Implications of Climate Change Driven Flooding in the McCaslin Brook Watershed

Photo Source: http://farm2.static.flickr.com/1252/1316790260_29ea11ff26.jpg

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Geography 578
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Capstone Statement

Locate parcels affected by flooding due to changes in precipitation in the McCaslin Brook Watershed in Oconto County, WI. A series of precipitation scenarios based on climate models are evaluated to assess local climate impact. Maps and charts are generated to guide in infrastructure development.

Conceptualization

Goal

The goal of this analysis is to create a map of affected parcels for a series of current and future flood events. By conducting a hydrologic and hydraulic analysis, the result is a range of flood scenarios for current land use and precipitation, and future land use and precipitation. The flood scenarios can aid in evaluating the impacts of the 10-year, 50-year, and 100-year floods to the future community's land use. See ***Figure 1*** for the Conceptualization Flow Chart.

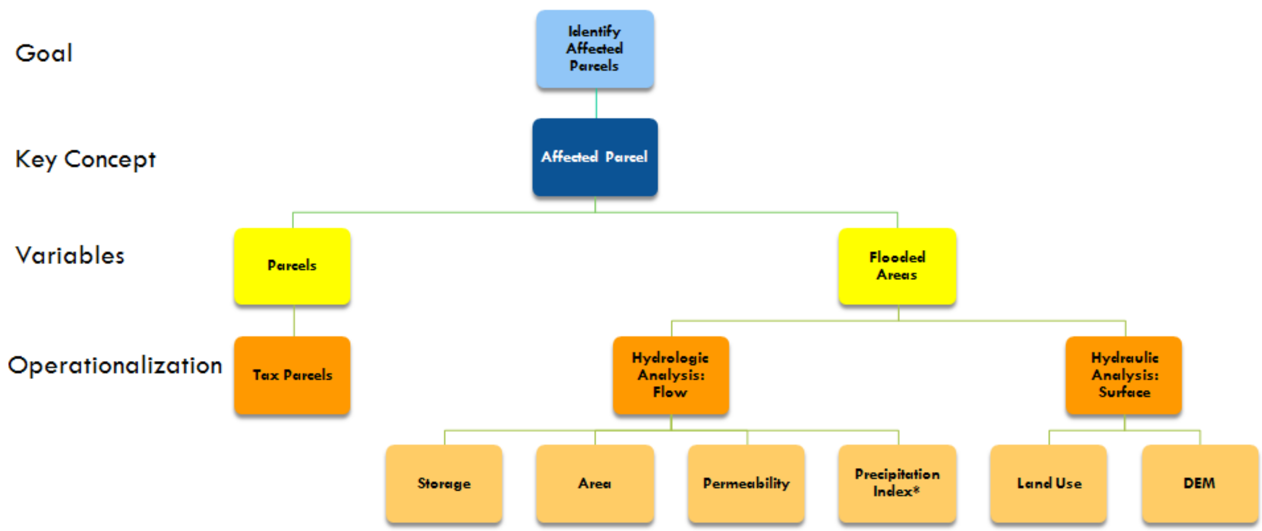

Figure 1: Conceptualization Flow Chart

Key Concept and Variables

The key concept to be evaluated is “affected parcels" which can be conceptualized as parcels and flooded areas. For this analysis, the risk of flooding was applied on a per parcel basis. This knowledge of flooding potential on the affected parcels will further help planners with infrastructure development near the McCaslin Brook.

Operationalization

The parcels can be operationalized as tax parcels. The tax parcels are assigned a single land use type in order to allow for further classification of the inundated parcels.

Flooded areas are operationalized through a hydrologic and hydraulic analysis. The goal of a hydrologic analysis is to find the amount of flow the watershed sends to the river system based on precipitation data. Hydraulic modeling then determines how the specific river system handles the flow of water.

The four characteristics operationalized in the hydrologic analysis are storage, area, soil permeability, and precipitation. For the hydraulic analysis, the main factors operationalized are land use, and the digital elevation model.

Implementation

It is helpful to first think about implementation in general terms before getting to the specifics. The following are the major implementation steps to find parcels that are affected by flooding:

1. Hydrologic Analysis
2. Hydraulic Analysis
3. Finding the Areas of Inundation
4. Finding the Affected Parcels

Step 1: Hydrologic Analysis

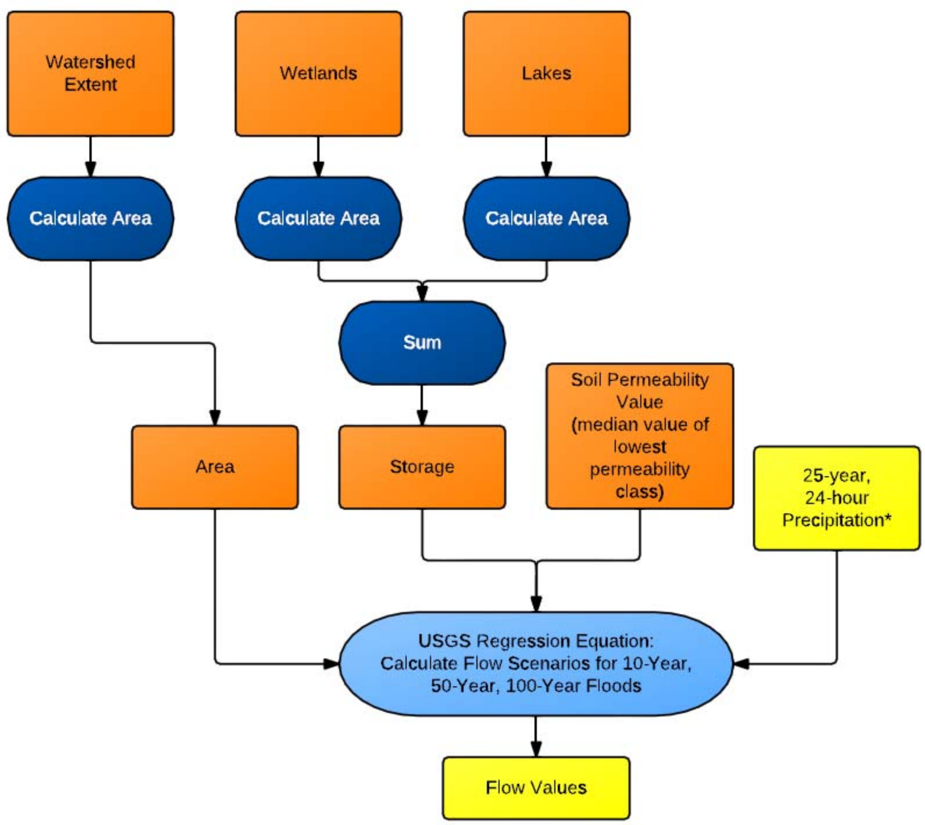

Figure 2: Hydrologic Analysis Implementation Flow Chart

See ***Figure 2*** for the Step 1 Implementation Flow Chart. In order to determine the amount of flow that the McCaslin Brook Watershed sends to the river system based on precipitation data, the USGS Regression Equations method was chosen. This is a methodology that is generally accepted by the Wisconsin Department of Natural Resources (WDNR) and the Federal Emergency Management Agency (FEMA) when performing flooding analyses.

Developed by J.F. Walker and W.R. Krug in *Flood-Frequency Characteristics of Wisconsin Streams* (2003), Wisconsin is broken up into five flood frequency zones based on similar physiographic characteristics (Congers, 1981). For each zone, a set of regression equations was developed to relate flood discharges and drainage-basin characteristics. Refer below to ***Table 1*** for the Zone 3 USGS regression equation.

Area 3 (57 stations)								
Q_2	=	$36.5\,A^{0.832}$	$SP^{-0.614}$	$ST^{-0.143}$	$I_{25}^{0.124}$	.1591	37	3-1
Q_5	=	$61.6\,A^{0.827}$	$SP^{-0.683}$	$ST^{-0.169}$	$I_{25}^{0.133}$	.1470	34	3-2
Q_{10}	=	$80.6\,A^{0.825}$	$SP^{-0.713}$	$ST^{-0.186}$	$I_{25}^{0.135}$	.1449	34	3-3
Q_{25}	=	$107.0\,A^{0.821}$	$SP^{-0.743}$	$ST^{-0.204}$	$I_{25}^{0.136}$	.1439	34	3-4
Q_{50}	=	$127.0\,A^{0.819}$	$SP^{-0.761}$	$ST^{-0.215}$	$I_{25}^{0.136}$	.1446	34	3-5
Q_{100}	=	$149.0\,A^{0.818}$	$SP^{-0.775}$	$ST^{-0.227}$	$I_{25}^{0.136}$	.1466	34	3-6

Table 1: USGS Regression Equations for Zone 3

[A, contributing drainage area in square miles; I_{25}-, 25-year, 24-hour precipitation intensity, in inches minus 4.2; ST, storage, in percent of basin area plus 1.0; SP, soil permeability of the least-permeable soil horizon in inches per hour; Q_n, peak flood discharge in cubic feet per second, with an *n*-year recurrence interval]

Area was determined by calculated using the watershed extent in GIS. Soil permeability was found by referring to the accompanying soil permeability map in the *Flood-Frequency Characteristics of Wisconsin Streams (Plate 2)*, using the lowest soil permeability range for the watershed extent and choosing the median value. Storage was calculated by summing the area of the lakes and wetlands in the watershed.

The I_{25} value for the current land use and precipitation scenarios was found by referring to the accompanying 25-year, 24-hour rainfall in Wisconsin by climatic section in the *Flood-Frequency Characteristics of Wisconsin Streams (refers to Huff and Angel, 1992)*. The I_{25} value for the future land use and precipitation scenarios was found by referring to the work of UW-Madison graduate student Zach Schuster who developed the 25-year, 24-hour rainfall as part of the Wisconsin Climate Change Initiative (WICCI) for 2046-2065 period. The average of the 14 climate change models was used, which is general practice in the climate modeling community.

Flow was found for the 10-year, 50-year, and 100-year floods to examine the range of flood events and how climate change may affect them.

