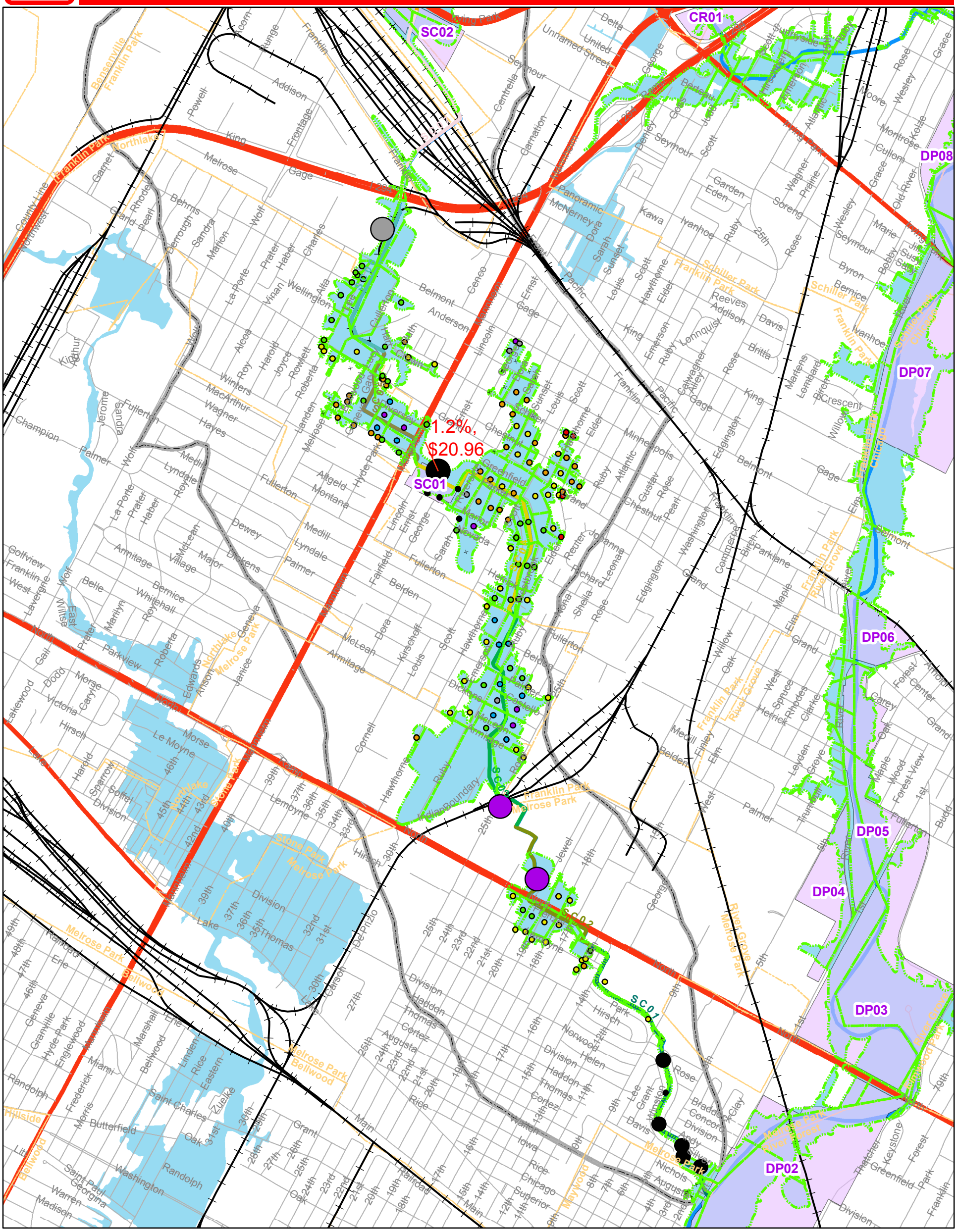
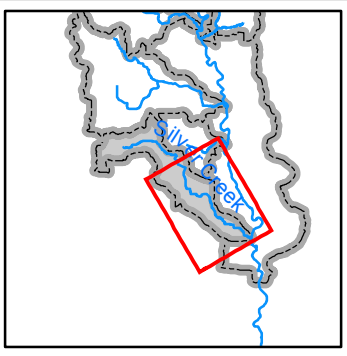
Silver Creek Vehicle Damage

U.S. Army Corps of Engineers
Chicago District





Frequency

- Removed
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

Reach

- SC01
- SC02
- SC03
- SC04
- SC05
- SC06
- SC07
- SC08

- RailRoads
- Roads
- Highways
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

EAD Contribution
Deviation from Mean

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.

0 750 1,500 3,000
Feet

Source: Floodplains - FEMA DFIRM Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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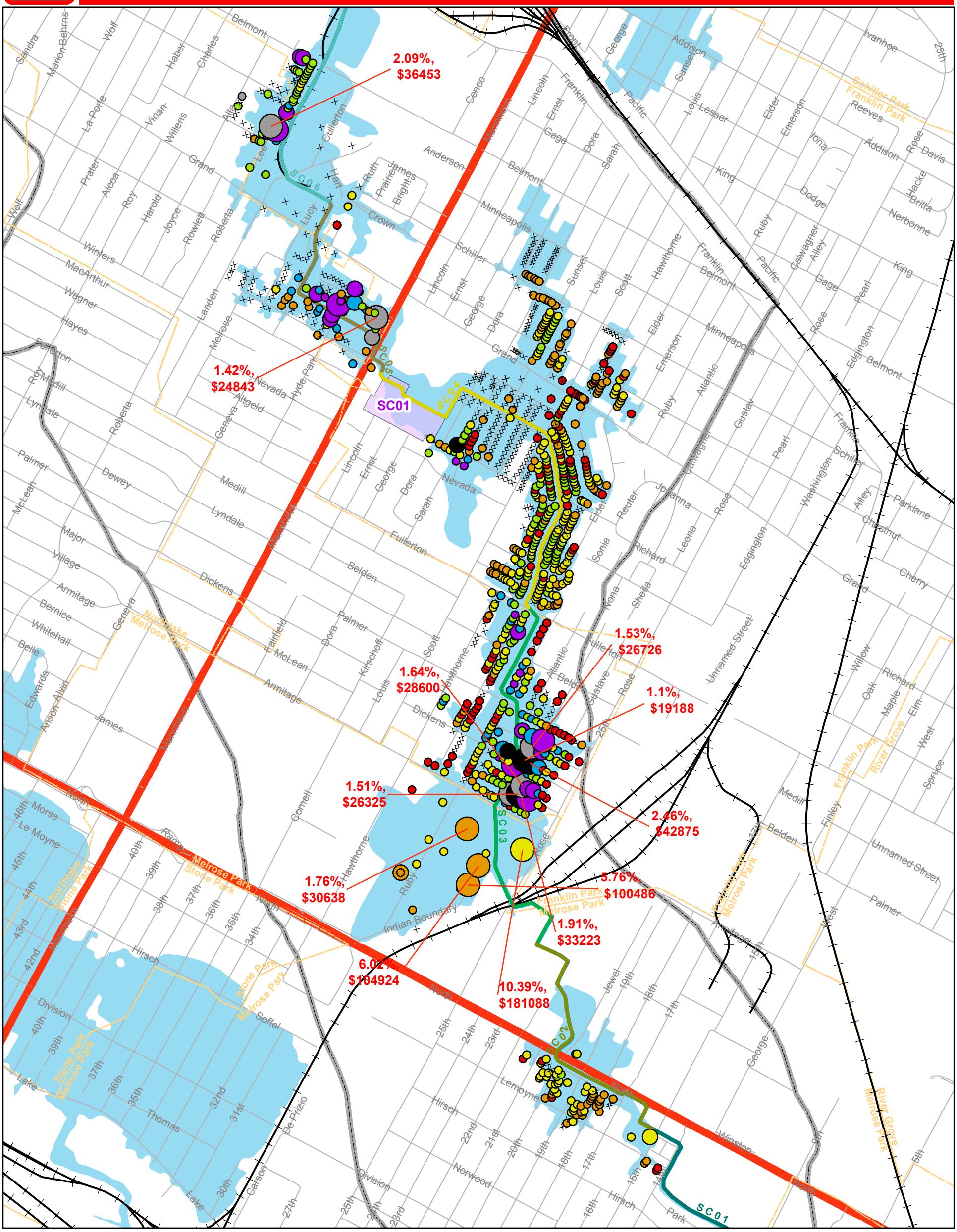
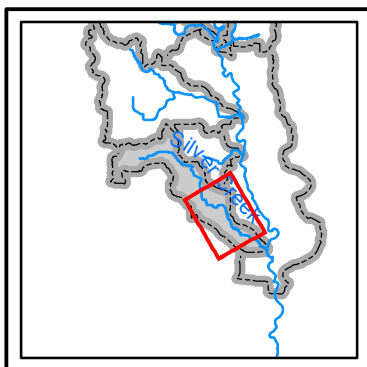
Silver Creek Structure Damage

U.S. Army Corps of Engineers
Chicago District





Frequency

- Removed
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

Reach

- SC01
- SC02
- SC03
- SC04
- SC05
- SC06
- SC07
- SC08

- RailRoads
- Roads
- Highways
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

EAD Contribution
Deviation from Mean

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.

