FEMA

Risk MAP and the Mapping the Zone Report

National Academies of Science – Mapping Sciences Committee

October 2011

RiskMAP

Increasing Resilience Together

Minimum Uncertainties in BFEs on Order of One Foot from Major Input Data Sources

- **Finding.** The sampling error of the base flood elevation estimated using flood frequency analysis of annual maximum stage heights measured at 30 long record USGS stream gage sites in North Carolina and Florida does not vary with drainage area, topography, or landscape type and has an average value of approximately 1 foot.

- **Finding.** Despite the difference in landscape flow processes between the dendritic stream river systems of North Carolina and the ponding landscapes in Florida, the resulting river base flood elevations determined at USGS gage sites have a similar sampling uncertainty.

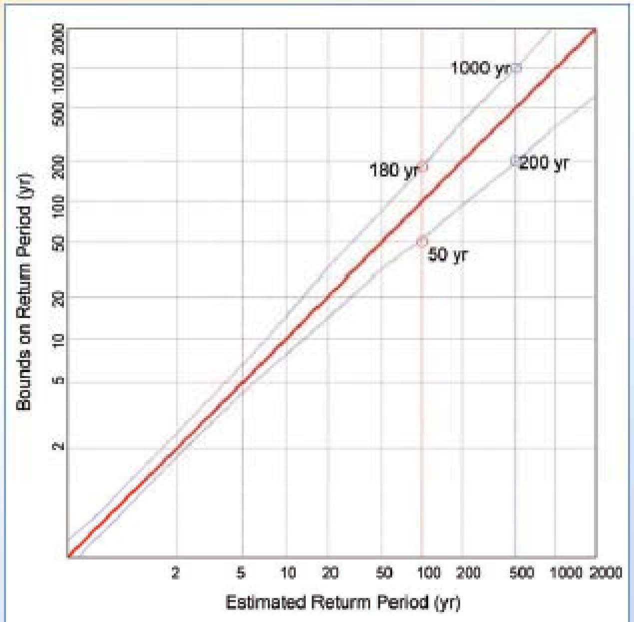


FIGURE 2 Return periods for flood discharge at the French Broad River in Asheville, North Carolina, for the expected flood discharge and its upper and lower confidence limits (dotted lines).

Minimum Uncertainties in BFEs on Order of One Foot from Major Input Data Sources

- **Finding.** Flood frequency analysis of stream gage records is the most reliable method of defining peak flood discharges. Discharges calculated from rainfall-runoff models or from regional regression equations adjusted for flood frequency analysis results at a nearby gage produce similar BFE profiles. The USGS regional regression equations also produce similar BFE profiles in the three reaches examined in this study. The only hydrologic method that significantly affects the BFE profile is to change the flood discharge to the limits of the prediction error of the regression equations—this raises or lowers the BFE profiles by an average of 1 to 3 feet in the three study reaches.
- **Finding.** Backwater effects of structures influence the base flood elevation profile on all three study reaches and are most pronounced in the coastal plain.

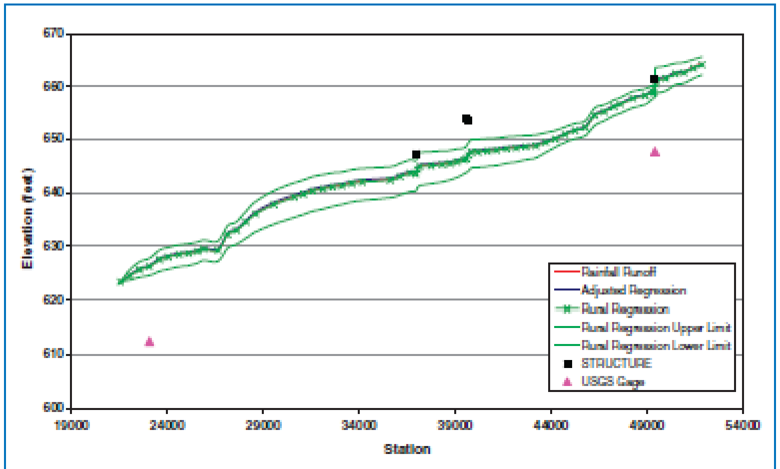


FIGURE 6 Effect of alternative hydrologic methods on the base flood elevation on Long Creek, North Carolina. The only hydrologic method that produced variations greater than 1 foot was the method that used the lower and upper confidence limits of the regression equation. Source: North Carolina Floodplain Mapping Program (2008)

Stream	Number of Structures	Extended to Next Structure[a]	Average Elevation (feet)[b]	Maximum Elevation (feet)[b]	Distance Upstream (miles)[c]
Ahoskie Creek	6	6	0.89	2.54	1.12
Long Creek	4	3	0.34	0.73	0.50
Swannanoa River	9	5	0.20	2.02	0.30

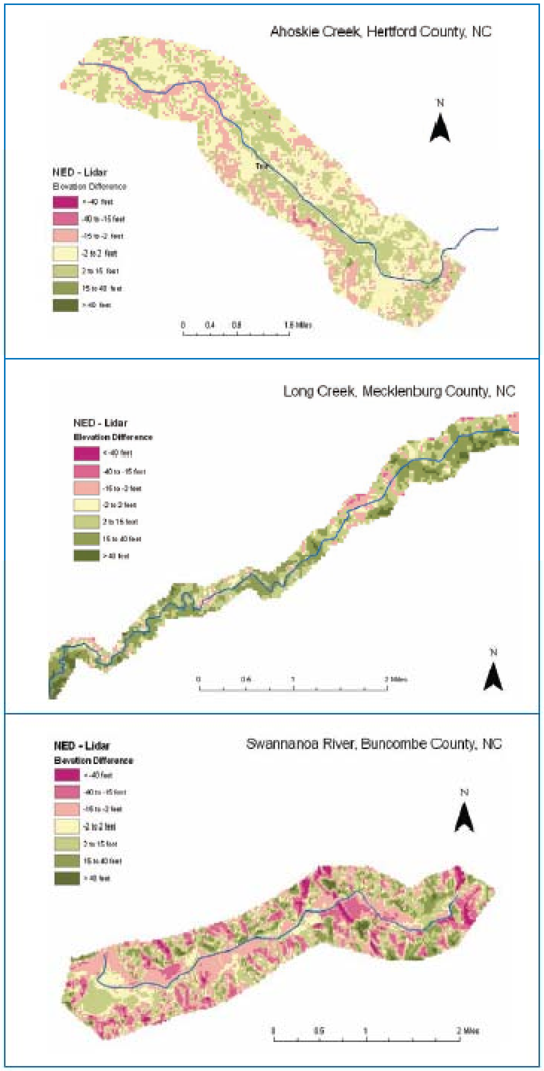
[a] An elevated backwater effect extended from one structure to the next one upstream.
[b] Refers to the difference between the two elevation profiles with and without structures.
[c] Average distance upstream from a structure from which backwater effects propagate.

