CRAB and MIT Chart Project

OF THE LOWER CHARLES RIVER

Agenda

- Organizations and People
- Project Background and Scope
- Experimental Methods and Instrumentation
- Watersheet Level
- Uncertainty and Error
- Digital Depth Charts
- Future Work

Charles River Alliance of Boaters

- Mission is to encourage safe and accessible boating by the entire community on the Lower Basin of the Charles.
- This includes power boaters, sailors, rowers, paddlers, and others, working together to keep the Charles River a healthy resource for the enjoyment of boaters and park users alike.
- A cornerstone of our effort is the development of better avenues of communication between and among this diverse community of users.
- www.CharlesRiverAllianceofBoaters.org

MIT Sea Grant College Program

- Mission is to conduct and support research and develop technology to enable scientific investigation into problems surrounding the health and human use of the sea
- Education and outreach efforts disseminate the results of our research, encourage the stewardship and the adoption of sustainable and useful technologies, and support public policy and industry with information that is relevant, evidence-based and scientifically sound.
- Wide variety of activity including the Autonomous Underwater Vehicles (AUV) Lab, the Design Lab for naval architecture and systems, and the MIT Sea Grant Marine Advisory Services group.
- SeaGrant.mit.edu

People

- Carl Zimba
  Project Coordinator
  Charles River Alliance of Boaters

- Michael Sacarny
  Project and Survey Lead
  Research Engineer, MIT Sea Grant College Program

- Madonna Yoder
  Chart Development and Survey Crew
  Student Intern, MIT Sea Grant College Program

- Ben Bray
  Arc-GIS Website Development
  Web Developer, MIT Sea Grant College Program

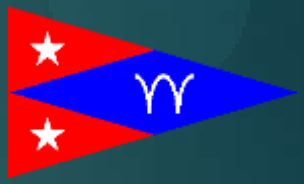
In-Kind Contributors

Sea Grant
Massachusetts Institute of Technology

MIT SAILING

Massachusetts Bays
NATIONAL ESTUARY PROGRAM

Financial Contributors



Individual Donors

Long-standing Concerns

- Shallow areas affect recreational use of the river
  - Several recent incidents resulting in damage to boats
- Sediment is reducing the channel width and depth
  - Faneuil Brook sandbar and removal
  - Muddy River delta
  - Areas near some docks are getting filled with sediment
    - Newton YC, Watertown YC, Community Rowing, BB&N Rowing
- Lots of anecdotal evidence of problem areas
- Little quantitative data

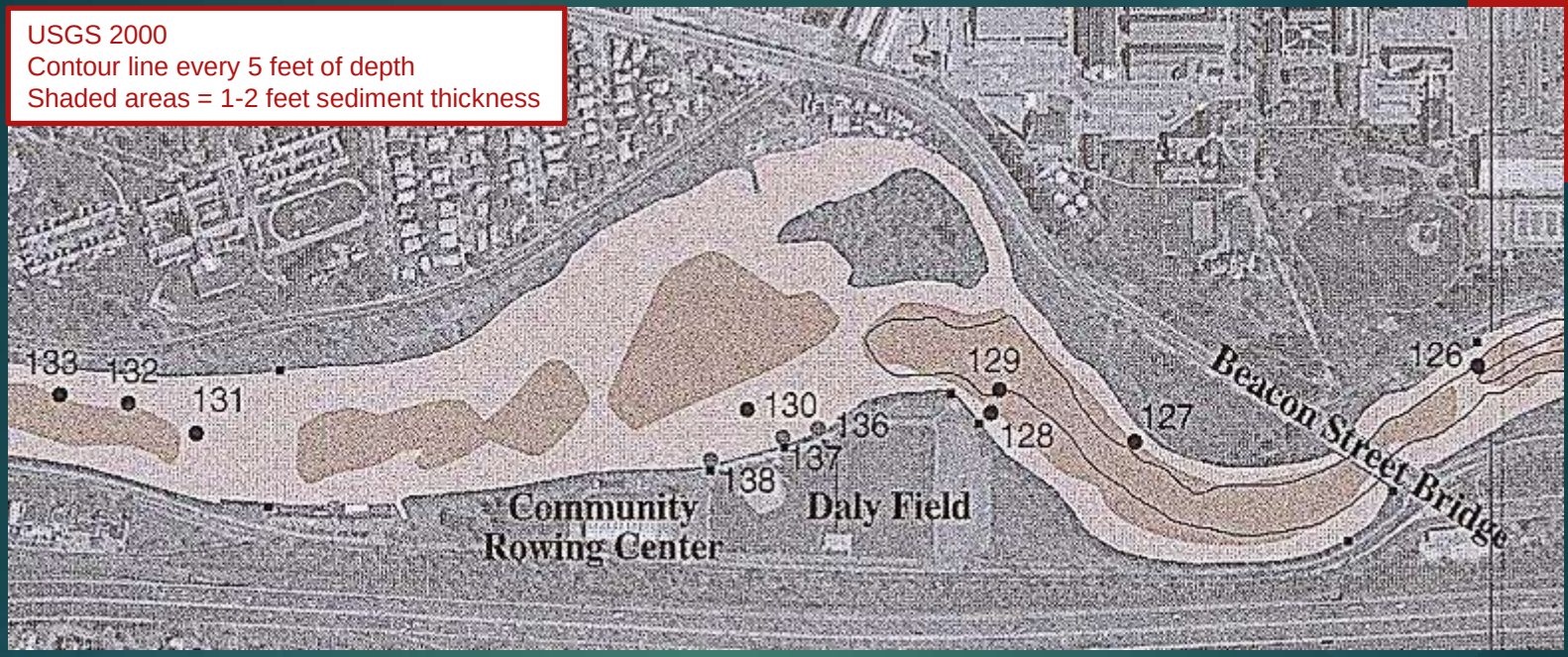
Historical Perspective

- Detailed depth charts of Charles River Basin
  - Watertown dam to Boston Harbor
  - 1902 Committee on the Charles River Dam
  - 2000 US Geological Survey
- More recent surveys have been done in selected areas
  - MDC / Cortell Associates, 1997, 20 transits at various locations between Newton YC and Science Park
  - Mirant-Kendall Station Outfall, 2010 ?
  - MIT Pierce Boathouse, 2013
  - Longfellow Bridge Rehabilitation
  - North Point Park area by Charles River Conservancy, 2016

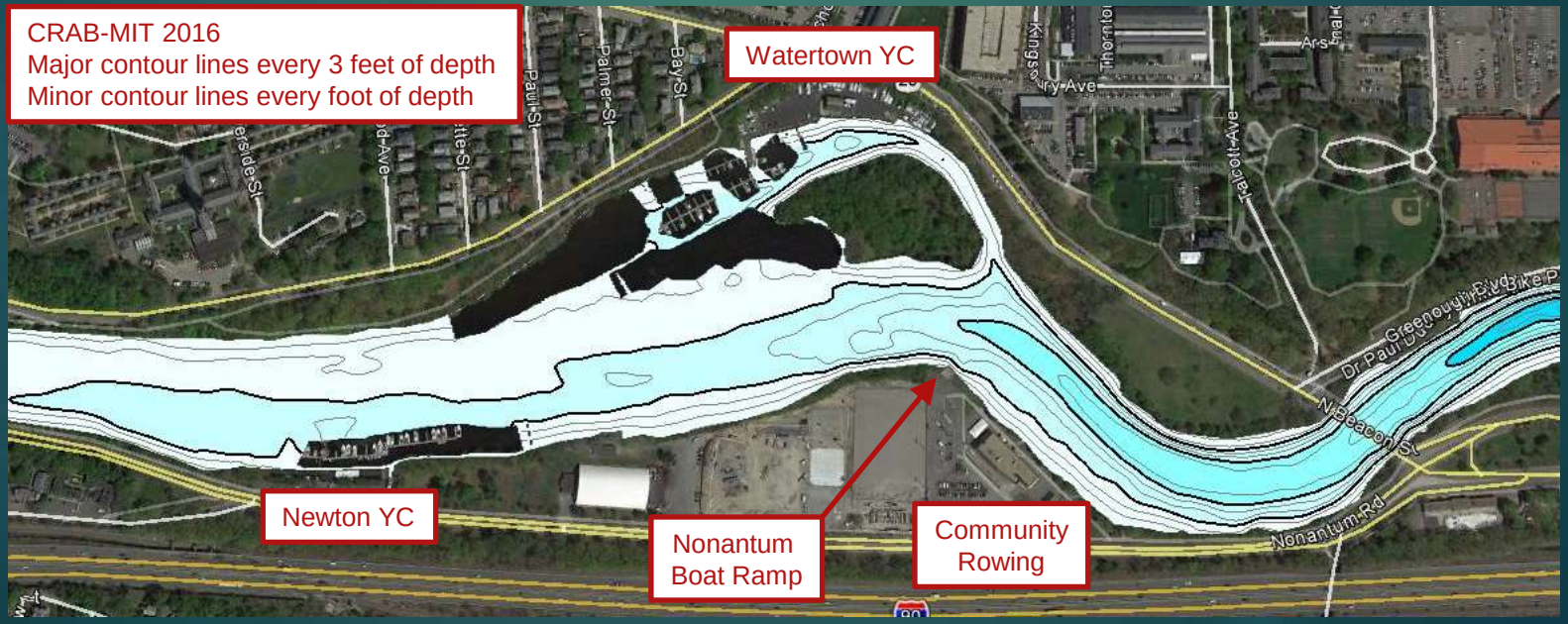
2000 USGS Survey

- Hydrographic survey done as part of larger studies
  - Spatial distribution, temporal variability, and chemistry of the salt wedge in the lower Charles River, USGS Report 00-4124
  - Distribution and potential for adverse biological effects of inorganic elements and organic compounds in bottom sediment, lower Charles River, USGS Report 00-4180
  - Streamflow, water quality, and contaminant loads in the lower Charles River watershed, USGS Report 02-4137
  - Potential Effects of Structural Controls and Street Sweeping on Stormwater Loads to the Lower Charles River, USGS Report 02-4220
- Charts were published with limited depth contours
  - Either every 2 meters or every 5 feet
  - Limited detail about underwater features