Step 2: Hydraulic Analysis

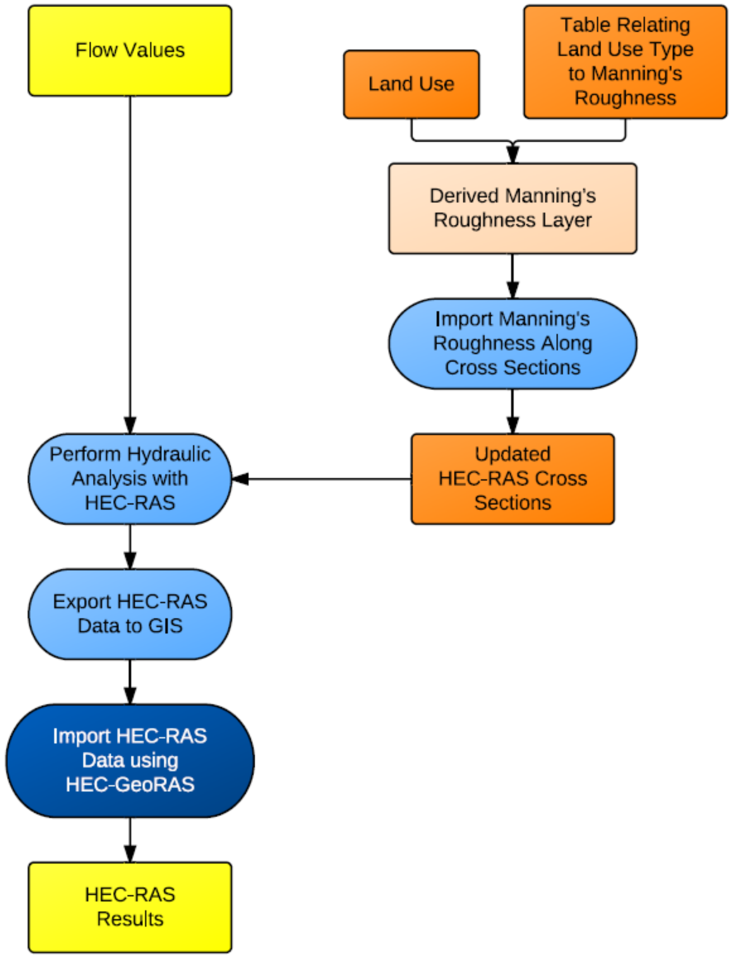

Figure 3: Hydraulic Analysis Implementation Flow Chart

Refer to ***Figure 3*** for the Step 2 Implementation Flow Chart. To define how the McCaslin Brook handles the flow calculated using the USGS Regression Equations, a model called HEC-RAS was chosen. The Hydrologic Engineering Centers River Analysis System, commonly referred to as HEC-RAS, was developed by the US Army Corps of Engineers and is generally accepted by the WDNR and FEMA when performing flooding analyses.

HEC-RAS operates by looking at a series of cross sections along the river. For each cross section, the user can define the elevations along the cross section, bridges and culverts, and the friction-loss that occurs due to changes in land use and floodplain roughness (called Manning's roughness, n). HEC-RAS then performs one-dimensional hydraulic calculations for the river system, using flow as a primary input. The output is a series of water elevations at each river cross section for the three different flow scenarios.

The McCaslin Creek HEC-RAS model that was used for this project was developed by Atkins (formerly PBS&J) in 2008 using LiDAR elevation data at each cross section and was downloaded through the WDNR Surface Water Viewer. However, the model was very general in terms of defining Manning's roughness along the river cross section (there was only one value for the channel, one for the left bank, and one for the right bank). It was determined that creating a more refined Manning's roughness along the river cross section for the current land use and future land use would greatly enhance the analysis.

A GIS layer was developed for the current and Manning's roughness using a table relating land use and Manning's roughness from several sources (see ***Table 2*** below). When possible, using the value determined by Chow was utilized, as Chow is the source most often relied upon for Manning's roughness values for the floodplain. Chow did not provide Manning's roughness values for all the of the different land use types in Oconto County, especially for developed land uses.

Land Use	Manning's Roughness Value	Source
Residential	0.15	Army Corps of Engineers
Commercial	0.05	Wamsley
Government	0.05	Wamsley
Parks & Recreation	0.025	Wamsley
Woodlands	0.12	Chow
Agricultural	0.04	Chow
Water	0.025	Chow
Mobile Homes	0.15	Army Corps of Engineers
Industrial	0.05	Wamsley
Roads	0.02	Chow
Transportation	0.02	Chow
Communications/Utilities	0.05	Wamsley
Open Space/Fallow Fields	0.03	Chow
Land Under Development	0.15	Army Corps of Engineers

Table 2: Manning's Roughness Values for Land Uses

The Manning's roughness values were imported along each river cross section for the current and future land use.

After inputting the Manning's roughness values, the flow scenarios were inputted for the current and future precipitation scenarios, and the HEC-RAS models were run, resulting in a current and future water surface elevation at each river cross section for the 10-year, 50-year, and 100-year floods.

Step 3: Finding the Areas of Inundation

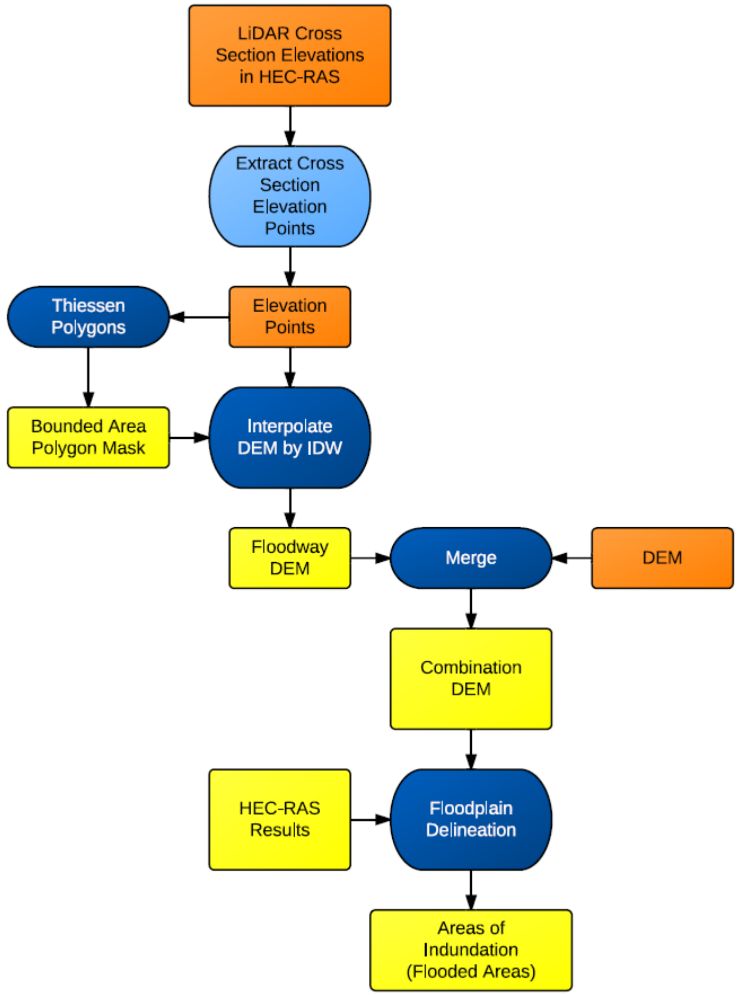

Figure 4: Finding Areas of Inundation Implementation Flow Chart

See ***Figure 4*** for the Step 3 Implementation Flow Chart. The next step is to take the results of the hydraulic modeling (the water surface elevations) and to bring them to the GIS environment to define the extent of flooding. In order to do this, a tool called HEC-GeoRAS was used. HEC-GeoRAS is the GIS extension of HEC-GeoRAS to define the areas of inundation. It requires the HEC-RAS output and a digital elevation model (DEM).

Unfortunately, the LiDAR elevation data was not available to for analysis without significant financial investment. Also, the 10-meter DEM did not have the resolution to properly capture the river channel (some of the water surface elevations were below the DEM and showed up as non-flooded). To partially remedy this problem, the LiDAR elevation data that was used to create the river cross in HEC-RAS was combined with the 10-meter DEM.

The LiDAR elevation data was extracted from HEC-RAS and imported into GIS as point data (x,y,z). Thiessen polygons were created to define the analysis boundary mask. Using the analysis boundary mask and the elevation data points, a floodway DEM was interpolated using the inverse distance weighted method (IDW). IDW was used because of the density of elevation points and because the local elevation points were important to the surface in order to capture the stream channel as best. The floodway DEM was then combined with the 10-meter DEM (to fill in the areas outside the floodway) to create a DEM to use for floodplain delineation.

The newly created DEM and the HEC-RAS output was inputted into the HEC-GeoRAS tool to define the areas of inundation for the current and future 10-year, 50-year, and 100-year floods (polygon).

Step 4: Finding the Affected Parcels

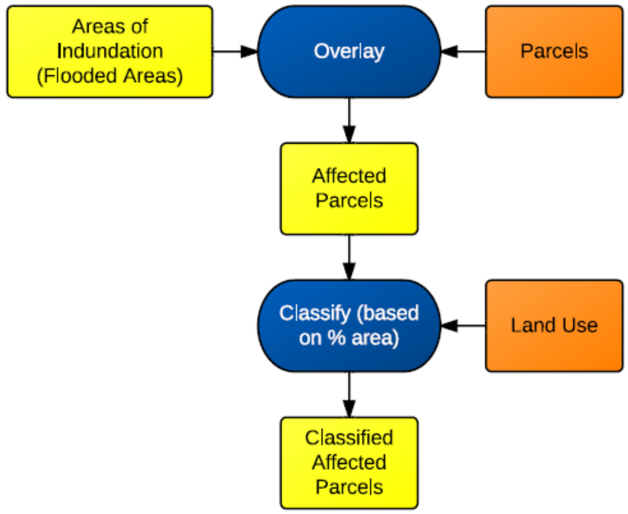

Figure 5: Finding the Affected Parcels Implementation Flow Chart

The final step in the analysis is combining the areas of inundation for each of the scenarios with parcels to find affected parcels. Refer to ***Figure 5*** for the Step 4 Implementation Flow Chart.

To define "affected" parcels, the approach was to calculate the percent of the parcel that was flooded and then further classify the results. To find the percent flooded area, a unique identifier was assigned to each parcel if not already present. Then, the area of each parcel was calculated. Next, the flooded area was erased from the parcel layer. The area of the parcel was calculated again to find the non-flooded area of each parcel. Using these two areas, the percent flooded area was calculated and related to the original parcel layer using the unique identifier. Parcels that were completed flooded (and therefore completely erased) were identified by inspection.

In order to classify the percent flooded areas, equal intervals of 20% were chosen. Equal interval is a useful classification scheme when looking across multiple data sets, and is intuitive.

The land use designation was also assigned to individual parcels for future and current land use. The future land use utilizes a simplified classification method when compared to the current land use.

