How do you account for fish habitat with a total station?

2015 CHaMP Camp

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Presenter:
Joe Wheaton (USU)

EcoLogical Research

UtahStateUniversity
ECOGEOMORPHOLOGY & TOPOGRAPHIC ANALYSIS LABORATORY

BONNEVILLE POWER ADMINISTRATION

ISEMP

CHaMP

OUTLINE

HOW DO YOU ACCOUNT FOR FISH HABITAT WITH A TOTAL STATION?

I. **Background**

II. Painting a Picture of Habitat – Topographically

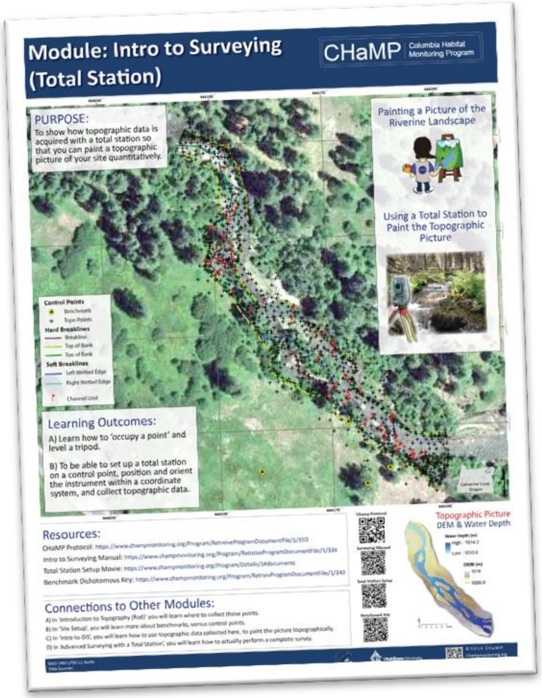
III. Quantifying Habitat – From Topography
   I. Hydraulics
   II. Geomorphology
   III. Fish Habitat

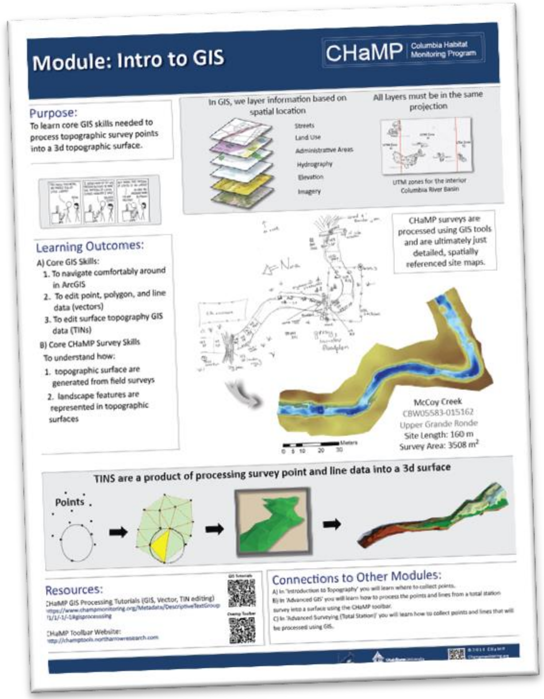
IV. Some Other Useful Byproducts of Topography

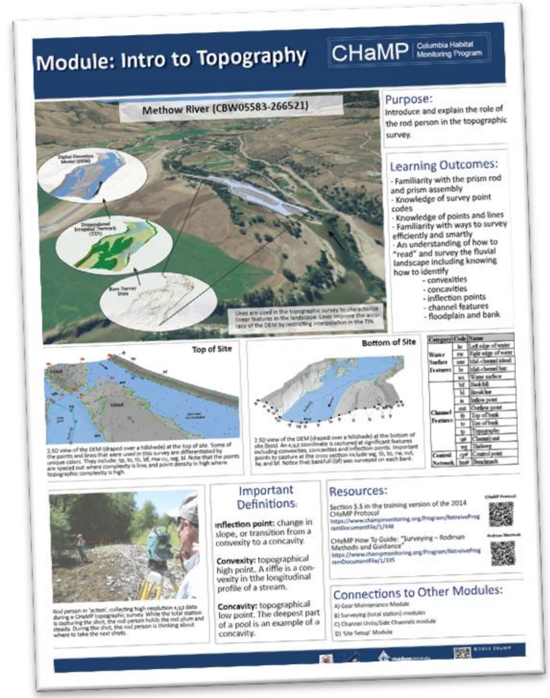
V. Take Homes

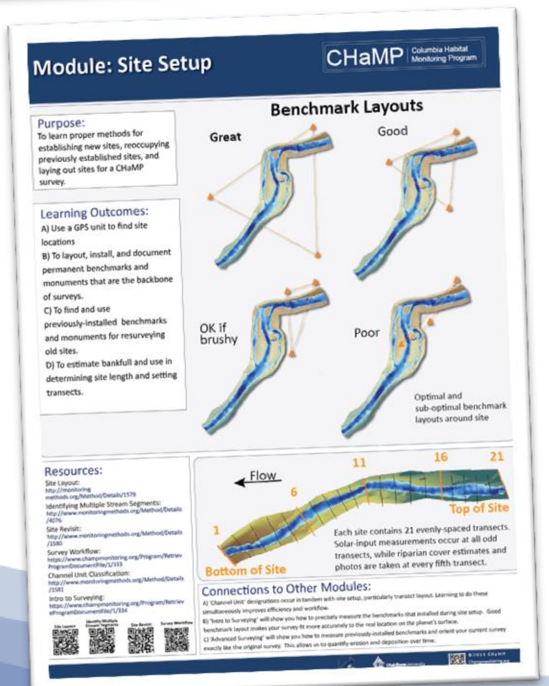
WHAT YOU'LL BE DOING THE NEXT 10 DAYS….

- If you're a CHaMP Newbie
- If you're a CHaMP Returnee









BONNEVILLE POWER ADMINISTRATION

Module: Advanced GIS

CHaMP Columbia Habitat Monitoring Program

Purpose:
To successfully process a CHaMP survey through the CHaMP Toolbar and generate a 3D topographic surface.

Learning Outcomes:
To understand how to:
1. Generate surfaces from total station point and line data.
2. Review accuracy of landscape representation in the surface.
3. Publish all files for upload to www.champmonitoring.org

CHaMP Surveys transform real landscape features

FROM THIS

Bear Valley Drone Imagery

TO THIS

Bear Valley Creek

The CHaMP Topo Processing Toolbar in ArcMap. This can be used to transform the surveyed point data.

Digital Elevation Models (DEMs) are used in CHaMP as raster (grid) representations of topography and are used to derive many useful metrics and drive simulation models. CHaMP DEMs are derived at 10 cm resolution from TINs.

'Detrending' the DEM removes the valley slope from the topography and highlights the local relief and morphology relative to the channels. Once detrended, water inundation extents can be simply approximated using the detrended CHaMP DEMs with the 'slicer tool,' that allows you to raise and lower water levels like filling or draining a bathtub.

Resources:
ChaMP GIS Processing Tutorials (GIS, Vector, TIN editing)
https://www.champmonitoring.org/Metadata/DescriptionDocImage/1/U1/U1GISprocessing
ChaMP Toolbar Website:
http://champtools.northarrowresearch.com

Connections to Other Modules:
A) You'll learn basic GIS skills in 'Intro to GIS.'
B) In 'Advanced Topography (Boat)' you'll learn where to survey points.
C) In 'Advanced Surveying (Total Station)' you'll learn how to survey a site and generate the total station file that will be imported into the ChaMP Toolbar.

Module: Data / Gear Management

CHaMP Columbia Habitat Monitoring Program

Purpose:
The CHaMP information system includes a web-based interface (www.champmonitoring.org), Data Broker, and iLogger. The goals of the information system include efficiently supporting field data collection and ensuring consistent high quality data.

Learning Outcomes:
A) Review Hitches on www.champmonitoring.org
B) Use Broker to acquire scouting materials for a hitch and a visit.
C) Use iLogger to download the visit packet from the Broker.
D) Use iLogger to validate and accept auxiliary data.
E) Use iLogger to upload the visit packet to the Broker.
F) Use Laptop to download session packet to the Broker.
G) Use Solemetric software to post-process Skyline images.
H) Use Broker to review auxiliary files, photos, topographic files, solar input files, and scanned forms.
I) Use Broker to accept visit files for upload to www.champmonitoring.org.
J) Review Data Check-in status on www.champmonitoring.org.
K) Review measurements on www.champmonitoring.org.

Field Equipment

End of Day

A Tiered Approach to Data Quality

Resources:
Hitch Planning
Data Logger - Overview:
Laptop Data Broker - Overview:
Post Processing - Solemetric Surfyer:
Laptop Data Broker - Publish Dataset Components:
CM.org Quality Assurance Guidelines:

Module: Discharge and Drift

CHaMP Columbia Habitat Monitoring Program

Purpose:
To learn how to measure stream discharge and how to sample drifting macroinvertebrates.

Learning Outcomes:
A) Collect a quantitative sample that describes the abundance and composition of macroinvertebrates actively drifting in the water column and at water surface of a site.
B) Collect depth and velocity measurements at increments along a cross-section in order to calculate discharge at a site.

Cross-section of a streambed showing location of discharge measurements

Water Surface

Measure depth and velocity

Prepare for collect macroinvertebrates

Invert the bottom of the net from resting on the streambed by using 2 cm vertical pecans. The depth of the flow is measured from the water surface to the bottom of the net mouth.

Macroinvertebrates in drift sample

Resources:
CHaMP Protocol:
Evaluation of Macroinvertebrates as a Food Resource:
CHaMP Benthic Macroinvertebrate Protocol:
CHaMP Macroinvertebrate Chain-of-Custody Form:
Macroinvertebrates - Blank Sample Jar Labels:

Module: Advanced Topography

CHaMP Columbia Habitat Monitoring Program

Purpose:
Provide hand's on training in topographic surveying by splitting into small groups and surveying a short section of stream. Emphasize (1) the importance of point spacing and distribution at sites of different sizes, (2) efficiency in survey workflow and good communication between rodman and gunner, and (3) how to best use the point and line codes

CRW05SR83-347500 (Murderer's Creek)

Learning Outcomes:
- Hand's on experience with surveying and using the total station and the prism rod
- Applied knowledge of survey point codes including when to use hard vs soft break lines
- Applied knowledge of "reading" the riverine landscape
- Knowledge of several types of work flow strategies

Surveying work flow strategies:

Small streams: survey along both banks and the channel in one pass
- Utilize verbal communication

Large streams: survey along one bank in the upstream direction, then survey the wetted channel moving downstream, then survey the other bank moving upstream
- Utilize hand signals and 2-way radio communication

Double rod person:
- Leapfrog technique
- Tip: when you are not getting the shot or are not ready, turn prism away from gunner (or, cover with hand)
- Tip: keep both rods at the same height as much as possible

Connections to Other Modules:
A) Surveying (total station)
B) Channel Units/Side Channels module
C) 'Site Setup' Module

Resources:
Section 5-5 in the training version of the 2014 ChaMP Protocol
https://www.champmonitoring.org/Program/RetrievedProgramDocumentFile/1/448
ChaMP How To Guide: "Surveying – Rodman Methods and Guidance"
https://www.champmonitoring.org/Program/RetrievedProgramDocumentFile/1/395

Module: Solar Input, Riparian, Photos, Water Quality, Site Map

CHaMP Columbia Habitat Monitoring Program

Purpose:
This module covers how to measure transect and site level attributes. The primary objective is to instill consistent and repeatable data collection methods while linking relationships between stream habitat and fish.

Learning Outcomes:
A) To understand how to use the SunEye to measure solar input.
B) To estimate riparian cover using standard measurement techniques.
C) To learn where and how to take photos at new and repeat sites.
D) To learn how to use the conductivity meter and alkalinity kit.
E) To draw a detailed map that is useful for revisiting sites.

Example Site Map

Solar Input

•Measured at all odd transects in the center of the MAIN WETTED channel.
•Measured 30 cm above the wetted surface

Riparian Estimates

•Collected on both banks at transects 1, 6, 11, 16, and 21 from the edge of BANKFULL

Photos

•Collected 1.5 meters from the ground at transects 1, 6, 11, 16, and 21 from the center of BANKFULL

Connections to Other Modules:
A) During 'Site Layout' you will learn how to layout transects.
B) During 'Channel Unit Attributes' you will learn about identifying main and side channels.

Resources:
Alkalinity Instructions
SunEye Manual:
Camera Manual:

Module: Advanced Surveying (Total Station)

CHaMP Columbia Habitat Monitoring Program

Purpose:
To learn how to complete a topographic survey of a site with a total station.