Minimum Uncertainties in BFEs on Order of One Foot from Major Input Data Sources

- The inherent uncertainty of flood hazard analysis is one of the major political / communication issues for the program
- This finding helps to understand the appropriate precision needed for other major modeling inputs
- Provides a reliable scientific basis for making key decisions, communicating externally about hazard data
- If the uncertainty introduced by an input source is one half of a foot or less, additional cost to improve the precision of the source is unlikely to produce a benefit
- One foot is the limit for best case - long record available for calibration. Where gage data is unavailable or shorter record, minimum uncertainty is likely higher.

Need Minimum Elevation Data Standards

- **Finding.** At Ahoskie Creek and the Swannanoa River, the stream and topographic data are well aligned for both lidar data and the NED , so while there are random differences between then, the average difference is small. At Long Creek, the stream and topographic data are aligned for the lidar data but not for the NED , so there is a large systematic difference between lidar and NED at this location.
- **Finding.** The base flood elevation profile is significantly more influenced by whether the National Elevation Dataset or lidar terrain data are used to define land surface elevation than by any variation of methods for calculating channel hydraulics.



Need Minimum Elevation Data Standards

- **Recommendation.** FEMA should increase collaboration with the USGS and state and local government agencies to acquire high-resolution, high-accuracy topographic data throughout the nation.
- **Finding.** In the three reaches examined, approximate study methods yield a good estimate of the number of acres in the Special Flood Hazard Area, provided the stream location and topographic information are properly aligned.
- **Finding.** The National Elevation Dataset and the tagged vector contour data from 1:24,000 topographic maps used to create it have an elevation uncertainty that is about 10 times larger than that defined by FEMA as acceptable for floodplain mapping.

TABLE 1 Elevation Difference Statistics, NED Minus Lidar

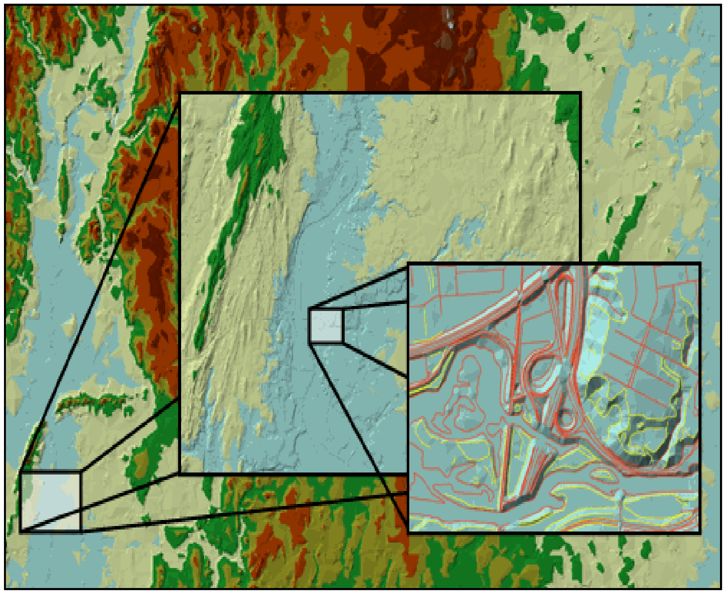
Stream	Mean (feet)	Standard Deviation (feet)	Minimum (feet)	Maximum (feet)
Ahoskie Creek	0.5	3.9	34.8	−25.3
Long Creek	14.7	15.6	81.5	−46.0
Swannanoa River	−2.0	17.5	89.7	−139.3

TABLE 2 Base Flood Elevation Differences Between Detailed and Approximate-NED Studies

Stream	Mean (feet)	Standard Deviation (feet)	Minimum (feet)	Maximum (feet)
Ahoskie Creek	0.95	1.30	−3.34	2.87
Long Creek	20.89	3.07	13.11	26.45
Swannanoa River	0.18	3.61	−5.12	9.91

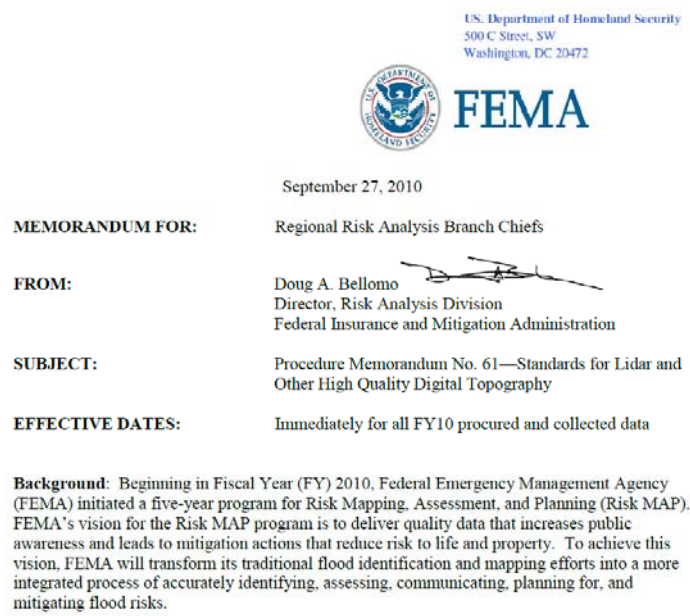
Elevation
Critical to Risk MAP Goals

- Central to reliable base flood elevation and floodplain delineations.
- Important to reliable risk assessments
- Support much more effective communication of flood risk
- Supports new flood risk products



Minimum elevation standards

- Procedure memo 61
- Aligned with USGS Specification, with variations for flood mapping
- 4 levels based on risk and terrain/slope
  - 24.5cm NSSDA 1m NPS
  - 49 cm NSSDA 2m NPS
  - 98 cm NSSDA 3.5m NPS
  - 150 cm NSSDA 5m NPS
- Focus on bare earth in the floodplain



U.S. Department of Homeland Security
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FEMA

September 27, 2010

MEMORANDUM FOR: Regional Risk Analysis Branch Chiefs

FROM: Doug A. Bellomo
Director, Risk Analysis Division
Federal Insurance and Mitigation Administration

SUBJECT: Procedure Memorandum No. 61—Standards for Lidar and Other High Quality Digital Topography