Results

The resulting flooded areas and corresponding affected parcels followed trends that could be expected. In each scenario, flooding increased as the model moved from the 10-year to the 50-year and the 100-year flood, as well as between current and future land use data. An example of the flooding output is shown in ***Figure 6*** below, with all of the scenarios attached in ***Appendix C.***

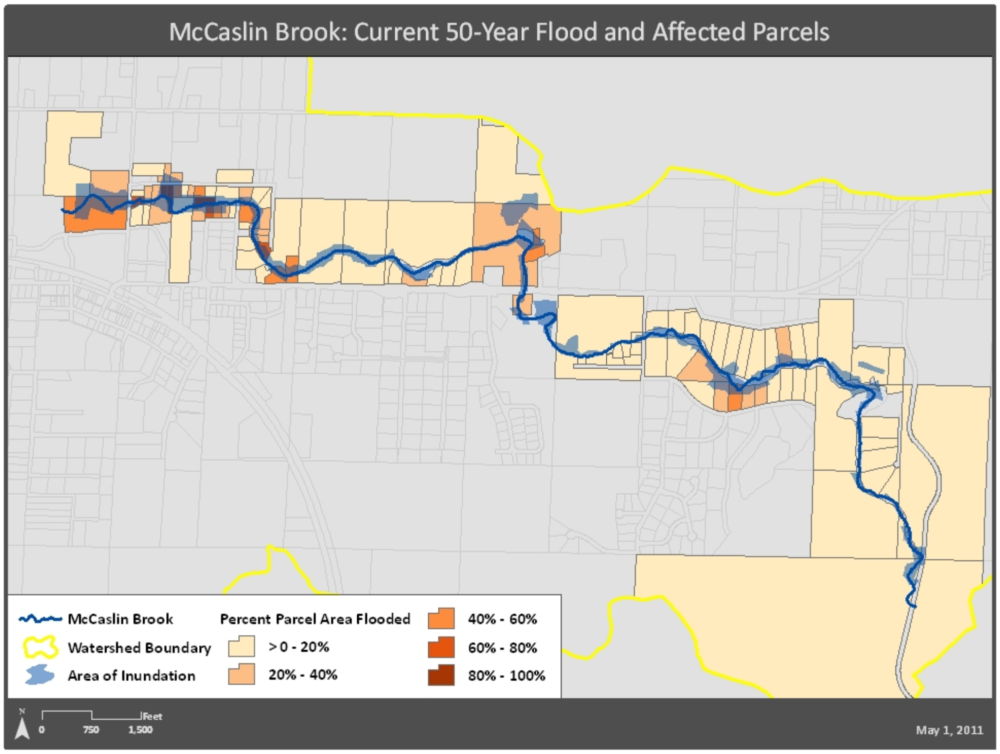

Figure 6: An example of flooding output. Reference Appendix C for full results.

When finding the affected parcels for the 10-year, 50-year, and 100-year flood events using current land use of Oconto County, the number of parcels affected by flooding was nearly constant, with only 94, 99, and 99 parcels affected by their respective floods. It is also important to mention that three of the five parcels affected by the 50-year and 100-year floods for current land use are classified as water. Only one parcel was classified as road and one parcel was classified as residential that was affected by the 50-year and 100-year floods and unaffected by the 10-year flood event, as shown in ***Table 3*** below.

	10-Year Flood	50-Year Flood	100-Year Flood
Current :			
Residential (221)	7	8	8
Water (252)	31	34	34
Woodlands (806)	32	32	32
Commercial (67)	0	0	0
Park (38)	1	1	1
Road (635)	14	15	15
Government (6)	0	0	0
Agriculture (29)	0	0	0
Mobile Homes (7)	0	0	0
Industrial (1)	0	0	0
Open Space (69)	9	9	9
Communication/Utilities (1)	0	0	0
Total:	94	99	99
Future:			
Residential (638)	56	57	58
Road (322)*	NA	NA	NA
Water (275)	41	41	41
Woodlands (534)	1	1	1
Commercial (304)	0	0	0
Park (44)	3	3	3
Government (6)	0	0	0
Agriculture (9)	0	0	0
Total:	101	102	103

Table 3: Tabulation of Affected Parcels

Although the number and types of affected parcels remained similar in each of the current flood events, the extent of the flood differed between the floods. In the 10-year flood, only 1,852 acres were affected compared to 2,261 acres for the 50-year flood and 2,387 acres for the 100-year flood. This difference is a 22% increase between the 10-year and 50-year flood, a 5.6% increase between the 50-year and 100-year flood, and a 28.9% increase between the 10-year and the 100-year flood events-- a significant increase in affected acreage.

The future affected parcels showed similar results between the 10-year, 50-year, and 100-year floods. There were 101 parcels that were affected in the 10-year flood, 102 parcels in the 50-year, and 103 parcels in the 100-year.

The inundated acres in the future scenarios followed closely with patterns seen in the current flooding with 2,421 acres, 2,883 acres and 3,111 acres affected in the 10-year, 50-year, and 100-year floods respectively. These increases were 19% between the 10-year and 50 year flood, 7.9% between the 50-year and 100-year flood, and 28.5% between the 10-year and 100-year flood, all shown in ***Table 4*** below.

Current Flood Scenarios:	**Parcels**	**Acres**	**Percent Increase**
10-Year Flood	94	1,852	-
50-Year Flood	99	2,261	22.0%
100-Year Flood	99	2,387	5.6%
Future Flood Scenarios:			
10-Year Flood	101	2,421	-
50-Year Flood	102	2,883	19.0%
100-Year Flood	103	3,111	7.9%
Direct Flood Comparisons:			
10-Year Flood (Current to Future)	-	-	30.7%
50-Year Flood (Current to Future)	-	-	27.5%
100-Year Flood (Current to Future)	-	-	30.3%

Table 4: Flooding Results

Another source of comparison useful for analyzing the results of the flood scenarios is direct comparison between each current and future flood scenario. Between the current and future 10-year floods, there was a 30.7% increase in flooded area. This trend continued among the 50-year and 100-year floods, which saw a 27.5% and 30.3% increase respectively.

It is important to note that the future land use has critical differences from the current land use. Future land use was a simplified plan with fewer categories and fewer road classifications. Many parcels close to the McCaslin Brook are projected to see significant land use change, as open and forested areas are predicted to become residential. Because of the increase in residential parcels, residential land use was the only category that increased dramatically in the number of affected parcels between current and future floods. Also, slightly higher flooding was seen among park parcels, which were also predicted to take over woodlands and open space. It is difficult to determine the impact of land cover change on flooding extent due to the simplified future land use plans obtained from Oconto County.

The increase in flooding between each current to future flooding scenario can be partially attributed to land cover change, however precipitation changes are also a major factor. Without keeping one of the variables constant we are unable to determine the impact of each individually at this time.

Problems and Limitations

As with any GIS analysis, the quality of data is key to the reliability of the analysis. This analysis contained multiple sources of error, of which only a few have been mentioned up to this point.

The unavailability of LiDAR elevation data for the township forced using a 10-meter resolution DEM, which proved too coarse in regions of the watershed to properly model flooding. Gaps existed in the flooding extent where the DEM did not pick up the McCaslin Brook at all. To remedy this issue, the more accurate cross-section elevation values were interpolated and combined with the 10-meter DEM to create a DEM that produced a more realistic flooding extent. The combination of DEMs and interpolation of values, though creating more believable results, brought with it more possibilities for error in the values. A major source of errors in interpolating a DEM is that the interpolation occurs in (x,y) space, and not along the meandering bends of the river. That means the flooding extent is more reliable near the locations of the cross sections and becomes sketchier farther away from the cross section locations.

Another source of error in our project was the use of the USGS regression in both the current and future scenarios. In the current scenarios the regression equations include a standard error of prediction for the equation for the 100-year flood discharge that ranges from 22 to 44%. However, the use of the regression equation for the future scenarios may be problematic because the variables and their weights may be less reliable.

As we previously mentioned, the future land use plans were very generalized, and did not allow for the flooding of roads which created the possibility for error among our results. Another issue with the future land use is that the time period of the data is unknown (Oconto County did not reveal when the "future" was), and it may or may not line up with the time period of future precipitation data. If the land use and precipitation data are for different time periods, the results could be questionable. However, since most of the land use change is moving from open space and forested to residential, it is unlikely that further change will be predicted. Related to this problem is inherit unreliability of the climate change models, which were simply averaged to remain conservative and ideally reduce error.

Another recognized source of error was within our original data layer, the Manning's roughness layer. When updating the Manning's roughness values to place more specific friction (or roughness value) into the HEC-RAS cross sections, we found that on some occasions our measurement of the channel locations did not match up with those in HEC-RAS. To limit errors, the original HEC-RAS channel locations were kept, as they were judged to be more accurate than the land use data acquired, which was parcel based. Parcels may have been created decades ago, and the location of the river could have easily changed. The HEC-RAS cross sections were created with 2008 LiDAR data.

Future Research

Obtaining LiDAR would greatly benefit this analysis by allowing a higher resolution elevation model, effectively eliminate one of the largest sources of error. Additionally, ground-truthing would allow us to better evaluate our model, and conquer irregularities in obtained data. One interesting idea to evaluate in the future would be to account for building footprints, as there is a major difference between a flooded yard and a flooded home or business. Also, taking a look at the role of the USGS Regression Equation with the possibility of evaluating other hydrologic models would offer the potential to refine our model as well as better determine the flooding extent. Finally, assessing the role of climate change driven precipitation increases versus the role of land use change would help to better understand future flooding impacts in the McCaslin Brook watershed.

Data Layers

A major contribution to the quality of the project is the availability and accuracy of data. The data layers and corresponding sources are as follows:

- Oconto County Hydrography (Oconto County)
- Wisconsin Department of Natural Resources 24K Hydrography (WDNR Surface Water Viewer)
- McCaslin Brook Watershed (USGS Watershed Boundary Data set & Purdue L-THIA Watershed delineation tool)
- DEM 10m (USGS Seamless Server)
- Aerial Imagery (NAIP, Bing, Google)
- Oconto County Wetlands (Oconto County)
- Wisconsin County Boundaries (WDNR)
- HEC-RAS import of McCaslin Stream-LiDAR Based (WDNR)
- 2007 Oconto County Land Use (Oconto County)
- Oconto County Future Land Use (Oconto County)
- 2009 Oconto County Tax Parcels (Oconto County)

Conclusion

This analysis located parcels affected by flooding due to changes in precipitation in the McCaslin Brook Watershed using USGS regression equations, HEC-RAS modeling software, and GIS software. The results of this analysis show that with increases in precipitation and changes in land use there is also an increase in future flooding. The percent increase of flooded acreage is approximately 30 percent. Additionally, there is a significant development of residential land in open space and woodlands in the McCaslin Brook Watershed.

