Modernization Updates: Architecture, Proof of Concept Design

August 6, 2014

Hazus Modernization – Architectural Considerations

Architectural Focus Areas

1. Replacement of Personal GeoDatabases (pGDB)
2. Migration/replacement of DTS packages
3. Replacement of VB6 components with .NET (C#)
4. Other Decisions/Findings (OS platforms, version of ArcGIS, etc.)

1. Replacement of Personal GeoDatabases (pGDB)

- Currently default state data (spatial as well as attribute data) is delivered in the form of Personal GeoDatabases (pGDBs)

Problem

- pGDBs are MS Access databases with significant size and performance constraints.
- For replacement of pGDBs, the following options have been evaluated:
  - ESRI File GeoDatabase
  - Relational database with spatial extension (SQL Server Express, to be specific)
  - Open-source spatial databases: SpatiaLite and PostGIS

Solution

- SQL Server Express (with spatial option) was chosen as the replacement for pGDBs
- Recommended version of SQL Sever Express is 2008 R2 (the same version currently used in Hazus)
- The possibility of using a later version (2012 or 2014) was considered; the recommendation is to stay with 2008 R2 for Task 3 to avoid additional moving parts
- 10GB per database size limit of SQL Express will be addressed by one database for each state
- Spatial data, that currently resides in pGDB, will be stored as the Geometry type in SQL Server

1. Replacement of Personal GeoDatabase (pGDB), continued

MS Access Considerations

- Besides pGDB, Hazus currently depends on MS access in areas including the following:
  - Flood module intermediate results data is stored in MS Access (to gain better performance by avoiding unnecessary transaction logging)
  - ShakeMap2Hazus also outputs data into MS Access database which in turn is used in EQ

- These databases can remain as MS Access databases for now because they are relatively small, therefore, not affected by the size or performance limitations of MS Access

Future Considerations

- We should plan for a future phase focusing specifically on migration of SQL Server 2008 to 2012 or 2014 for the following reasons:
  - Microsoft has made a lot of improvements to spatial data processing starting in SQL Sever 2012
  - Regular support for SQLServer 2008 R2 expired in July, 2014; extended support is available till 2019

2. Replacement of DTS Packages

- DTS is an ETL (extract, transform, load) tool from Microsoft
- Currently, DTS packages are used to copy and aggregate data from default state databases (MS Access pGDBs) to SQLServer Express databases

Problem

- Microsoft has deprecated DTS and replaced it with SSIS which is not available in SQLServer Express edition

Solution

- The primary reason why DTS is used today in Hazus is that data resides in two different database platforms
- Default state data (attributes and spatial) in MS Access personal Geo-Databases (pGDB)
- Study region/final results attribute data in SQL Server Express
- Once MS Access-based pGDBs are replaced with SQL Server Express, Hazus will be using a single database platform for source data and Study region/final results
- New custom component(s) will be developed to replace all functionalities currently provided through DTS

3. Replacement of VB6 Code with .NET (C#)

Problem

- VB6 is outdated and needs to be replaced
- Hazus Flood module is largely dependent on VB6

Solution

- **.NET Framework, Development IDE:**
  - The latest version of .Net Framework (4.5) will be used
  - Visual Studio 2010 IDE will be used; .NET Framework 4.5 will be made available in Visual Studio 2010 by adding a NuGet package
- **Impact on other modules besides Flood:**
  - Shell makes a call to each module; so, considerations will be made during design to make sure that impact of the flood module updates is minimal on Shell by keeping the new interface similar (if not the same) to the existing one
- **Dependency on ArcObjects (lower-level API)**
  - As recommended by ESRI, higher level API- GeoProcessing Tools (GP Tools) will be used (instead of ArcObjects), as applicable

4. Other Technology Upgrade Decisions

Target platform (OS, ESRI ArcGIS Desktop version)

- Windows 7 32-bit, 64-bit, Windows 8
- Current target is ArcGIS Desktop 10.2.2 (Hazus has not been tested against 10.2.3)

Third-party components

- Crystal Reports: move to a single version of Crystal Reports- v11
- FarPoint Spread Control: Use .NET implementation of FarPoint Spread Control 8 in .NET code; VC++ code will still continue to use current COM component
- Tx Text Control: All modules use it through the Shell; so it can remain as-is

Other considerations

- Dependency on J# and Xceed
  - CDMS uses a J# API for data compression; Xceed Zip library is used elsewhere in Hazus for compression
  - Extended support for SQLServer 2008 R2 is available till 2019