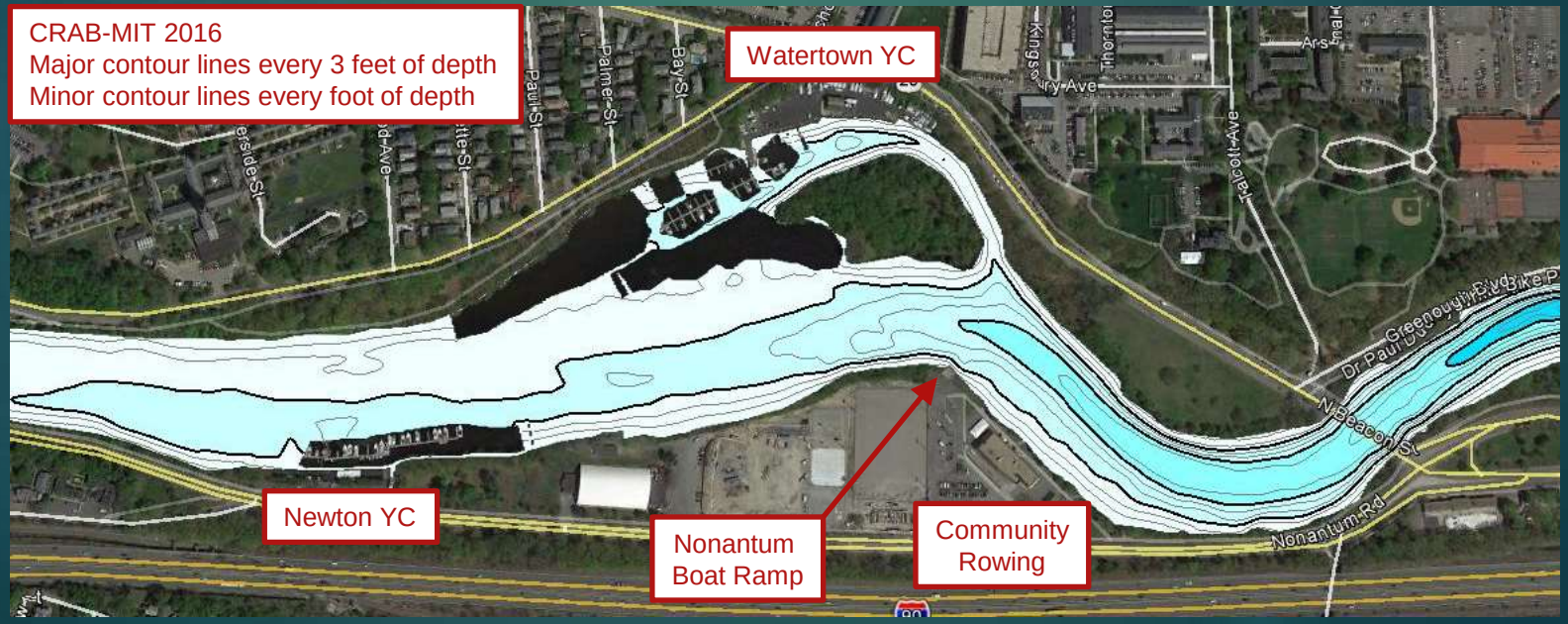
USGS 2000
Contour line every 5 feet of depth
Shaded areas = 1-2 feet sediment thickness



CRAB-MIT 2016
Major contour lines every 3 feet of depth
Minor contour lines every foot of depth




Committee on the Charles River Dam, 1902
Major contour lines every 5 feet of depth
Minor contour lines every foot of depth
BEACON ST.
U. S. GOVERNMENT
WATERTOWN ARSENAL
BEECH
BOSTON & ALBANY R. R.
N
4500
5000
5280
Pancuit Station

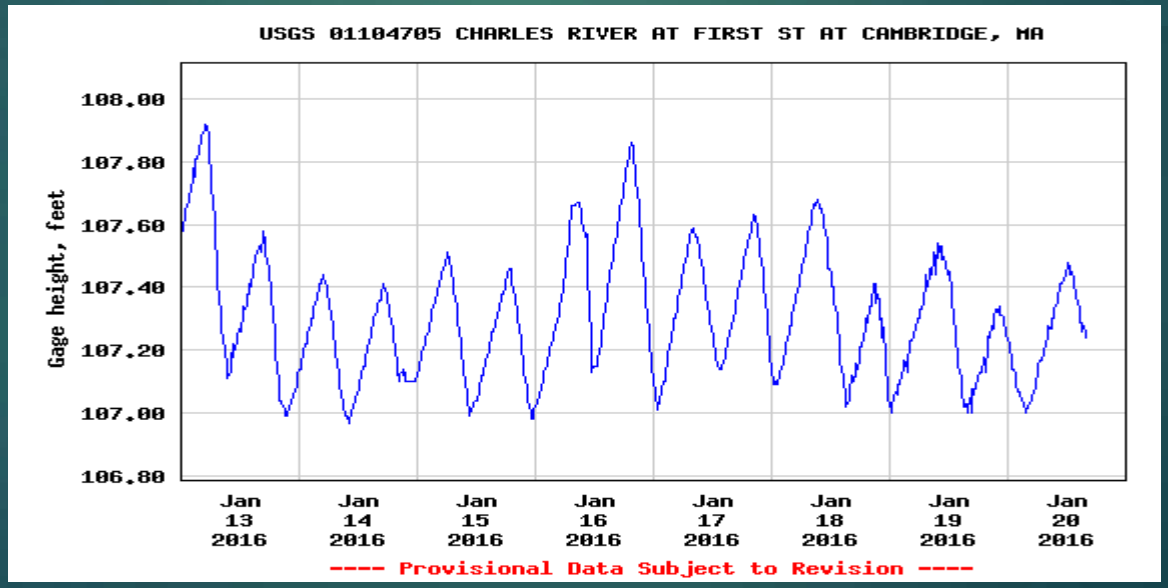

CRAB-MIT 2016
Major contour lines every 3 feet of depth
Minor contour lines every foot of depth
Watertown YC
Newton YC
Nonantum Boat Ramp
Community Rowing
Palmer St
Bay St
Paul St
Parcot Ave
Nonantum Rd

CRAB and MIT Partnership

- Goal is to obtain high quality quantitative data
  - Good enough to compare with future measurements
  - Disclaimer : Not suitable as a navigational aid
- Depth data collection
  - Using fish-finder sonar units and GPS
- Characterize the influence of daily water releases
  - Use stream gauge data loggers over several months
  - Correlate magnitude and temporal variations to USGS gauge
- Deliverables
  - Web-based charts: Arc-GIS, Google Earth, Google Map
  - Printed wall poster and chart booklet
  - Chart data for navigational instruments

Data Measurements

- Depth using sonar fish-finders
- Position and time using GPS
- Height of water sheet using stream gauge data loggers
  - Apply a correction to sonar depth data
  - Zero depth = 107.5 ft @ USGS First St gauge



Depth Measurements

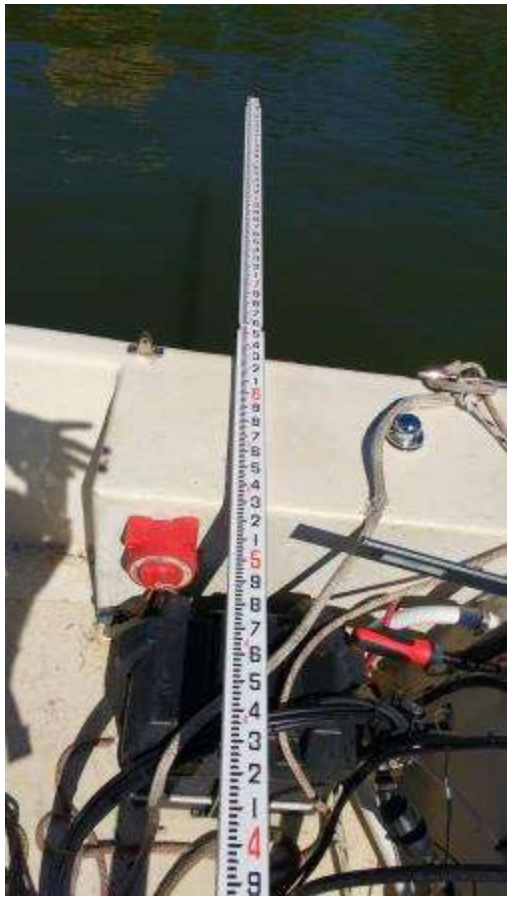
- Equipment
  - Lowrance HDS-7 chartplotter/fishfinder
  - Lowrance HST-WSBL 200 kHz broadband sonar transducer
  - Lowrance LSS-2 800 kHz sidescan sonar transducer
  - Lowrance Point-1 GPS
  - Onset HOBO U20L-4 Water Level (13 ft) Data Loggers
- Survey Tracks
  - Where the river was wide, survey lines were spaced between 30 and 65 feet apart and drive at speeds between 3 and 4.8 knots
  - Where the river was narrow, several passes were made up and down the river over multiple weeks
  - Broadband sonar was used in all surveys to measure depth
  - Sidescan sonar was used downriver of the BU Bridge to image the river bottom