Painting a Picture of the Riverine Landscape

Using a Total Station to Paint the Topographic Picture

Learning Outcomes:
A) Learn how to 'occupy a point' and level a tripod.
B) To be able to set up a total station on a control point, position and orient the instrument within a coordinate system, and collect topographic data.
C) Learn how to use 'stakeout points' to locate difficult to find benchmarks and complete 'checks.'
D) Learn how to 'code' points and lines - so that *you have more colors and brushes to help paint your picture.*
E) Learn when to use reflectorless measuring.
F) Take legible field notes.
G) Setup traverse kit.

Topographic Picture DEM & Water Depth

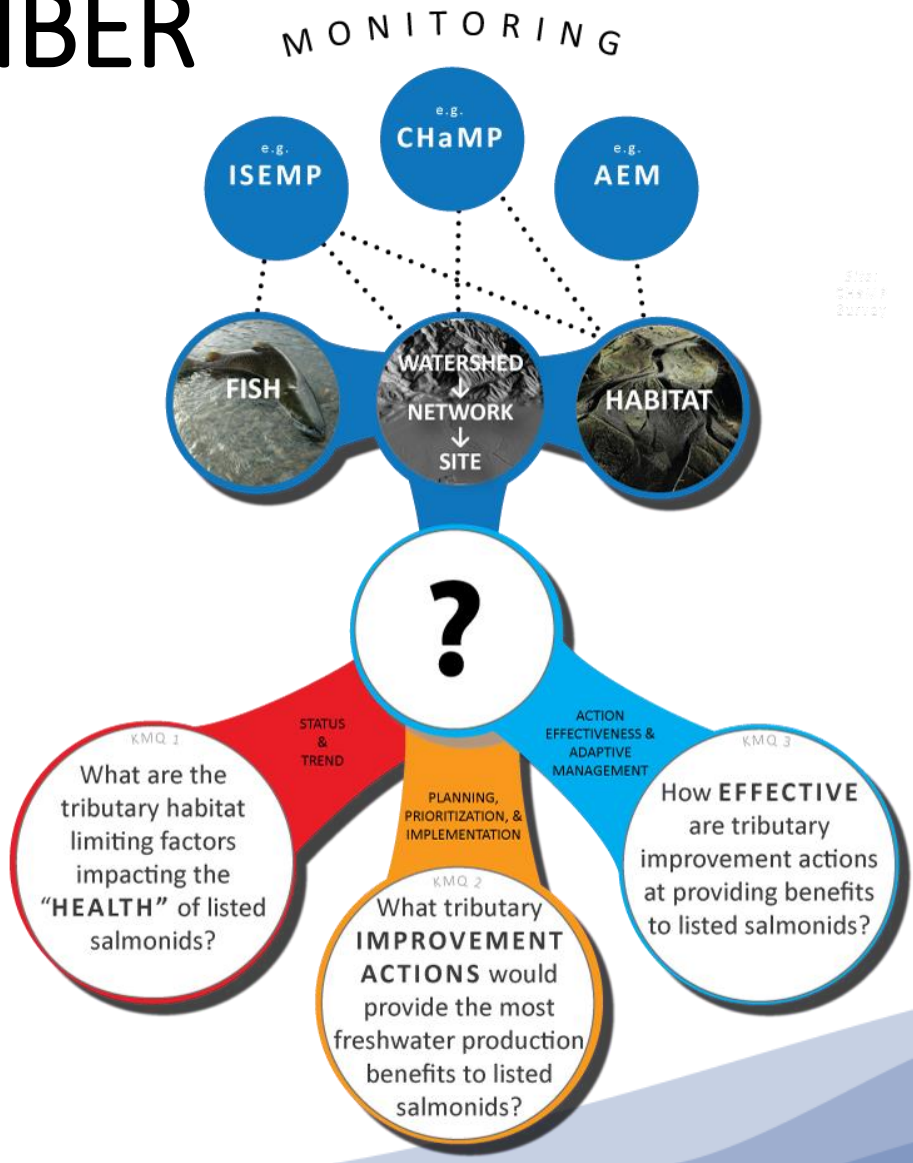
Resources:
ChaMP Protocol:
Intro to Surveying Manual:
Total Station Setup Movie:
Benchmark Dichotomous Key:

Connections to Other Modules:
A) In 'Introduction to Topography (Rod)' you will learn where to collect these points.
B) In 'Site Setup', you will learn more about benchmarks, versus control points.
C) In 'Intro to GIS', you will learn how to use topographic data collected here, to paint the picture topographically.
D) In 'Advanced Surveying with a Total Station', you will learn how to actually perform a complete survey.

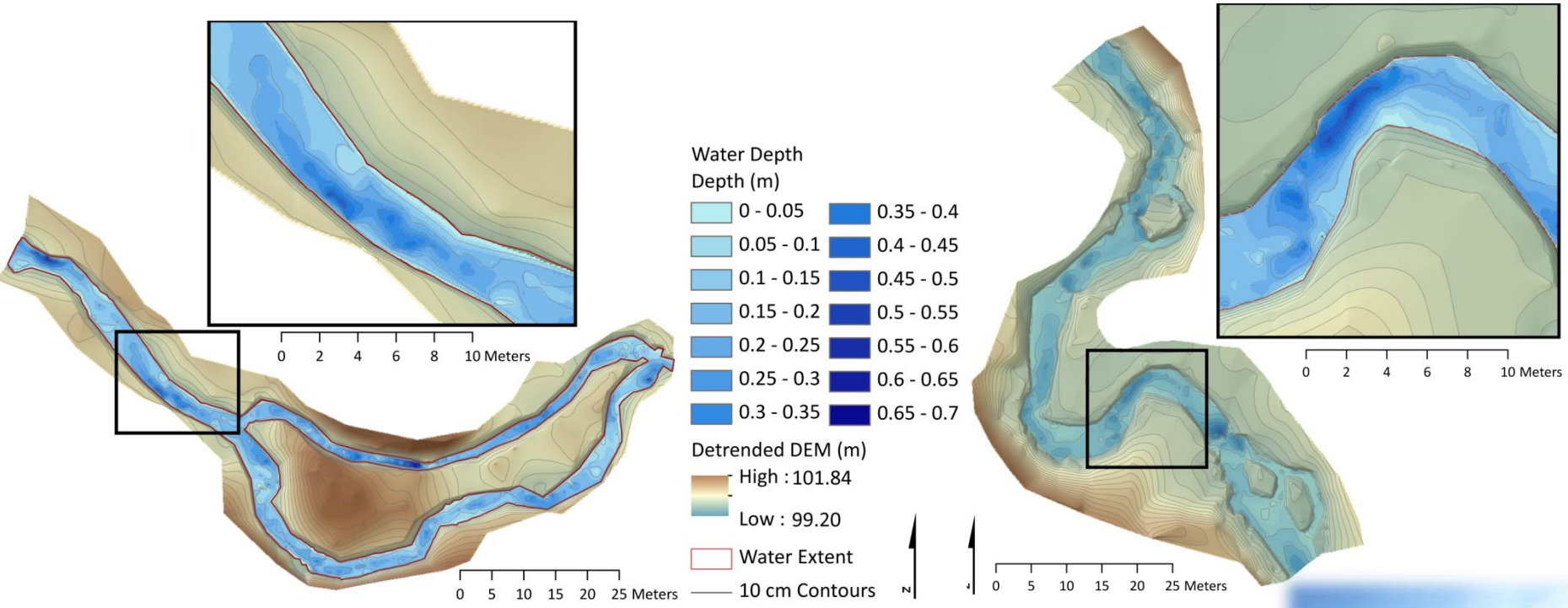
BONNEVILLE POWER ADMINISTRATION

WHAT YOU'LL BE DOING AS A CHaMP CREW MEMBER

- Honing your skills as a topographic artist!
- Helping collect data that is actively being used to address KMQs related to salmon
- Contributing to building a rich archive of data that will be harvested for many years to come



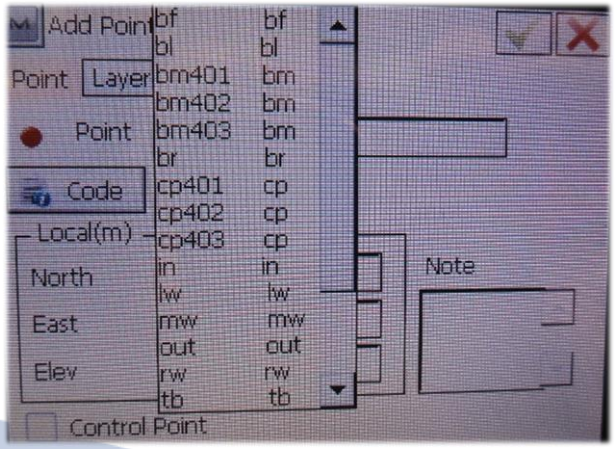
MAKING PRETTY MAPS IS A BIG PART…



- You are both artists and technicians… you need to paint us a quantitative picture

YOU ARE NOT JUST SURVEYORS
YOU ARE ARTISTS…

- We define for you:
  - The subject matter
  - The medium
  - The pallet



Your *canvas* is the site extent

Your *pallet* of point codes

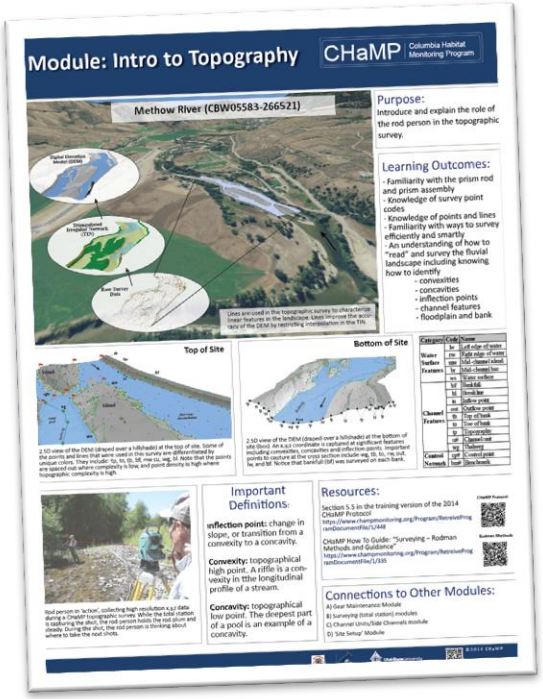
Your *brush* is the survey rod & prism

BUT, YOU ARE NOT ABSTRACT ARTISTS!

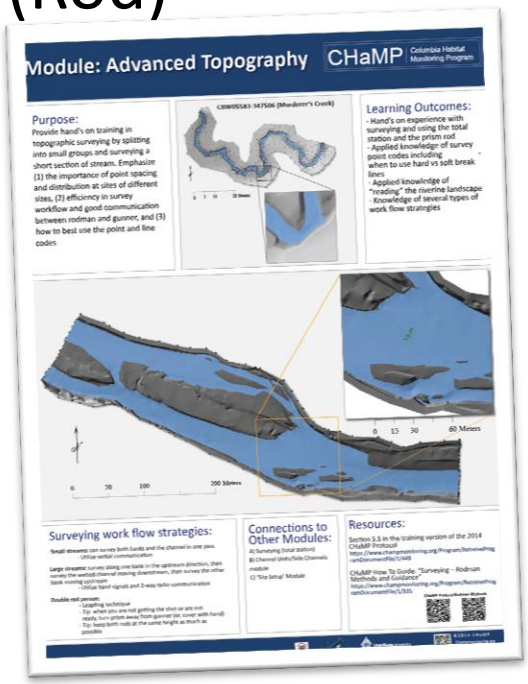
- Think of it as a pen & ink dot drawing….
- OR a detailed oil painting (when you connect the dots in GIS)
- NOT a watercolor
- NOT an abstraction

MODULES YOU'LL LEARN HOW TO DO THE PEN WORK (DOTS)

- Intro to Topography (Rod)