Additional considerations that need further analysis

- ESRI ArcGIS Desktop version 10.3 and ArcGIS Pro options are being evaluated based on input from ESRI conference
- Impact on CDMS: Impact Analysis is being performed to determine the level of effort required to make CDMS work with the new database platform (SQL Server 2008 R2)
- Hazus currently uses Microsoft Jet engine to interact with MS Access; Microsoft Jet database engine is considered a deprecated product
  - Impact Analysis is being performed to determine the level of effort required to remove dependency on the Jet Engine
- In addition to all the VB6 components of Flood module, there are two VB6 components in EQ/Shell. Impact Analysis is being performed to determine level of efforts required to replace these EQ/Shell components with .NET

Hazus Modernization – Proof of Concepts

Upcoming National Flood Hazard Layer (NFHL) and Hazus Flood Model Integration Proofs of Concept:

1. **Integrate NHFL and additional flood-related data to model and provide alternate to Hazus Flood Model Level 1 hazard analysis for the 100 year, and 500 year (where available) Return Periods (RPs)**

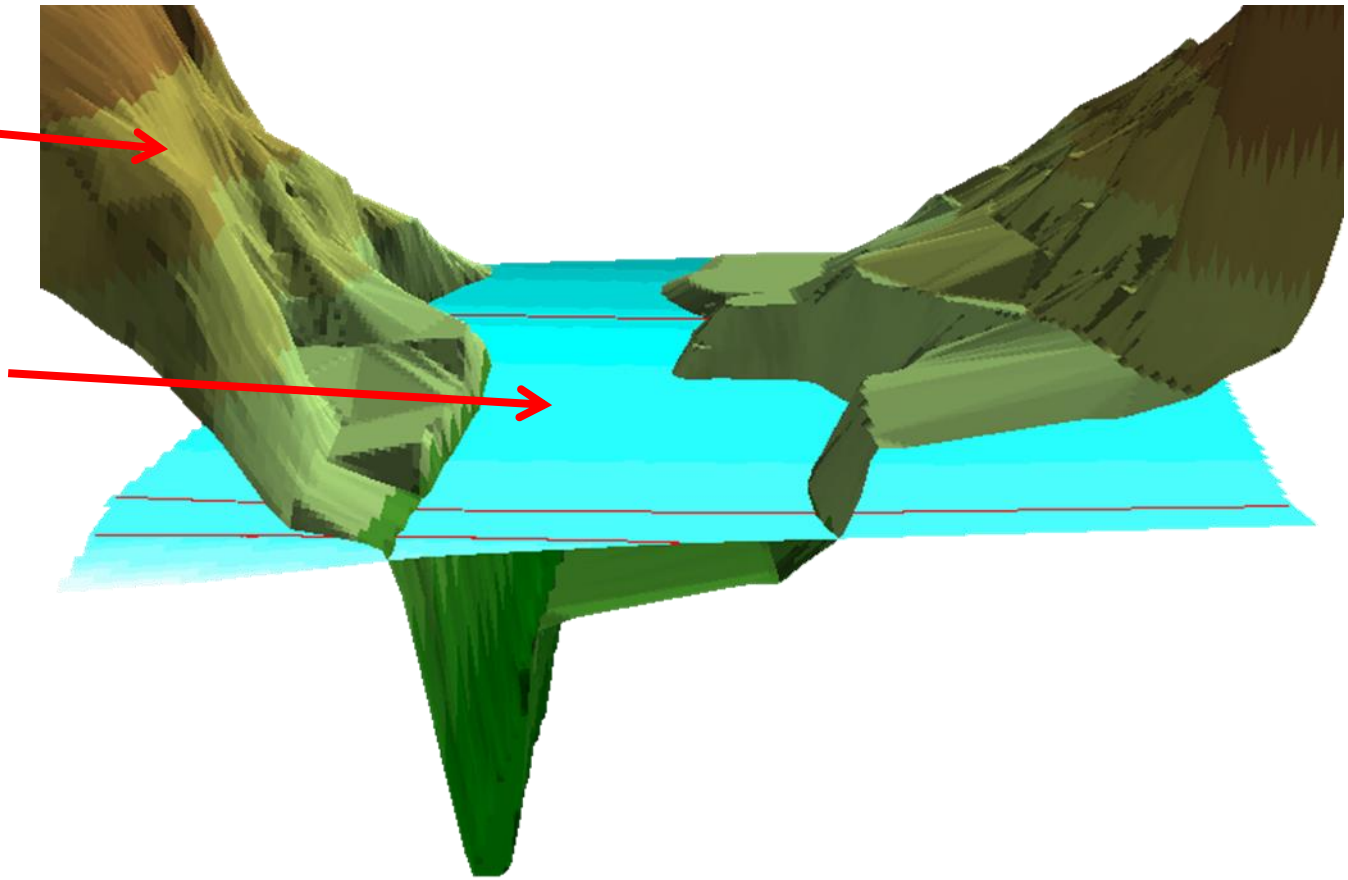
2. **If #1 is successful, using NFIP rating curves to produce losses for the additional RPs and Average Annualized Loss (AAL) analysis**