Sonar/GPS mounting

Crew

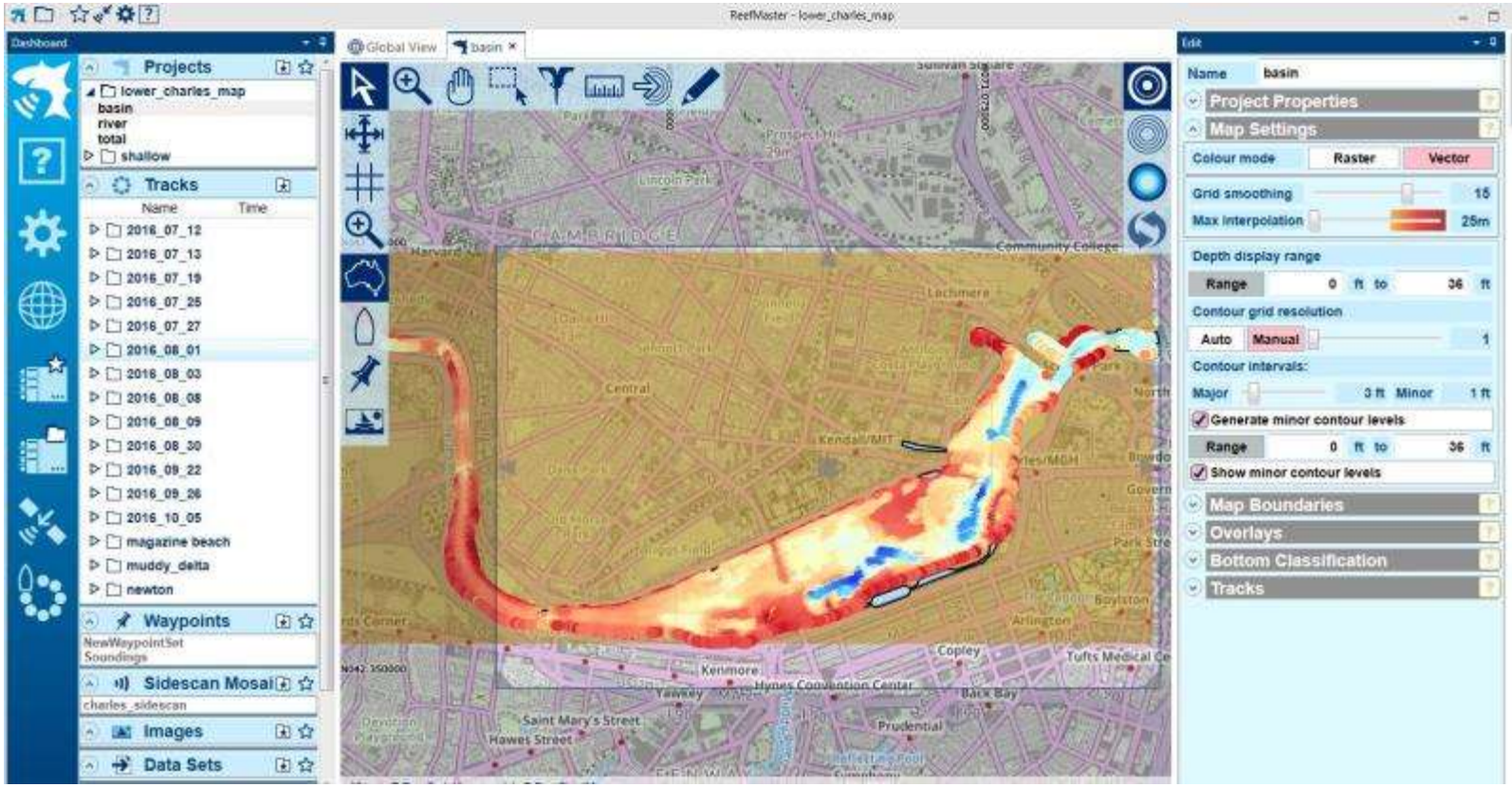
Chartplotter underway

Depth spot checks



Hobo water level loggers

ReefMaster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Projects
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total
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Tracks
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Time
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2016_07_25
2016_07_27
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2016_08_03
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2016_08_09
2016_08_30
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magazine beach
muddy_delta
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Waypoints
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Soundings
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Colour mode
Raster
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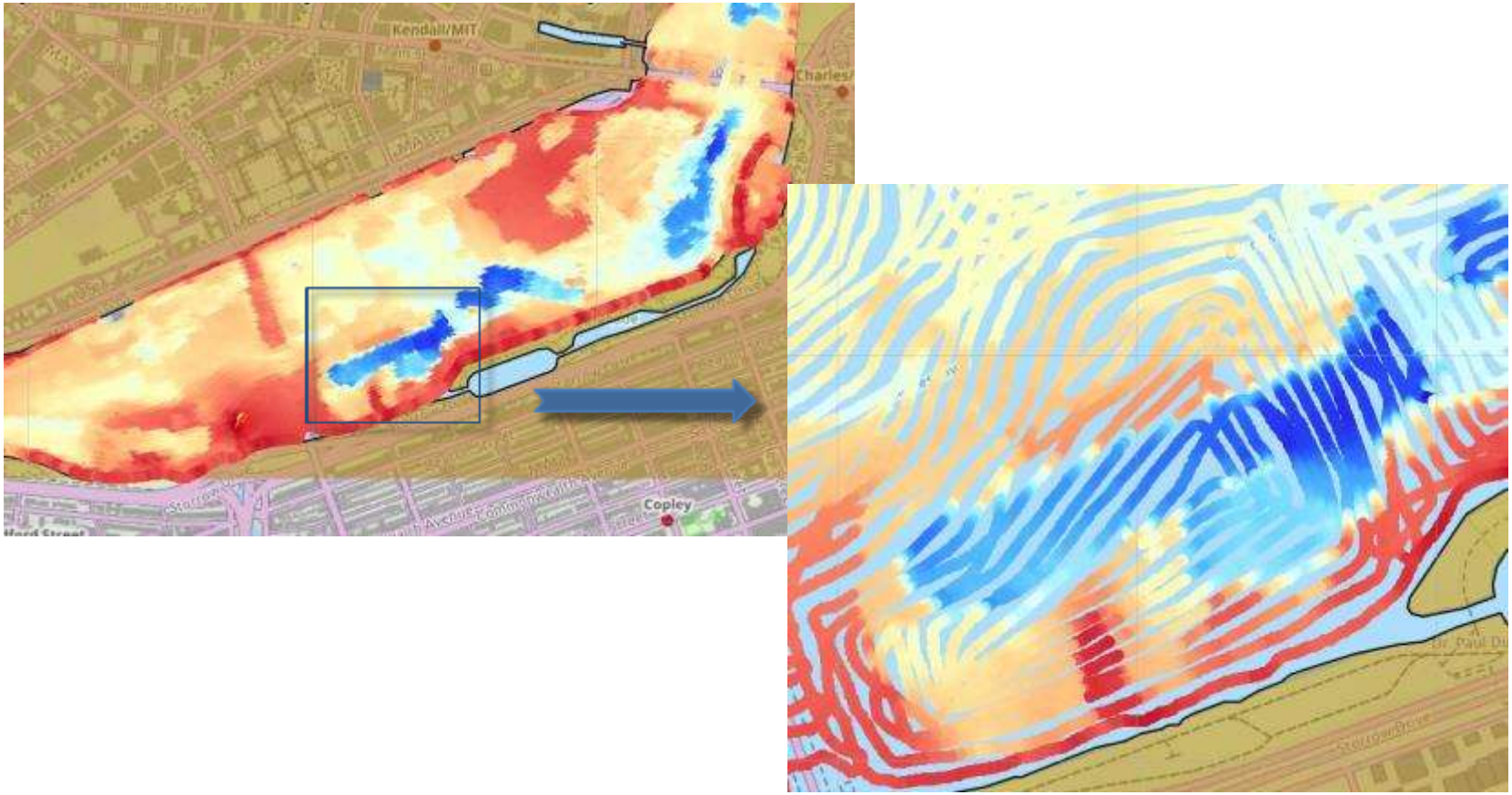
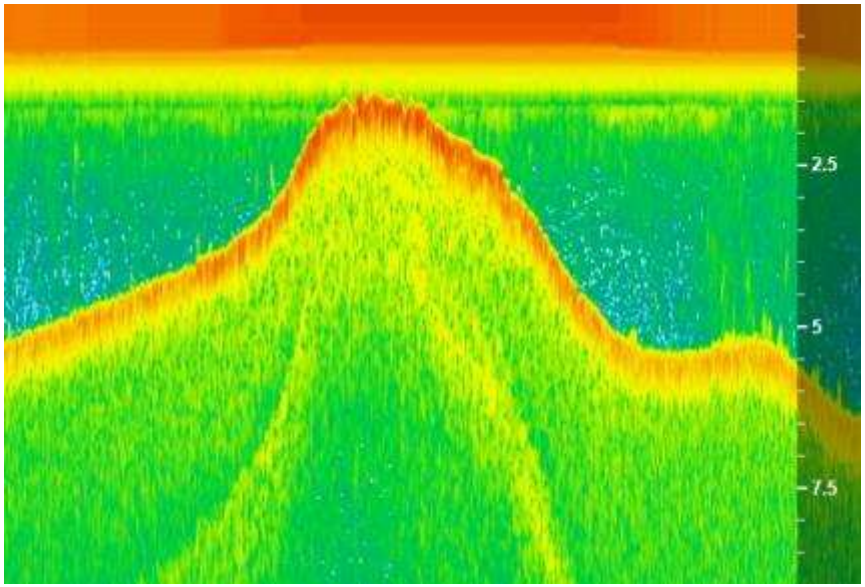
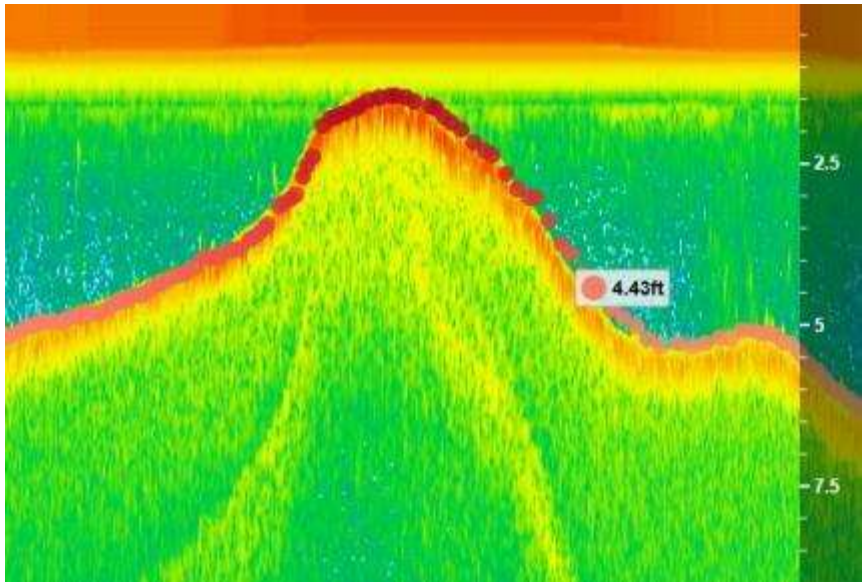
Grid smoothing
15
Max interpolation
25m
Depth display range
Range
0 ft to 36 ft
Contour grid resolution
Auto
Manual
1
Contour intervals:
Major
3 ft
Minor
1 ft
Generate minor contour levels
Range
0 ft to 36 ft
Show minor contour levels
Map Boundaries
Overlays
Bottom Classification
Tracks
CAMBRIDGE
Harvard
Community College
Lechmere
Central
Kendall/MIT
Kenmore
Hynes Convention Center
Copley
Back Bay
Prudential
Saint Mary's Street
Hawes Street
Boylston
Arlington
Tufts Medical Ce
Park Stre