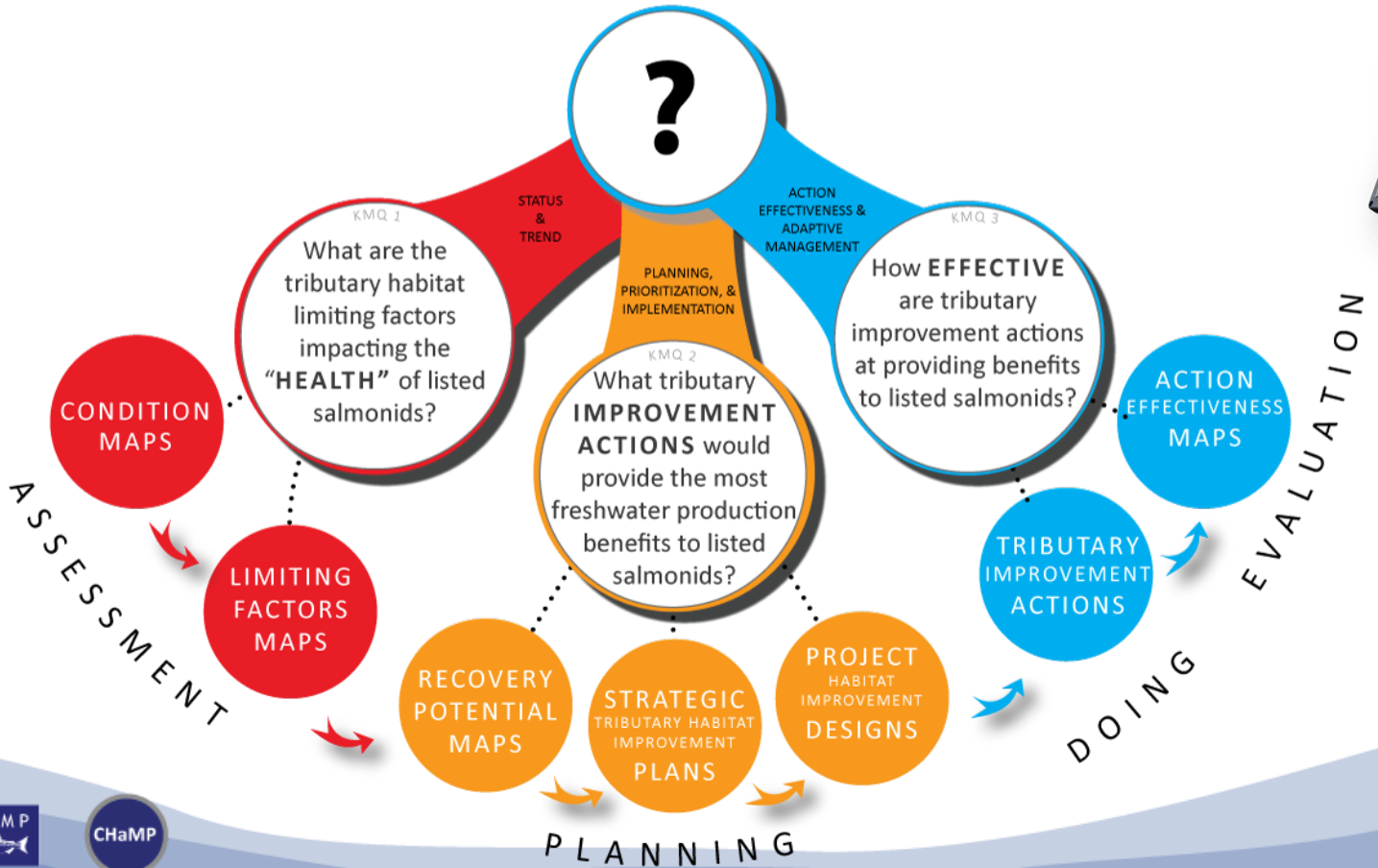
- Advanced Topography (Rod)



PURPOSE OF TALK

- Address:

How do you account for fish habitat with a total station?



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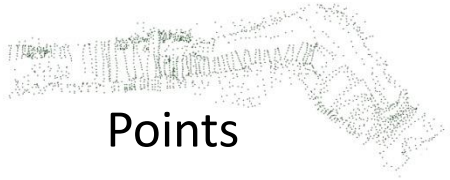
HOW DO WE CHARACTERIZE HABITAT?

- Can be done with stick & tape

- But when we do it with topography, we can support a richer range of more mechanistic analyses

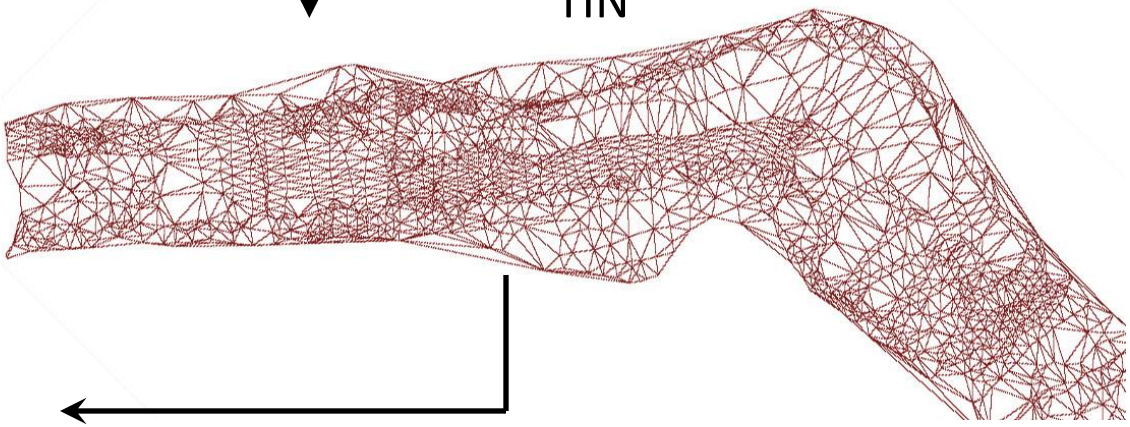
BUILDING A TIN FROM XYZ Points

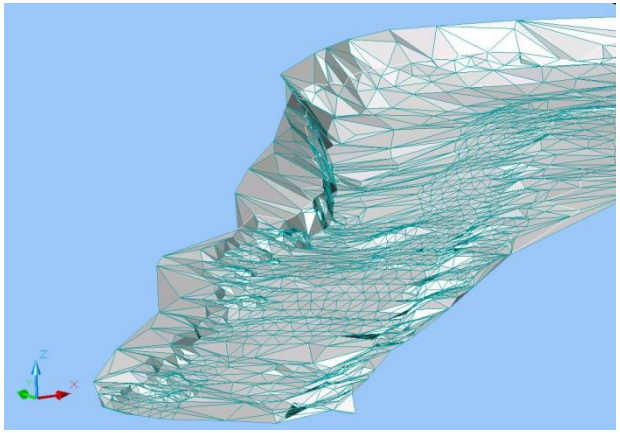
Triangular Irregular Network (TIN): the simplest and most common interpolation technique for building surfaces with irregularly spaced elevation data (McCullagh, 1981)



Points

TIN



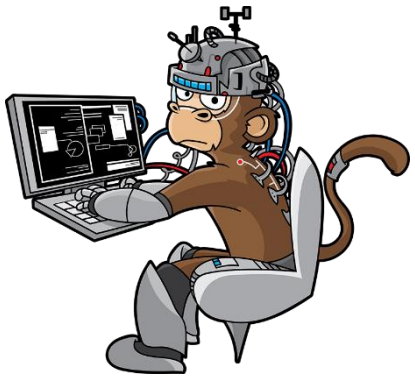


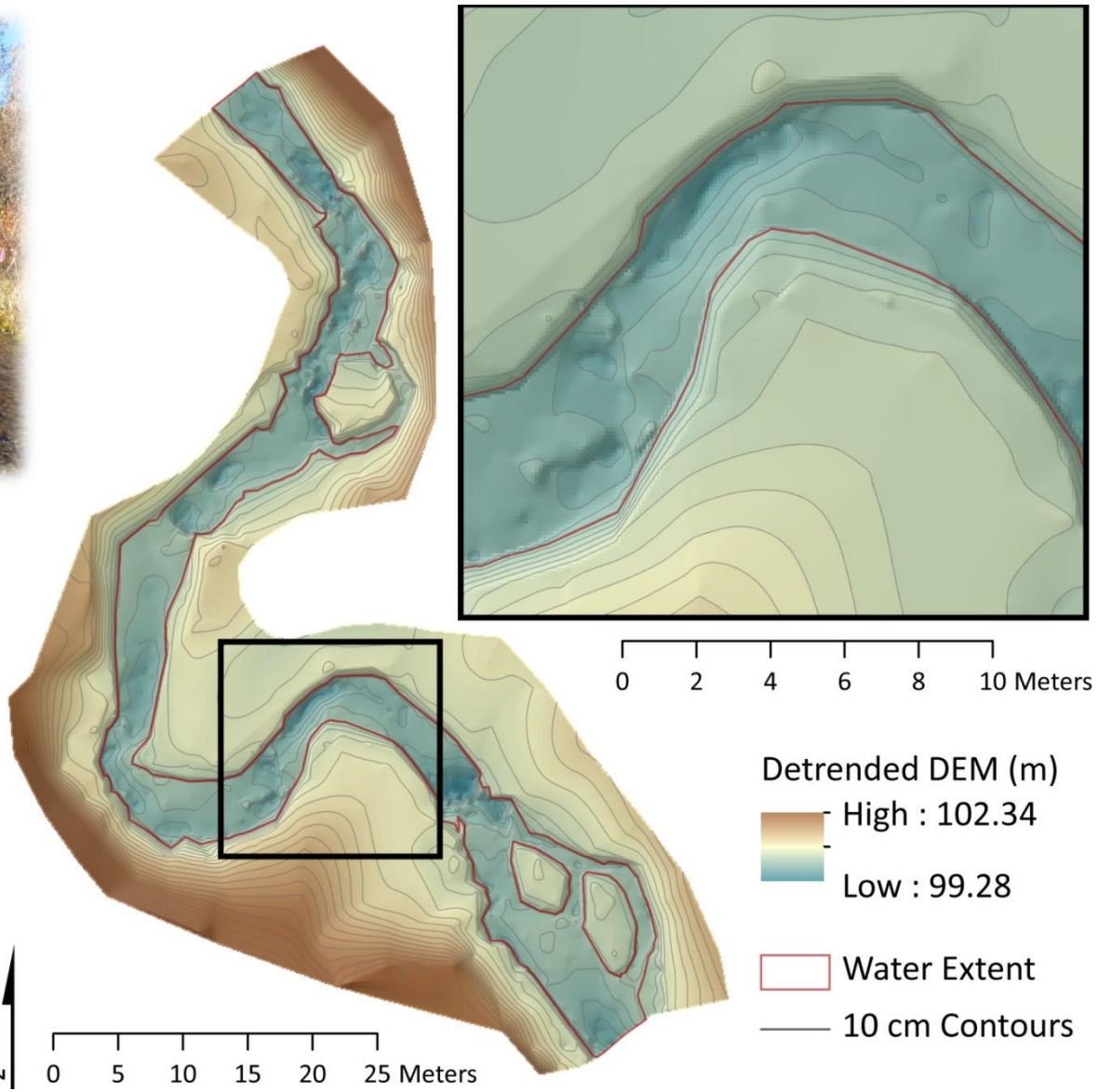
3D Surface Visualization of TIN

McCullagh MJ. 1981. Creation of smooth contours over irregularly distributed data using local surface patches. Geophysical Analysis. 13: 51-63.

YOU TAKE OWNERSHIP OF THE DATA

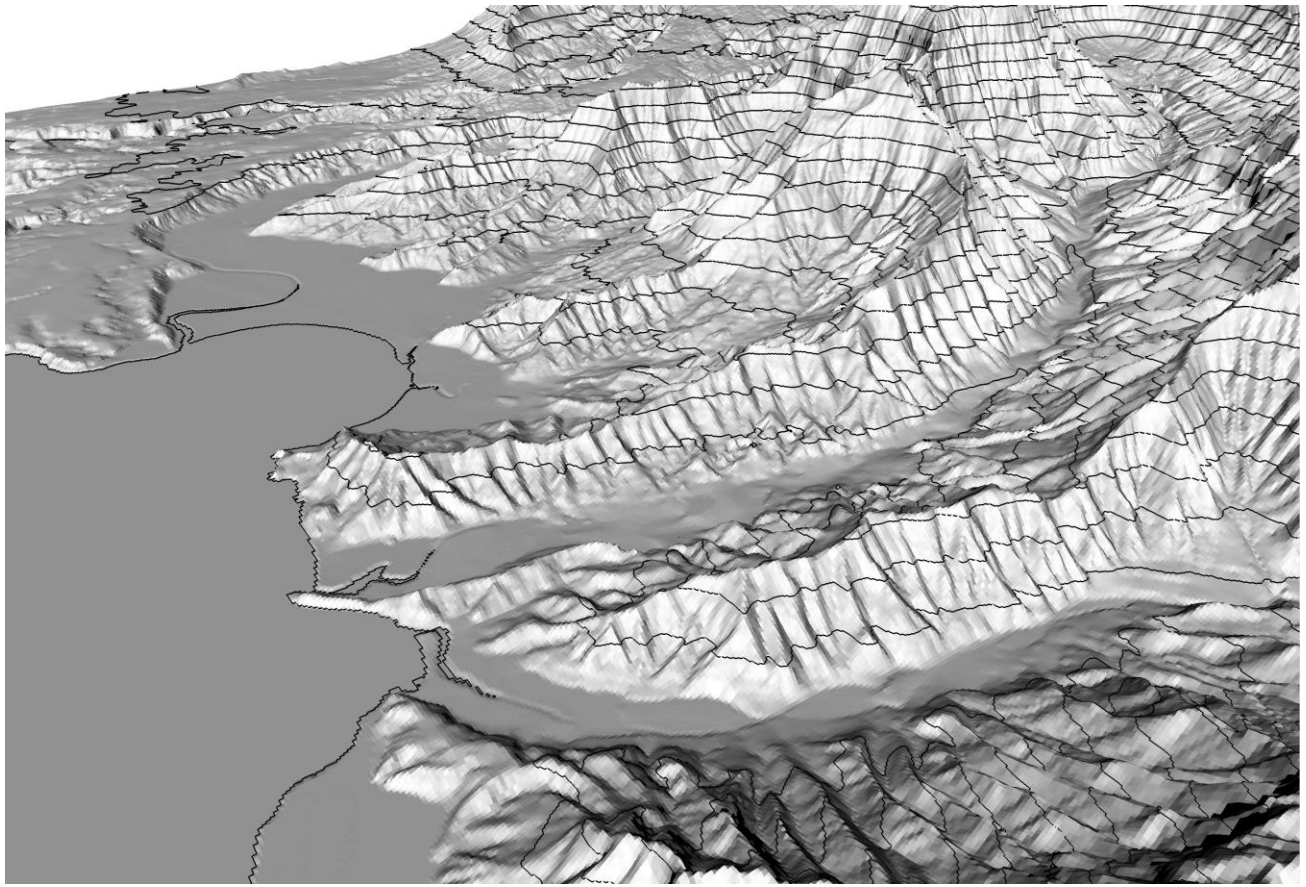
Crews post process the data!