Developing a Depth Grid

- ***Obtain 3D terrain***

- ***Develop flood surface from flood hazard data***

- ***Subtract terrain from flood surface***



Integrating the NFHL data to generate the Hazus Flood Model hazard

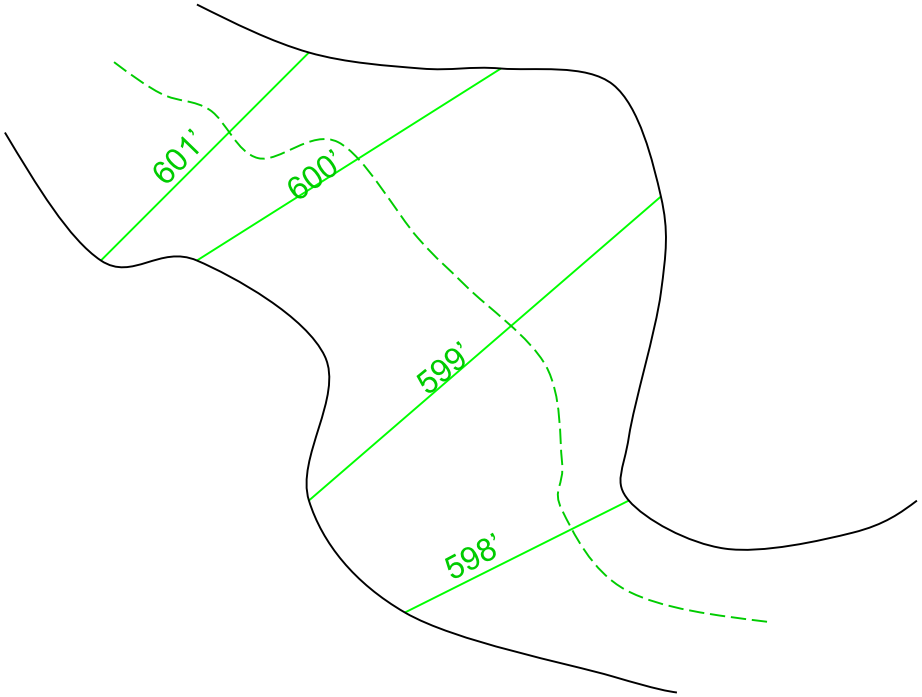
- Benefit: Agreement with NFHL floodplain boundary extent, use of higher quality product.
- Challenge: achieve realistic flood depths by “reverse engineering” NFHL floodplain data

- Hazus Flood model users must currently model their own flood hazard before calculating flood losses either as Level 1 or using external H&H tools such as HEC-RAS, HEC-GeoRAS, and/or other flood modeling engineering software tools
- NFHL provides flood hazard boundary polygon for the 100 year RP, and occasionally 500 year

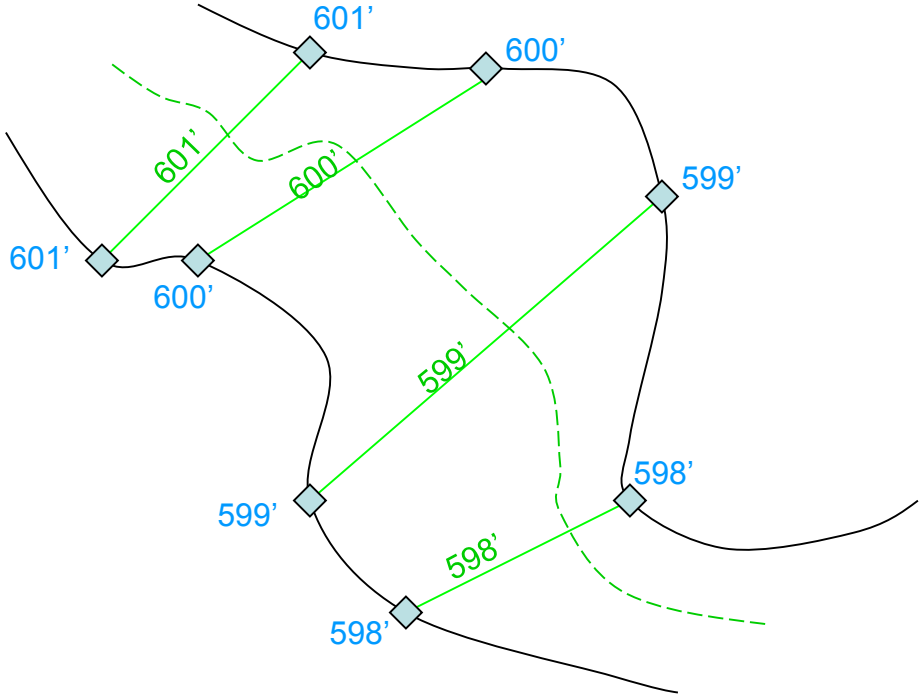
- Three possible approaches are proposed for using NHFL data to provide alternative to Level 1 Flood analysis in Hazus, and obtain the required depth grids:
  1. AE Zone Approach – using BFE cross-sections from NFHL AE Zone data, interpolate the depth grid by sampling flood elevation values at cross-section endpoints.
  2. A Zone Approach – where BFE cross-sections are not available, approximate cross-sections by finding the centerline of a waterway, and drawing lines of equal flood elevation perpendicular to the centerline.
  3. A Zone Vector Approach – Alternatively to the A Zone approach, assume a uniform flood elevation along approximated cross-sections, and subtract terrain elevation values to obtain a depth grid.