ReefMaster: Tracklines

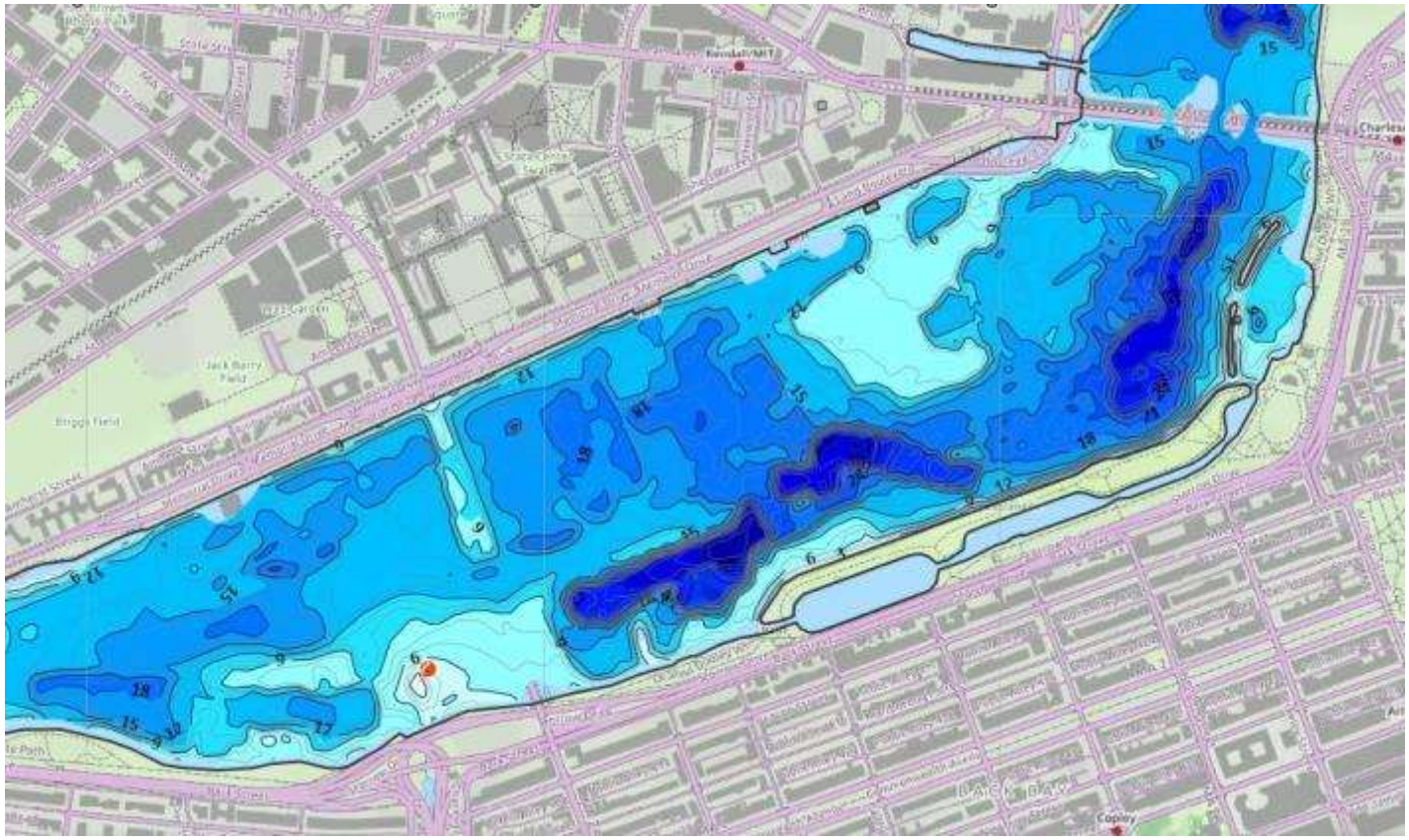


ReefMaster: Sonar

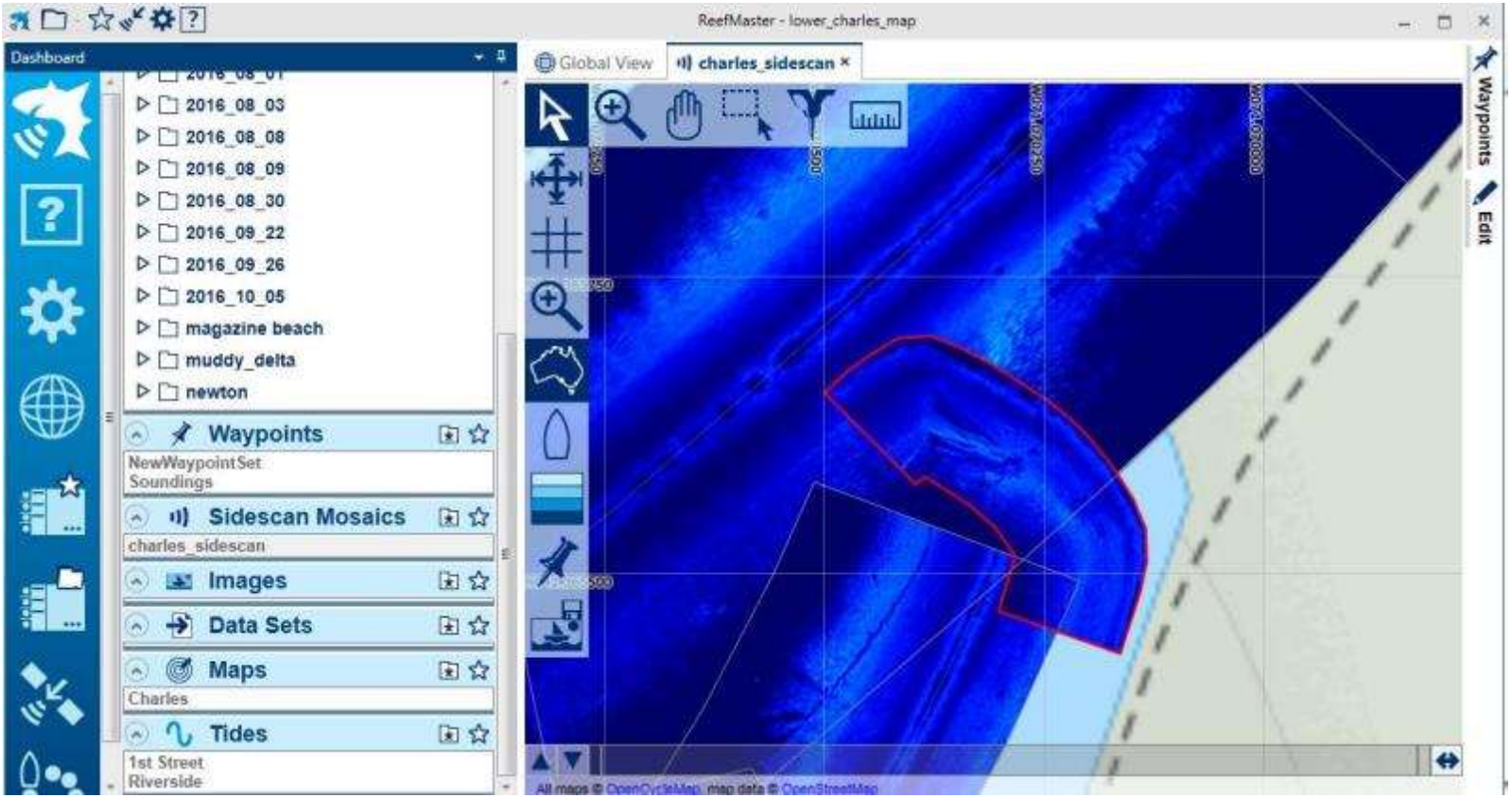




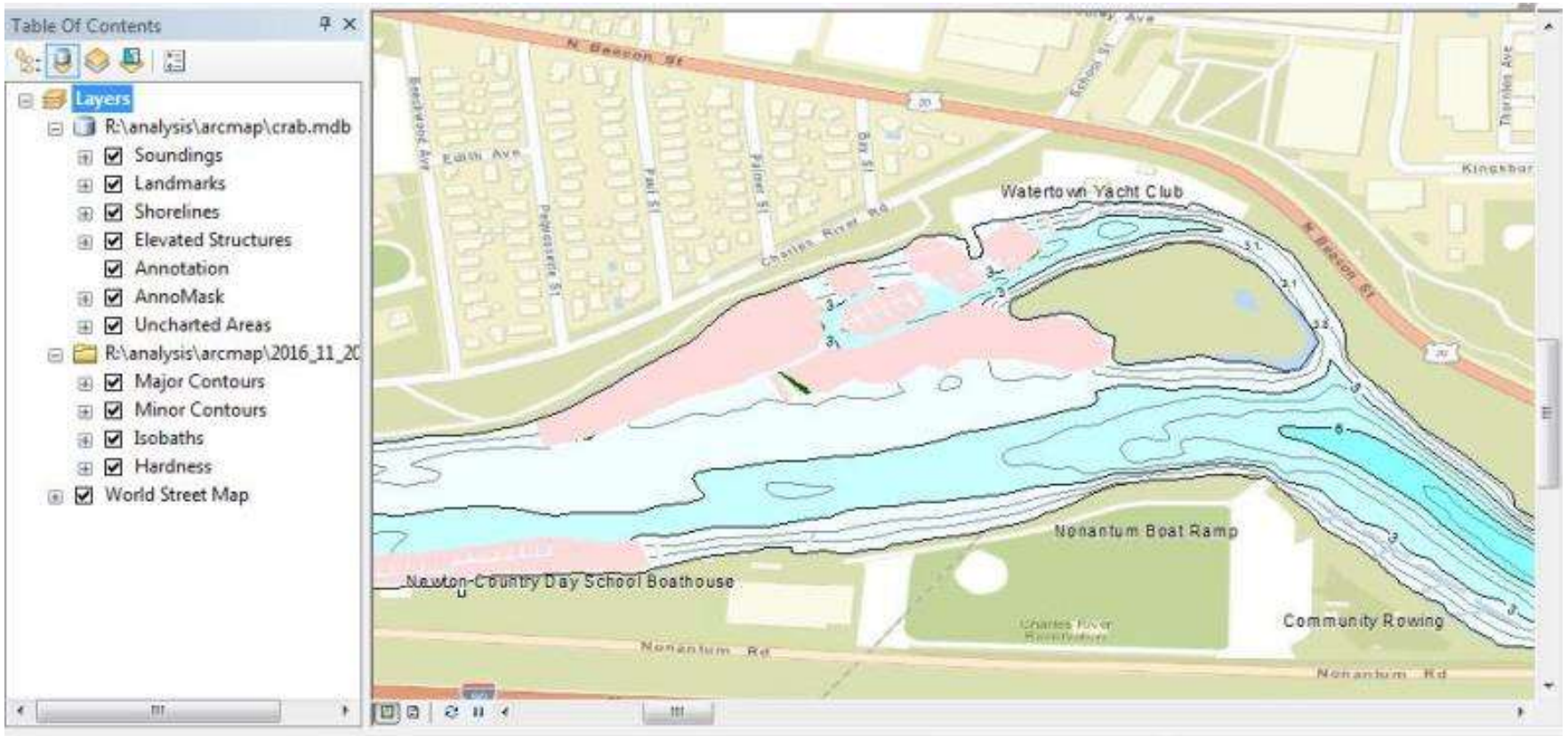
ReefMaster: Raw chart



ReefMaster: Side scan mosaic

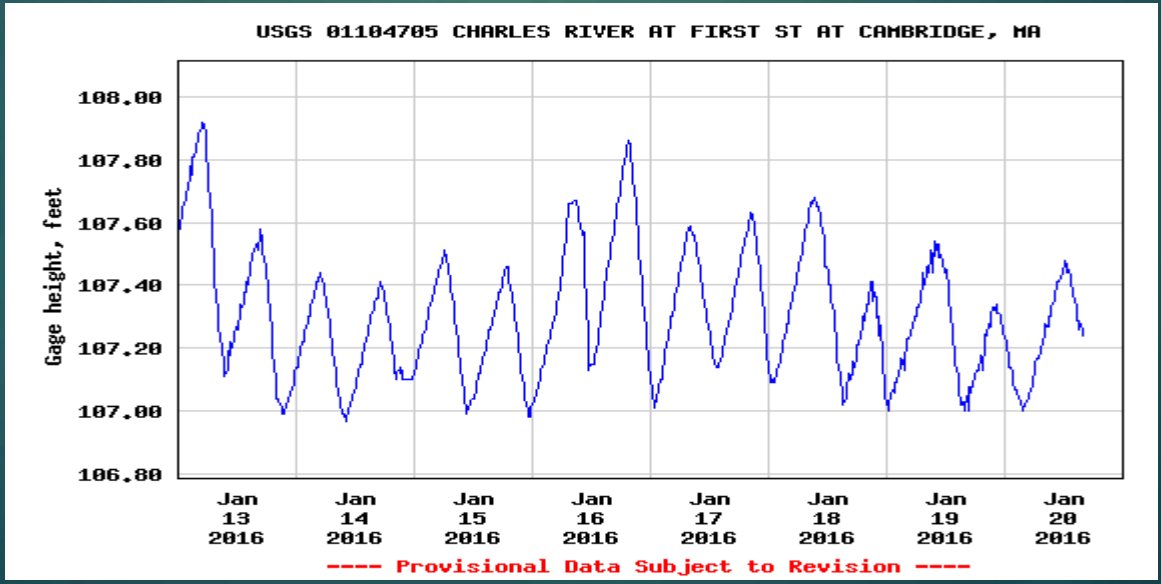


ArcMAP component layers

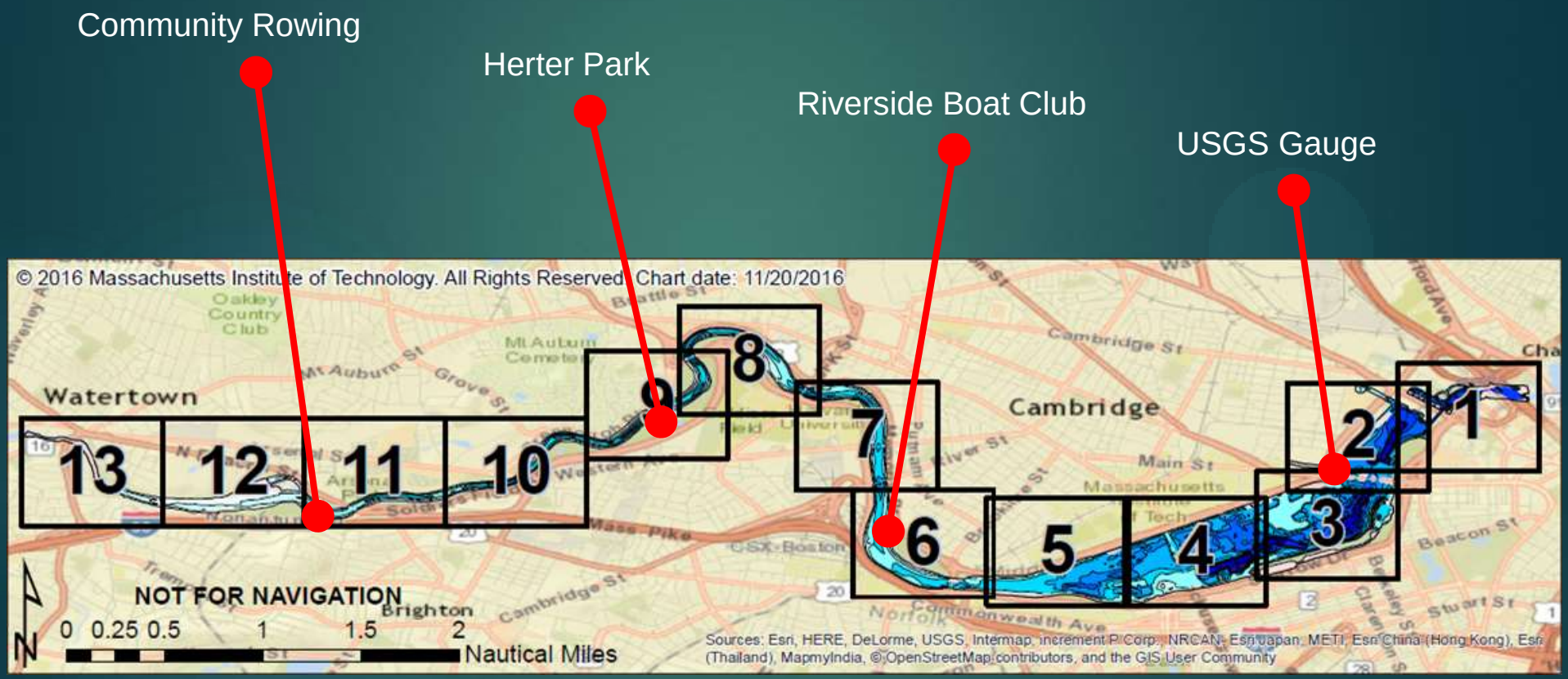