0 462.5 925 1,850
Feet

Source: Floodplains - FEMA DFIRM Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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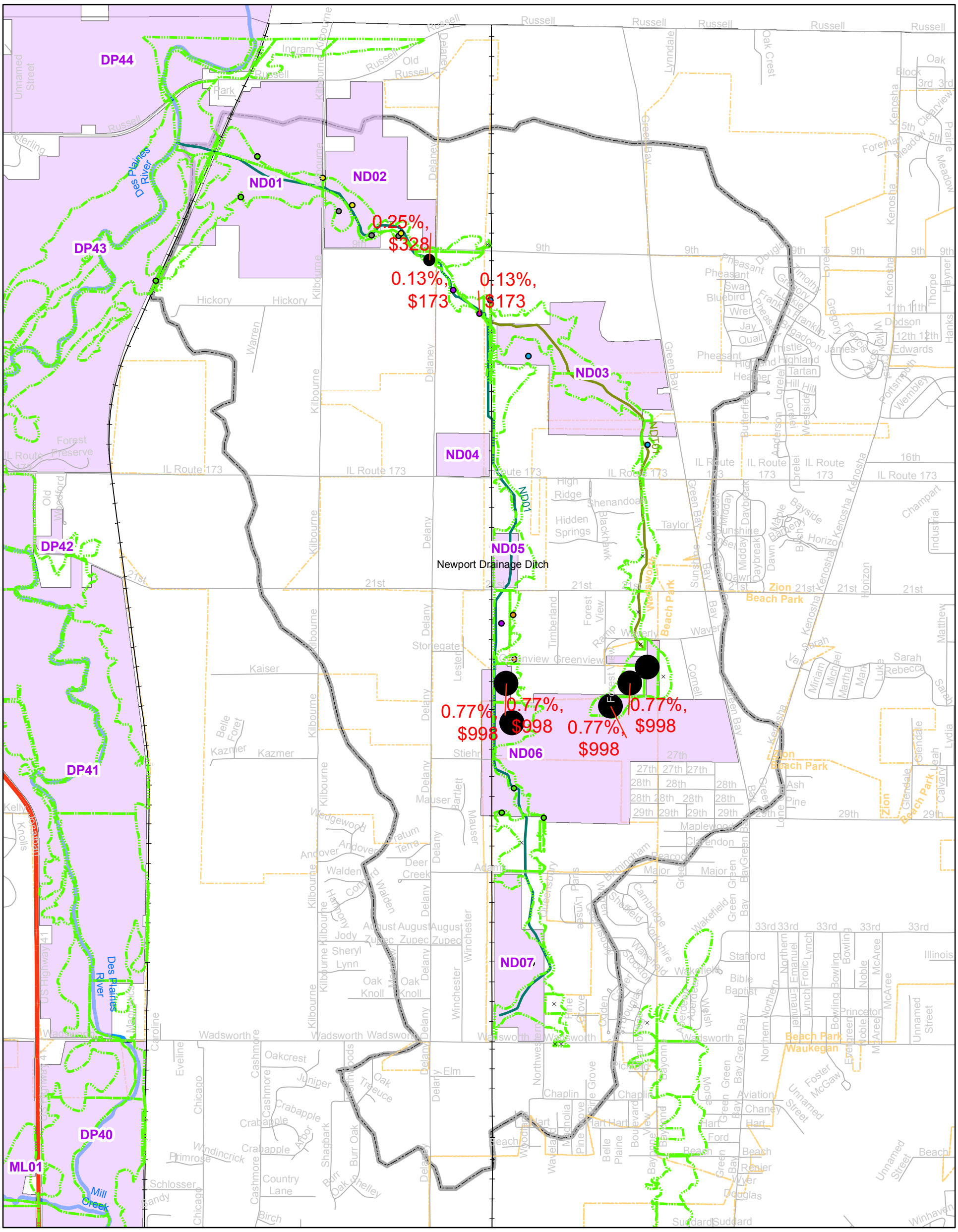
Newport Ditch and Tributary Vehicle Damage

U.S. Army Corps of Engineers
Chicago District



Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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Newport Ditch and Tributary Structure Damage

U.S. Army Corps of Engineers
Chicago District

DP44
DP43
DP42
DP41
DP40
ML01
ND01
ND02
ND03
ND04
ND05
ND06
ND07
NDT01
Newport Drainage Ditch
91.31%, $118591
Des Plaines River
Mill Creek
Wadsworth Beach Park
Zion Beach Park
Beach Park Waukegan
IL Route 173
US Highway 41

Legend

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR
- ND01
- NDT01
- Roads
- Highways
- RailRoads
- Streams
- Counties
- Municipality
- Floodplain
- Vehicle Damages
- FDR Potential Reservoir Sites

0 800 1,600 3,200
Feet

EAD Contribution

PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

N W E S

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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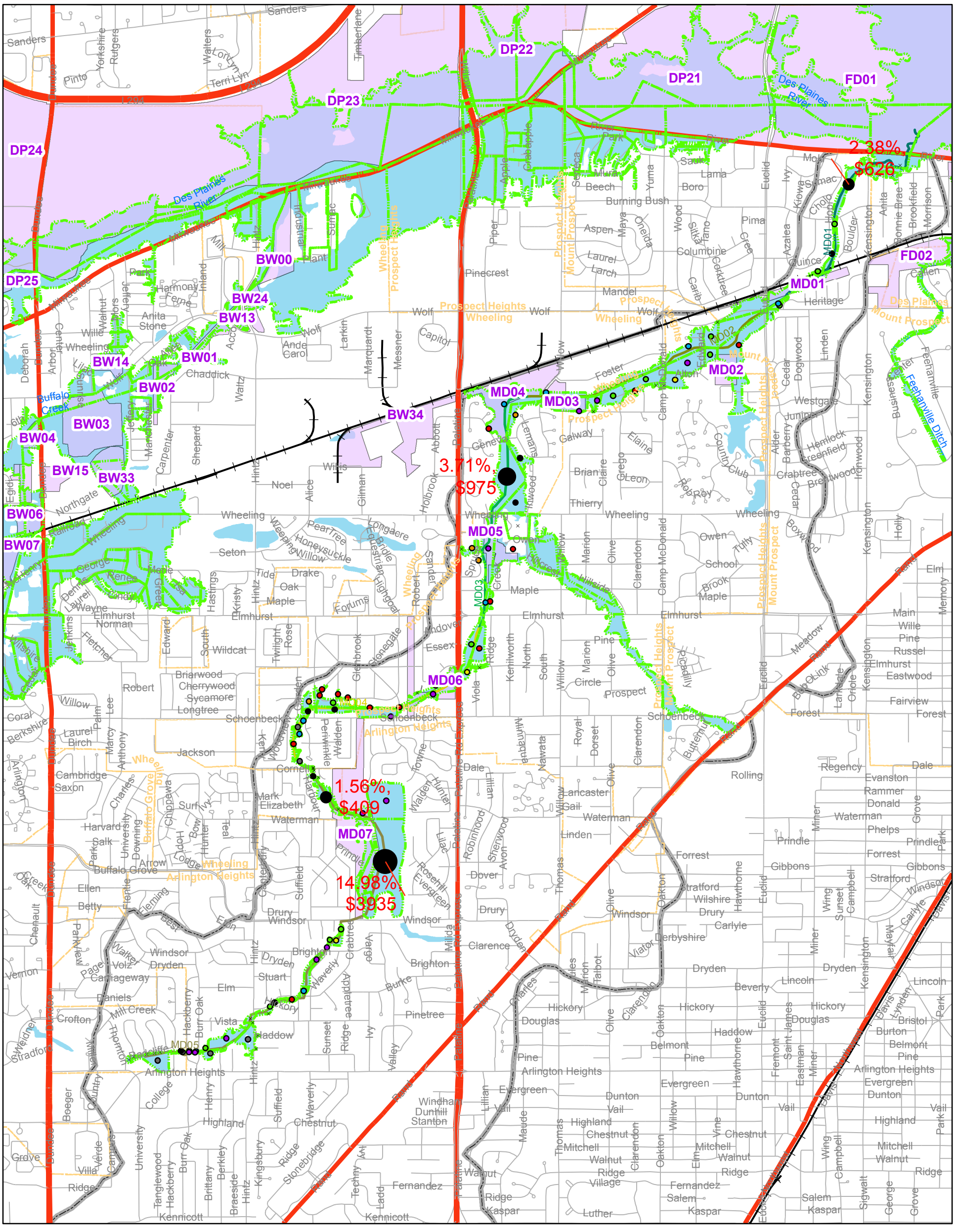
McDonald Creek Vehicle Damages

U.S. Army Corps of Engineers
Chicago District



Legend

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR
- MD01
- MD02
- MD03
- MD04
- MD05
- Roads
- Highways
- RailRoads
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

EAD Contribution

PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.