1. AE Zone Approach

- Using BFE cross-sections from NFHL AE Zone data, interpolate the depth grid by sampling Water Surface Elevations (WSE) at cross-section endpoints.



Green = BFE polylines available from FEMA AE Zones, showing **lines** of equal elevation for the 100-year flood

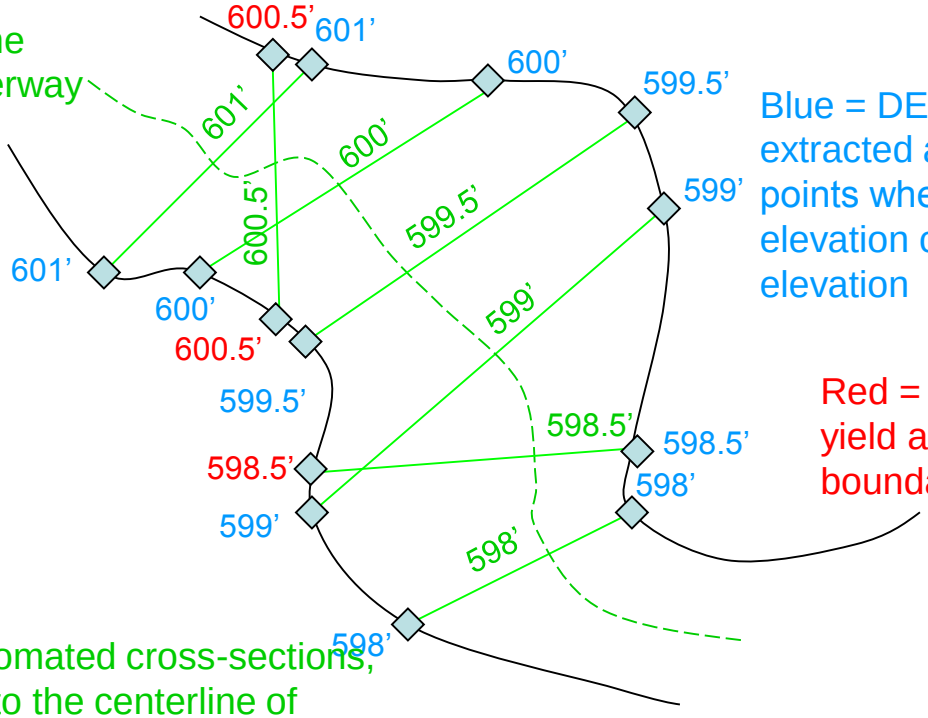


Blue = Extracted endpoints of each BFE polyline, showing **points** of equal elevation for the 100-year flood

2. A Zone Approach

- A Zone Approach – where BFE cross-sections are not available, approximate cross-sections by finding the centerline of a waterway, and drawing lines of equal flood elevation perpendicular to the centerline.