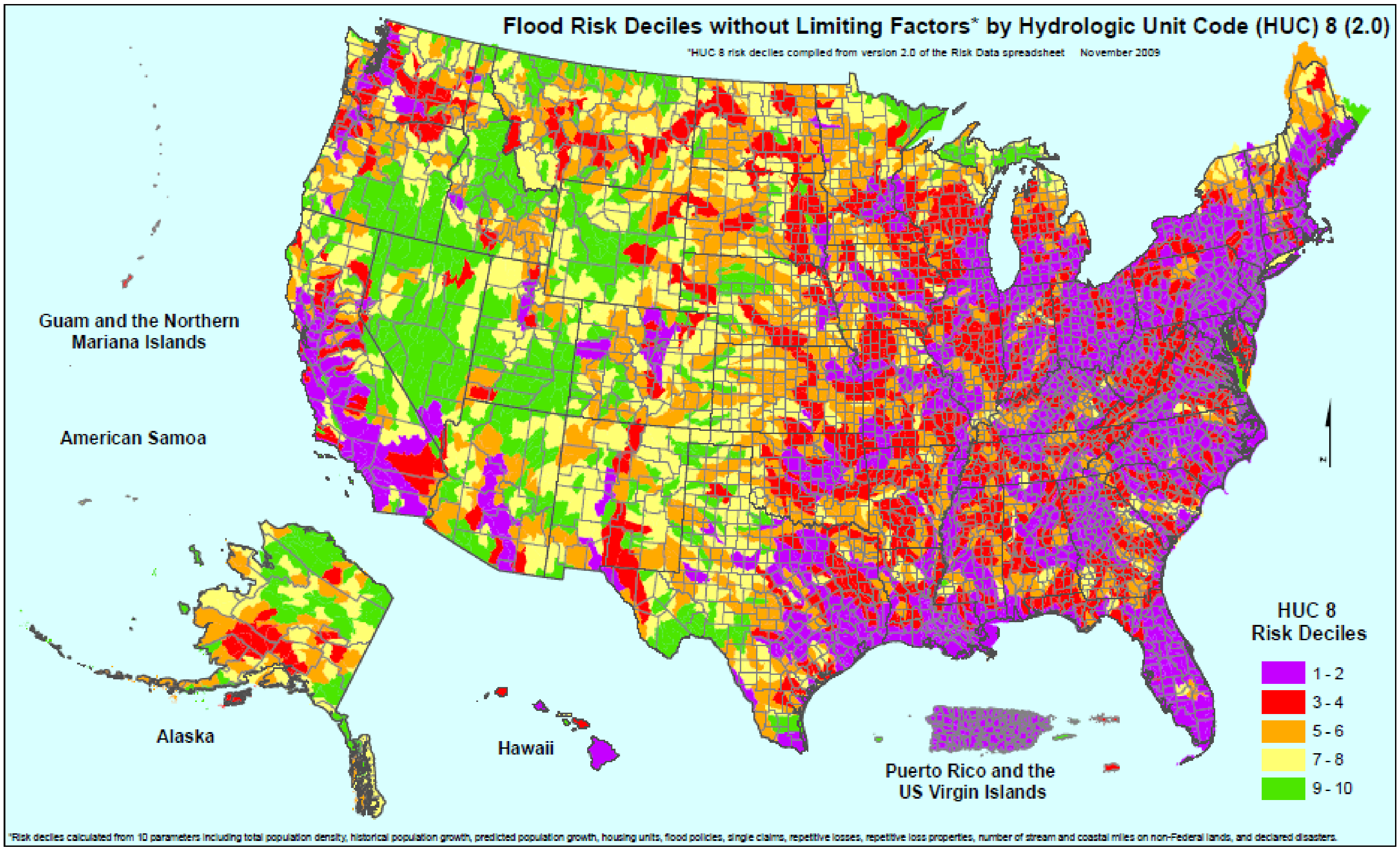
EFFECTIVE DATES: Immediately for all FY10 procured and collected data

Background: Beginning in Fiscal Year (FY) 2010, Federal Emergency Management Agency (FEMA) initiated a five-year program for Risk Mapping, Assessment, and Planning (Risk MAP). FEMA's vision for the Risk MAP program is to deliver quality data that increases public awareness and leads to mitigation actions that reduce risk to life and property. To achieve this vision, FEMA will transform its traditional flood identification and mapping efforts into a more integrated process of accurately identifying, assessing, communicating, planning for, and mitigating flood risks.

Approach

- FY10 and FY11 - $20M annually
- Budget reductions in FY12 will reduce elevation investment proportionately
- The priority areas
  - Highest flood risk locations
  - Do not have recent, accurate elevation data
  - Identified flood hazard data update needs

Prioritize Projects by Risk



Key Strategies:

- Reuse existing lidar
- Stratify requirements by risk and terrain.
  - Only the very flattest areas will require very high accuracy
  - Most of the need will be medium or low accuracy lidar (relative to typical lidar standards)
  - Very lowest risk areas might use existing data
- Cost share for new data wherever possible

Specifications

- Typical lidar data requirements are very demanding in terms of vertical accuracy and collection density
- For many flood hazard analyses, FEMA does not need data collected at the highest standards
- Goal is to avoid processing that is not needed for flood hazard analyses
- Minimum standard where partners provide funding

Partnering

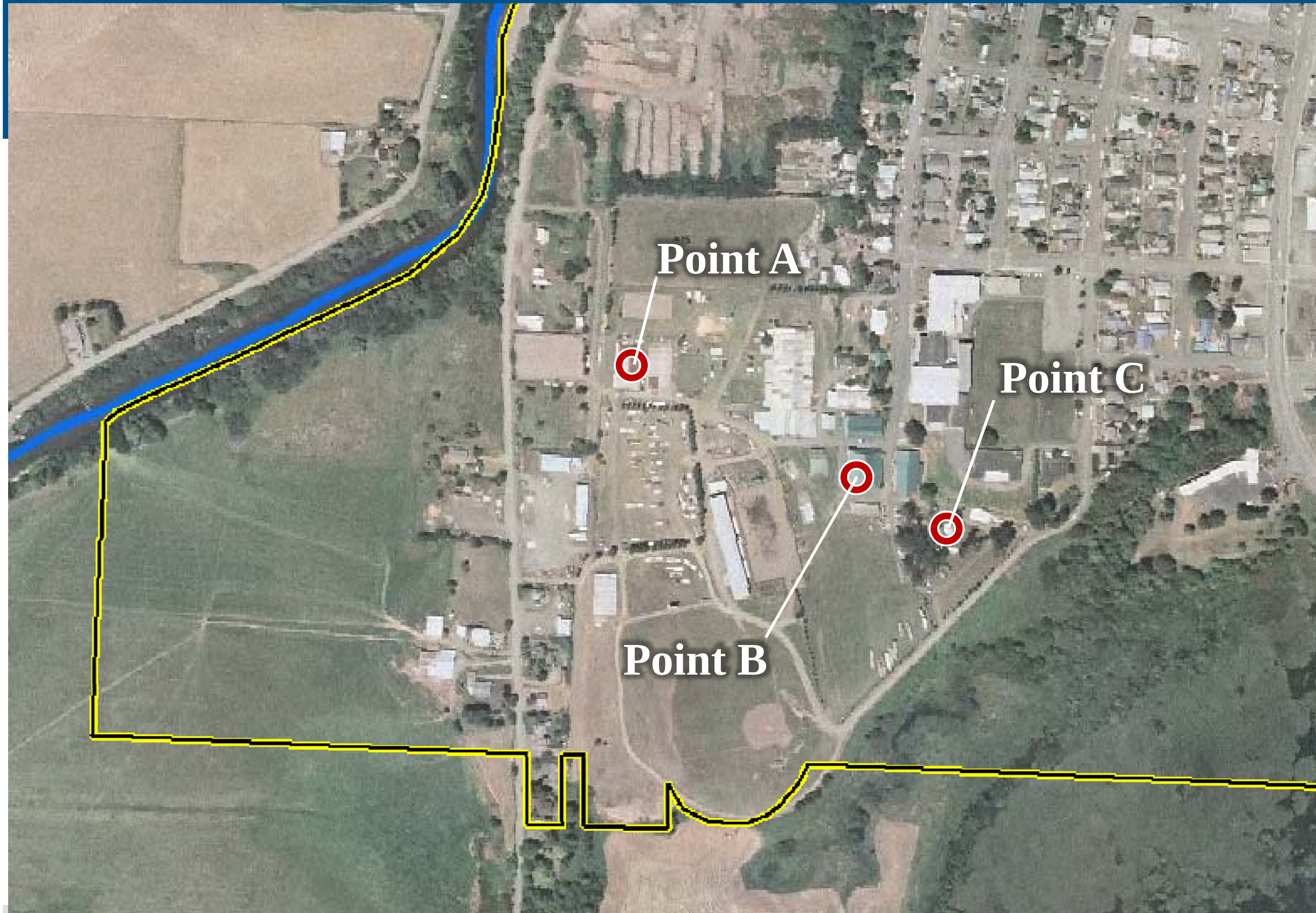
- FEMA Focuses Elevation Coordination through National Digital Elevation Program
- Coordination Activities Have Increased Substantially
  - Annual meeting to share plans for next fiscal year
  - Leverage USGS liaison network and existing FEMA State relationships to look for partnerships
  - Substantial amount of data purchased through USGS GPSC