0 750 1,500 3,000
Feet

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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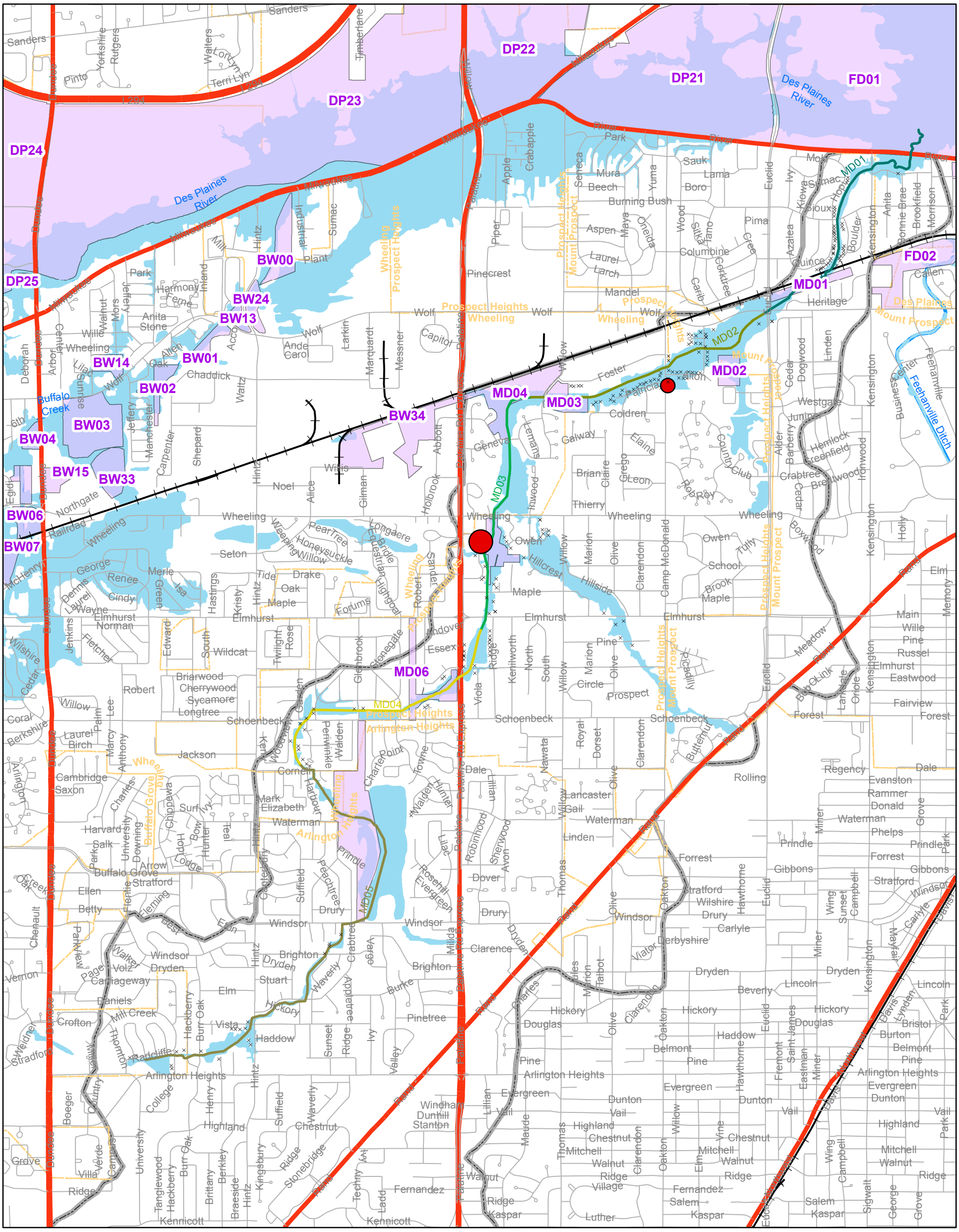
McDonald Creek Structure Damages

U.S. Army Corps of Engineers
Chicago District



Legend

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR
- MD01
- MD02
- MD03
- MD04
- MD05
- Roads
- Highways
- RailRoads
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

EAD Contribution

PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.

0 750 1,500 3,000
Feet

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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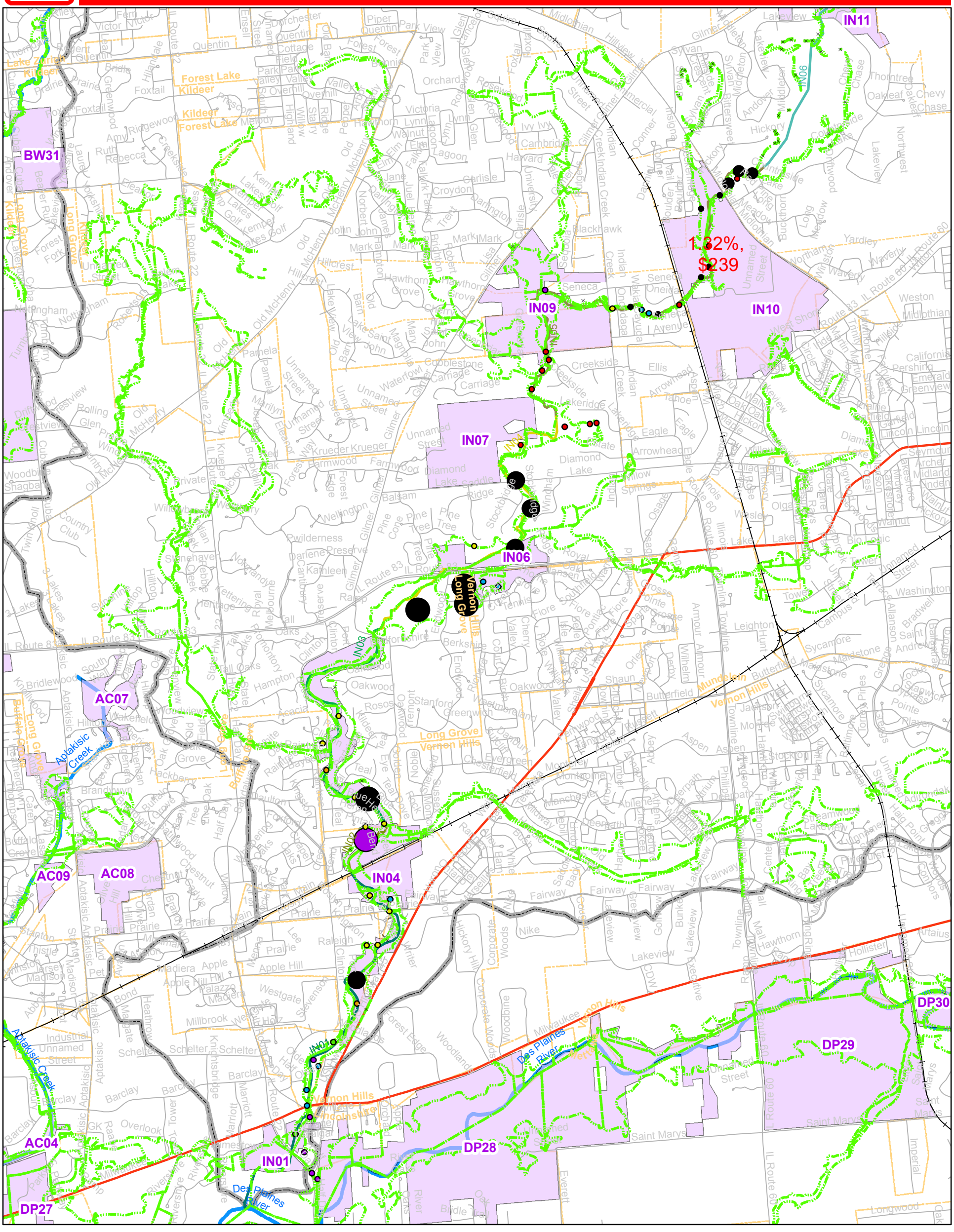
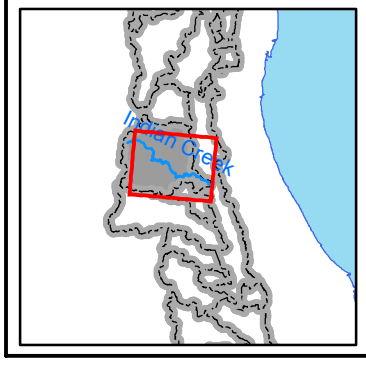
Indian Creek Vehicle Damages

U.S. Army Corps of Engineers
Chicago District





Legend

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR
- IN01
- IN02
- IN03
- IN04
- IN05
- IN06
- RailRoads
- Roads
- Highways
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- FDR Potential Reservoir Sites
- Vehicle Damages

0 1,000 2,000 4,000
Feet

EAD Contribution

PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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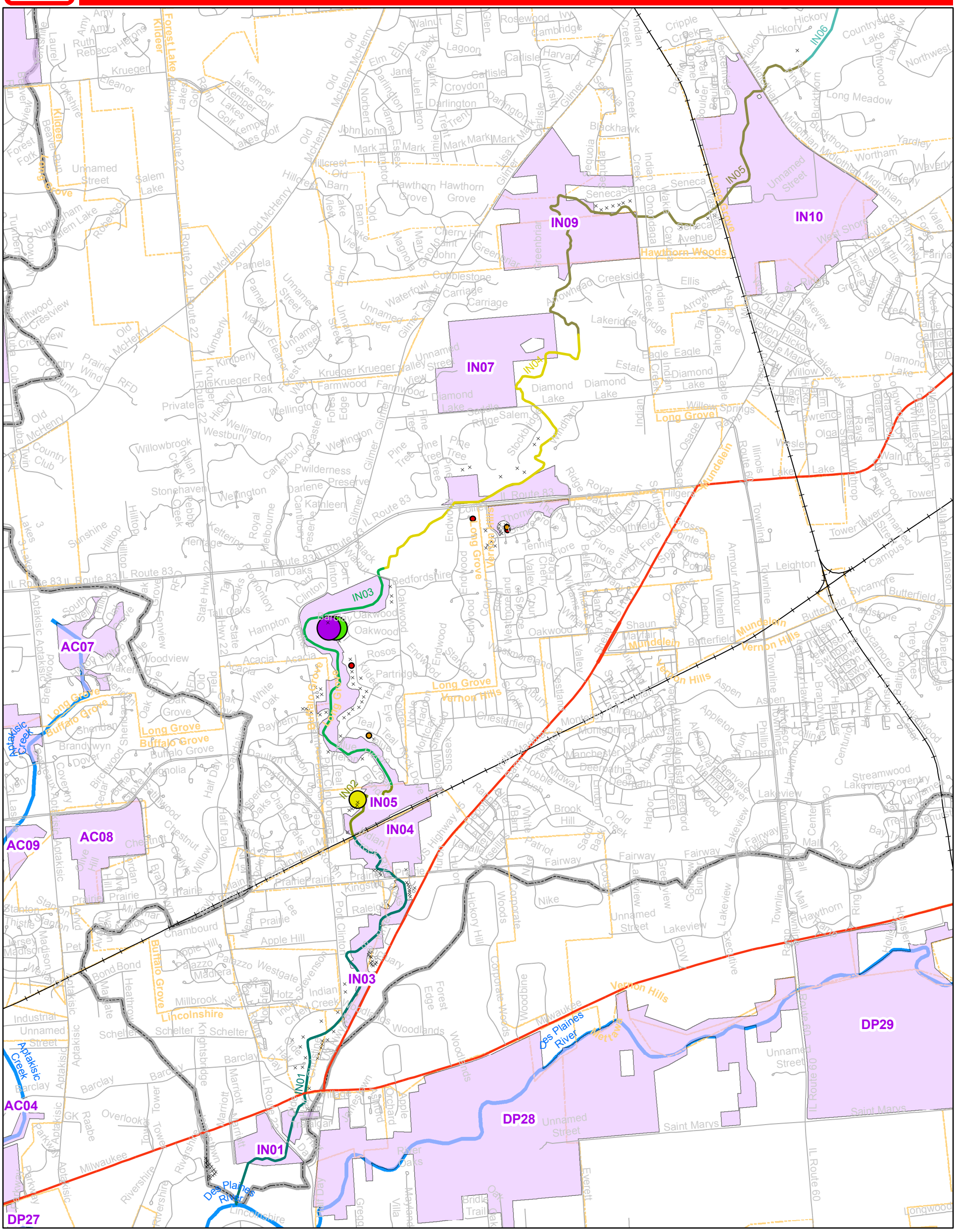
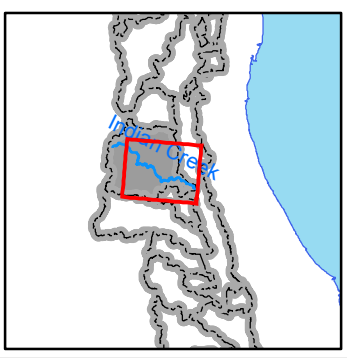
Indian Creek Structure Damage