Green = determine centerline of waterway

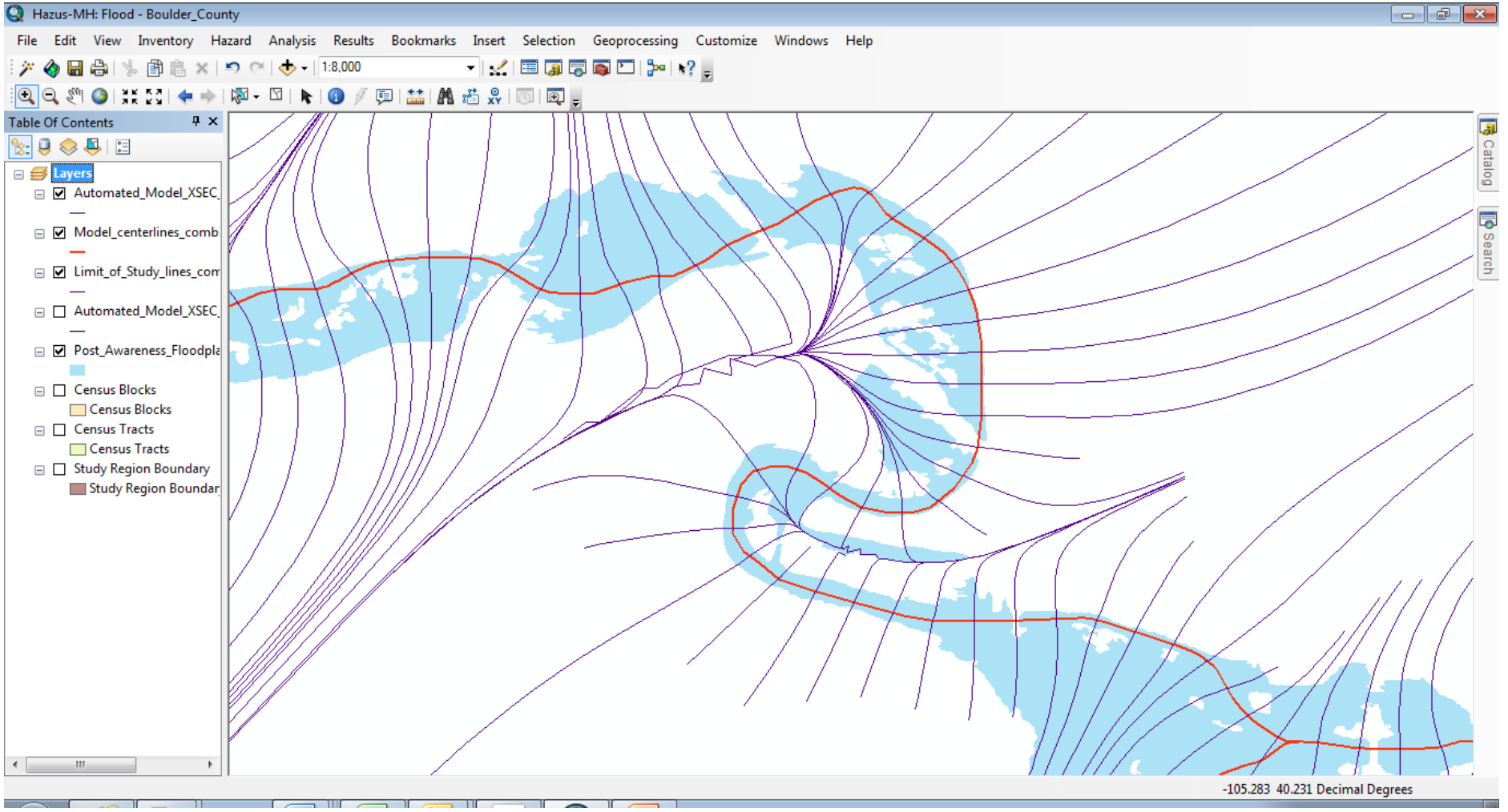


Blue = DEM elevation values can be extracted along each cross-section. At end points where flood depth is 0’, flood elevation can be assumed to equal DEM elevation

Red = criss-crossing cross-sections yield abnormal WSEs at NFHL boundary

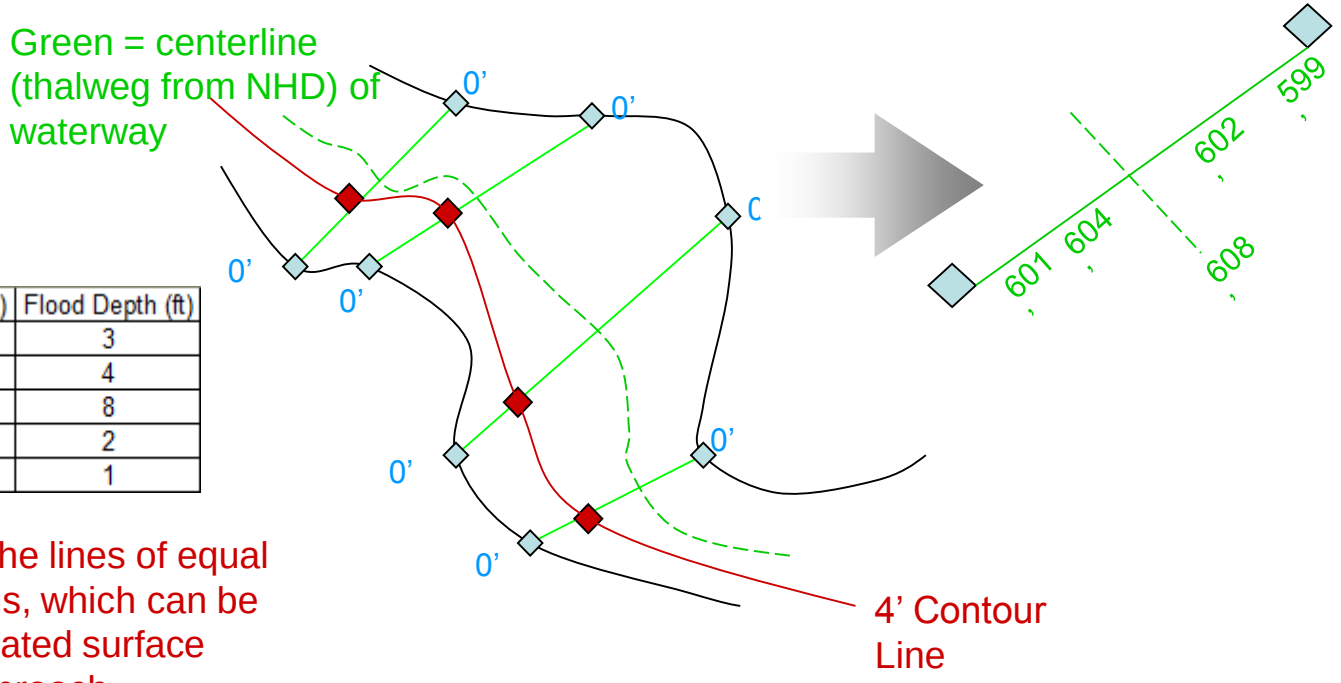
Green = software automated cross-sections, drawn perpendicular to the centerline of waterway for lines of equal water surface elevation