All SHFAs Need Published Flood Elevations

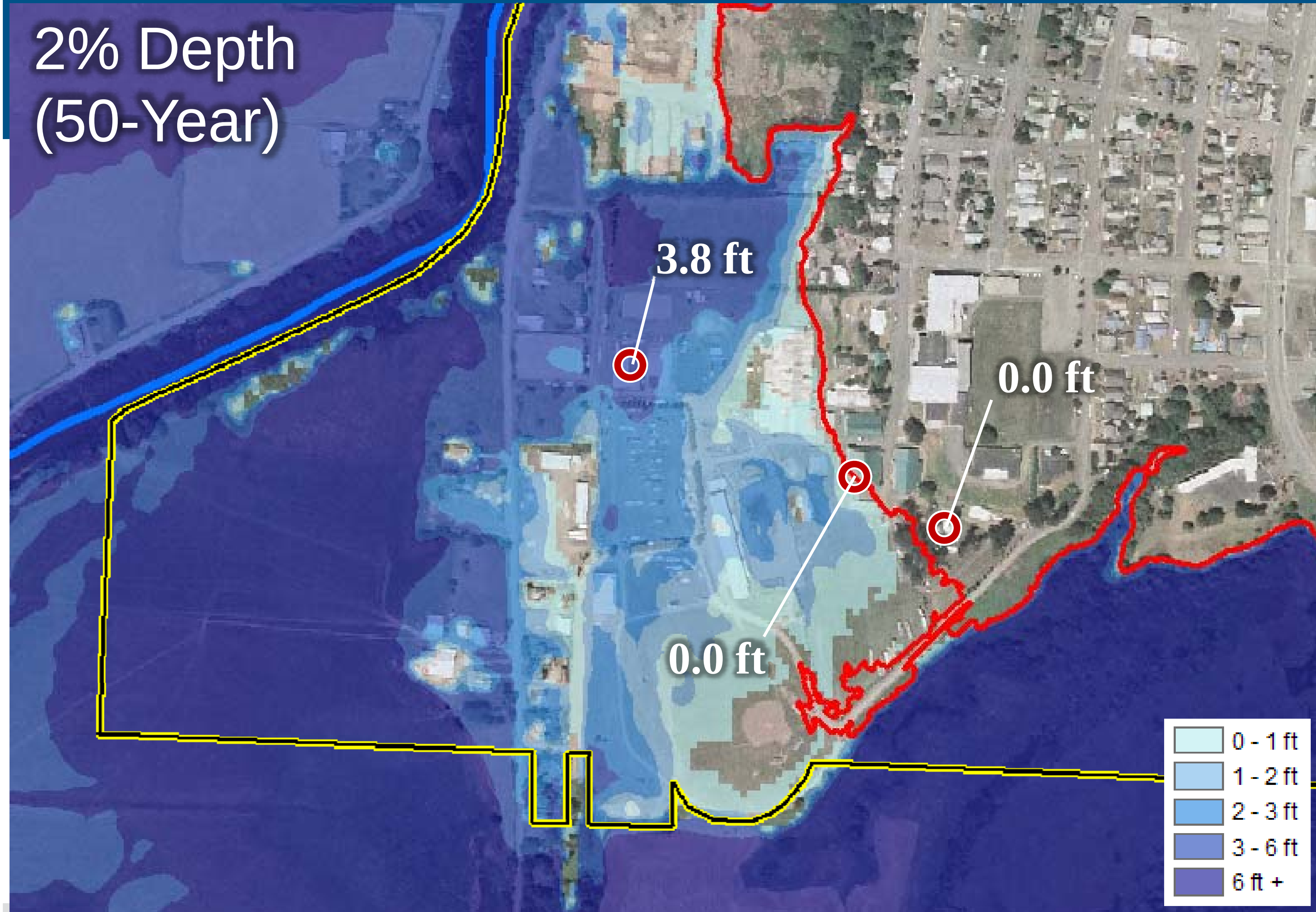
- **Finding.** Significant flood losses could be avoided by replacing maps that contain inaccurate spatial definitions and that lack base flood elevations with maps that accurately define the spatial extent of the SFHA and provide base flood elevations. The marginal benefits derived from these more accurate maps exceed the marginal costs of their preparation. Determination of base flood elevations produces the greatest increment of benefits.
- **Finding.** No single approach to map preparation is appropriate for all circumstances. The benefits and costs of each method are risk and vulnerability dependent.
- **Recommendation.** The flood study method should be determined based on the accuracy of the topographic data in the county or watershed under study and the current and future risk to those in the mapped area.
- **Implementation.** All flood hazard analyses in Risk MAP must be model based, 5 frequencies computed with elevations determined.