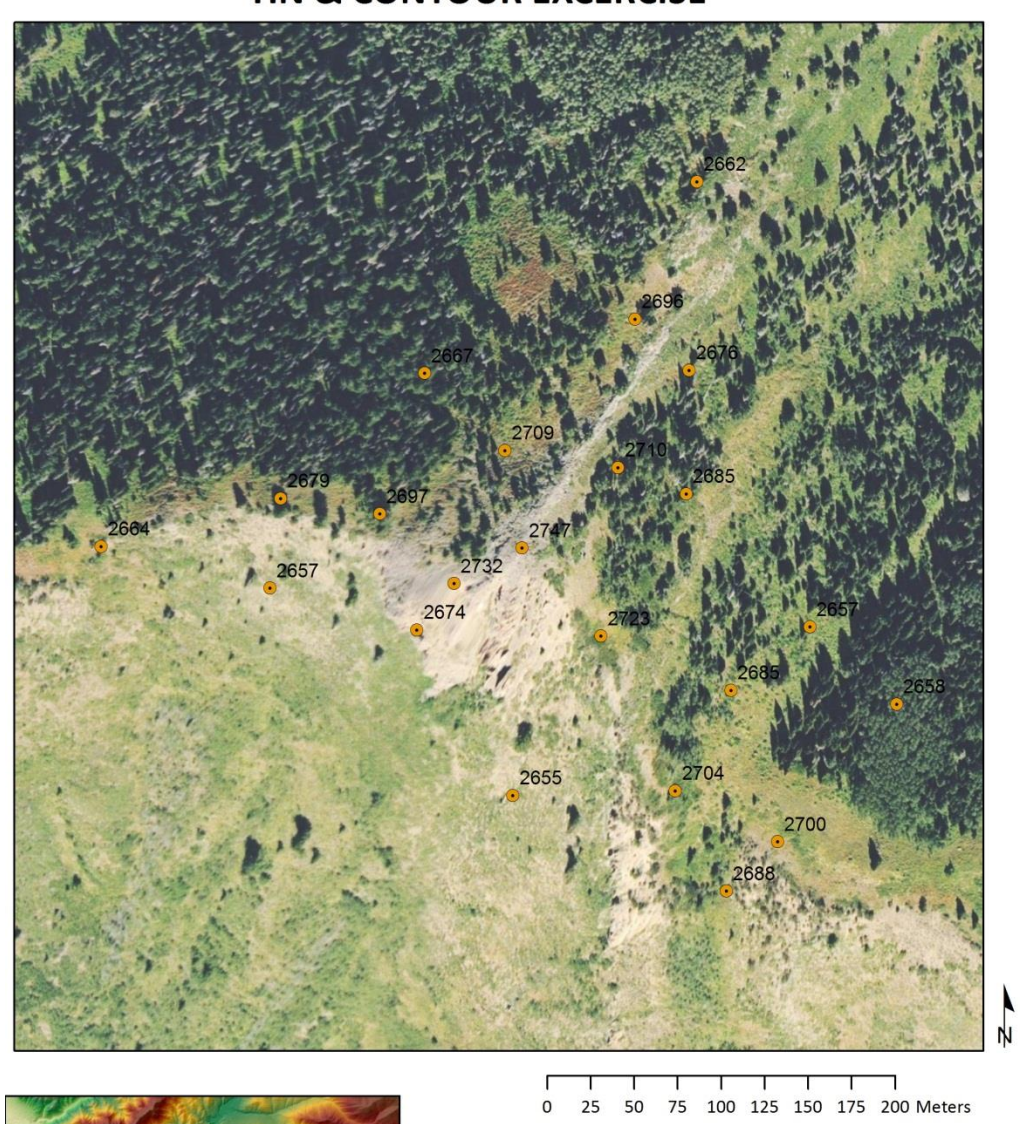
CONTOURS

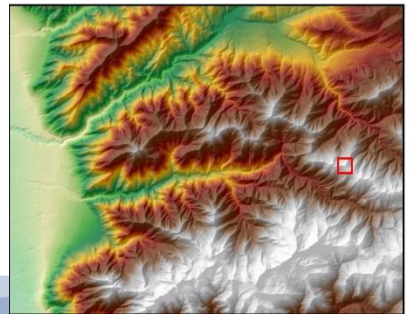
- Lines of equal elevation… helps when draped over a 3D hillshade…



AN EXERCISE

- Elevations are real
  - Derived from 10 m DEM
- Integer Elevations
  - Rounded up elevations
- Context:
  - This is a peak where three ridges come together
  - Up between Big Cottonwood and Little Cottonwood Canyons in Wasatch Mountains

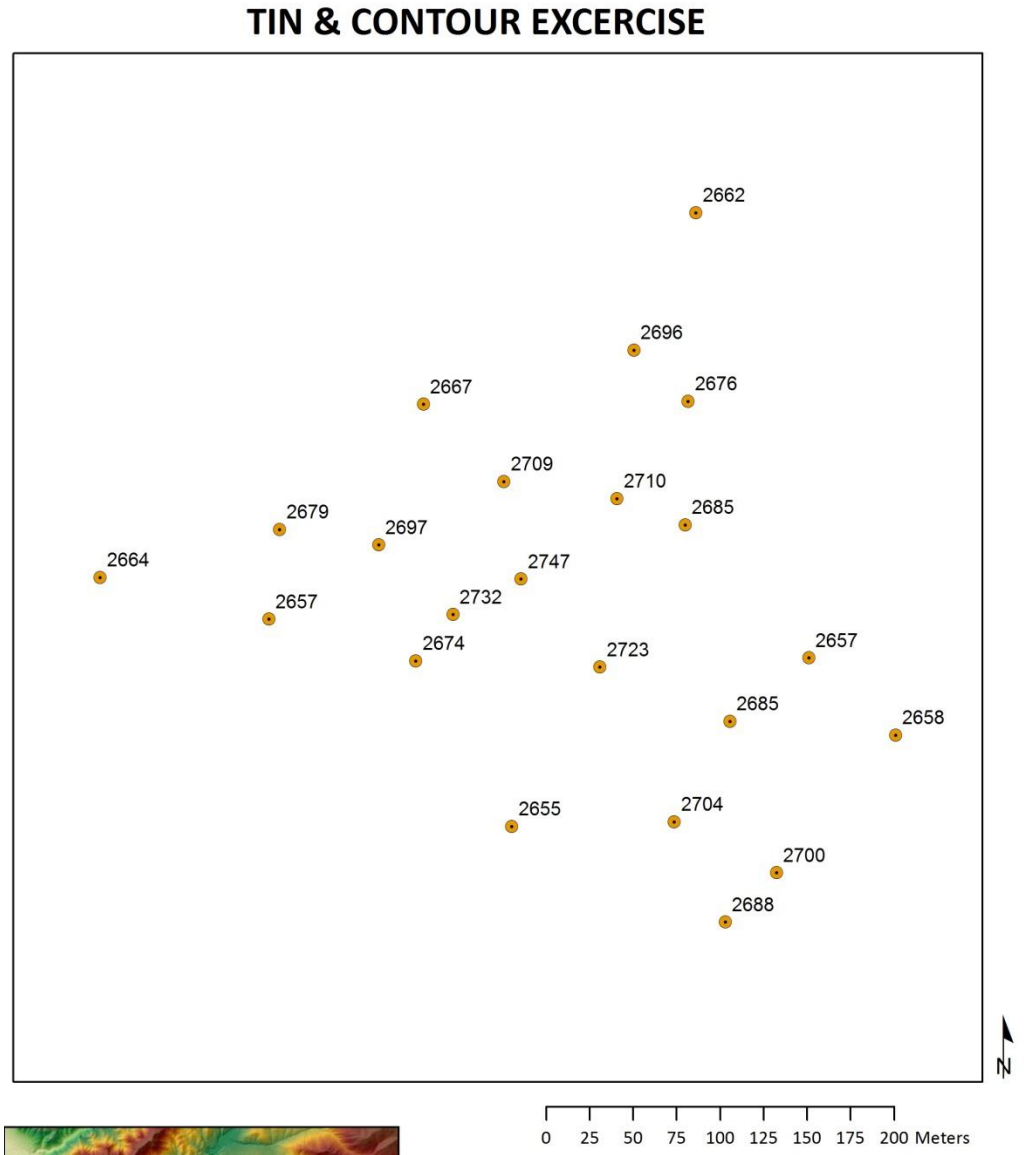


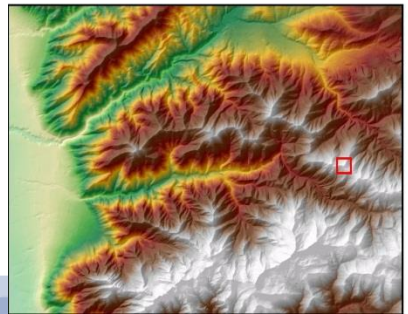


INSTRUCTIONS:
1. Connect all the dots to create a TIN
2. For each TIN edge, determine how many contours would intersect it at a 10 m contour interval (lightly label the contours)
3. Connect the contours up to draw a contour map

OVERVIEW

- We want to make a Contour Map from These Points
- Make a TIN first
- Divide up the tin lines by where our contour interval intersects them
- Connect the dots (those lines are contours)
- Label your Contours