Works Cited

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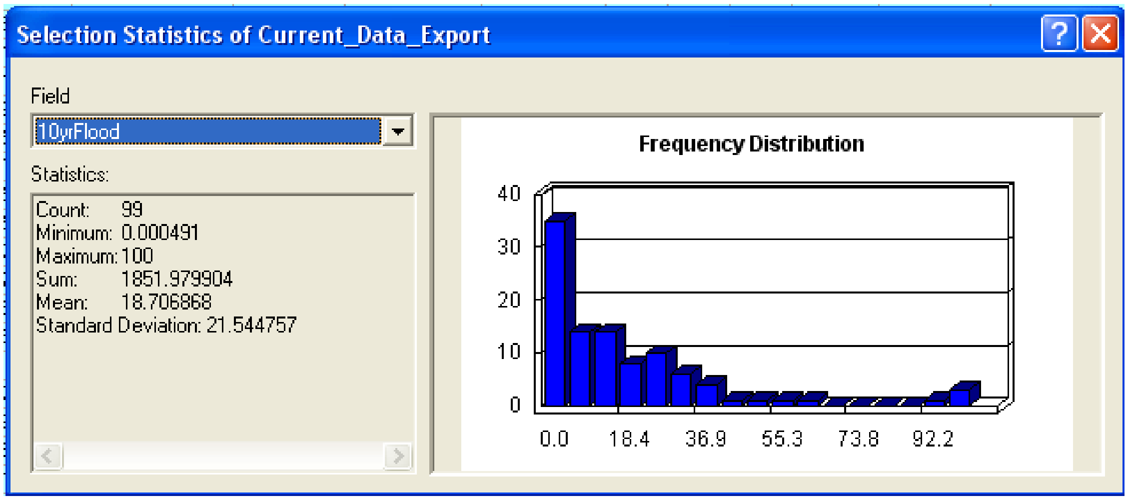
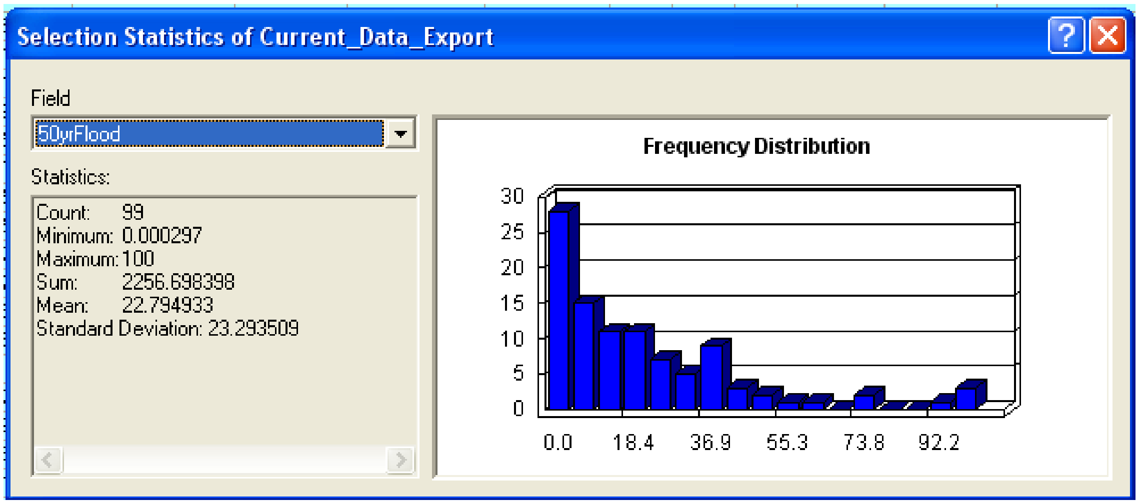
Appendix A: Supporting Data

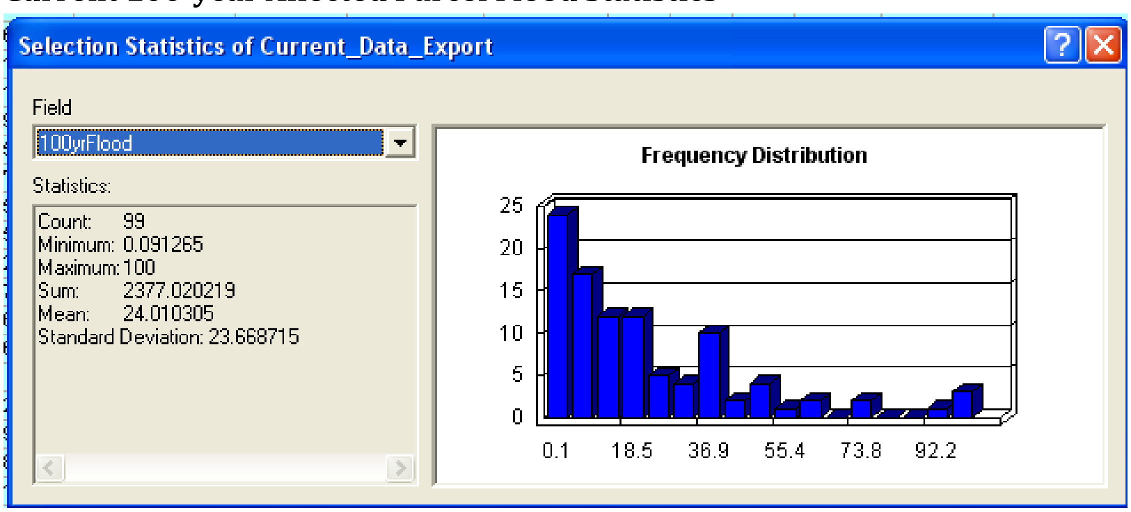
Current 10-year Affected Parcel Flood Statistics



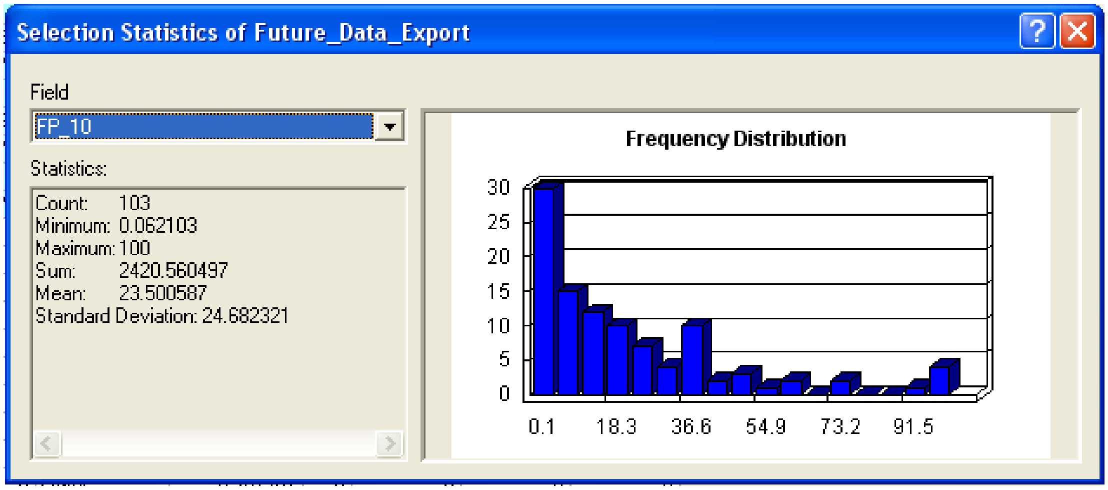
Current 50-year Affected Parcel Flood Statistics



Current 100-year Affected Parcel Flood Statistics



Future 10-year Affected Parcel Flood Statistics



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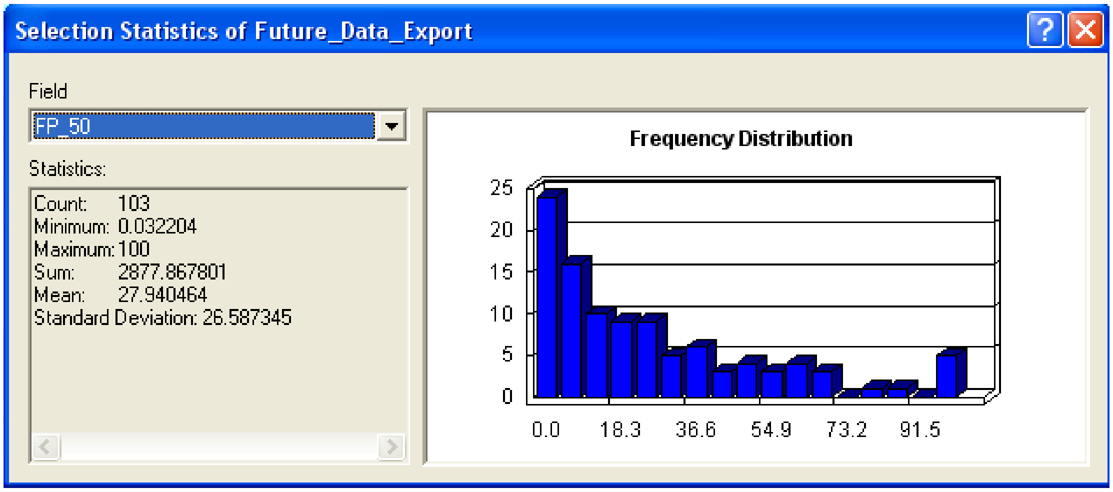
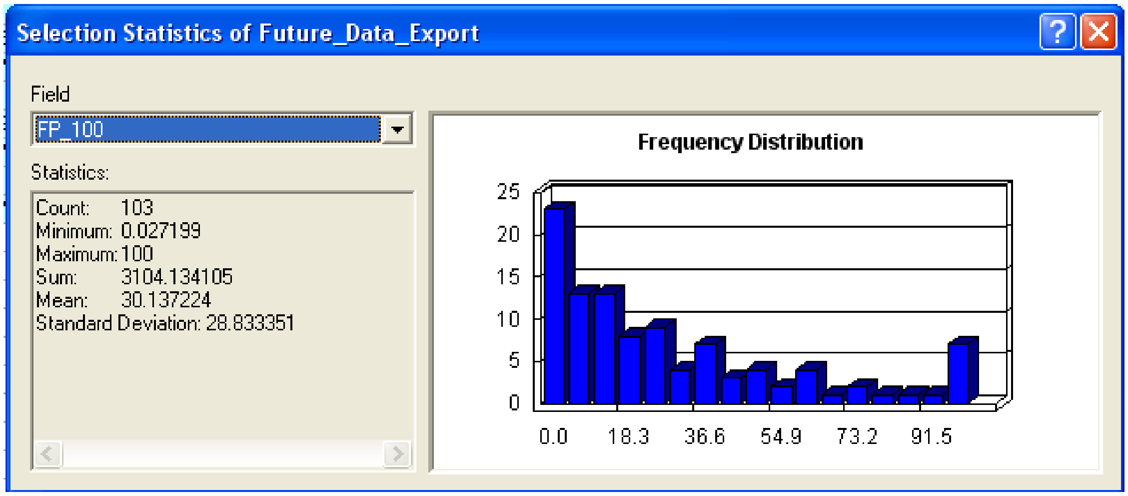
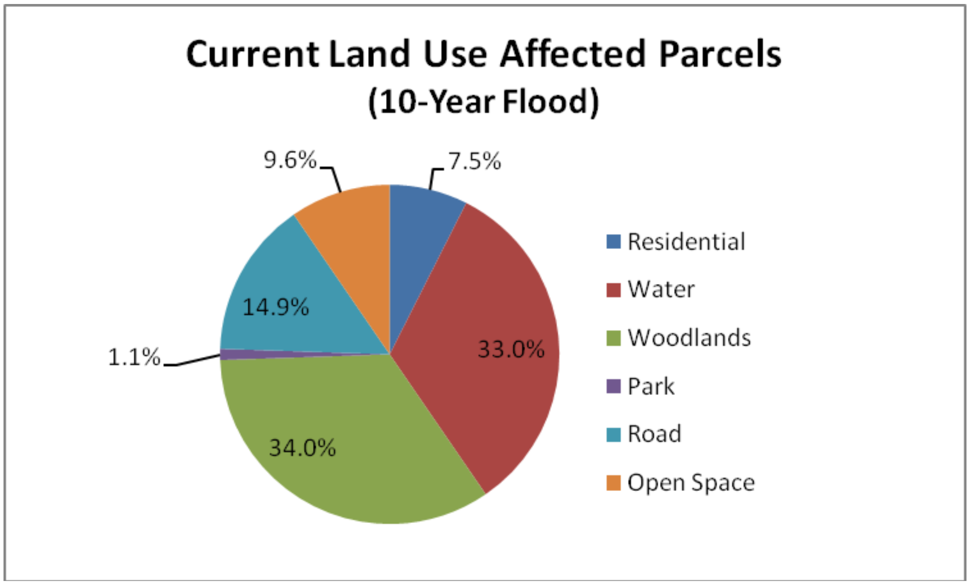
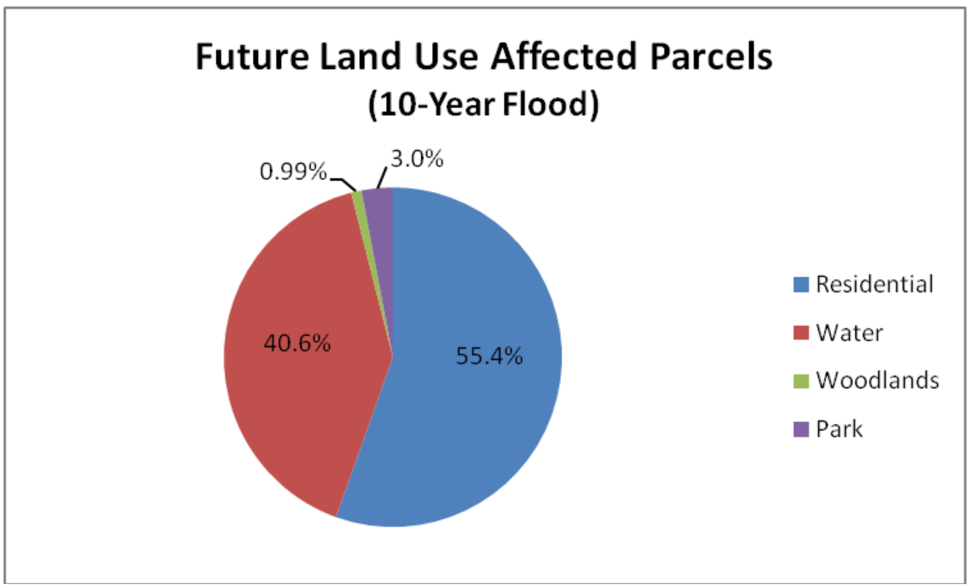