Develop Maps Showing Risk

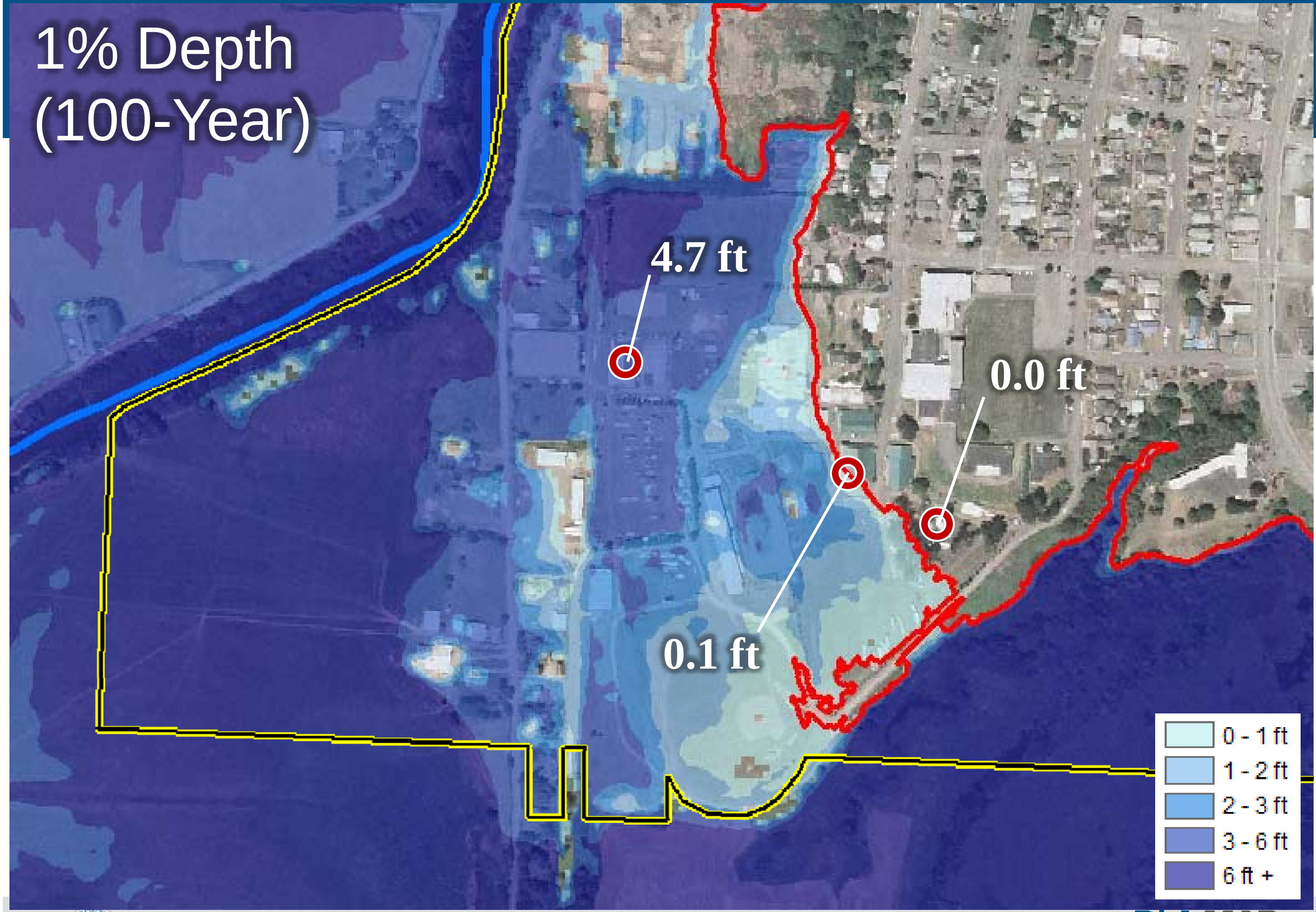
- **Finding.** FEMA ’s transition to digital flood mapping during the Map Modernization Program creates opportunities to develop a variety of hazard and risk maps.
- **Finding.** Combining the appropriate attributes of FEMA DFIRM s with attributes of NOAA inundation maps, USACE risk maps, and the innovative mapping techniques developed by state and local entities and other countries would significantly enhance the communication of flood risk information to those who live in floodplains or manage floodplain development.
- **Finding.** The mapped location of buildings inside or outside an SFHA does not adequately convey a sense of flood hazard. Flood risk can be assessed and communicated more effectively in terms of the relative elevations of the structures and facilities in the flood hazard area.
- **Recommendation.** FEMA should commission a study on technology and metrics to analyze and communicate flood risk.