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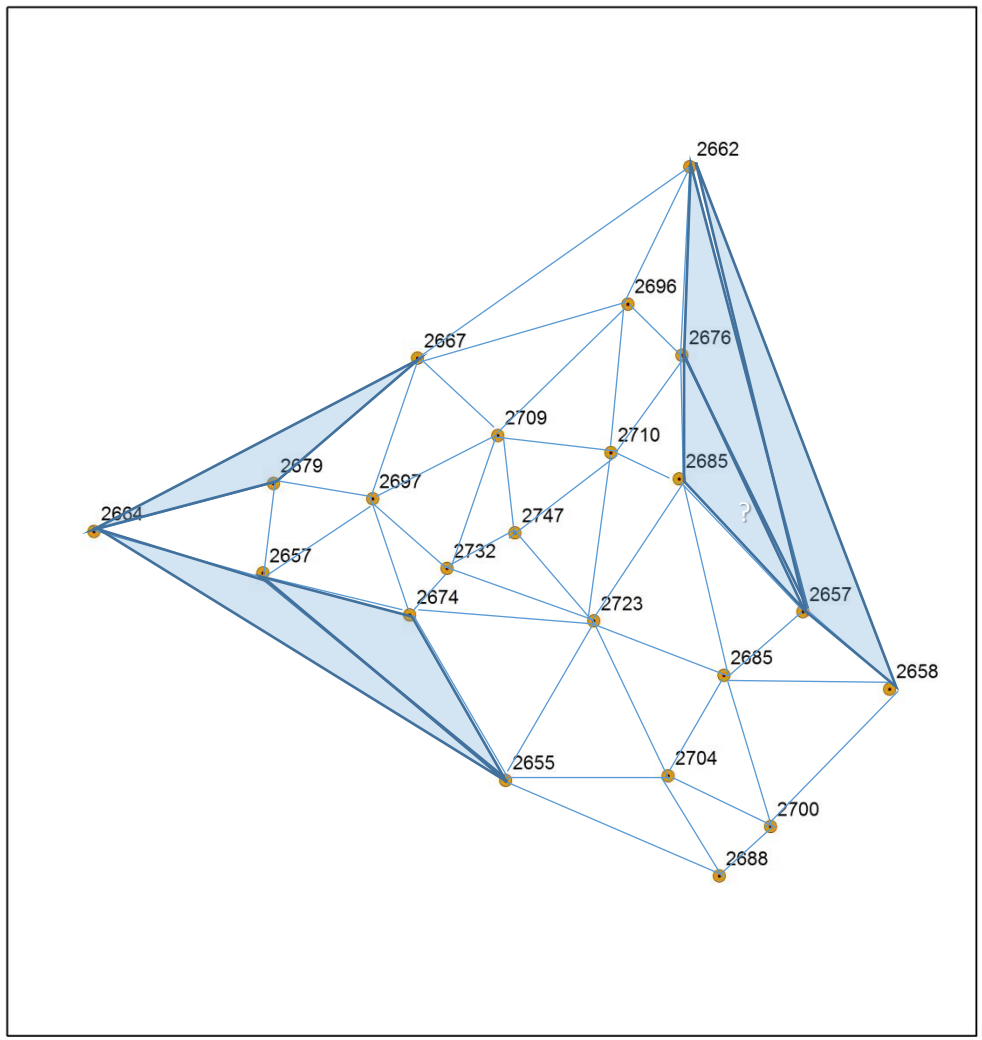
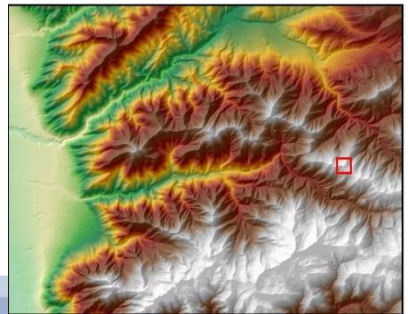
CONNECTING DOTS

- Start anywhere…
- Find three closest points
- Try and make your triangles as equilateral as possible…
- Careful with over interpolation





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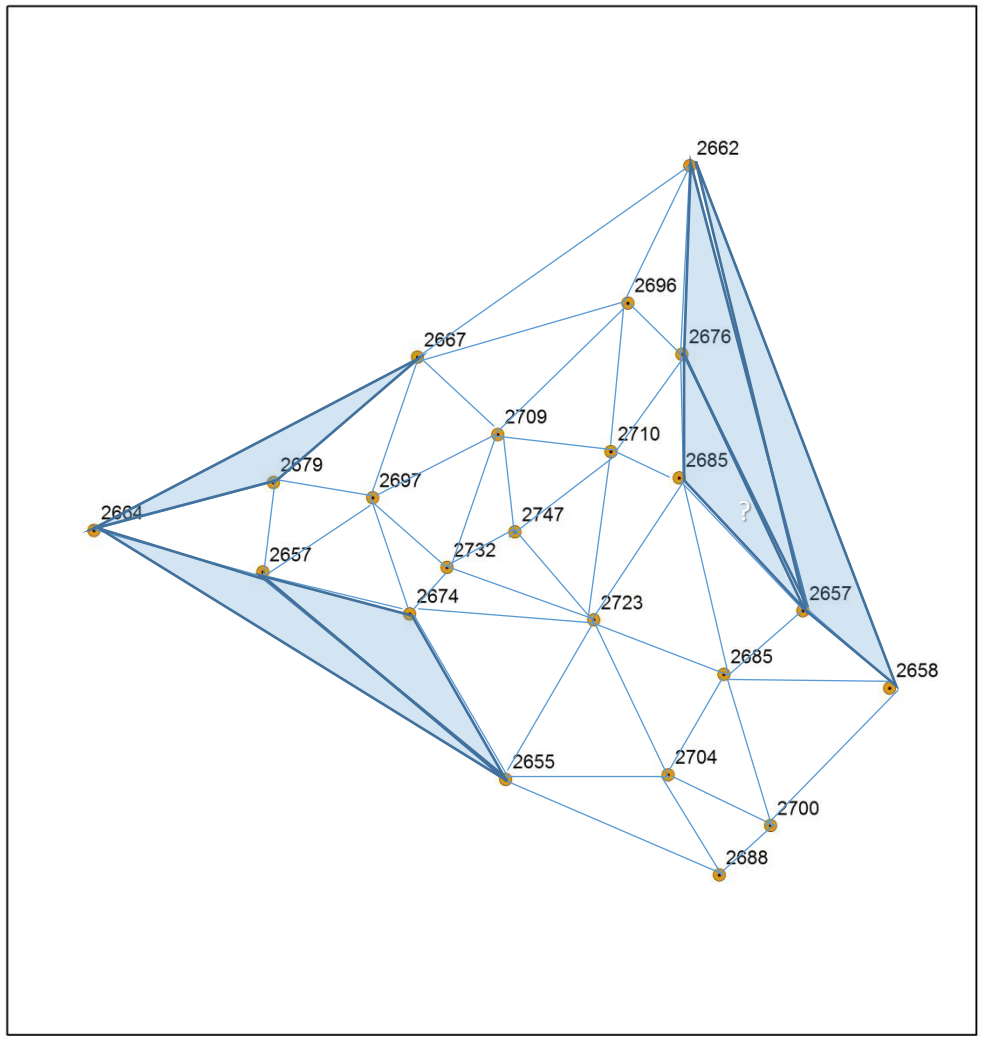

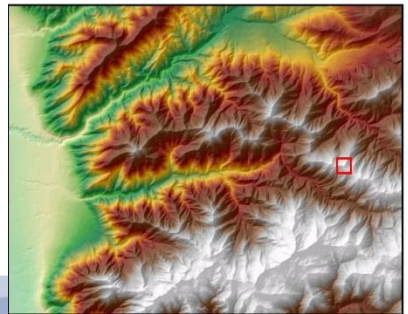

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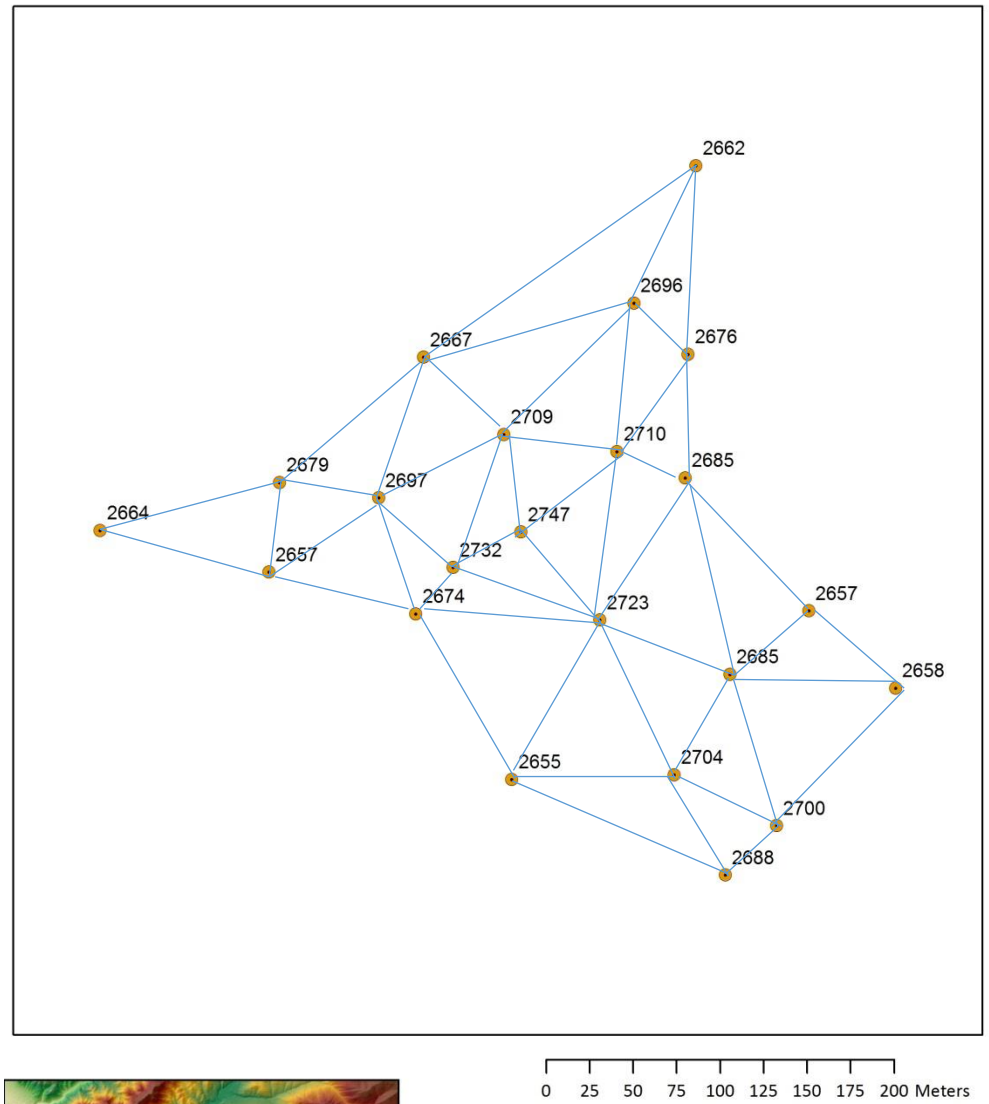
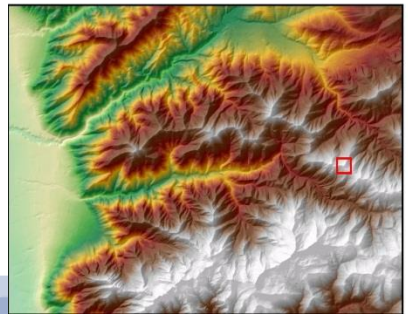
A TIN to CONTOURS

- What is max elevation?
  - 2747 m
- What is minimum elevation?
  - 2657 m
- What is elevation range?
  - 2747 – 2657 = **90 m**
- What is a good contour interval?
  - How about 10 m?





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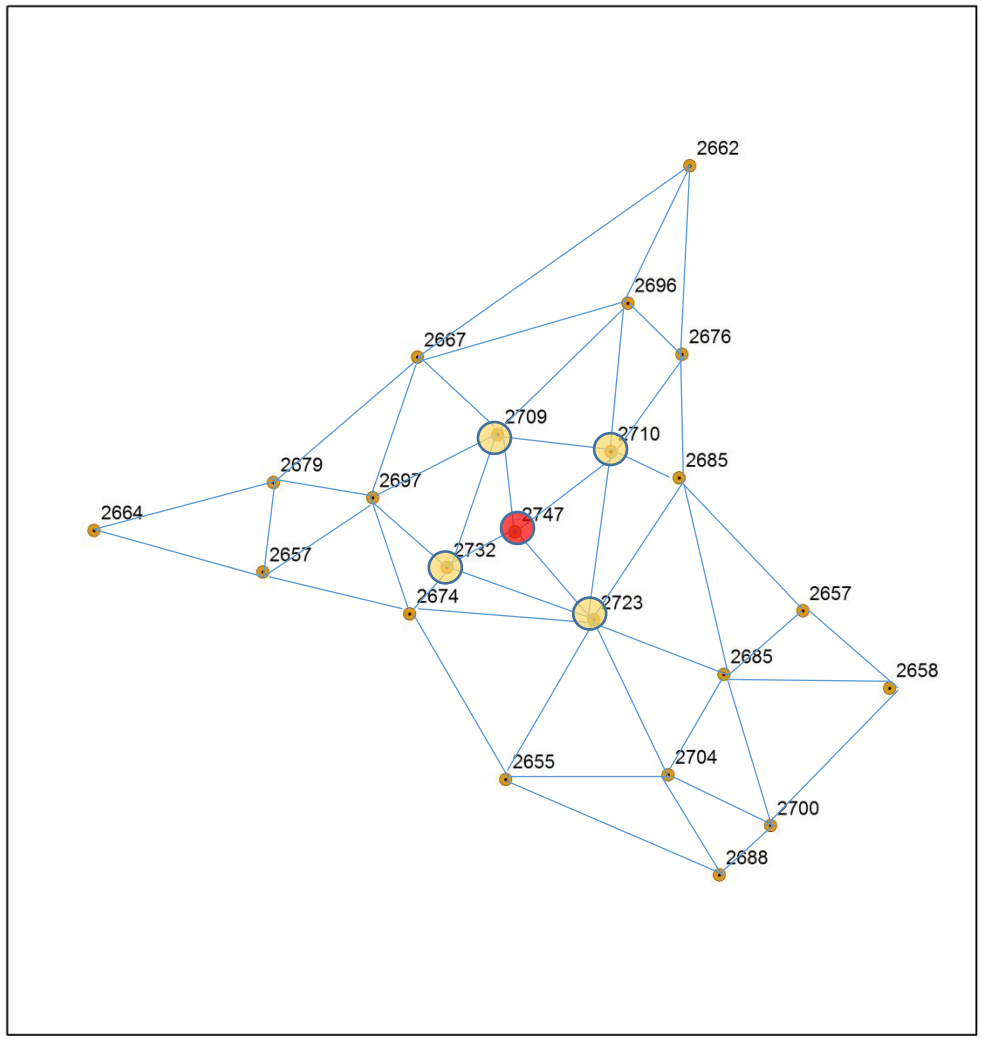
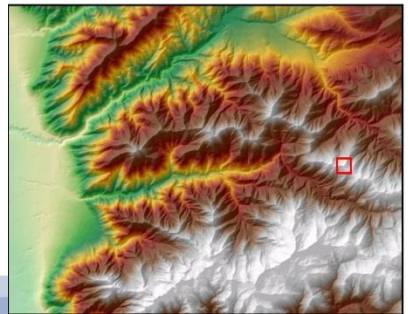
A TIN to CONTOURS