Future 100-year Affected Parcel Flood Statistics

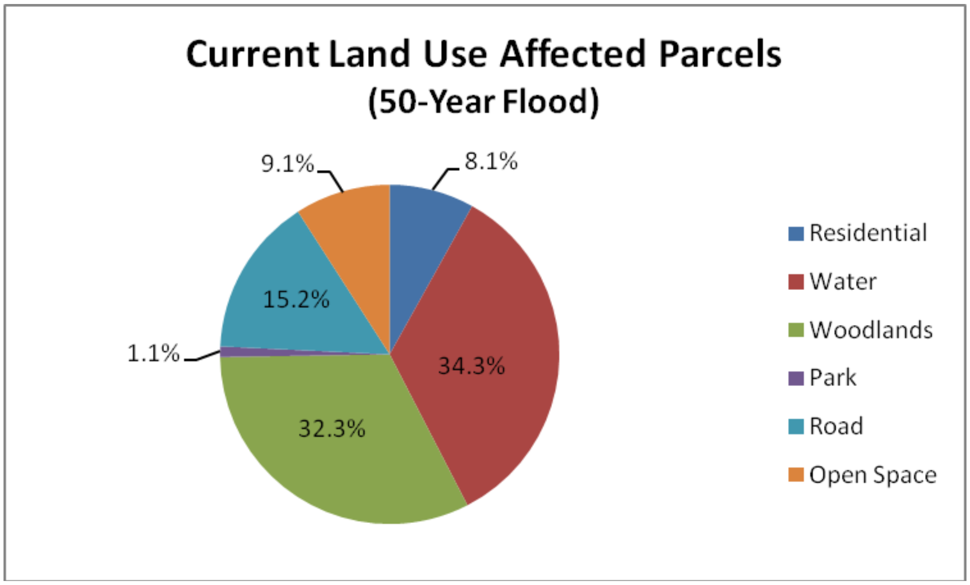


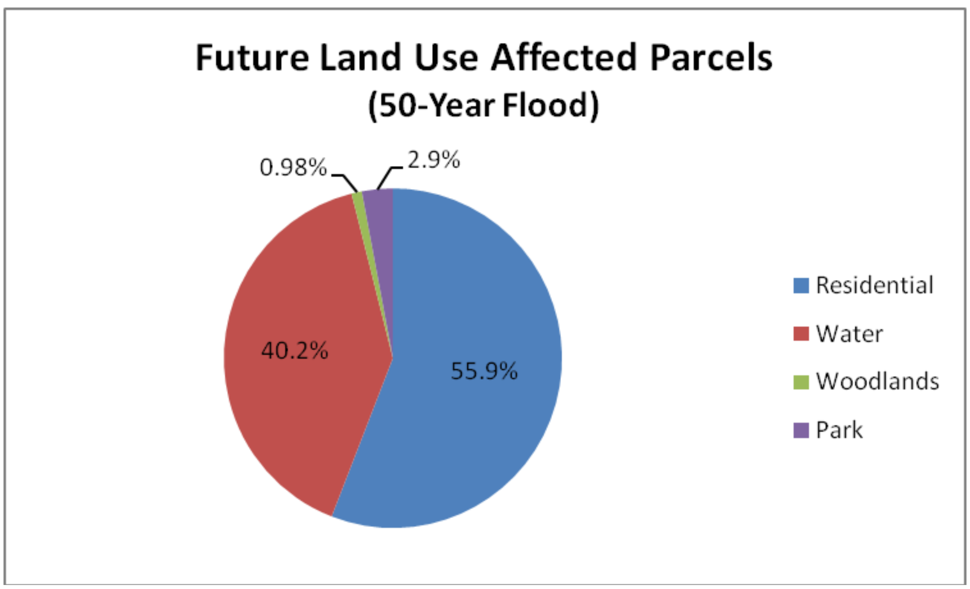
Comparison of Affected Parcels for Current and Future for the 10-year Flood



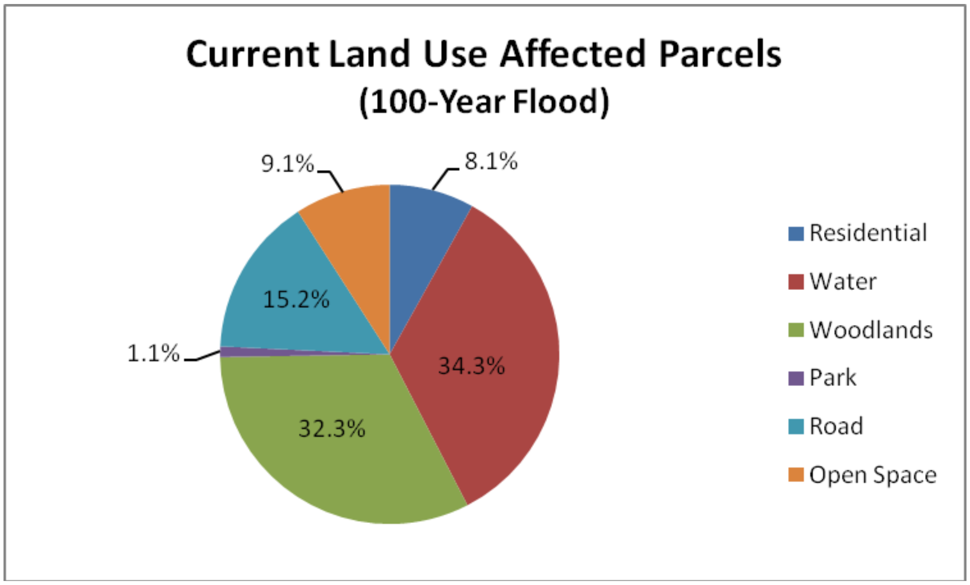


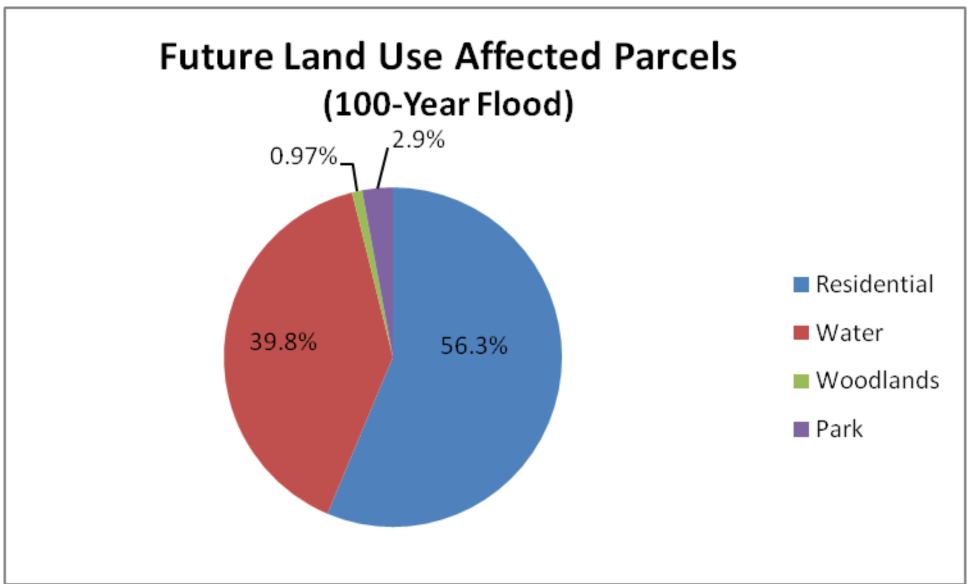
Comparison of Affected Parcels for Current and Future for the 50-year Flood





Comparison of Affected Parcels for Current and Future for the 100-year Flood





Appendix B: Metadata

Final_Mannings_N
Shapefile

Keywords

Theme: Manning's roughness

Place: McCaslin Brook, Oconto County, WI

Description

Abstract

This shapefile is for the downstream portion of the McCaslin Brook, Oconto County, WI. It contains Manning's roughness values for the floodplain to be used with HEC-RAS for a hydraulic analysis.

Purpose

It was determined that creating a more refined Manning's roughness along the river cross section for the current land use would greatly enhance a HEC-RAS analysis.

Status of the data

Complete

Data update frequency: None planned

Time period for which the data is relevant

Date and time: 05-01-2011

Description: publication date

Publication Information

Who created the data: Holly Powell, Tim Pollari, Danielle Lee, Matt Lamb

Date and time: 05-01-2011 at time 7:07 PM

Data storage and access information

File name: Final_Mannings_N

Type of data: vector digital data

Location of the data:

\\DISCOVERY\Classes\g578\DBs\Climate Change and Flooding\GIS\Mannings_N\Final_Mannings_N.shp

Data processing environment: Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 3; ESRI ArcCatalog 9.3.1.3000

Accessing the data

Size of the data: 1.580 MB

Data transfer size: 1.580 MB

Constraints on accessing and using the data

Access constraints: To be accessed for educational purposes.

Use constraints:

Only for use with HEC-RAS analysis for educational purposes.