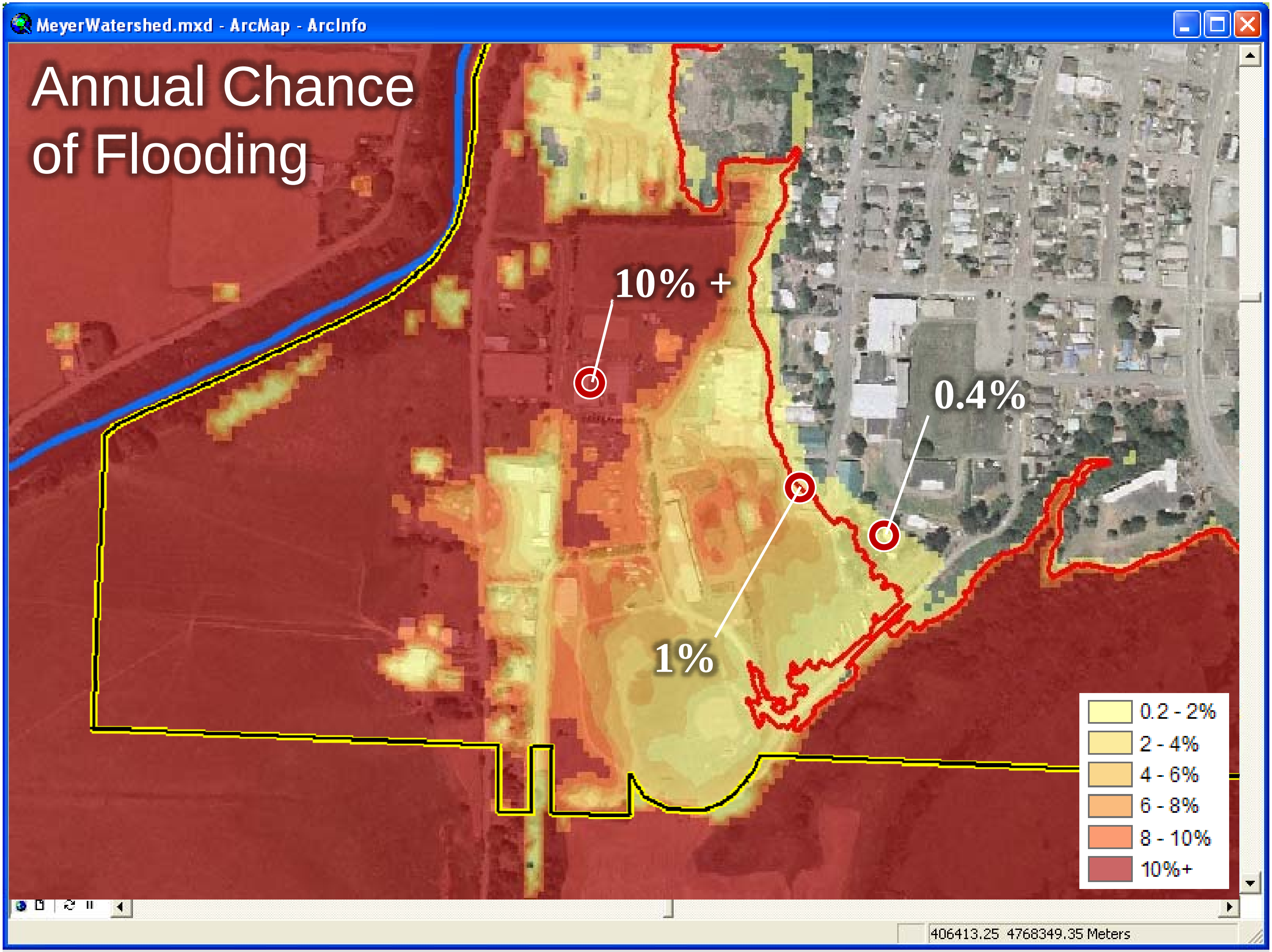

Point A
Point B
Point C

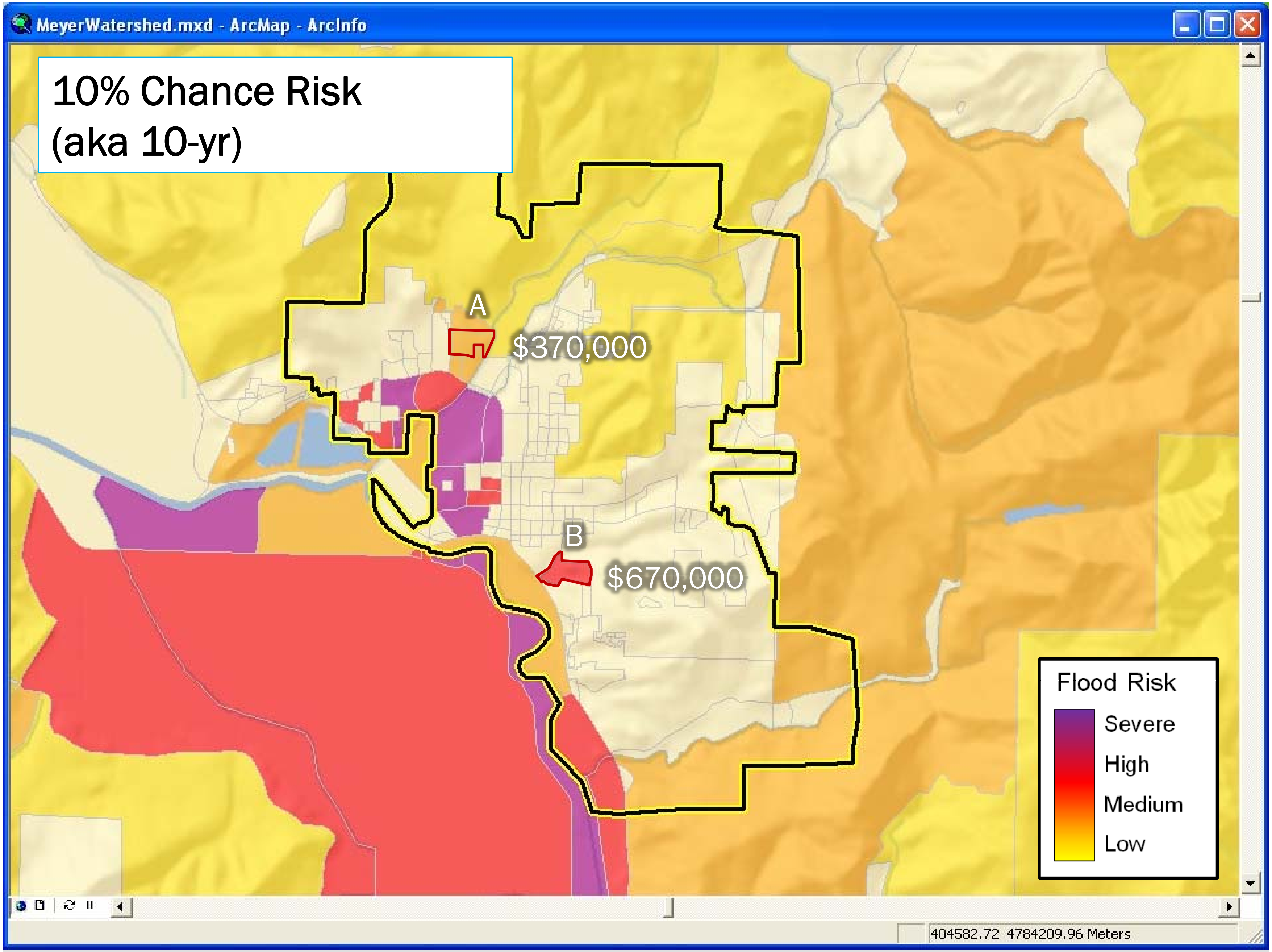
10% Depth (10-Year)