- Using a 10 meter contour interval… start with 2740 contour

1. Find point(s) higher then 2740
2. Find connecting lower points
3. Put equidistant 1 m contour ticks between lines from 2747 to nearest lower neighbors.
4. Count down 7 to 2740, and make bold
5. Connect dots (linearly or artistically)





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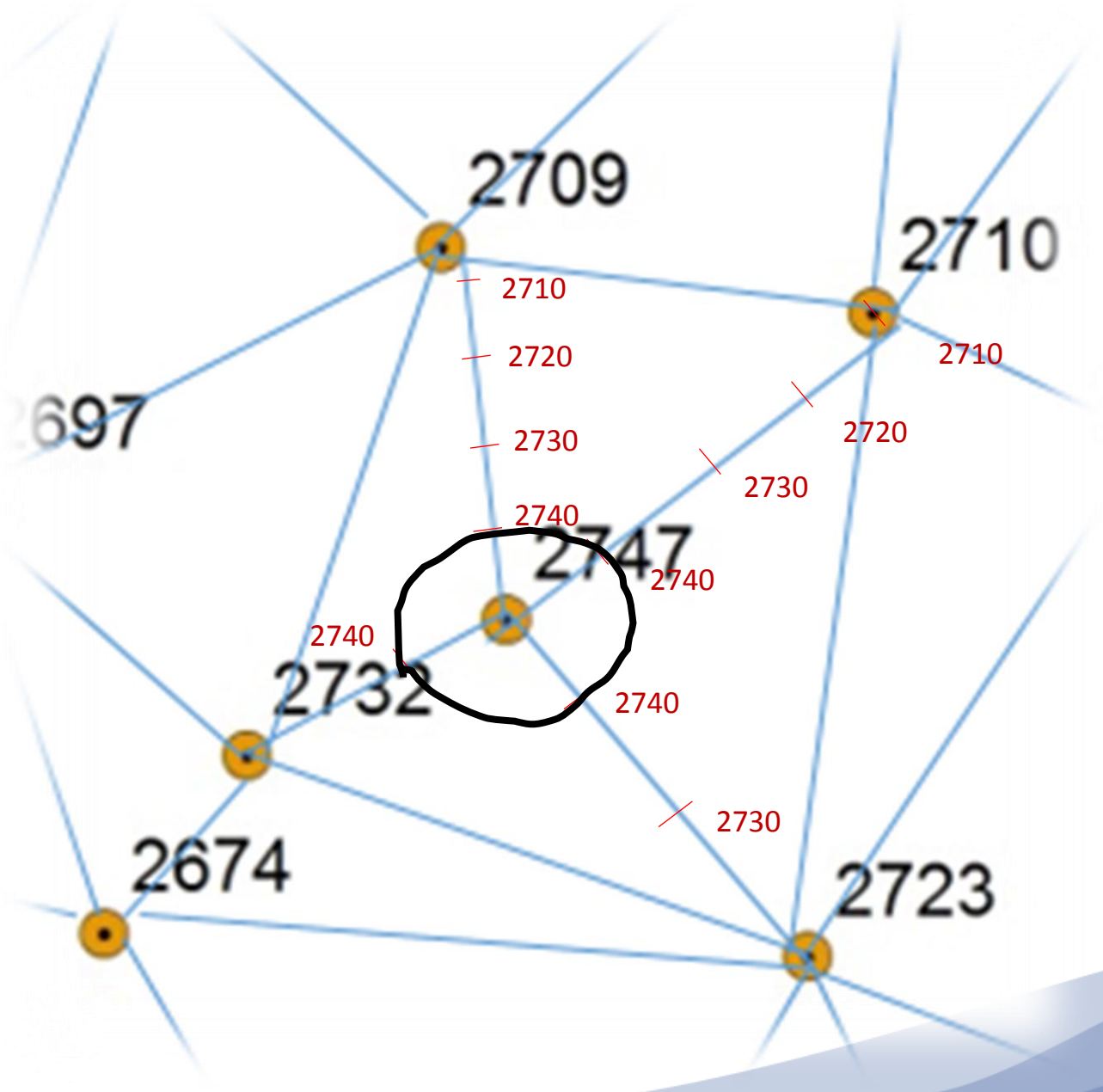
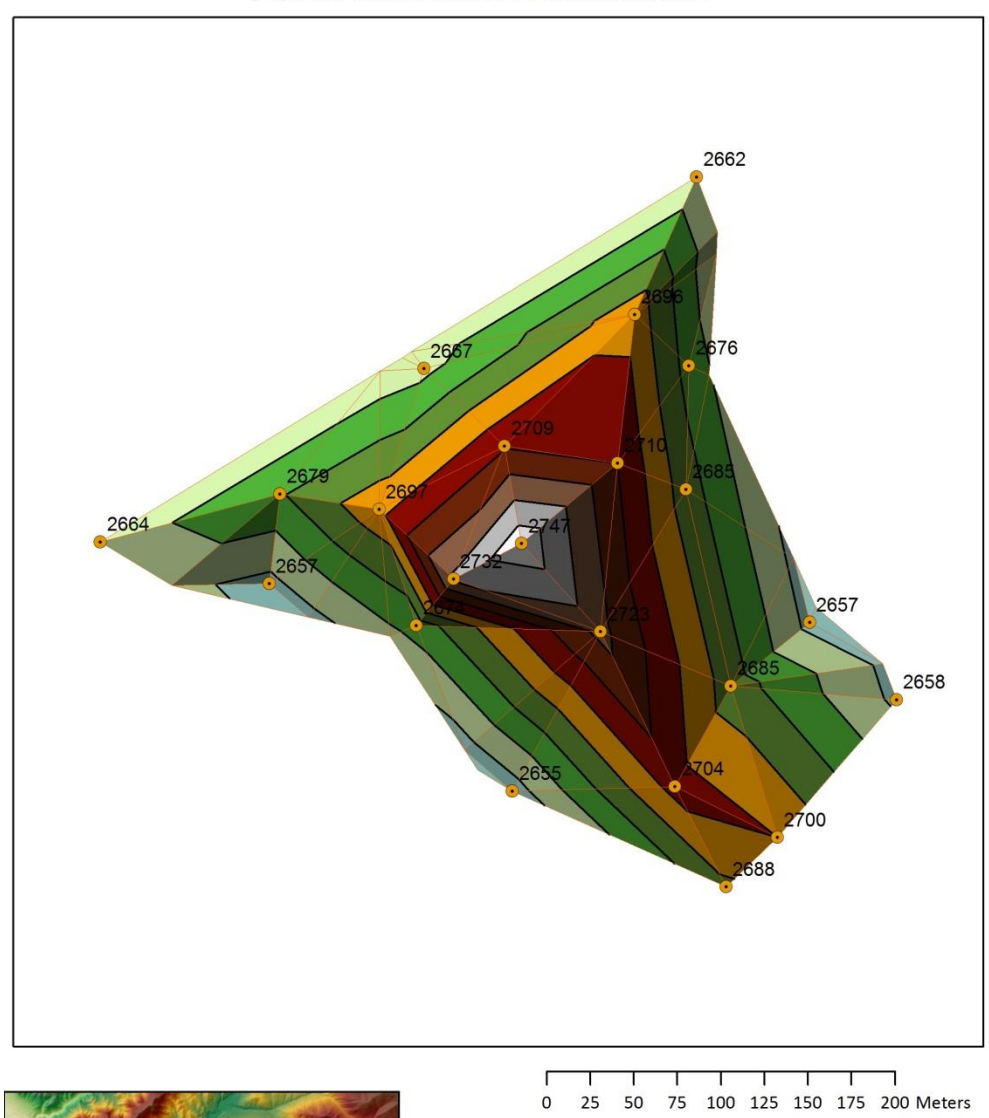
CONTOURS

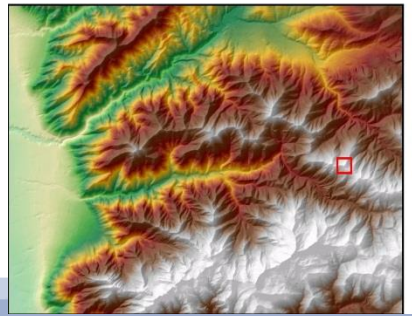
1. Put ticks where 10 m contours would be
2. Between 2747 and 2732 how many 10 m contours?



YOUR CONTOURS?

- Here's the ArcGIS derived TIN shown w/ same 10 m contour interval you should have used
- How close does yours look to this?





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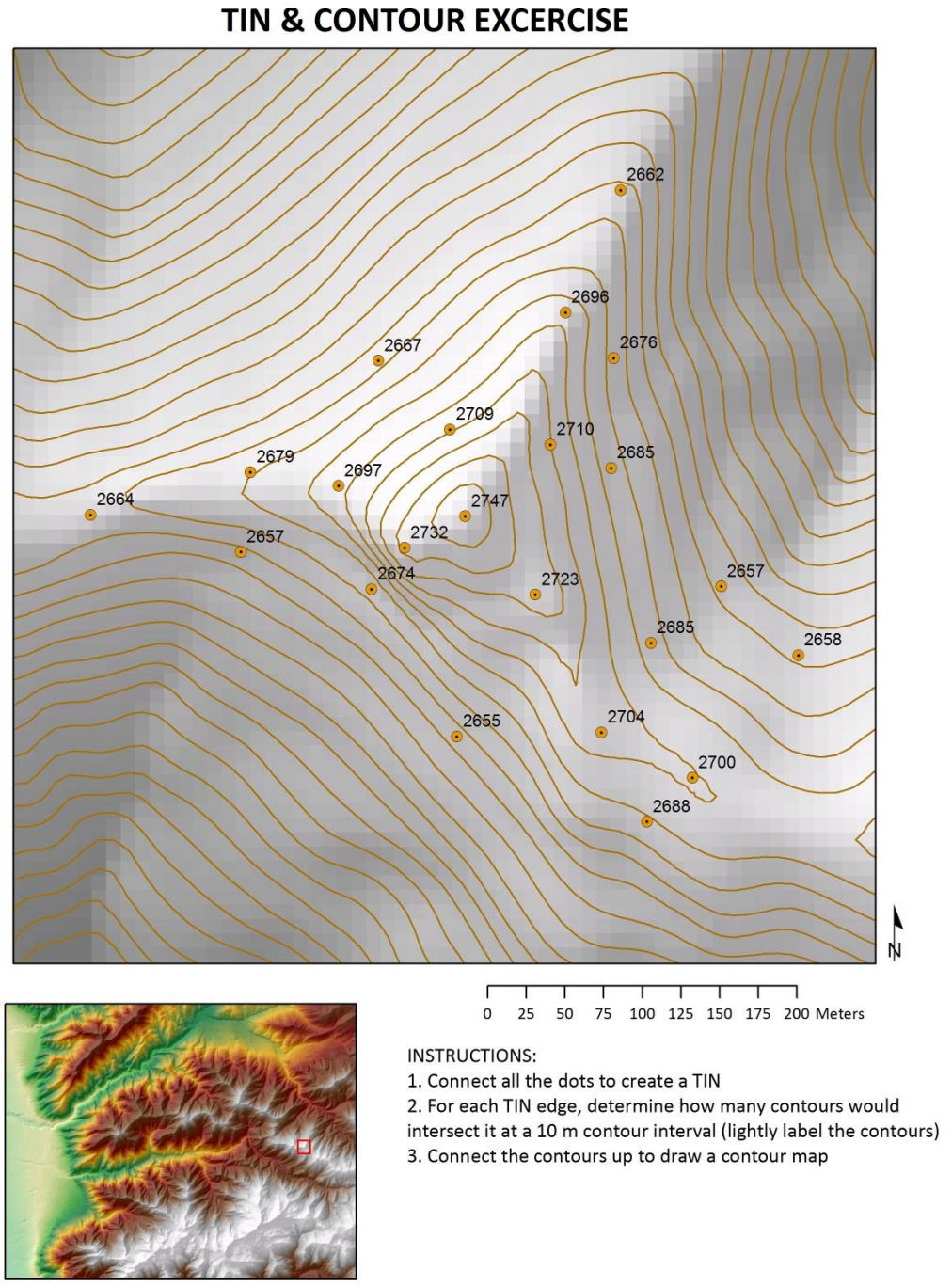
BONNEVILLE POWER ADMINISTRATION ISEMP CHaMP