Correcting Depth for Watersheet Height

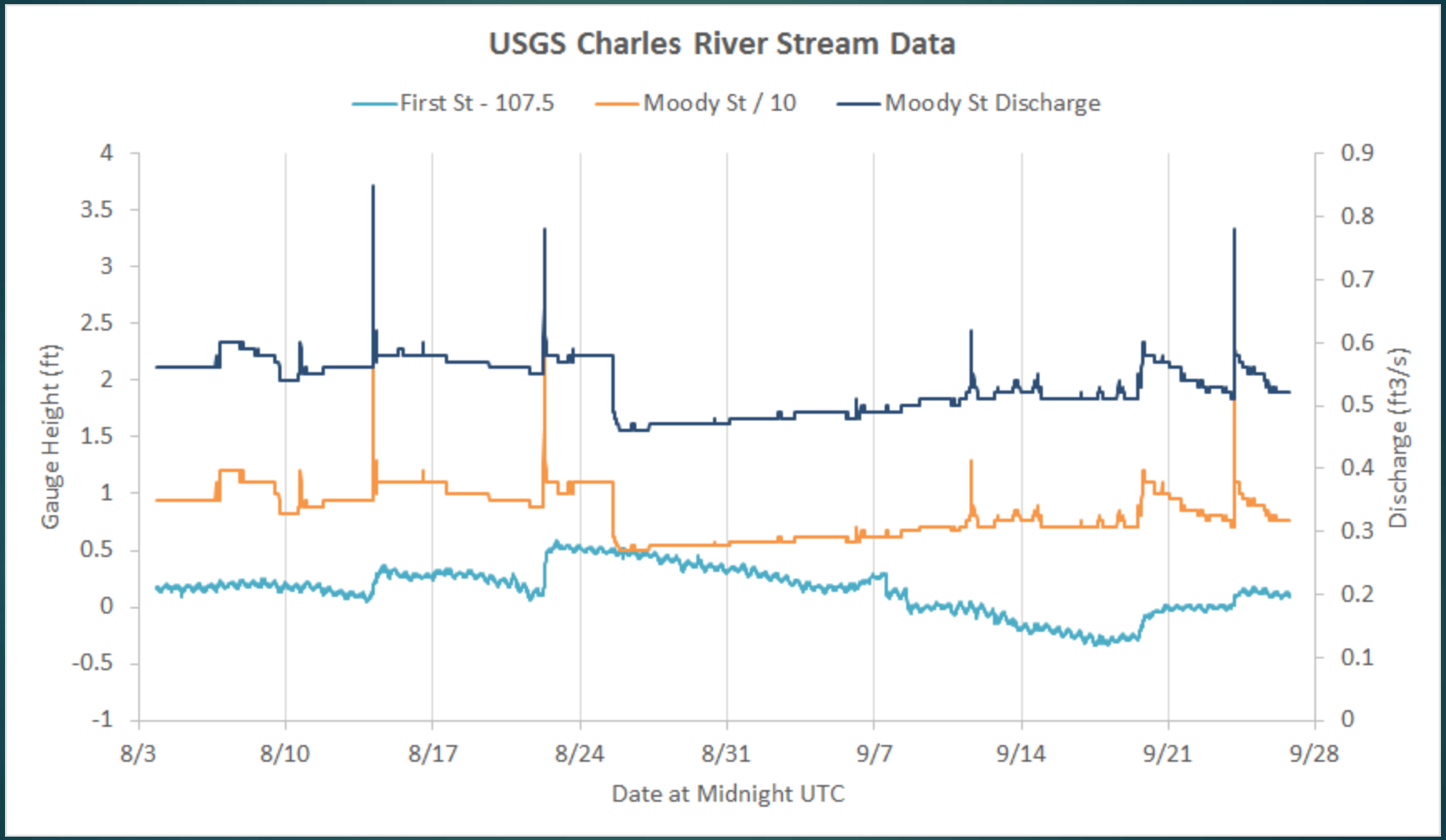
- Measured depth must be adjusted for height of watersheet
  - Time dependent
  - Location dependent ?
- Does lower Charles behave as a river, a lake, or both ?
  - If river, correction is dependent on both time and location
  - If lake, correction is dependent on time only