Details about this document

Contents last updated: 20110504 at time 17125900

Who completed this document

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Standards used to create this document

Standard name: FGDC Content Standards for Digital Geospatial Metadata

Standard version: FGDC-STD-001-1998

Time convention used in this document: local time

Metadata profiles defining additional information

ESRI Metadata Profile: http://www.esri.com/metadata/esriprof80.html

Horizontal coordinate system

Projected coordinate system name: Oconto County

Geographic coordinate system name: GCS_North_American_1983_HARN

Details

Map Projection Name: Transverse Mercator

Scale Factor at Central Meridian: 0.999991

Longitude of Central Meridian: -87.908333

Latitude of Projection Origin: 44.397222

False Easting: 600000.000129

False Northing: 0.000000

Planar Coordinate Information

Planar Distance Units: survey feet

Coordinate Encoding Method: coordinate pair

Coordinate Representation

Abscissa Resolution: 0.000000

Ordinate Resolution: 0.000000

Geodetic Model

Horizontal Datum Name: D_North_American_1983_HARN

Ellipsoid Name: Geodetic Reference System 80

Semi-major Axis: 6378137.000000

Denominator of Flattening Ratio: 298.257222

Bounding coordinates

Horizontal

In decimal degrees

West: -88.637019

East: -88.455429

North: 45.358272

South: 45.261572

In projected or local coordinates

Left: 412678.077447

Right: 459124.617242

Top: 350872.106189

Bottom: 315978.552979

Lineage

FGDC lineage

Process step 1

Process description: Dataset copied.

Source used: N:\Myfiles\Oconto\County\LandUse\2006_LU _Update\Oconto_county_lu5

Process date: 20090420 at time 09333000

Process step 2

Process description: Dataset copied.

Source used: N:\Myfiles\Oconto\County\LandUse\2006_LU _Update\Final\Oconto_County_2007_Land_Use

Process date: 20090617 at time 10023000

Process step 3

Process description: Dataset copied.

Source used: C:\WorkSpace\Oconto\Oconto_County_2007_Land_Use

Process date: 20090617 at time 10025800

Process step 4

Process description: Dataset copied.

Process date: 20110501 at time 18512700

ESRI geoprocessing history

1. Process

Date and time: 20110419 at time 185506

Tool location: C:\Program Files\ArcGIS\ArcToolbox\Toolboxes\Analysis Tools.tbx\Clip

Command issued

Clip "Oconto County 2007 Land Use" mccaslin_watershed "S:\g578\DBs\Climate Change and Flooding\GIS\Mannings_N\Clip_LU_2007_Oconto.shp" #

2. Process

Date and time: 20110419 at time 190303

Tool location: C:\Program Files\ArcGIS\ArcToolbox\Toolboxes\Data Management Tools.tbx\Dissolve

Command issued

Dissolve Clip_LU_2007_Oconto "S:\g578\DBs\Climate Change and Flooding\GIS\Mannings_N\LU_2007_Oconto_Dissolve2.shp" LU1 # MULTI_PART DISSOLVE_LINES

Spatial data description

Vector data information

ESRI description

Final_Mannings_N

ESRI feature type: Simple

Geometry type: Polygon

Topology: FALSE

Feature count: 998

Spatial Index: TRUE

Linear referencing: FALSE

SDTS description

Feature class: SDTS feature type, feature count

Final_Mannings_N: G-polygon, 998

Details for Final_Mannings_N

Type of object: Feature Class

Number of records: 998

Description

Manning's roughness (n) for floodplain

Attributes

FID

Alias: FID
Data type: OID
Width: 4
Precision: 0
Scale: 0
Definition: Internal feature number.
Definition Source: ESRI

Shape

Alias: Shape
Data type: Geometry
Width: 0
Precision: 0
Scale: 0
Definition: Feature geometry.
Definition Source: ESRI