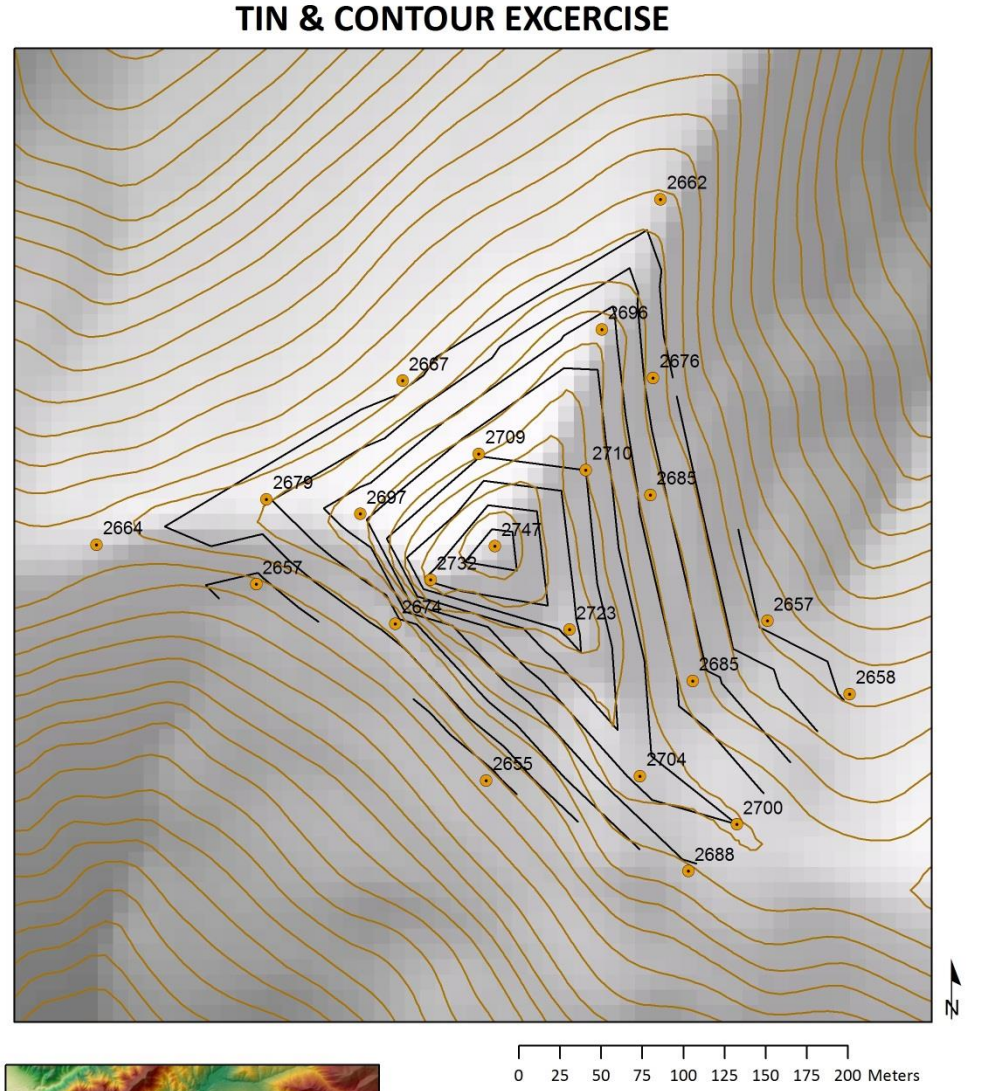
ACTUAL

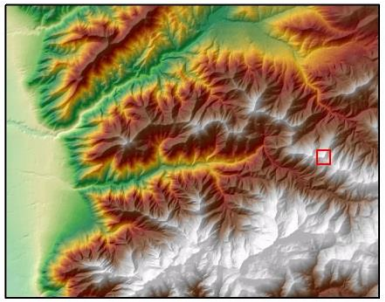
- Here's what the actual 10 m contours look like for this location
- Hillshade shown in background
- Both derived from USGS NED 10 m DEM



COMPARED

- Reasonably close…
- Why are they different?
- How many points did we use (i.e. sample)?
- How many points were used for brown contours?
- What is difference between contour interval, pixel resolution and point resolution?





INSTRUCTIONS:
1. Connect all the dots to create a TIN
2. For each TIN edge, determine how many contours would intersect it at a 10 m contour interval (lightly label the contours)
3. Connect the contours up to draw a contour map

BONNEVILLE POWER ADMINISTRATION
ISEMP
CHaMP

OUTLINE

HOW DO YOU ACCOUNT FOR FISH HABITAT WITH A TOTAL STATION?

I. Background

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III. Quantifying Habitat – From Topography

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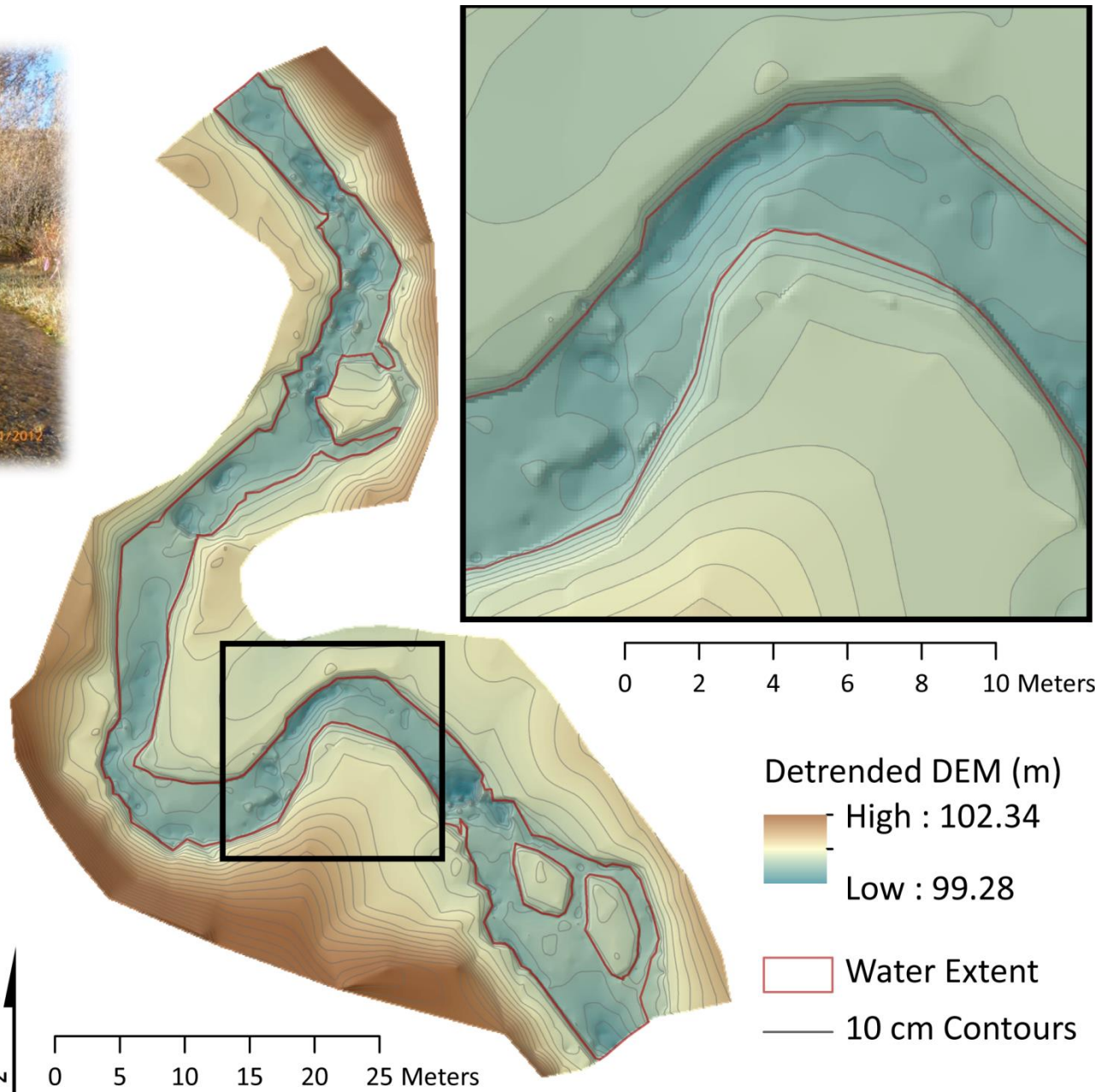
- II. Geomorphology
- III. Fish Habitat

IV. Some Other Useful Byproducts of Topography

V. Take Homes

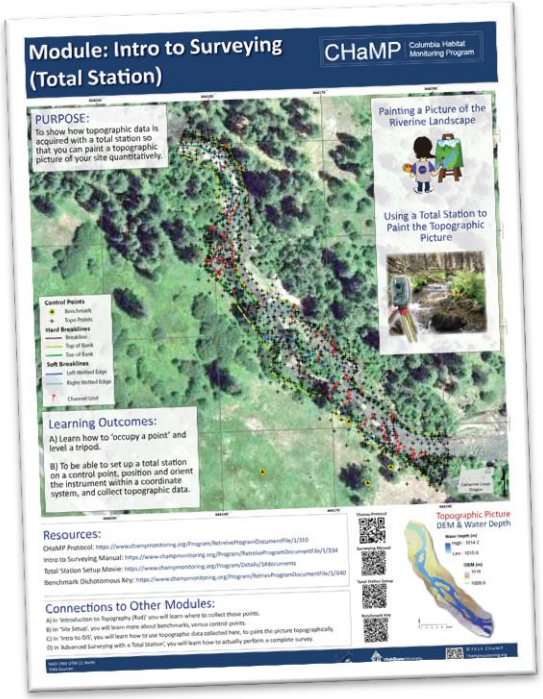
WHAT DO YOU DO WITH TOPO SURVEY?

1. Build TIN
2. Convert to DEM
3. Detrend
4. Morphology Pops out
5. Flood….



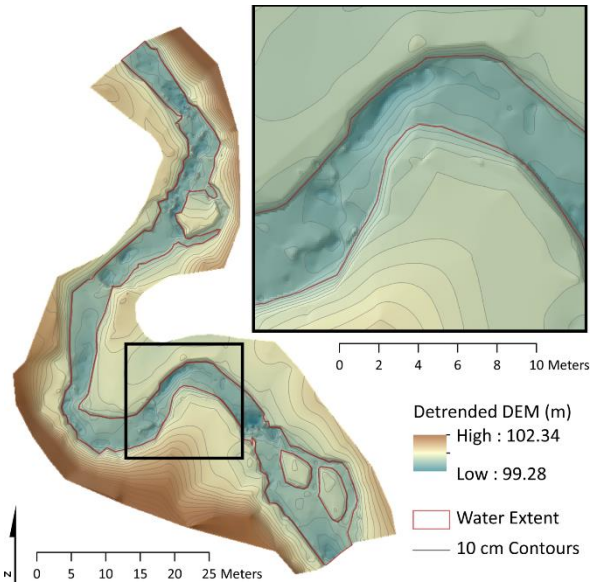
MODULES YOU'LL LEARN HOW TO CONNECT THE DOTS

- Intro to GIS



- Advanced GIS

WHAT WE DO WITH TOPO SURVEY?