Stream Gauge Data Loggers

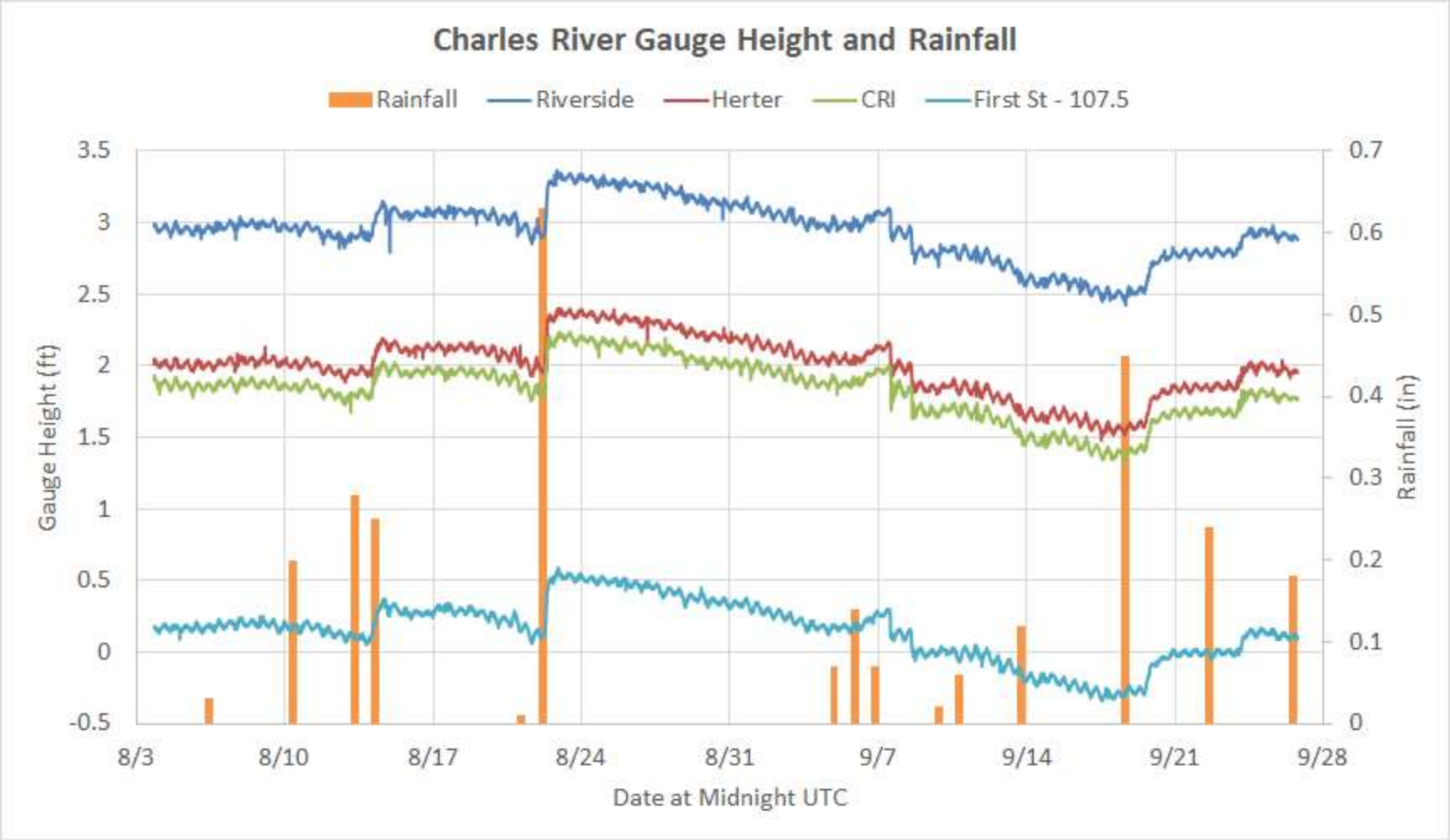


USGS Gauge Height and Discharge



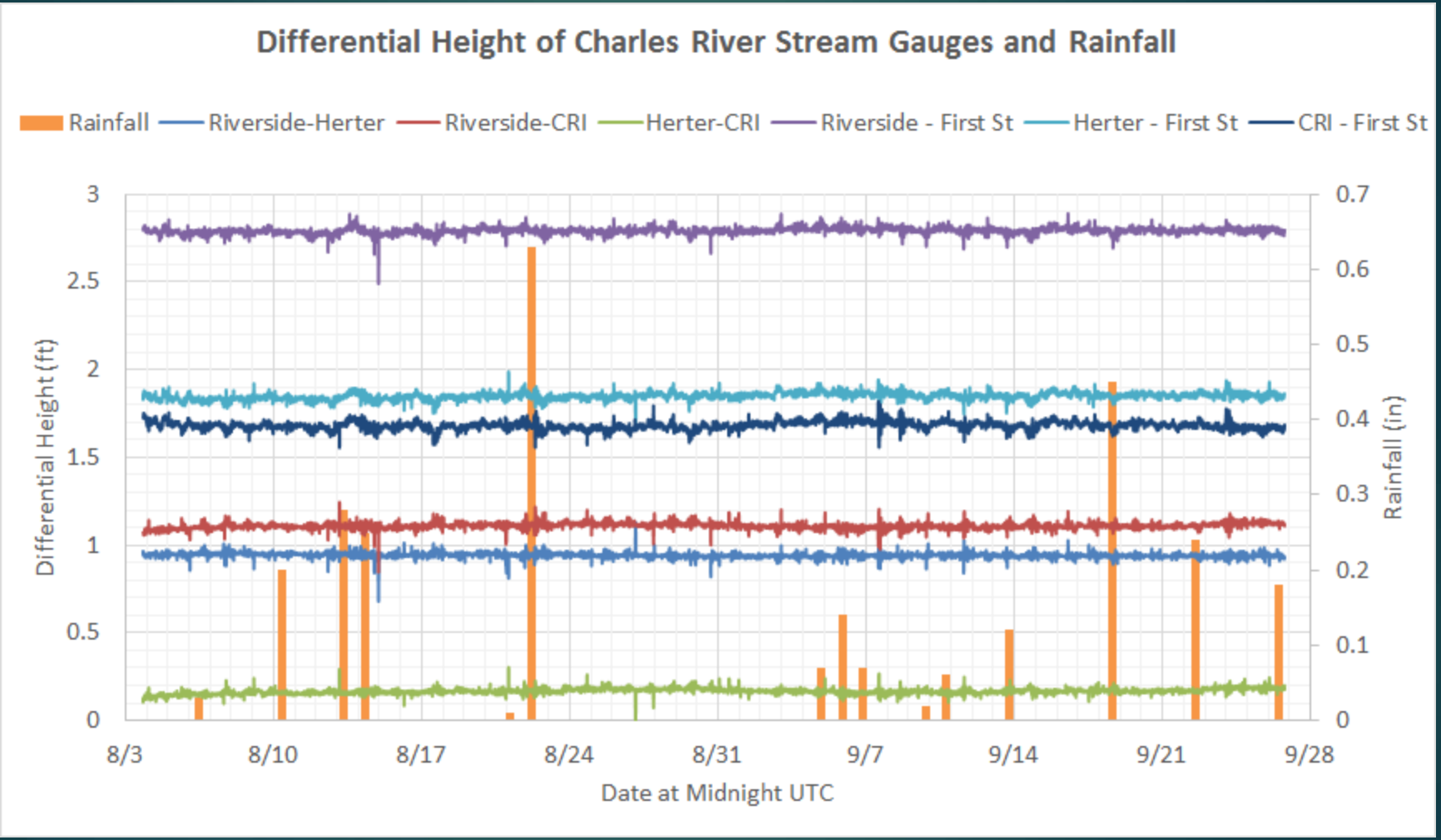
Gauge Heights and Rainfall

Water level : 5177 data points @ 15 minute intervals for each gauge

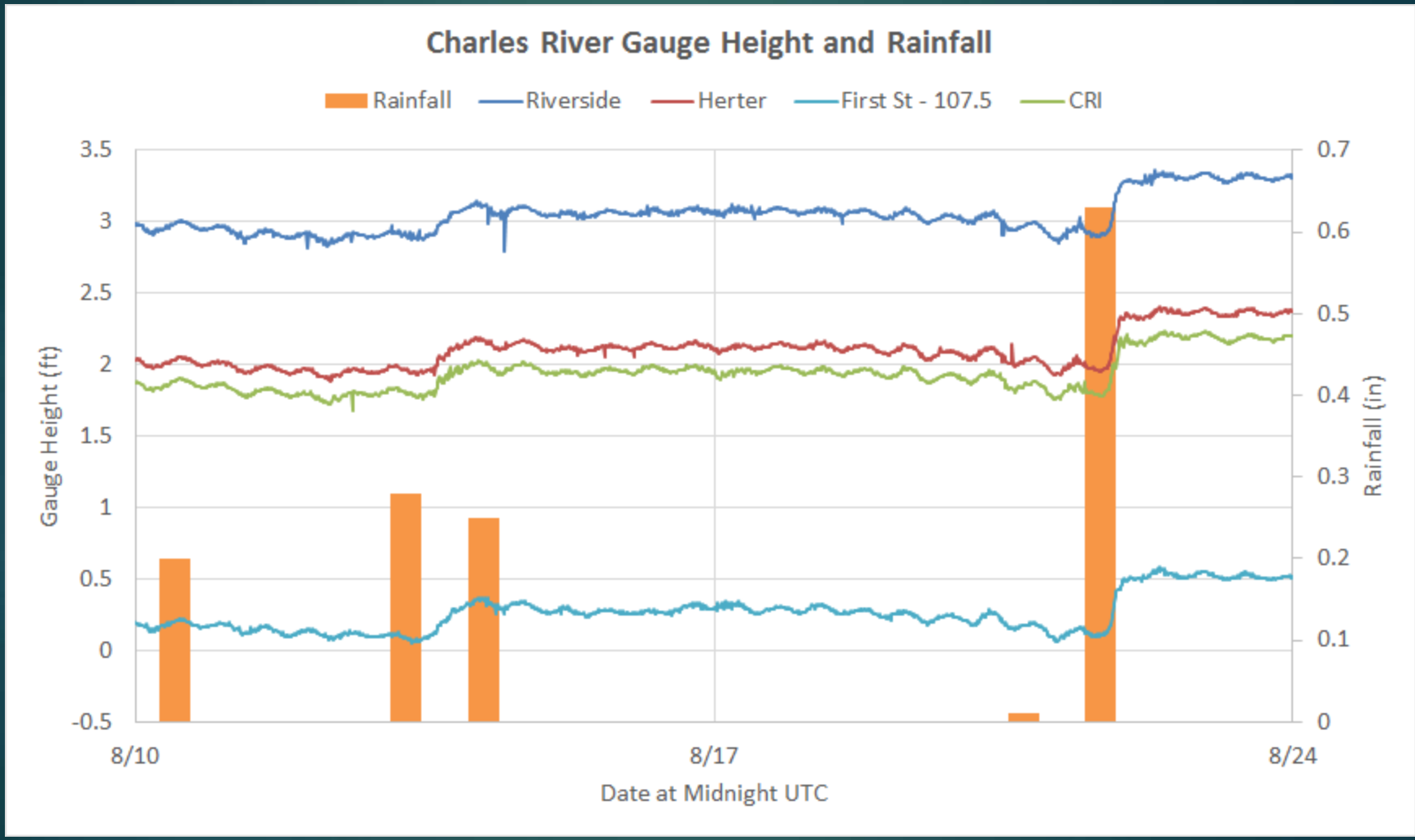


Rainfall : data from BWSC gauge in Allston

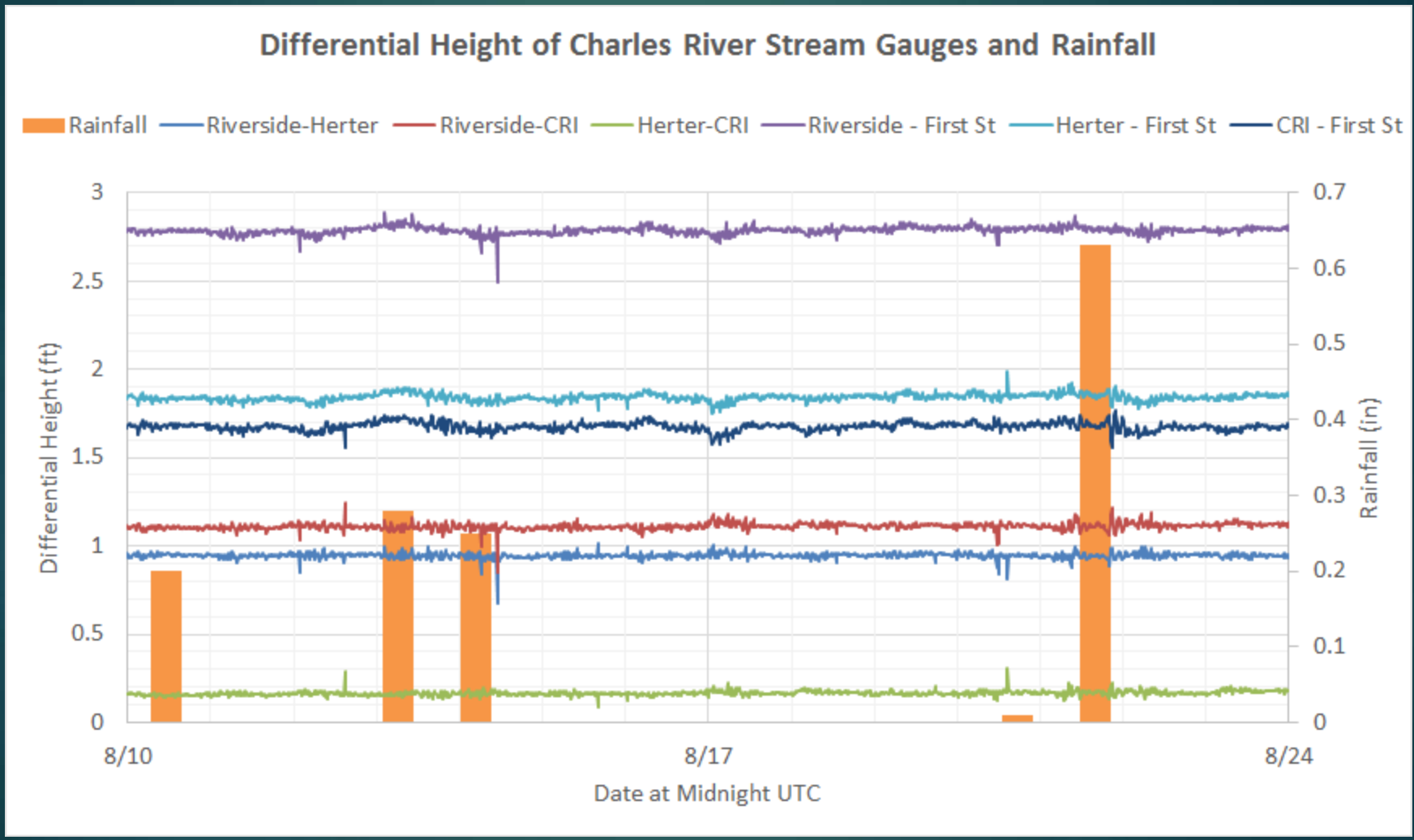
Differential Gauge Heights



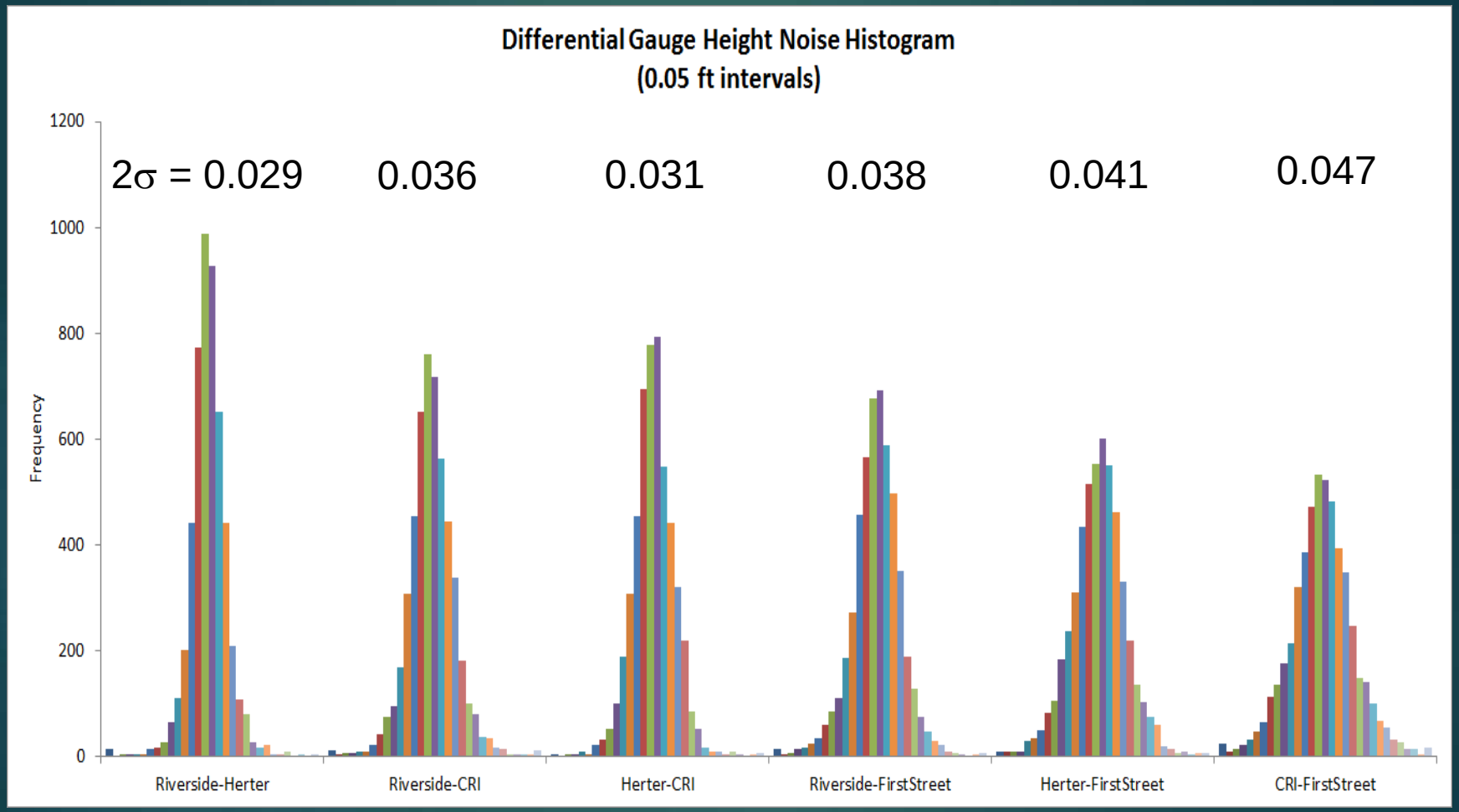
Gauge Heights and Rainfall



Differential Gauge Heights



Gauge Height Noise Histogram



Uncertainty in Data

- Vertical Uncertainty
  - Transducer : 2% on a hard bottom, 5% on soft bottom
  - Water Sheet Height : < 0.05 foot
  - Estimated Total Depth Uncertainty : ± 5%
  - Depth is normalized to the height of the water sheet
  - Zero depth = 107.5 ft @ USGS First St gauge
- Horizontal Uncertainty