LU1

Alias: LU1

Data type: Number

Width: 4

N_Value

Alias: N_Value

Data type: Float

Width: 13

Number of decimals: 11

LUCode

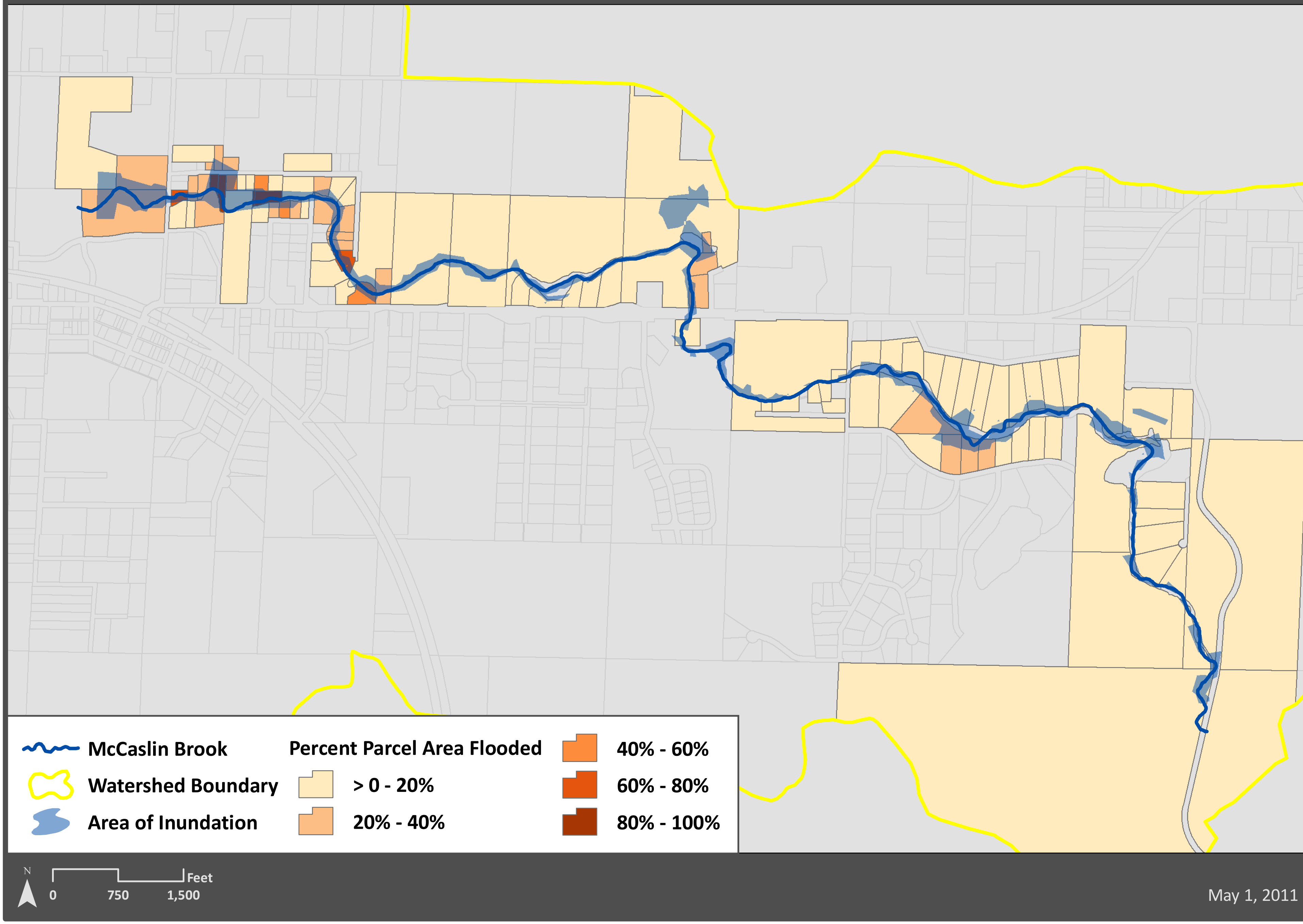
Alias: LUCode

Data type: String

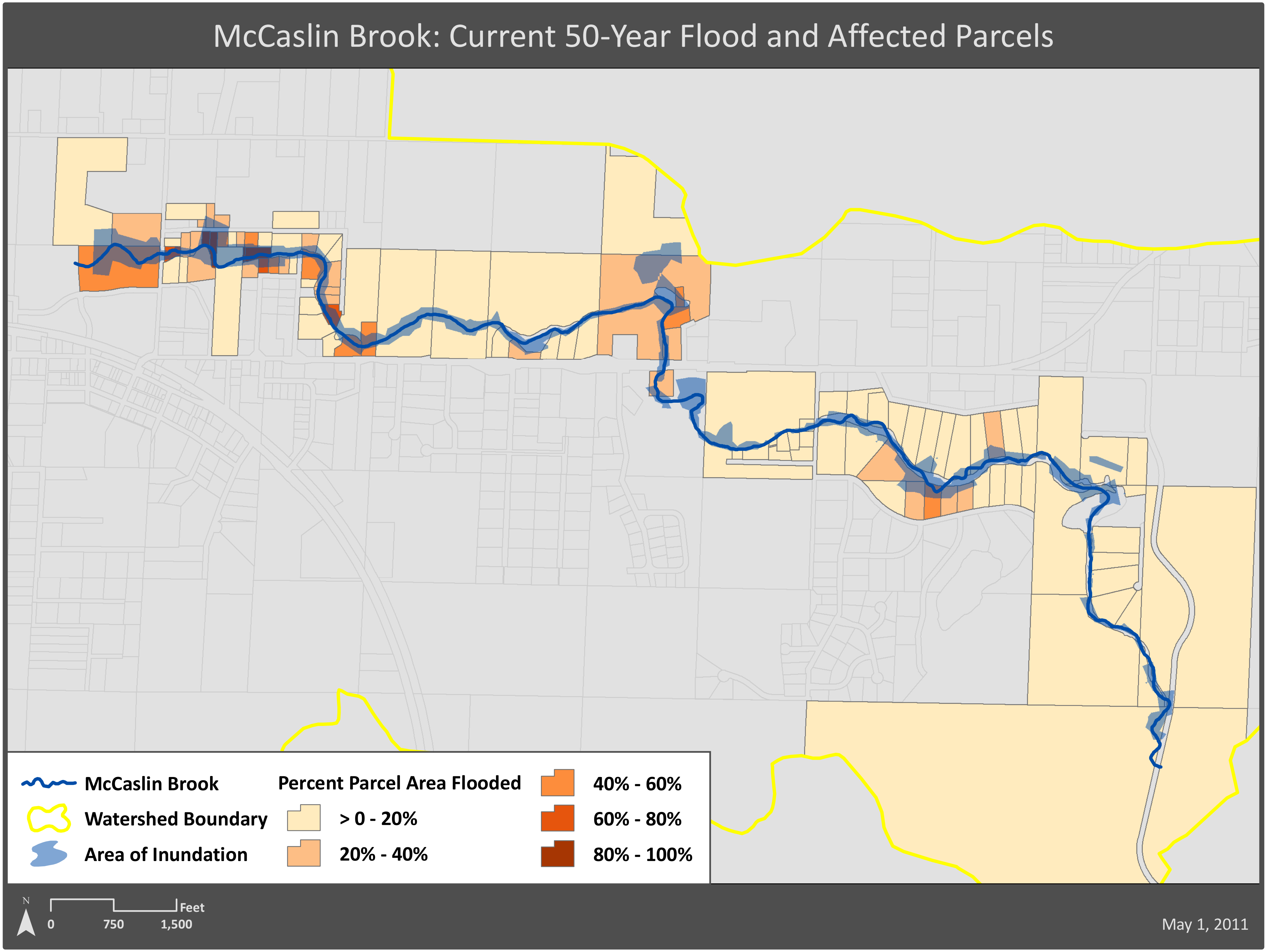
Width: 50

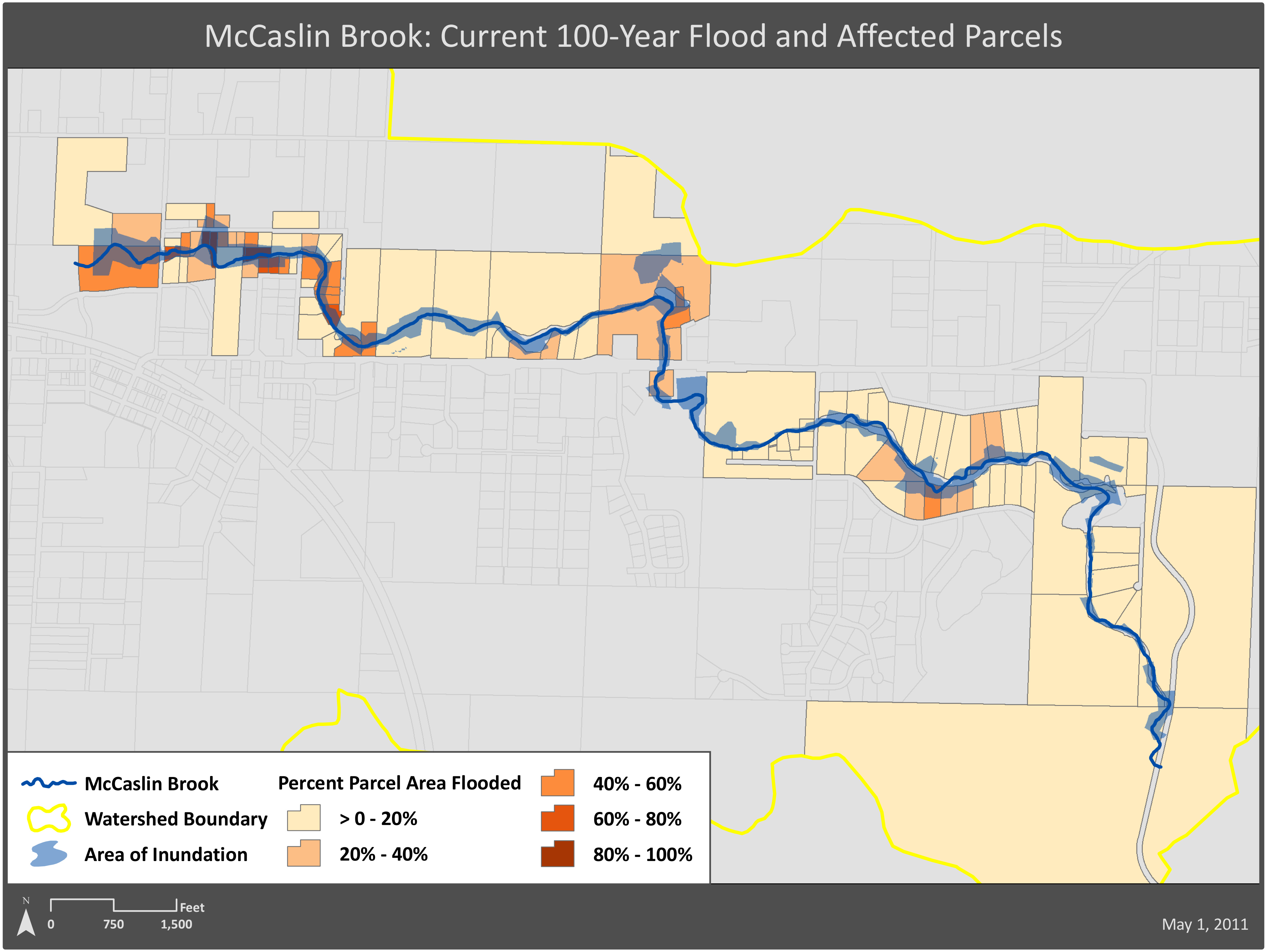
Appendix C: Map Results

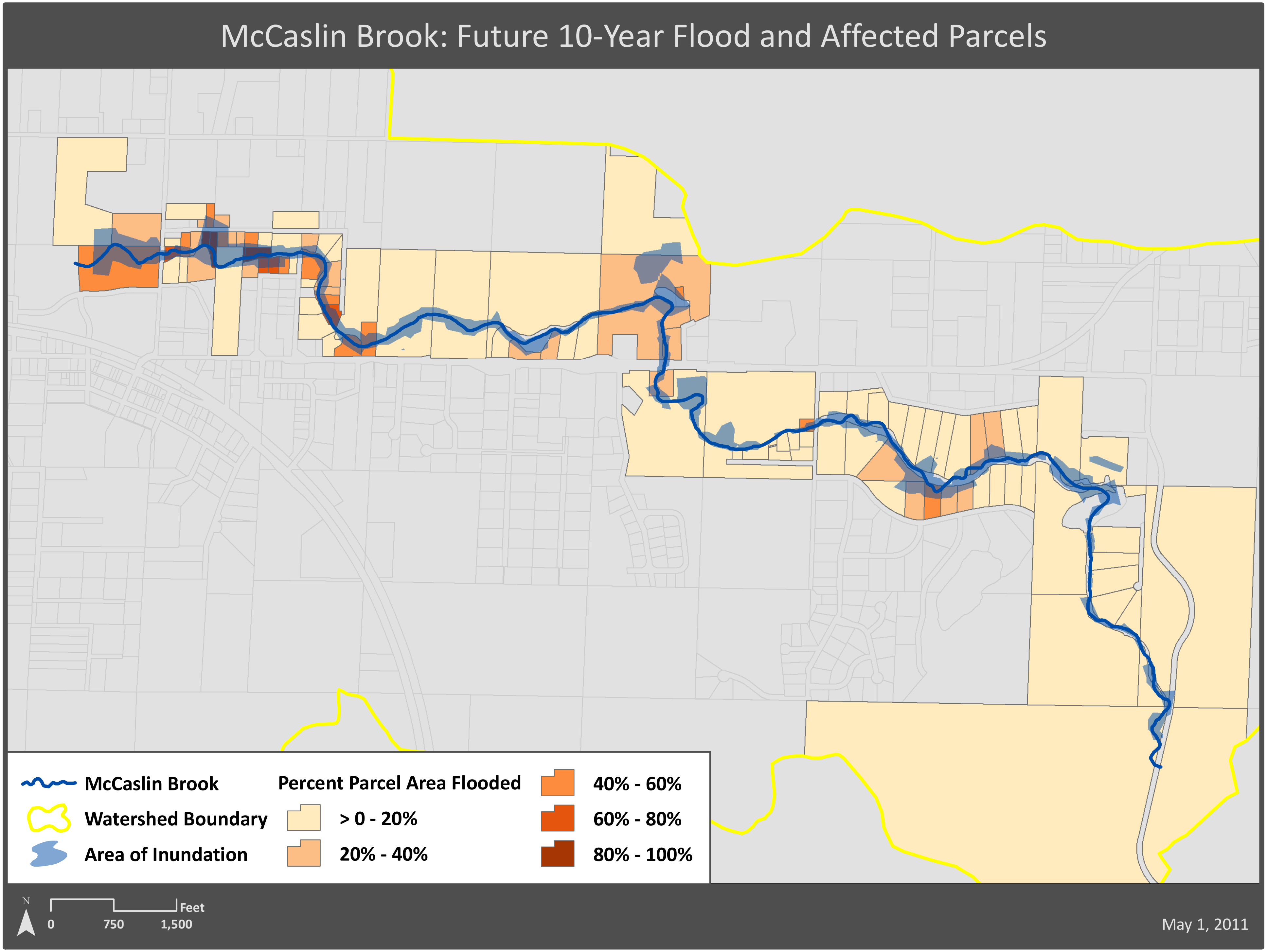
McCaslin Brook: Current 10-Year Flood and Affected Parcels