U.S. Army Corps of Engineers
Chicago District





Legend

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR
- IN01
- IN02
- IN03
- IN04
- IN05
- IN06
- RailRoads
- Roads
- Highways
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- FDR Potential Reservoir Sites
- Vehicle Damages

0 850 1,700 3,400
Feet

EAD Contribution
PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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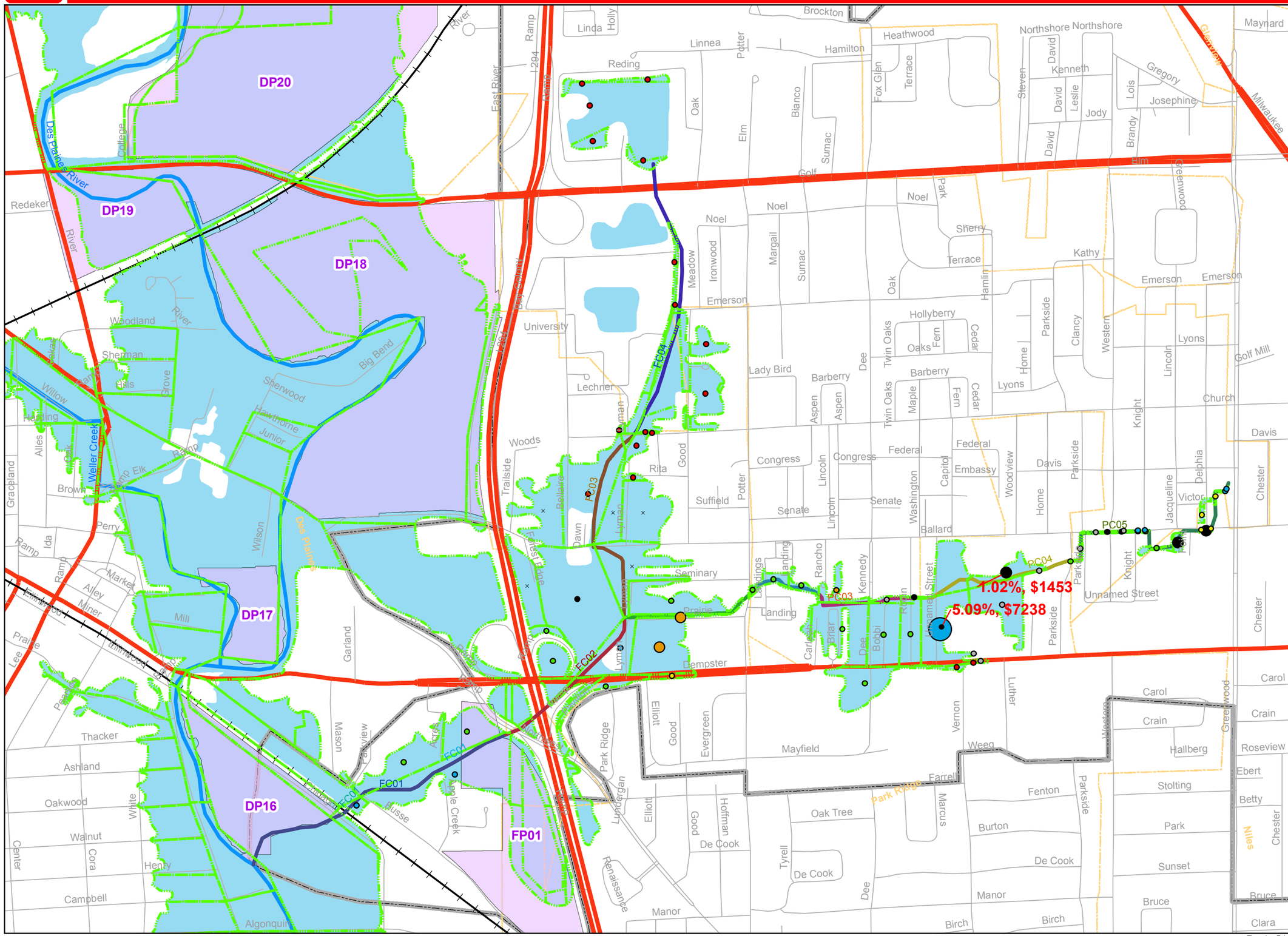
Farmers Prairie Creek - Vehicle Damages

U.S. Army Corps of Engineers
Chicago District



Legend

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR
- RailRoads
- Roads
- Highways
- Streams

Reach

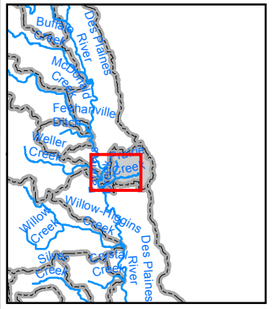
- FC01
- FC02
- FC03
- FC04
- PC01
- PC02
- PC03
- PC04
- PC05
- Counties
- Subwatersheds
- Floodplain
- FDR Potential Reservoir Sites
- Vehicle Damages

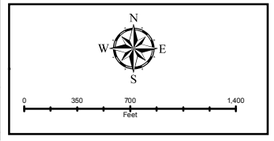
EAD Contribution

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- > 1.5 Std. Dev.

Source: Floodplains - FEMA DFIRM Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets/Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

Location Map





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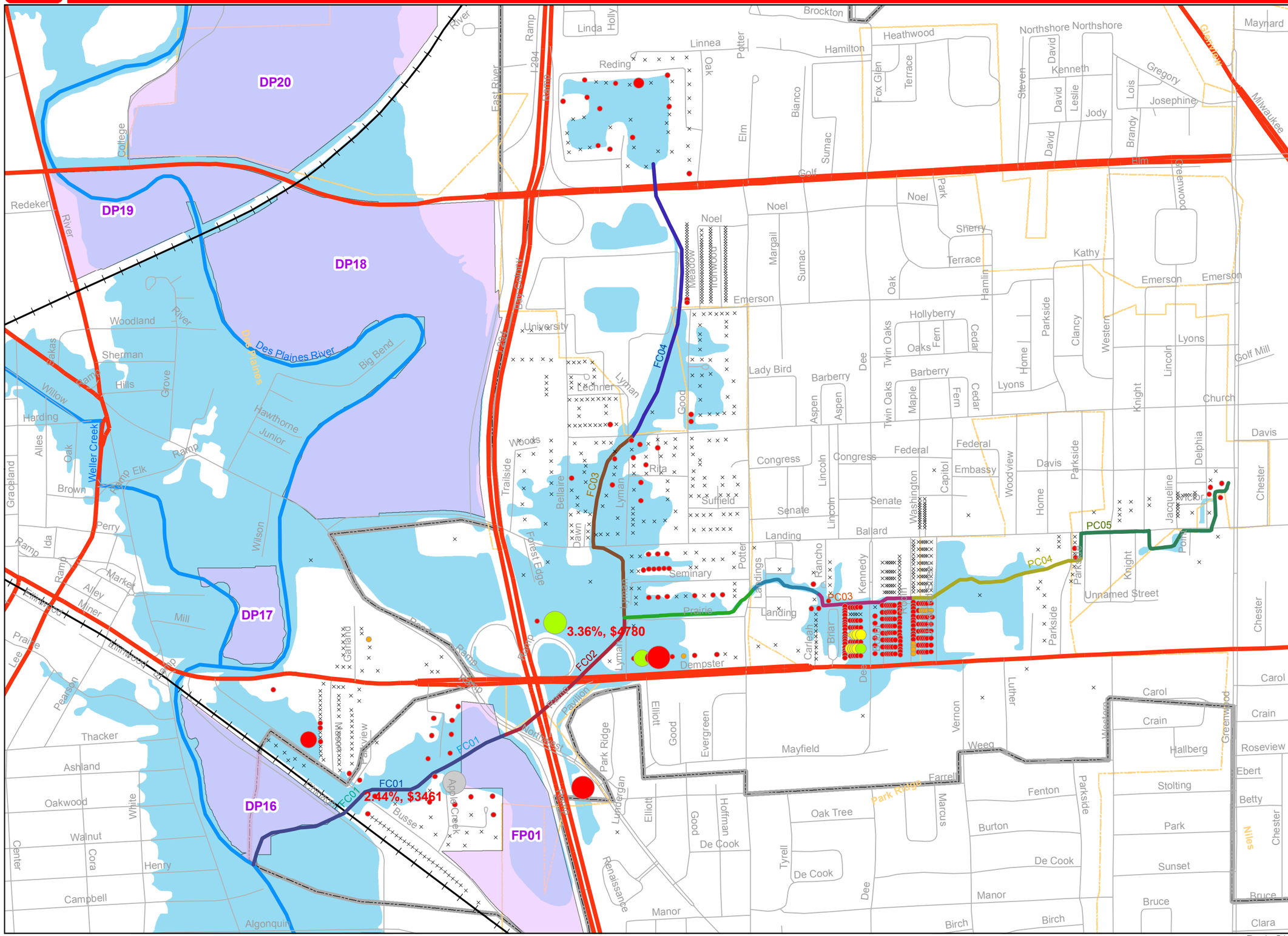
Farmers Prairie Creek - Structural Damages