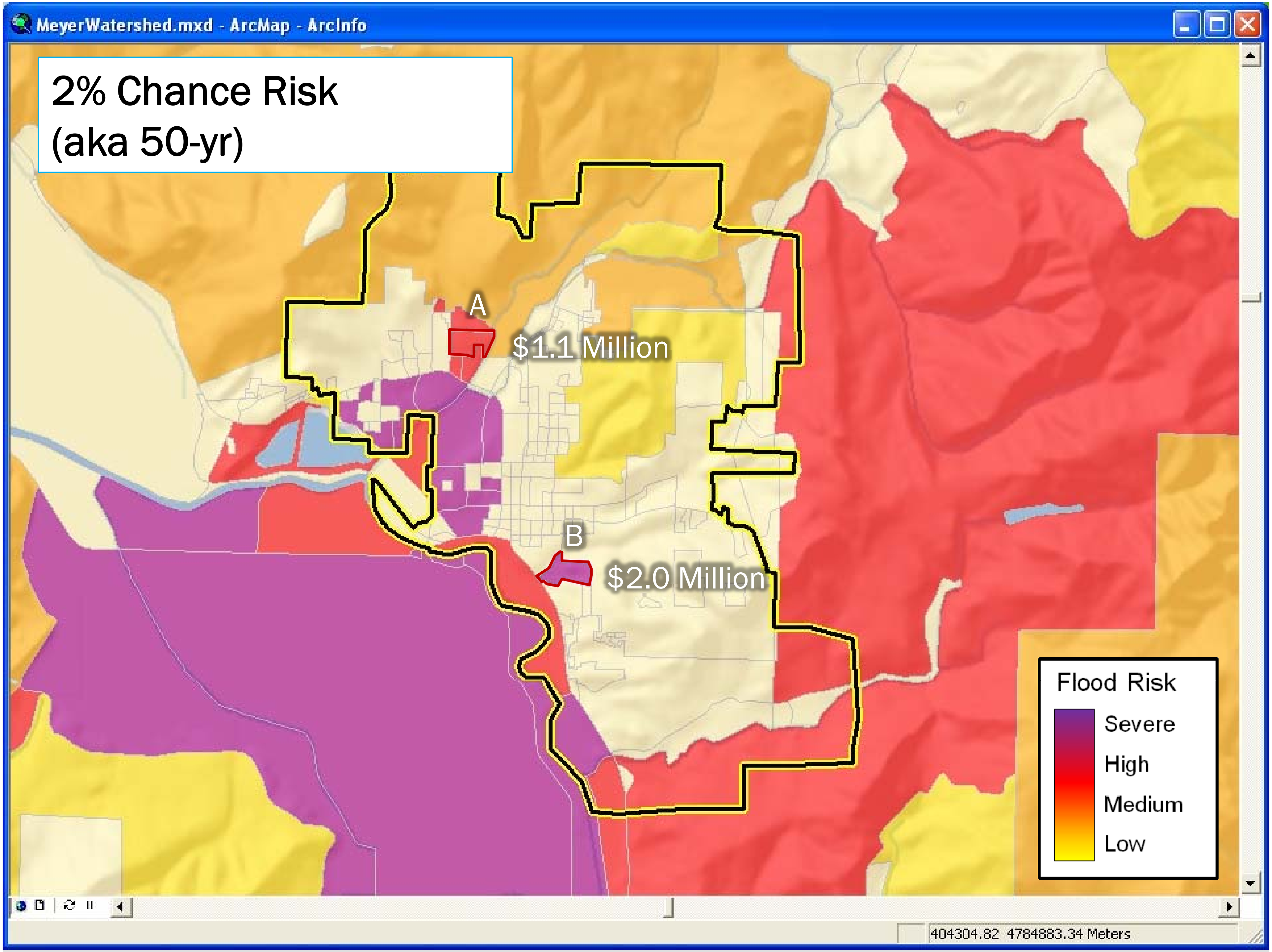

2% Depth
(50-Year)
3.8 ft
0.0 ft
0.0 ft
0 - 1 ft
1 - 2 ft
2 - 3 ft
3 - 6 ft
6 ft +

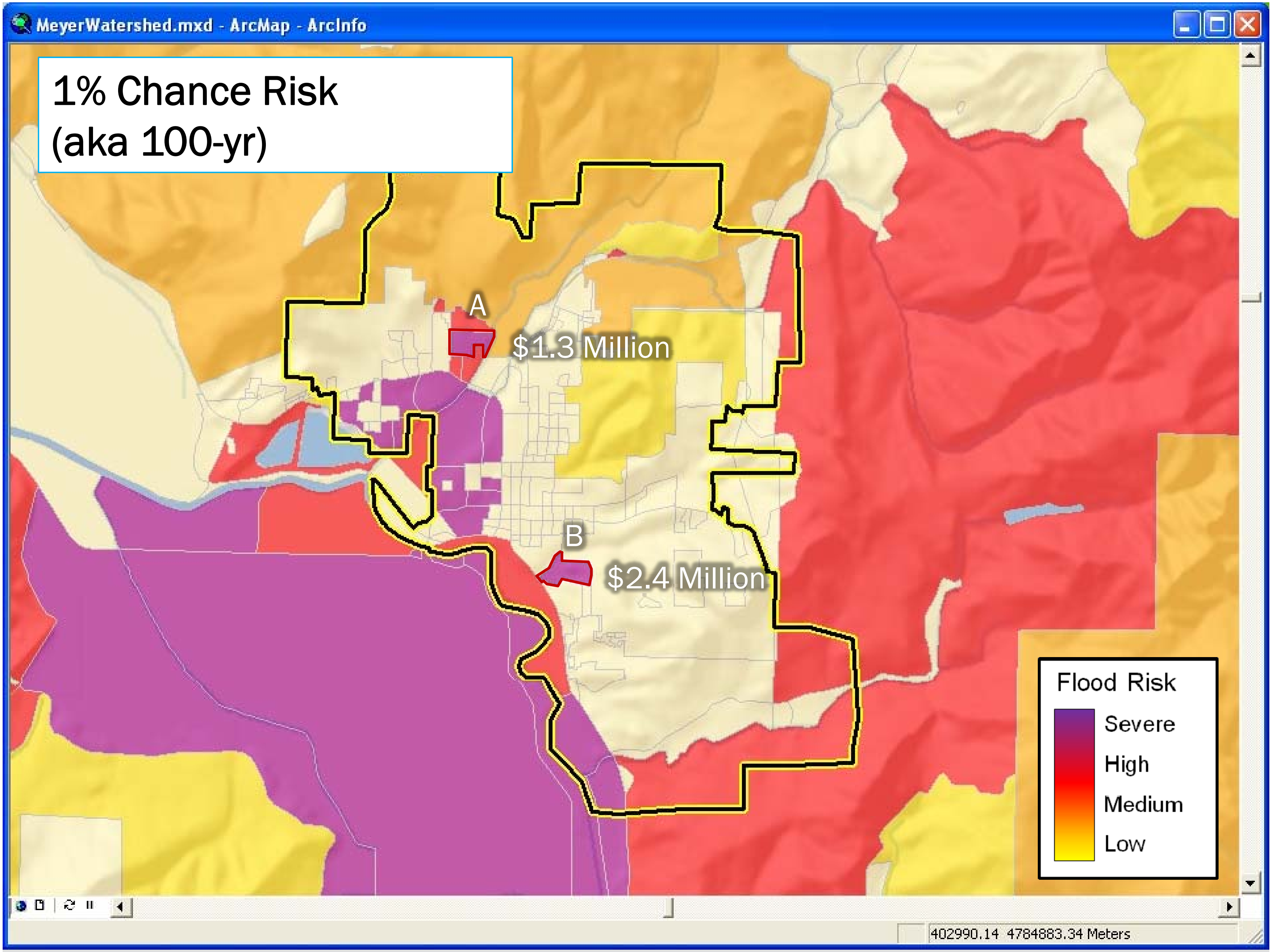
1% Depth (100-Year)