Automated Cross-Sections-First Order Approximation (FOA)



3. A Zone Vector Approach

- A Zone Vector Approach – Alternatively to the A Zone approach, assume a uniform flood elevation along approximated cross-sections, and subtract the terrain contour polygons to obtain a depth as vector polygons.



Flood Elevation (ft)	Terrain Elevation (ft)	Flood Depth (ft)
601	598	3
604	600	4
608	600	8
602	600	2
599	598	1

Subtracting the terrain from the lines of equal flood elevation to flood depths, which can be used to generate the interpolated surface described in the AE Zone approach.

What is the quality of the FEMA dataset

Horizontal errors: leads to errors in extracted DEM elevations

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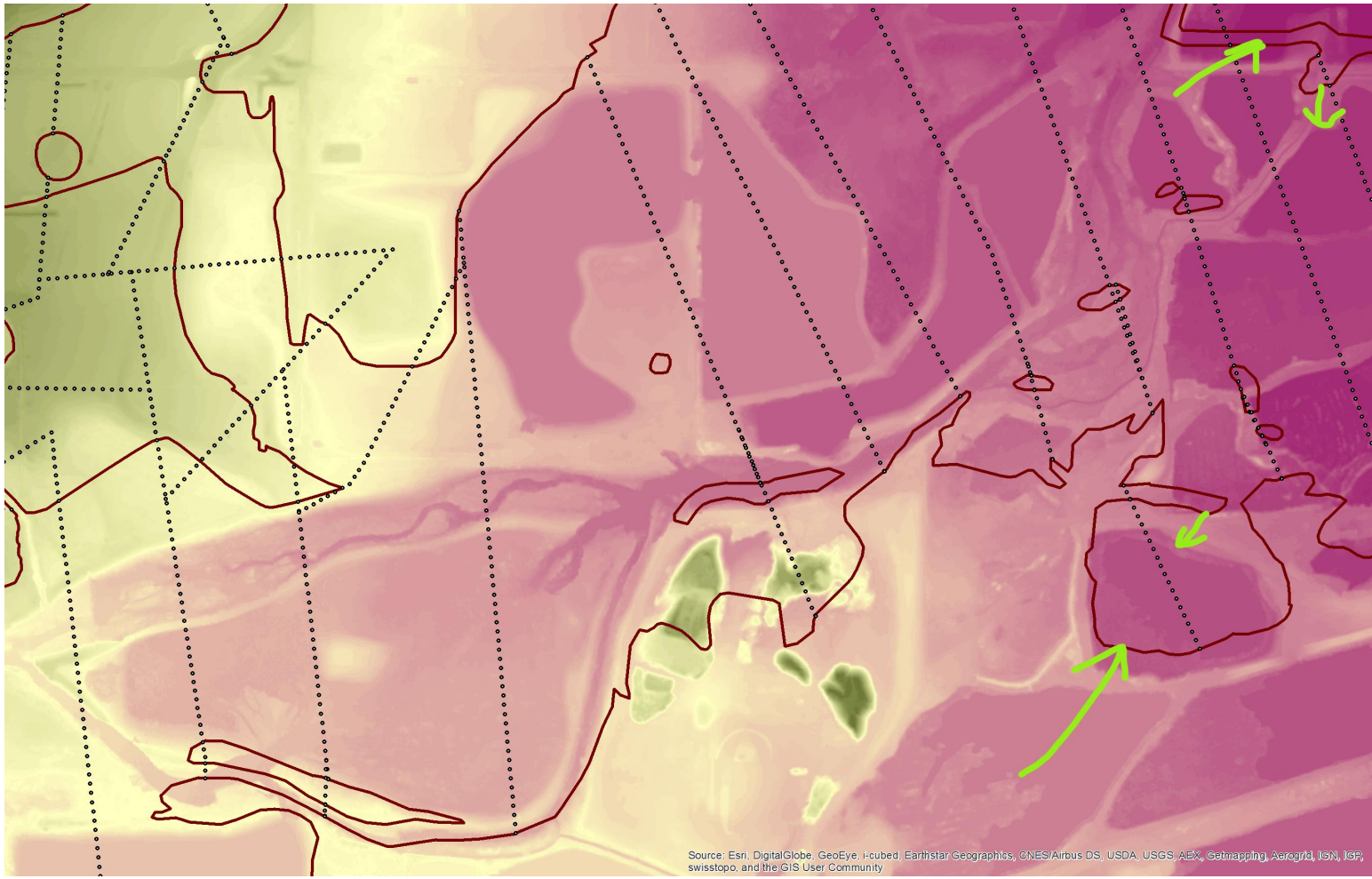
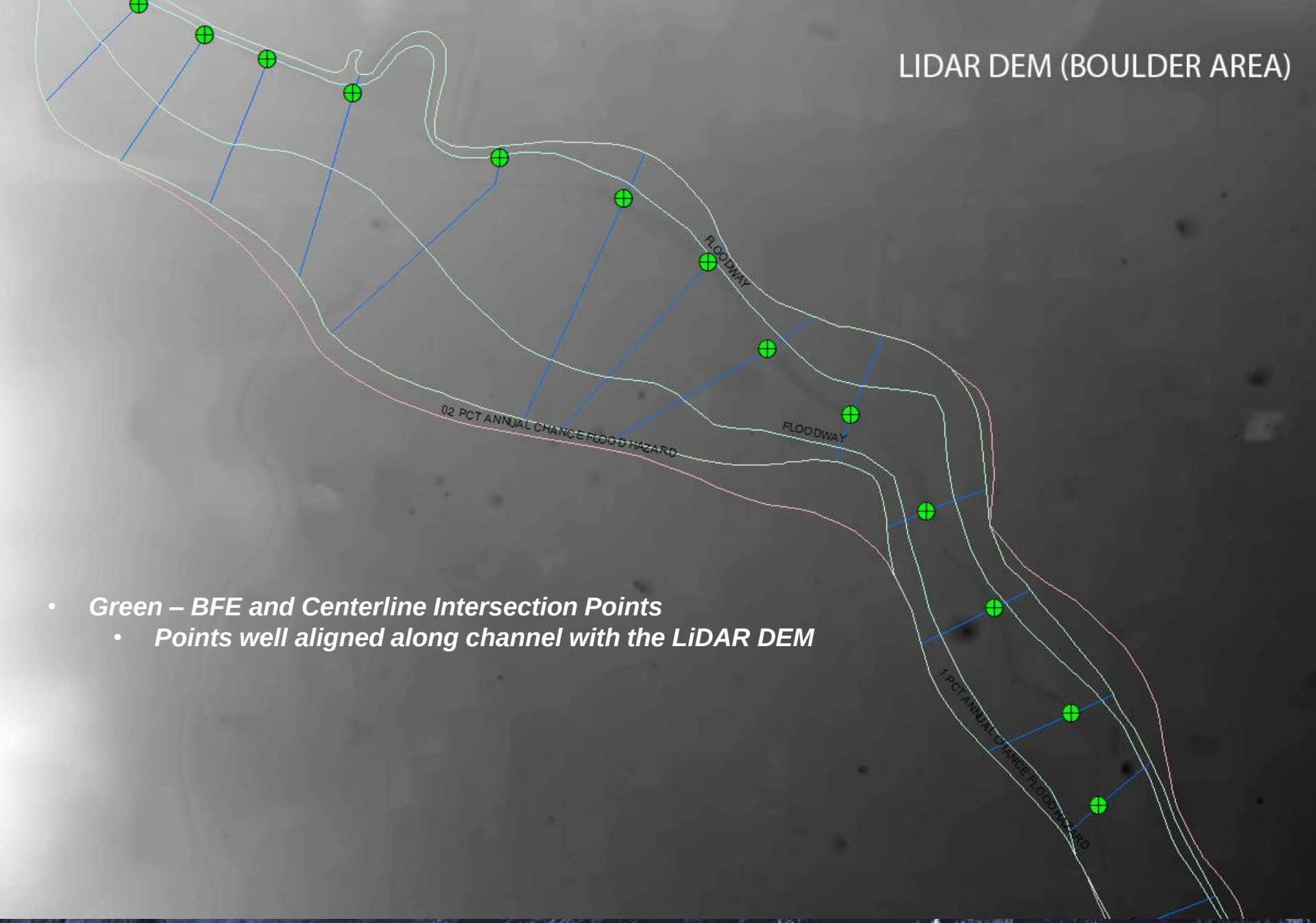