U.S. Army Corps of Engineers
Chicago District



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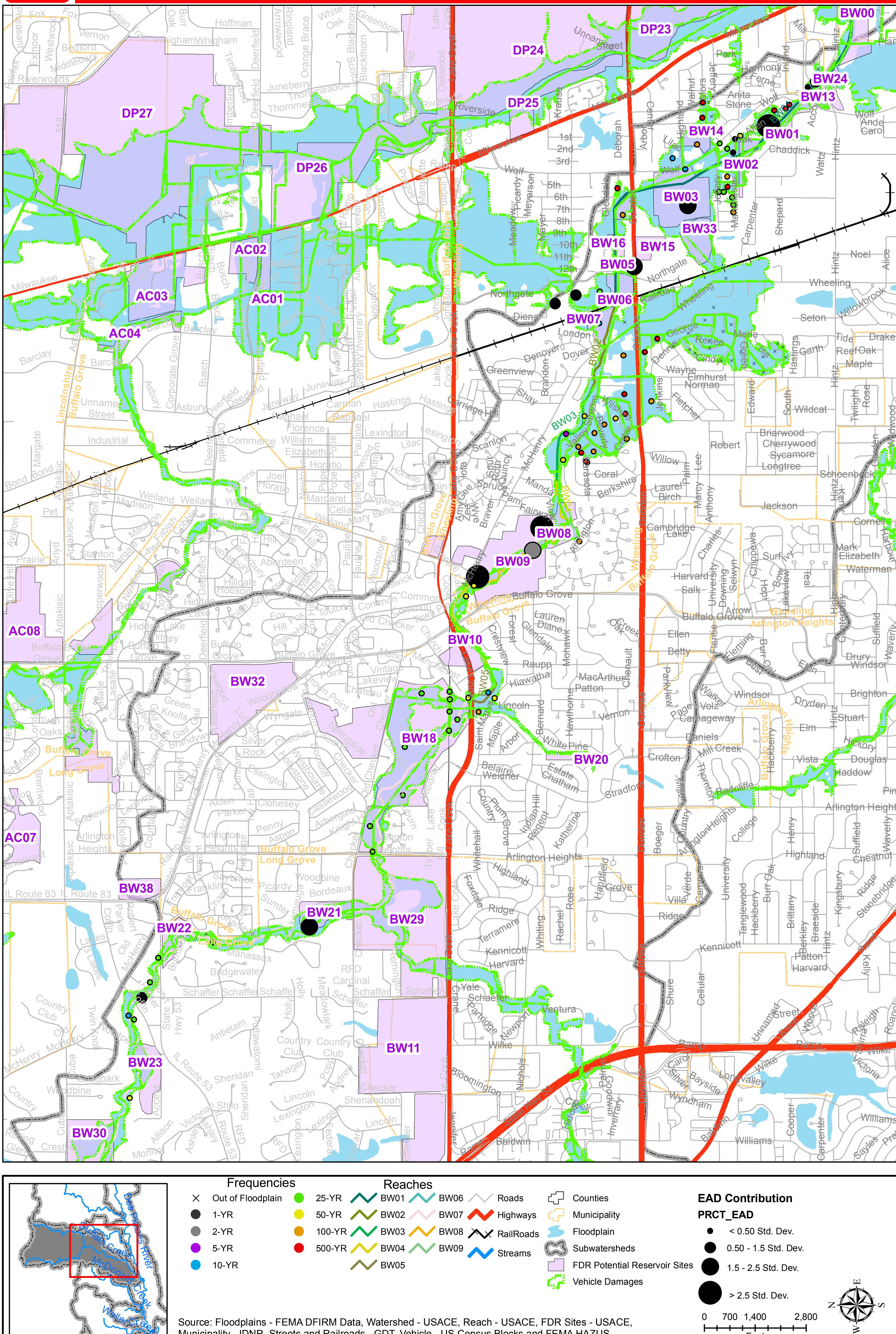
EAD 2010 W/ Uncertainty ($1,000) 2009PL										
	APT	RES	COM	IND	PUB	VEH_DAM	RD_REP	TR_FLD	TR_REP	Total
Silver Creek	$ 3.40	$ 1,094.76	$ 284.00	$ 227.77	$ 0.13	$ 98.87	NA	NA	NA	$ 1,708.93
Farmers-Prairie Creek	$ 2.20	$ 62.88	$ 70.54	$ 0.00	$ 20.44	$ 203.22	NA	NA	NA	$ 359.29
Buffalo Wheeling Creek	$ 12.45	$ 266.45	$ 28.59	$ 8.84	$ -	$ 168.09	NA	NA	NA	$ 484.41
Willow-Higgins Creek	$ 0.01	$ 4.47	$ 14.41	$ -	$ -	$ 27.79	NA	NA	NA	$ 46.67
Indian Creek	$ -	$ 9.11	$ 0.00	$ -	$ -	$ 68.11	NA	NA	NA	$ 77.22
Bull Creek	$ -	$ 5.98	$ -	$ -	$ 3.42	$ 49.48	NA	NA	NA	$ 58.88
Newport Ditch	$ -	$ 137.24	$ -	$ -	$ -	$ 12.84	NA	NA	NA	$ 150.08
Mill Creek	$ -	$ -	$ -	$ -	$ -	$ -	NA	NA	NA	$ -
Weller Creek	$ -	$ 76.77	$ 0.07	$ 0.00	$ -	$ 114.77	NA	NA	NA	$ 191.61
McDonald Creek	$ -	$ 0.13	$ -	$ -	$ -	$ 96.55	NA	NA	NA	$ 96.68
Overall	$ 18.06	$ 1,657.78	$ 397.61	$ 236.61	$ 23.99	$ 839.73	NA	NA	NA	$ 3,173.79
EAD 2020 W/ Uncertainty ($1,000) 2009PL										
	APT	RES	COM	IND	PUB	VEH_DAM	RD_REP	TR_FLD	TR_REP	Total
Silver Creek	$ 3.78	$ 1,286.96	$ 479.86	$ 404.20	$ 0.41	$ 104.59	NA	NA	NA	$ 2,279.79
Farmers-Prairie Creek	$ 2.20	$ 62.88	$ 70.54	$ 0.00	$ 20.44	$ 203.22	NA	NA	NA	$ 359.29
Buffalo Wheeling Creek	$ 12.13	$ 285.50	$ 29.82	$ 9.38	$ -	$ 171.19	NA	NA	NA	$ 508.02
Willow-Higgins Creek	$ 0.25	$ 3.38	$ 19.73	$ 0.08	$ -	$ 28.28	NA	NA	NA	$ 51.72
Indian Creek	$ -	$ 38.69	$ 0.33	$ -	$ -	$ 78.21	NA	NA	NA	$ 117.23
Bull Creek	$ -	$ 7.54	$ -	$ -	$ 4.55	$ 45.69	NA	NA	NA	$ 57.78
Newport Ditch	$ -	$ 158.94	$ -	$ -	$ -	$ 13.64	NA	NA	NA	$ 172.58
Mill Creek	$ -	$ -	$ -	$ -	$ -	$ -	NA	NA	NA	$ -
Weller Creek	$ -	$ 99.80	$ 0.07	$ 0.00	$ -	$ 118.38	NA	NA	NA	$ 218.26
McDonald Creek	$ -	$ 0.15	$ -	$ -	$ -	$ 97.82	NA	NA	NA	$ 97.97
Overall	$ 18.37	$ 1,943.86	$ 600.34	$ 413.66	$ 25.40	$ 861.01	NA	NA	NA	$ 3,862.65

APT	Apartment and Townhomes
RES	Residential Structures
COM	Commercial Structures
IND	Industrial Structures
PUB	Public Structures
VEH_DAM	Damage to stationary vehicles
RD_REP	Flood induced road damages
TR_FLD	Delay damages induced by road closures
TR_REP	Damages due to delays induced by road repair work