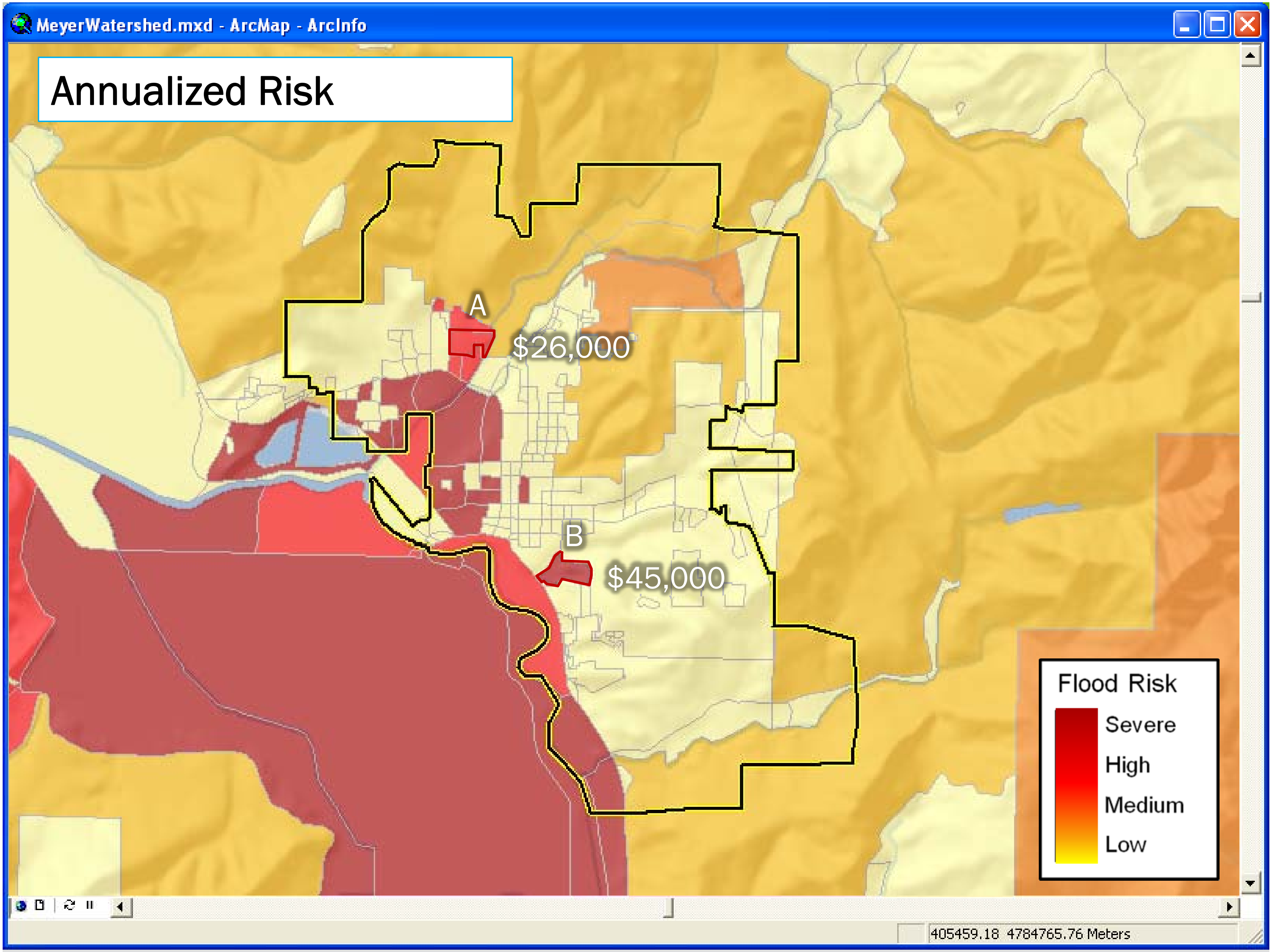



MeyerWatershed.mxd - ArcMap - ArcInfo
Annual Chance of Flooding
10% +
0.4%
1%
0.2 - 2%
2 - 4%
4 - 6%
6 - 8%
8 - 10%
10%+
406413.25 4768349.35 Meters


MeyerWatershed.mxd - ArcMap - ArcInfo
10% Chance Risk
(aka 10-yr)
A
$370,000
B
$670,000
Flood Risk
Severe
High
Medium
Low
404582.72 4784209.96 Meters


MeyerWatershed.mxd - ArcMap - ArcInfo
2% Chance Risk
(aka 50-yr)
A
$1.1 Million
B
$2.0 Million
Flood Risk
Severe
High
Medium
Low
404304.82 4784883.34 Meters


MeyerWatershed.mxd - ArcMap - ArcInfo
1% Chance Risk
(aka 100-yr)
A
$1.3 Million
B
$2.4 Million
Flood Risk
Severe
High
Medium
Low
402990.14 4784883.34 Meters


MeyerWatershed.mxd - ArcMap - ArcInfo
Annualized Risk
A
$26,000
B
$45,000
Flood Risk
Severe
High
Medium
Low
405459.18 4784765.76 Meters

Continue to Evolve Coastal Methodologies with Latest Science

- **Finding.** There are significant long-term linear trends in sea levels around the U.S. coastline; in most cases, sea levels are rising with respect to the land surface. The rate of change of sea level is significant when compared to flood map accuracy standards.
- **Recommendation.** FEMA should redefine the V zone boundary based on a 1.5-foot breaking wave rather than the present 3-foot wave.
- **Recommendation.** FEMA should work with other federal agencies and academic institutions to develop a test bed to assess and compare the various models used for coastal flood mapping. As a start, FEMA should compare the flood maps for the New Orleans region produced by IPET using coupled 2-D surge and wave models with those produced by FEMA using a 2-D surge model and a 1-D wave model.
- **Recommendation.** FEMA should use coupled 2-D surge and wave models to reduce uncertainties associated with the use of a 2-D surge model and the 1-D WHA FIS model. Before choosing which models to incorporate into mapping practice, an analysis of the impact of various uncertainties on the models should be undertaken.
- **Recommendation.** FEMA should work toward a capability to use coupled surge-wave-structure models to calculate base flood elevations, starting with incorporating coupled two-dimensional surge and wave models into mapping practice.
- **Recommendation.** FEMA should expand collection of high-resolution topographic data to all coastal counties and require collection of post-storm topographic data to validate storm surge and wave models and improve their accuracy.
- **Recommendation.** FEMA should work with NOAA and the USACE to acquire high-accuracy bathymetric data in coastal, estuarine, and riverine areas.
- **Recommendation.** FEMA should begin mapping E zones to better serve insurance and floodplain management needs.
- **Recommendation.** FEMA should commission an external advisory group to conduct an independent, comprehensive assessment of coastal flood models to identify ways to reduce uncertainties in the models and to improve the accuracy of BFEs.

Continue to Evolve Coastal Methodologies with Latest Science

- Performing major study on the impact of climate change on the NFIP
- Standardized inclusion of 1.5 foot wave boundary on new coastal maps (Limit of Moderate Wave Action)
- Use coupled 2-D surge-wave models to calculate wave setup
- Study at University of Florida comparing 1-D WHAFIS model to 2-D SWAN model
- Working with USACE to further evaluate WHAFIS and develop strategies for future modeling tools
- Working with Interagency Working Group on Ocean and Coastal Mapping

Other Operational Improvements

- **Recommendation.** FEMA should ensure that new flood information, revisions, and Letters of Map Change are incorporated into the digital Flood Insurance Rate Maps as soon as they become effective.
- National Flood Hazard Layer
- **Recommendation.** FEMA should calibrate hydrologic models using actual storm rainfall data from multiple historical events, not just flood design storms.
- Revised Hydrologic Standards – Appendix C
- **Recommendation.** FEMA should require that every flood study be accompanied by detailed metadata identifying how each stream and coastline reach was studied and what methods were used to identify the magnitude and extent of the flood hazard and toproduce the map.
- **Recommendation.** FEMA should reference all stream and coastal studies within its Mapping Information Platform to the USGS National Hydrography Dataset.
- Revised documentation standards – Appendix M
- **Finding.** The variation in peak flow predictions between regions illustrates the importance of developing regression equations at the river basin level, independent of state boundaries. States with significantly outdated regression equations that should be updated include Michigan, Massachusetts, New Jersey, California, and New Hampshire.
- Risk MAP Watershed Approach