  - GPS Accuracy : ±3 meters
  - Point-to-point precision is much lower
  - GPS signal is degraded under bridge, especially the Zakim Bridge
- Difference between track path and width of track
  - Data measured at 10 Hz, every 0.85 ft at 5 knots along the track path
  - Depth perpendicular to the track (width) is extrapolated by the software
    - Non-overlapping tracks
    - Caution with over-extrapolating the width

Development of Digital Charts

- ReefMaster PRO mapping software
  - Processing of raw sonar data
  - 2-dimensional contours of depth and relative hardness
  - ESRI shapefiles for the ArcGIS ArcMap software
- ArcGIS ArcMap software
  - Generation of ArcGIS Online chart
  - Additional geospatial data
    - Contour annotation
    - Landmarks
    - Elevated structures
    - Detailed shorelines
  - Data exported for Google Earth, Google Map, chart booklet, wall chart

Digital Charts

Several formats have been developed by MIT and CRAB.
All with be available to the public via CRAB website.

- Web-based
  - Arc-GIS, hosted by MIT
  - Google Earth
  - Google Map
- Printed
  - Wall Poster
  - Chart Booklet
- Data for navigational instruments
  - kmz file that can be converted by user

Exploration of on-line chart and mosaic

- Arc_GIS Online chart
  http://seagrant.mit.edu/charleschart/

What's Next ?

- Public release of data and charts this winter
- Completion of depth measurements next summer
  - Handful of shallow areas
  - More detailed measurements near bridges
- Develop better understanding of bottom hardness data
- Comparison to 1903 and 2000 USGS surveys underway
- Can we determine sediment thickness ?
- Monitor changes in future