Buffalo Creek Vehicle Damage

U.S. Army Corps of Engineers Chicago District



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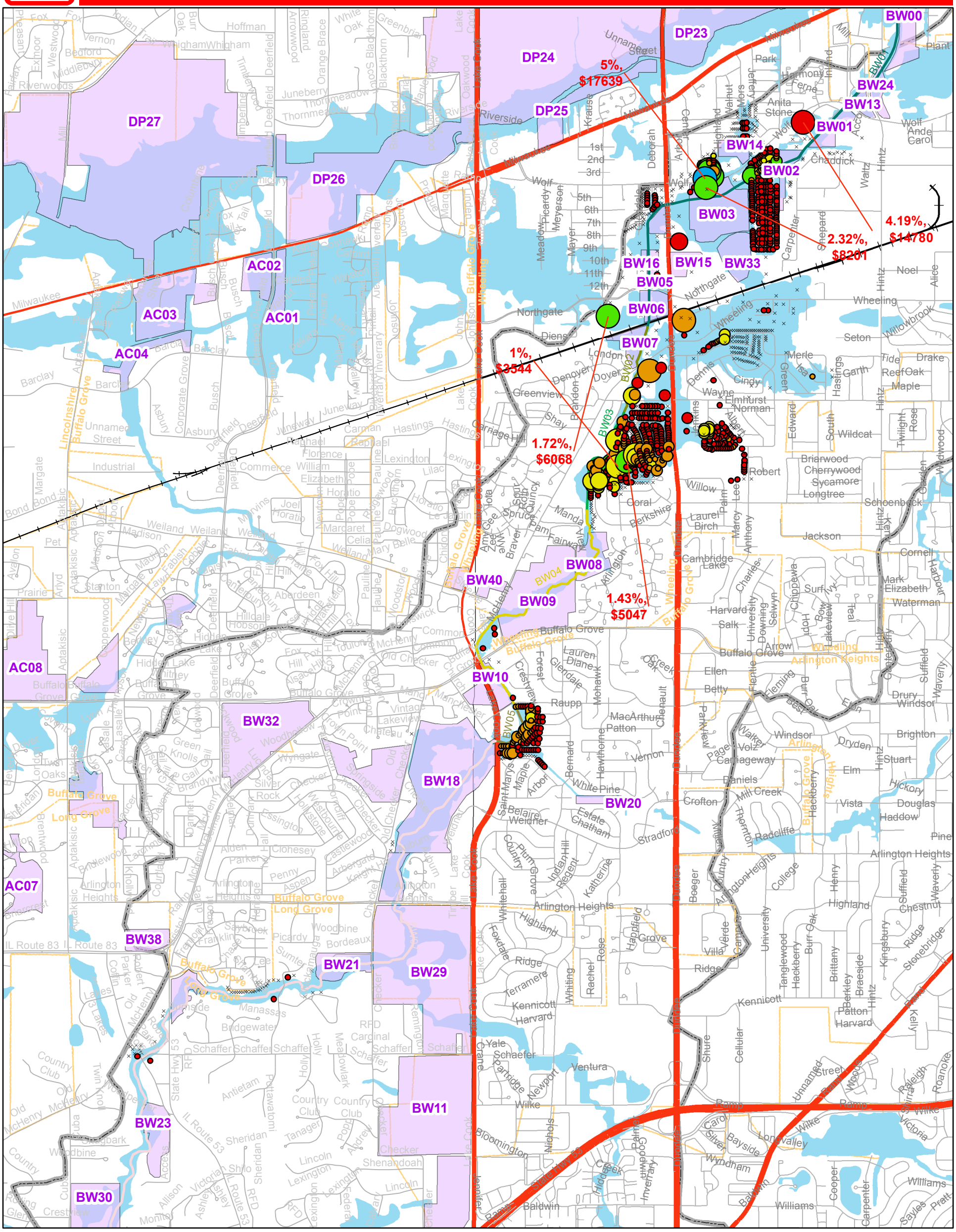
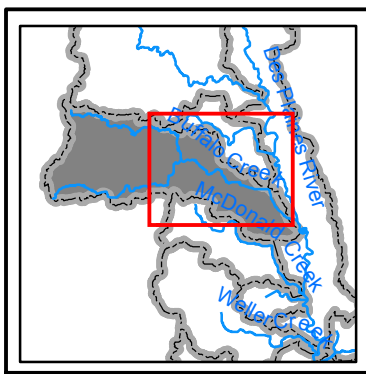
Buffalo Creek Structure Damage

U.S. Army Corps of Engineers
Chicago District





Frequencies

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

Reaches

- BW01
- BW02
- BW03
- BW04
- BW05
- BW06
- BW07
- BW08
- BW09

- Roads
- Highways
- RailRoads
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- FDR Potential Reservoir Sites
- Vehicle Damages

EAD Contribution

PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

0 700 1,400 2,800
Feet

Source: Floodplains - FEMA DFIRM Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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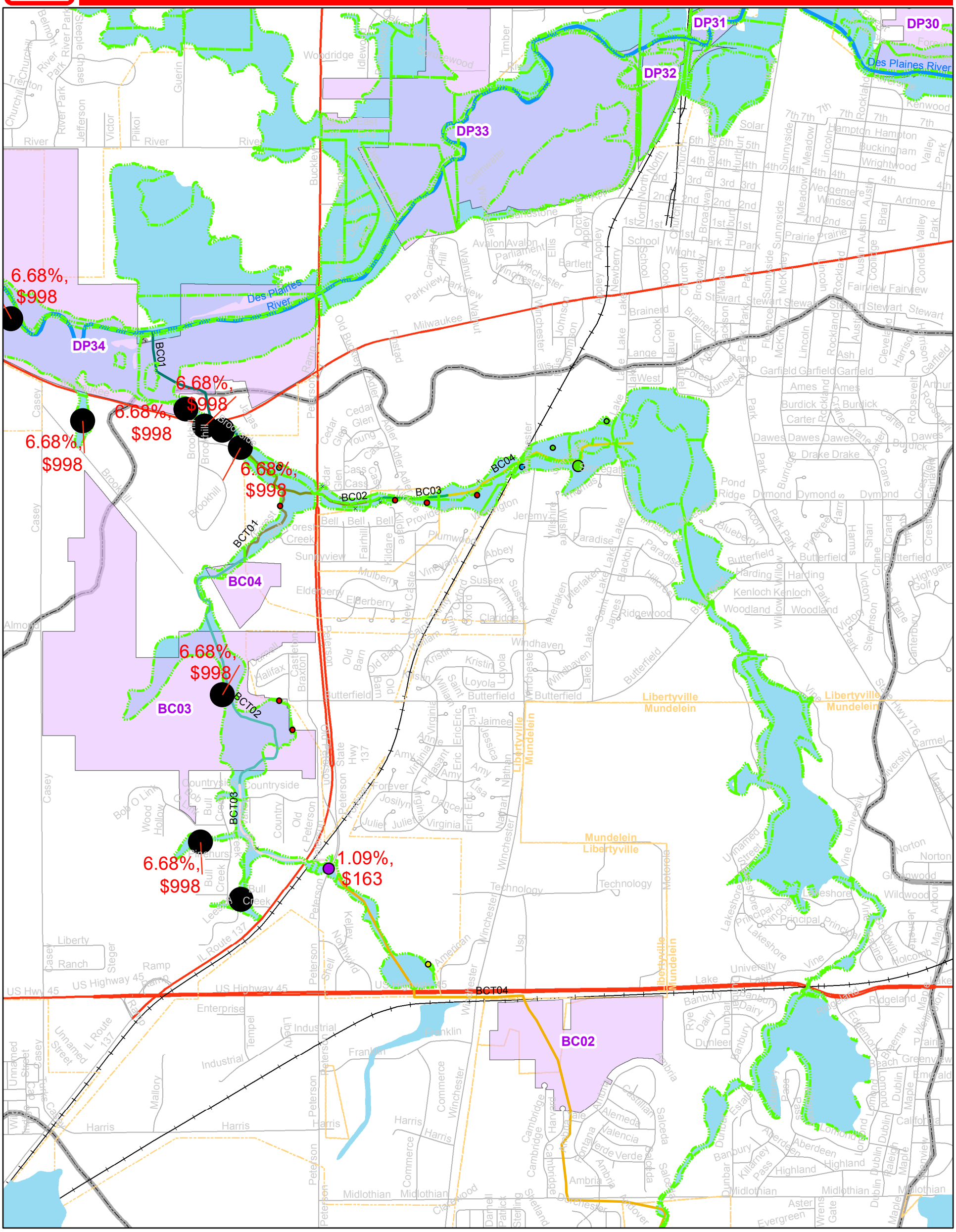
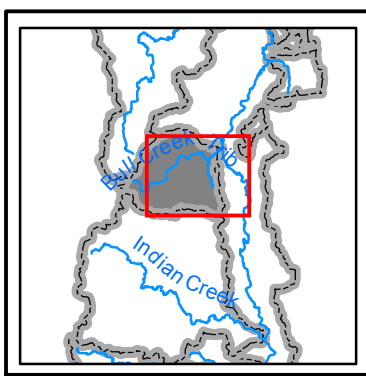
Bull Creek Vehicle Damages

U.S. Army Corps of Engineers
Chicago District





Frequency

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

Reaches

- BC01
- BC02
- BC03
- BC04
- BCT01
- BCT02
- BCT03
- BCT04

- Streams
- RailRoads
- Roads
- Highways
- Counties
- Municipality
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

0 500 1,000 2,000
Feet

EAD Contribution

PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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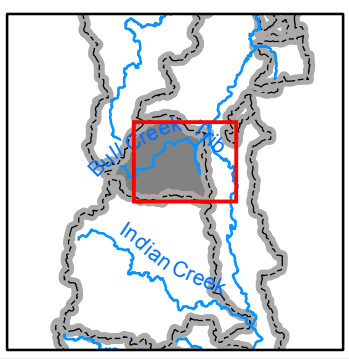
Bull Creek Structural Damages

U.S. Army Corps of Engineers
Chicago District

DP30
DP31
DP32
DP33
DP34
BC01
BC02
BC03
BC04
BCT01
BCT02
BCT03
BCT04
Des Plaines River
1.8%, $269
1.23%, $184
3.22%, $481
1.58%, $236
1.93%, $289
1.85%, $276
18.99%, $2836
9.37%, $1400
2.14%, $320
4.8%, $717
1.4%, $209
5.24%, $783
Libertyville
Mundelein



Frequency

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR

Reaches

- BC01
- BC02
- BC03
- BC04
- BCT01
- BCT02
- BCT03
- BCT04

- Streams
- RailRoads
- Roads
- Highways
- Counties
- Municipality
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