Need metrics to assess relative error

- Error statistics
- Differences between DEM and BFE vertex elevations within the channel
- Chart and statistics for % of points in the area with negative depths
- Histograms of positive & negative depths – this is normally distributed
    - One for all BFE points
    - One for the FEMA centerline
- All we can do is measure relative error, not absolute. Need benchmark data for this

Green – BFE and Centerline Intersection Points

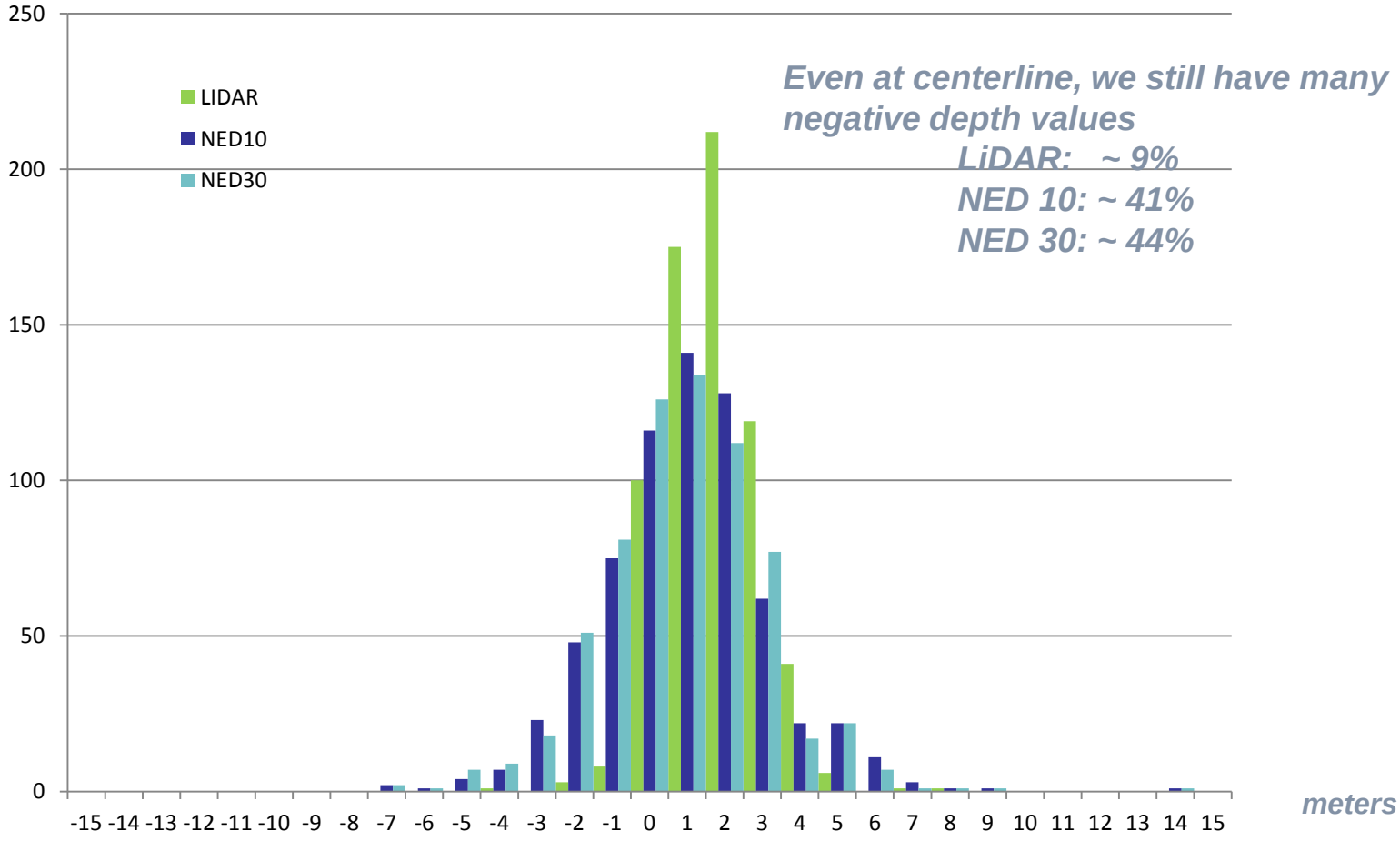
LIDAR DEM (BOULDER AREA)



- ***Green – BFE and Centerline Intersection Points***
  - ***Points well aligned along channel with the LiDAR DEM***

Flood depth distribution by DEM source

Positive depth	LIDAR	NED10	NED30
	0.916168	0.588323	0.561377



Even at centerline, we still have many negative depth values

LiDAR: ~ 9%
NED 10: ~ 41%
NED 30: ~ 44%

The errors don't change much between 1-arc-second and 1/3-arc-second DEMs
Much better for 0.5 meter LiDAR

Q&A

- For additional questions
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