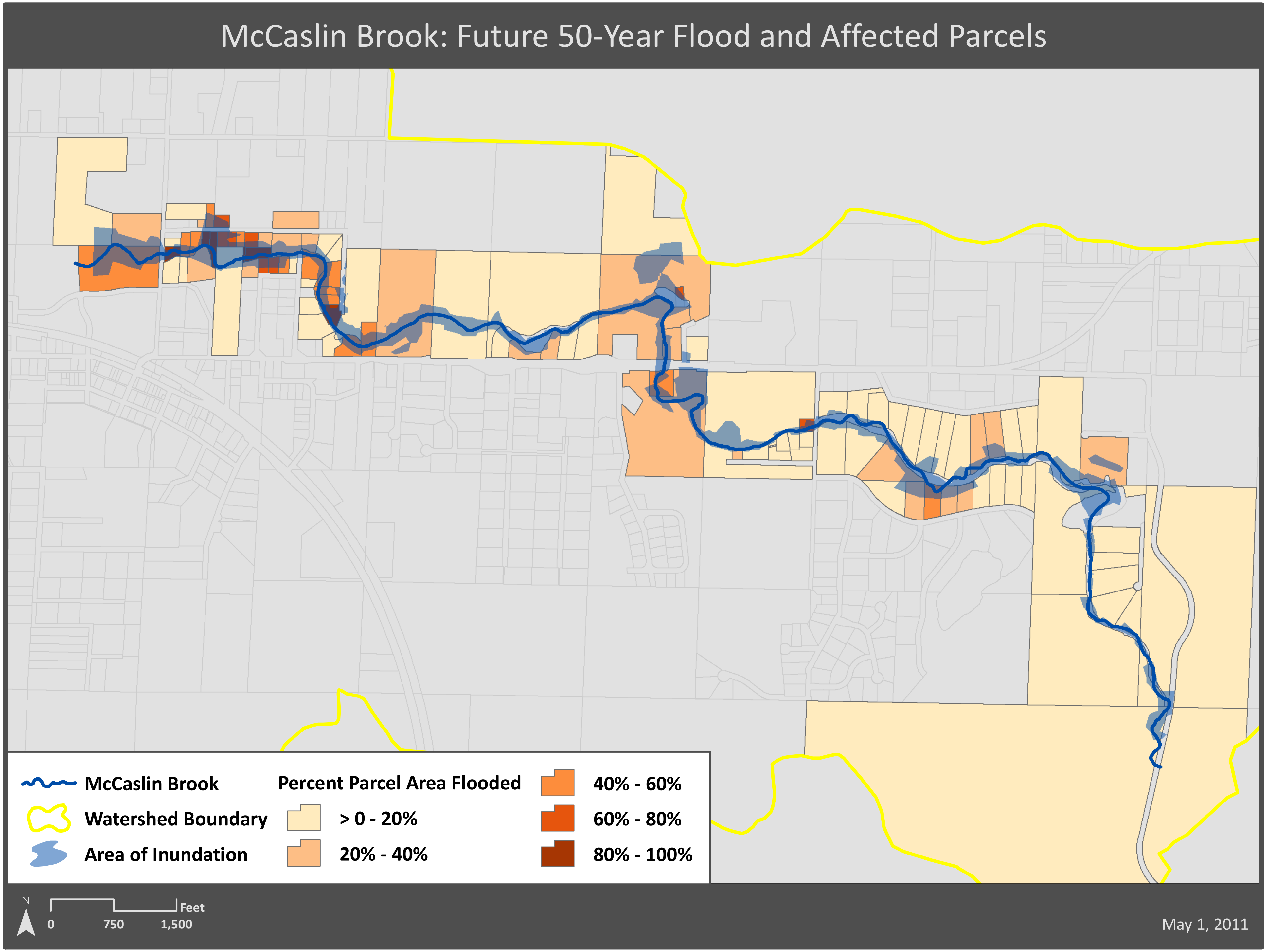


May 1, 2011

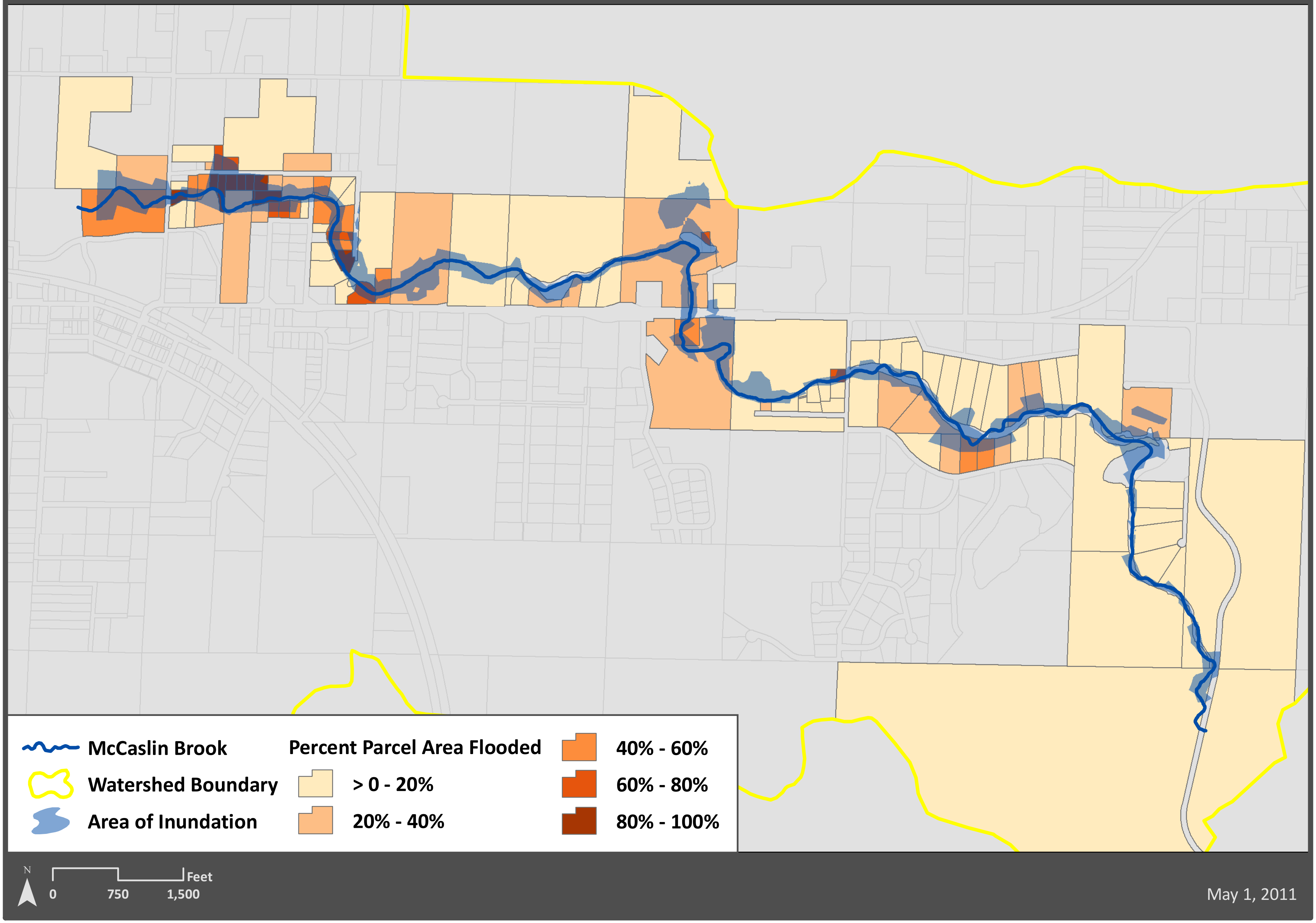

McCaslin Brook: Current 50-Year Flood and Affected Parcels
McCaslin Brook
Watershed Boundary
Area of Inundation
Percent Parcel Area Flooded
> 0 - 20%
20% - 40%
40% - 60%
60% - 80%
80% - 100%
N
Feet
0
750
1,500
May 1, 2011


McCaslin Brook: Current 100-Year Flood and Affected Parcels
McCaslin Brook
Watershed Boundary
Area of Inundation
Percent Parcel Area Flooded
> 0 - 20%
20% - 40%
40% - 60%
60% - 80%
80% - 100%
N
Feet
0
750
1,500
May 1, 2011

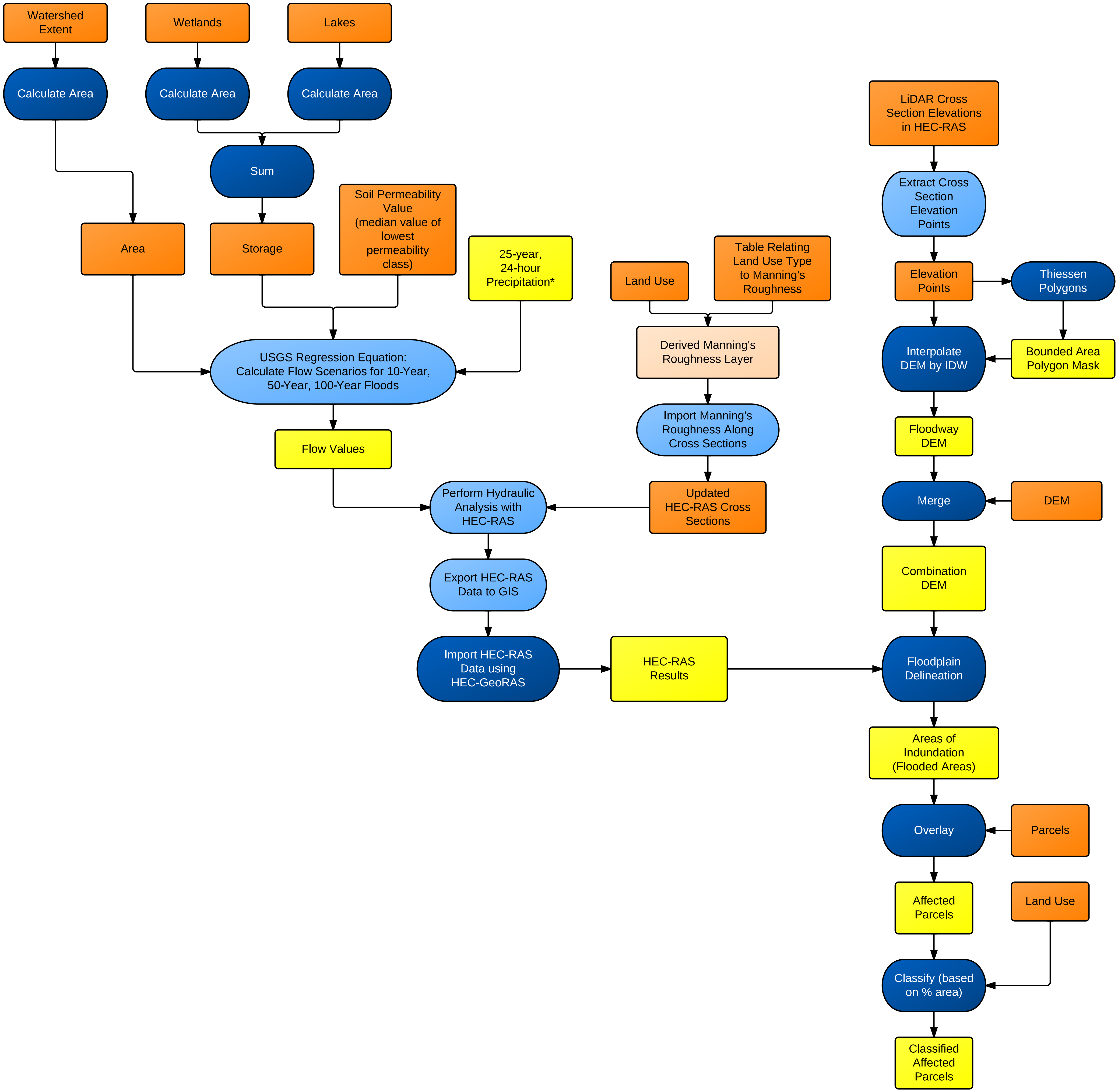

McCaslin Brook: Future 10-Year Flood and Affected Parcels
McCaslin Brook
Watershed Boundary
Area of Inundation
Percent Parcel Area Flooded
> 0 - 20%
20% - 40%
40% - 60%
60% - 80%
80% - 100%
N
0
750
1,500
Feet
May 1, 2011


McCaslin Brook: Future 50-Year Flood and Affected Parcels
McCaslin Brook
Watershed Boundary
Area of Inundation
Percent Parcel Area Flooded
> 0 - 20%
20% - 40%
40% - 60%
60% - 80%
80% - 100%
N
0
750
1,500
Feet
May 1, 2011

McCaslin Brook: Future 100-Year Flood and Affected Parcels



Appendix D: Complete Implementation Flow Chart


Watershed Extent
Wetlands
Lakes
Calculate Area
Calculate Area
Calculate Area
Sum
Area
Storage
Soil Permeability Value (median value of lowest permeability class)
25-year, 24-hour Precipitation*
USGS Regression Equation: Calculate Flow Scenarios for 10-Year, 50-Year, 100-Year Floods
Flow Values
Land Use
Table Relating Land Use Type to Manning's Roughness
Derived Manning's Roughness Layer
Import Manning's Roughness Along Cross Sections
Updated HEC-RAS Cross Sections
Perform Hydraulic Analysis with HEC-RAS
Export HEC-RAS Data to GIS
Import HEC-RAS Data using HEC-GeoRAS
HEC-RAS Results
LiDAR Cross Section Elevations in HEC-RAS
Extract Cross Section Elevation Points
Elevation Points
Thiessen Polygons
Interpolate DEM by IDW
Bounded Area Polygon Mask
Floodway DEM
Merge
DEM
Combination DEM
Floodplain Delineation
Areas of Indundation (Flooded Areas)
Overlay
Parcels
Affected Parcels
Land Use
Classify (based on % area)
Classified Affected Parcels