0 500 1,000 2,000
Feet

EAD Contribution
PRCT_EAD

- < 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

N E S W

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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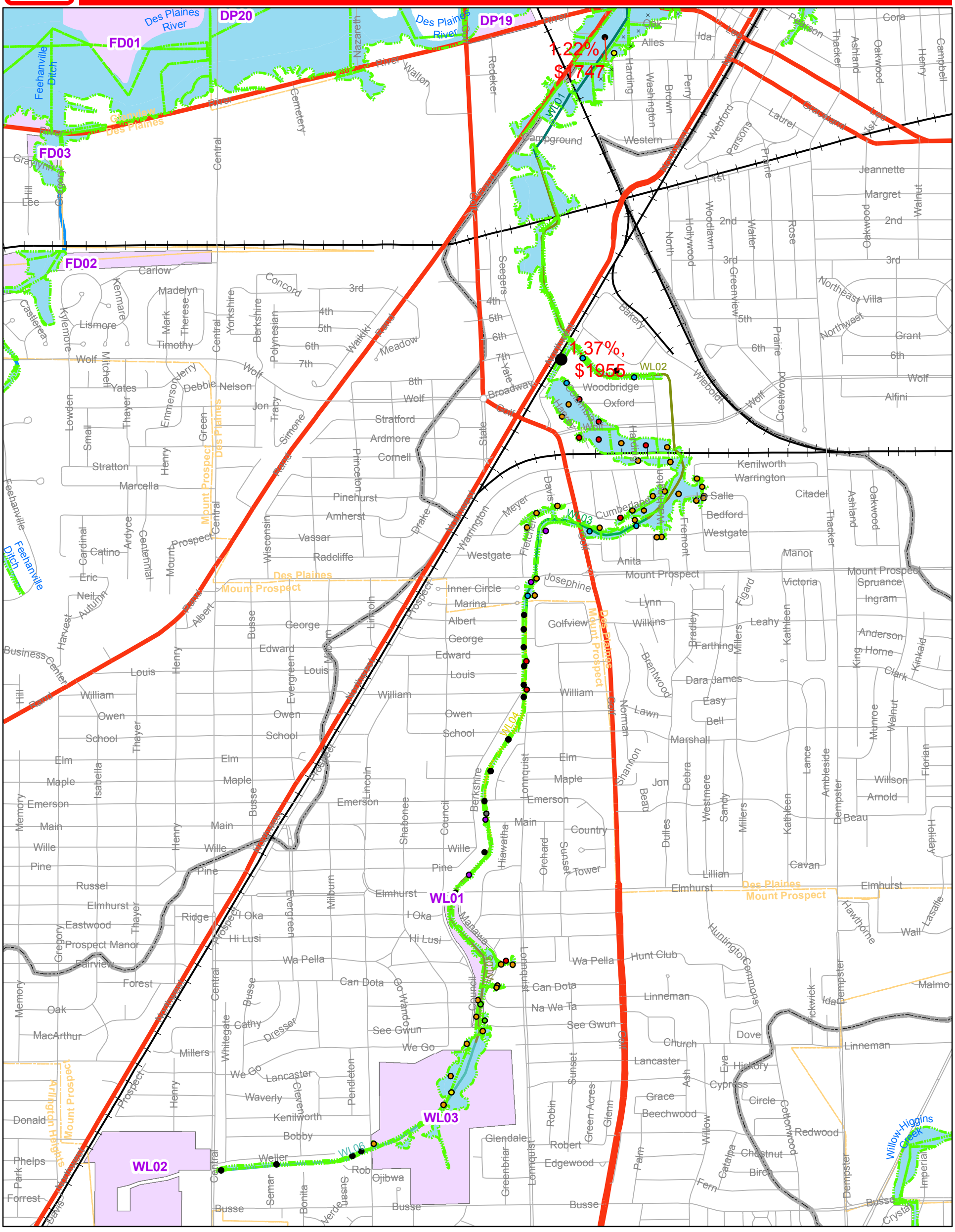
Weller Creek Vehicle Damages

U.S. Army Corps of Engineers
Chicago District



Legend

Frequency

- Out of Floodplain
- 1-YR
- 2-YR
- 5-YR
- 10-YR
- 25-YR
- 50-YR
- 100-YR
- 500-YR
- WL01
- WL02
- WL03
- WL04
- WL05
- WL06
- Roads
- Highways
- RailRoads
- Streams
- Counties
- Municipality
- Floodplain
- Subwatersheds
- Vehicle Damages
- FDR Potential Reservoir Sites

0 490 980 1,960
Feet

EAD Contribution
'GIS Report$'.PRCT_EAD

- < -0.50 Std. Dev.
- -0.50 - 0.50 Std. Dev.
- 0.50 - 1.5 Std. Dev.
- 1.5 - 2.5 Std. Dev.
- > 2.5 Std. Dev.

Source: Floodplains - FEMA Q3 Data, Watershed - USACE, Reach - USACE, FDR Sites - USACE, Municipality - IDNR, Streets and Railroads - GDT, Vehicle - US Census Blocks and FEMA HAZUS

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Attachment 5

CELRC-PM-PL-F 13 April 2009

MEMORANDUM FOR RECORD

SUBJECT: Examination of LiDAR elevation per Cook and Lake County Parcel relative to the MWRD and Illinois Department of Natural Resources survey of that parcel's structure

DEFINITION OF TERMS AS USED IN THIS DOCUMENT

MEAN – The average elevation calculated for a parcel based on LiDAR point data.
MIN – The minimum elevation for a parcel based on LiDAR point data.
MAX – The maximum elevation for a parcel based on LiDAR point data.
FFE – The first floor elevation of a parcels main structure as measured by MWRD's contractor.
LWE – The low water entry point of a parcels main structure as measured by MWRD's contractor.
GFE – The ground elevation of a parcels main structure as measured by MWRD's contactor.
Average STDEV on Parcel – Each parcel's mean elevation and standard deviation is tabulated for all elevations recorded for that parcel. This value is the average of standard deviations across the residential classification under review.
Average – the average difference amongst a particular category.
Stdev – the standard deviation of the difference amongst a particular category.
UCL,LCL – the upper (UCL) and lower (LCL) confidence limits of the average at an alpha of 5%.
RES – Residential Structure general classification
1SWB – One Story Structure with basement
2SWB – Two Story Structure with basement
1SNB – One Story Structure no basement
2SNB – Two Story Structure no basement
SLWB – Split Level with basement

PROCESS

1. Cook/Lake County Parcel GIS layer was joined to the PIN list from the MWRD/INDR survey data.
2. Cook County LiDAR point/Lake County Contour data was converted to a TIN and then a raster file using 15 foot posting per point. The ESRI function used, Zonal Statistics as Table, requires the use of a raster image. The process intersects the parcel polygon and the raster and computes statistics for raster cells in that polygon. The focus of the study herein is on the MEAN elevation per parcel, MIN elevation per parcel, and MAX elevation per parcel.
3. The examination focused on the difference between the elevations that were actually measured for the main structure that sits on a parcel and what could be obtained from the LiDAR or Contour data set.

4. We used the simplifying assumption of normality within the dataset.
5. Dataset was trimmed by tossing our values which show a difference between the survey elevation and the comparison elevation of greater or less than 10 feet.
6. Upper and Lower confidence limits were established to indentify if categories were statistically different.
7. Beginning damages is measured as the distance from the first floor to the lowest water entry elevation, however if the ground elevation is higher than the LWE, then the distance from the first floor to the ground entry is the beginning depth at which flooding would occur.

REVIEW

Cook County

1. Residential One-Story with Basement
    a. There is a strong correlation between the mean value of the parcel's elevation and the first floor, lowest adjacent elevation, and the ground elevation; however, there is also a strong correlation of these values to the maximum value of the parcel.
    b. The lowest adjacent elevation and the ground elevation are not statistically different; therefore they are treated as equals. In this case individual structure beginning damages would not have to be calculated; rather the smallest difference of lowest adjacent elevation value and the ground elevation was taken due to their values being so close. In the case of this category the value was 0.7 subtracted from 2.96. The beginning damage for this occupancy code is 2.26 feet below first floor.
2. Residential Two-Story with Basement
    a. There is a strong correlation between the mean value of the parcel's elevation and the first floor, lowest adjacent elevation, and the ground elevation; however, there is also a strong correlation of these values to the maximum value of the parcel.
    b. The lowest adjacent elevation and the ground elevation are statistically different; therefore the value that produces the smallest absolute difference from the first floor was taken to be the beginning depth damage. In the case of this category the GFE value was 1.01 subtracted from 3.50. The beginning damage for this occupancy code is 2.49 feet below first floor.
3. Residential Split Level with Basement
    a. Again, there is a strong correlation between the mean parcel elevation and the maximum parcel valuation to the surveyed first floor. Again, there is no

statistical difference between the lowest adjacent elevation and the ground elevation.

b. Since there no statistical difference between LWE and GFE, but the value ranging from 0.49 to 0.80 and approximate averaged value of 0.6 was subtracted from 2.41. The beginning depth damage for this occupancy code is 1.81 feet below the first floor.

Lake County

- Lake County shows a strong correlation to the Parcel's maximum elevation. This could be due impart to selecting the high ground as the most suitable location to build since the inception of the NFIP. It may also be tied to the algorithm used to strip trees and buildings out of the initial ground survey. The maximum could reflect the foundation of homes after the initial ground has been processed.

1. Residential One-Story with Basement
    a. The first floor is 1.78 higher than the maximum parcel elevation. The beginning depth damage is 2.33 feet.
2. Residential Two-Story with Basement
    a. The first floor is 2.64 higher than the maximum parcel elevation. The beginning depth damage is 2.66 feet.
3. Residential One-Story no Basement
    a. The first floor is 1 higher than the maximum parcel elevation. The beginning depth damage is 0.95 feet.
4. Residential Two-Story no Basement
    a. The first floor is 2.39 higher than the maximum parcel elevation. The beginning depth damage is 0.46 feet.
5. Tri-Level with Basement
    a. The first floor is 2.32 higher than the maximum parcel elevation. The beginning depth damage is 1.3 feet.
6. Tri-Level no Basement
    a. The first floor is 1.94 higher than the maximum parcel elevation. The beginning depth damage is 0.92 feet.
7. Bi-Level with Basement
    a. The first floor is 1.71 higher than the maximum parcel elevation. The beginning depth damage is 1.33 feet.
8. Bi-Level no Basement
    a. The first floor is 1.79 higher than the maximum parcel elevation. The beginning depth damage is 0.8 feet.

RES ,1SWB, Cook County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	2.96	1.5	3.03	2.88									
LWE-MEAN	0.69	1.7	0.79	0.59									
GFE-MEAN	0.79	1.2	0.85	0.72									
FFE-MIN	4.18	1.7	4.28	4.09									
LWE-MIN	2.16	2.2	2.29	2.04									
GFE-MIN	2.23	1.9	2.34	2.13									
FFE-MAX	1.92	1.3	1.98	1.85									
LWE-MAX	-0.37	1.8	-0.24	-0.50									
GFE-MAX	-0.30	1.2	-0.18	-0.41									

Average STDEV on Parcel 0.77

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,2SWB, Cook County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	3.50	1.7	3.64	3.35									
LWE-MEAN	0.49	2.1	0.70	0.28									
GFE-MEAN	1.01	1.4	1.13	0.88									
FFE-MIN	4.85	2.1	5.05	4.65									
LWE-MIN	2.60	2.9	2.88	2.33									
GFE-MIN	3.07	2.6	3.30	2.83									
FFE-MAX	2.13	1.3	2.24	2.02									
LWE-MAX	-1.03	2.1	-0.75	-1.31									
GFE-MAX	-0.51	1.3	-0.29	-0.73									

Average STDEV on Parcel 1.26

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,SLWB, Cook County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	2.41	1.6	2.62	2.19									
LWE-MEAN	0.49	1.9	0.79	0.19									
GFE-MEAN	0.80	1.5	1.02	0.58									
FFE-MIN	3.84	2.0	4.13	3.55									
LWE-MIN	2.19	2.8	2.62	1.76									
GFE-MIN	2.41	2.4	2.74	2.08									
FFE-MAX	1.27	1.0	1.40	1.14									
LWE-MAX	-0.78	1.7	-0.45	-1.11									
GFE-MAX	-0.43	1.1	-0.13	-0.73									

Average STDEV on Parcel 1.11

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,1SNB, Cook County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	3.72	2.5	5.48	1.95									
LWE-MEAN	0.63	3.2	4.27	-3.02									
GFE-MEAN	1.59	2.3	3.32	-0.14									
FFE-MIN	5.22	3.2	7.77	2.68									
LWE-MIN	2.23	1.9	3.75	0.72									
GFE-MIN	3.42	3.2	5.77	1.08									
FFE-MAX	2.37	1.8	3.72	1.01									
LWE-MAX	-1.14	2.7	2.56	-4.83									
GFE-MAX	-0.17	1.4	1.79	-2.13									

Average STDEV on Parcel 1.14

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,2SNB, Cook County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	4.05	3.8	9.36	-1.25									
LWE-MEAN	4.37	2.9	8.41	0.33									
GFE-MEAN	3.47	3.4	8.22	-1.29									
FFE-MIN	5.26	#DIV/0!	#DIV/0!	#DIV/0!									
LWE-MIN	4.40	#DIV/0!	#DIV/0!	#DIV/0!									
GFE-MIN	3.13	#DIV/0!	#DIV/0!	#DIV/0!									
FFE-MAX	1.18	0.2	1.51	0.84									
LWE-MAX	-0.33	1.2	1.93	-2.59									
GFE-MAX	-1.23	0.6	#NUM!	#NUM!									

Average STDEV on Parcel 2.99

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,SLNB, Cook County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	3.77	#DIV/0!	#DIV/0!	#DIV/0!									
LWE-MEAN	-0.35	#DIV/0!	#DIV/0!	#DIV/0!									
GFE-MEAN	6.13	#DIV/0!	#DIV/0!	#DIV/0!									
FFE-MIN	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!									
LWE-MIN	7.49	#DIV/0!	#DIV/0!	#DIV/0!									
GFE-MIN	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!									
FFE-MAX	2.61	#DIV/0!	#DIV/0!	#DIV/0!									
LWE-MAX	-4.87	#DIV/0!	#DIV/0!	#DIV/0!									
GFE-MAX	1.61	#DIV/0!	#DIV/0!	#DIV/0!									

Average STDEV on Parcel 3.95

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,1SWB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	4.64	2.6	5.02	4.25									
LWE-MEAN	2.37	2.9	2.82	1.91									
GFE-MEAN	1.94	3.0	2.42	1.46									
FFE-MIN	5.96	2.2	6.34	5.58									
LWE-MIN	4.26	2.5	4.66	3.86									
GFE-MIN	3.89	2.7	4.33	3.46									
FFE-MAX	1.78	2.7	2.22	1.34									
LWE-MAX	-0.55	3.0	0.09	-1.18									
GFE-MAX	-1.03	3.0	-0.34	-1.72									

Average STDEV on Parcel 1.83

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,2SWB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	4.95	2.3	5.15	4.74									
LWE-MEAN	2.58	2.5	2.81	2.35									
GFE-MEAN	2.10	2.6	2.35	1.86									
FFE-MIN	6.36	2.3	6.59	6.13									
LWE-MIN	4.84	2.6	5.07	4.60									
GFE-MIN	4.39	2.7	4.63	4.14									
FFE-MAX	2.64	2.5	2.87	2.41									
LWE-MAX	-0.02	3.0	0.31	-0.35									
GFE-MAX	-0.44	3.0	-0.09	-0.78									

Average STDEV on Parcel 1.57

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,1SNB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	3.36	2.4	3.74	2.99									
LWE-MEAN	2.52	2.4	2.91	2.14									
GFE-MEAN	2.20	2.3	2.58	1.82									
FFE-MIN	4.60	2.4	5.00	4.19									
LWE-MIN	3.92	2.6	4.36	3.49									
GFE-MIN	3.75	2.7	4.19	3.31									
FFE-MAX	1.00	2.2	1.39	0.61									
LWE-MAX	0.05	2.3	0.52	-0.41									
GFE-MAX	-0.27	2.3	0.20	-0.75									

Average STDEV on Parcel 1.40

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,2SNB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	3.67	1.8	3.91	3.42									
LWE-MEAN	3.35	1.7	3.59	3.11									
GFE-MEAN	3.11	1.7	3.35	2.87									
FFE-MIN	4.69	1.9	4.97	4.42									
LWE-MIN	4.51	1.9	4.78	4.24									
GFE-MIN	4.34	1.9	4.61	4.06									
FFE-MAX	2.39	1.9	2.66	2.12									
LWE-MAX	1.93	2.1	2.24	1.62									
GFE-MAX	1.68	2.1	2.01	1.36									

Average STDEV on Parcel 0.88

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,TLWB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	3.97	2.2	4.51	3.43									
LWE-MEAN	2.73	2.2	3.28	2.18									
GFE-MEAN	2.26	2.0	2.76	1.76									
FFE-MIN	5.08	2.2	5.65	4.51									
LWE-MIN	3.97	2.2	4.54	3.40									
GFE-MIN	3.90	2.5	4.51	3.28									
FFE-MAX	2.32	2.6	3.01	1.63									
LWE-MAX	0.66	2.9	1.49	-0.18									
GFE-MAX	0.19	2.8	1.03	-0.65									

Average STDEV on Parcel 1.00

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,TLNB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	4.07	2.0	4.61	3.52									
LWE-MEAN	3.31	2.1	3.88	2.75									
GFE-MEAN	2.81	1.9	3.32	2.29									
FFE-MIN	6.03	2.6	6.83	5.23									
LWE-MIN	5.67	2.8	6.49	4.86									
GFE-MIN	5.20	2.7	5.95	4.45									
FFE-MAX	1.94	2.5	2.66	1.23									
LWE-MAX	1.02	2.5	1.80	0.25									
GFE-MAX	0.40	2.2	1.10	-0.29									

Average STDEV on Parcel 1.63

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,BLWB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	3.59	2.1	4.35	2.83									
LWE-MEAN	2.61	1.7	3.24	1.98									
GFE-MEAN	2.12	1.5	2.71	1.54									
FFE-MIN	4.43	1.9	5.19	3.66									
LWE-MIN	3.66	1.8	4.36	2.97									
GFE-MIN	3.16	1.7	3.82	2.51									
FFE-MAX	1.71	1.6	2.32	1.09									
LWE-MAX	0.38	2.4	1.47	-0.70									
GFE-MAX	-0.10	2.2	1.04	-1.24									

Average STDEV on Parcel 1.09

Statistical Different

NOTE: Elevation Differences greater than 10' or -10' were removed from analysis

RES ,BLNB, Lake County

Category	Average	Stdev	UCL	LCL	FFE-MEAN	LWE-MEAN	GFE-MEAN	FFE-MIN	LWE-MIN	GFE-MIN	FFE-MAX	LWE-MAX	GFE-MAX
FFE-MEAN	5.03	2.2	6.37	3.69									
LWE-MEAN	4.70	3.1	6.70	2.69									
GFE-MEAN	3.18	2.9	5.06	1.29									
FFE-MIN	6.69	2.2	8.29	5.09									
LWE-MIN	5.55	2.7	7.54	3.56									
GFE-MIN	4.60	1.9	5.89	3.32									
FFE-MAX	1.79	3.6	4.46	-0.89									
LWE-MAX	0.99	4.3	4.15	-2.17									
GFE-MAX	-0.53	3.7	2.42	-3.48									

Average STDEV on Parcel 1.75

Statistical Different