- For Physical Habitat, I will talk to you about:
  - Hydraulics, Geomorphology leads to fish habitat
- For why fish might care, Pete will talk to us about more specifically what fish need out of their habitat
- For upscaling these results to address Key Management Questions, Chris will talk to us about Survey Design & Extrapolation for Life Cycle Modelling

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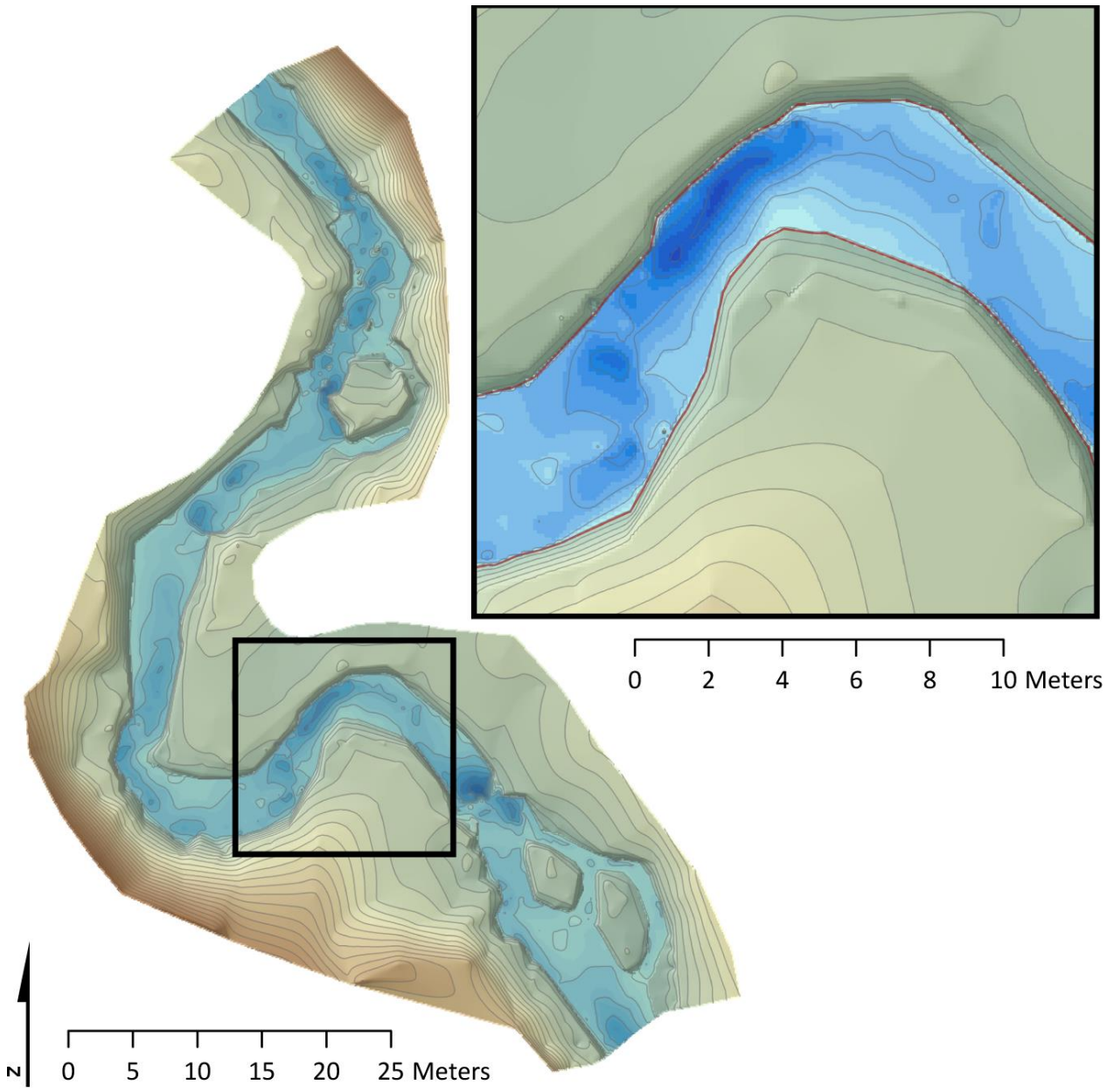
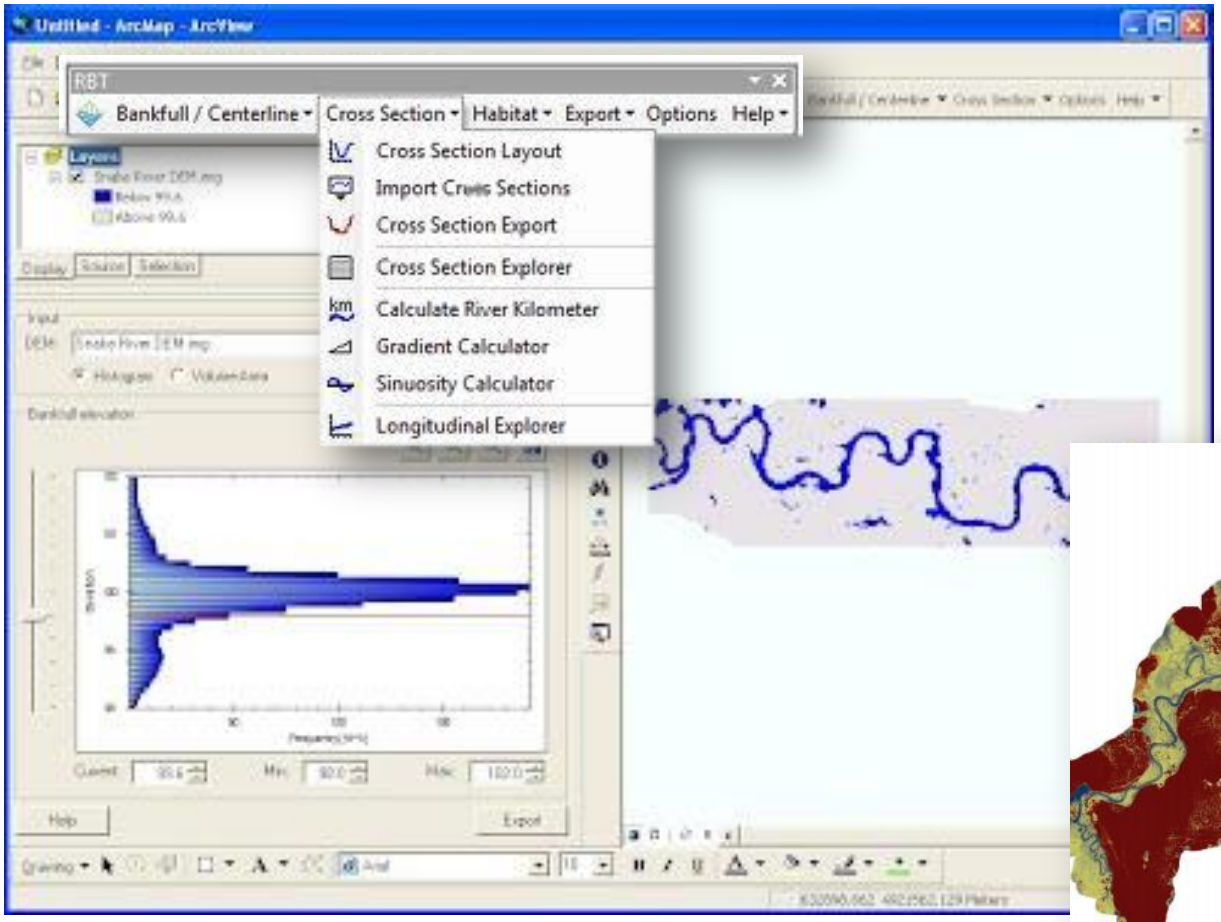
½ A HYDRAULIC MODEL

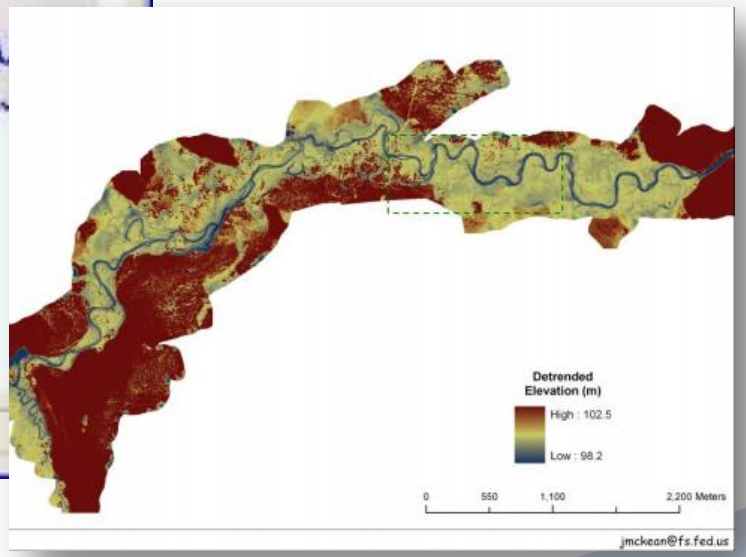
From field data… survey of waters edge…



RIVER BATHYMETRY TOOLKIT

- Poor Man's Hydraulic Model…





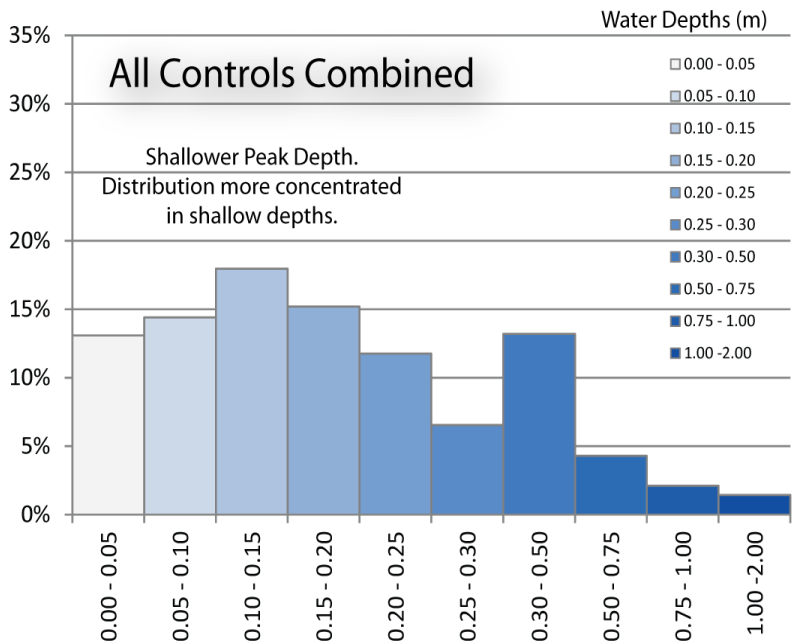
RBT: http://essa.com/tools/rbt/

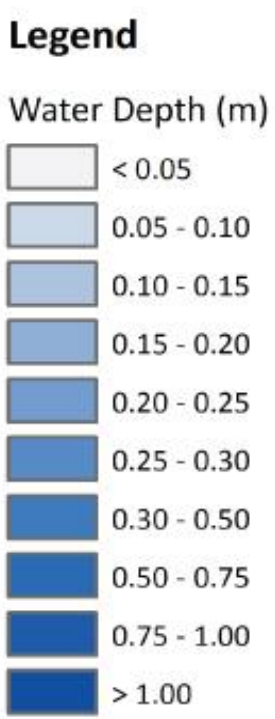
McKean et al. (2009)
DOI: doi:10.3390/rs1041065

DEPTH HETEROGENEITY

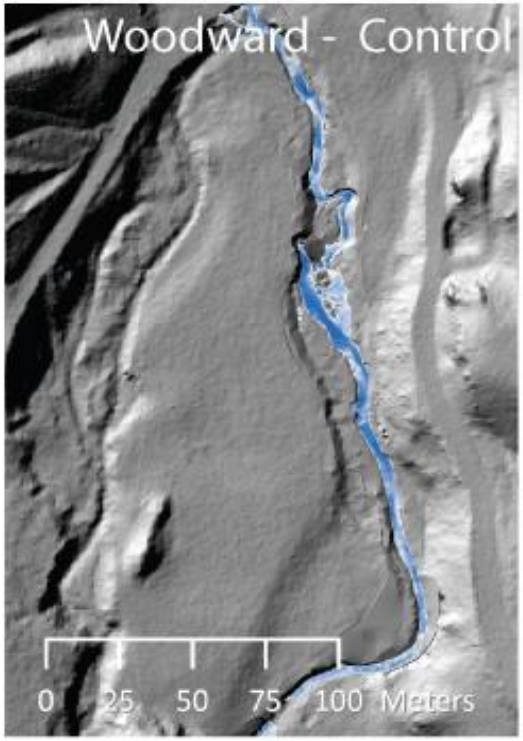
- Use depth distributions to look at one form of diversity of hydraulic habitat
- Comparison of restoration treatment (using beaver) & controls

A

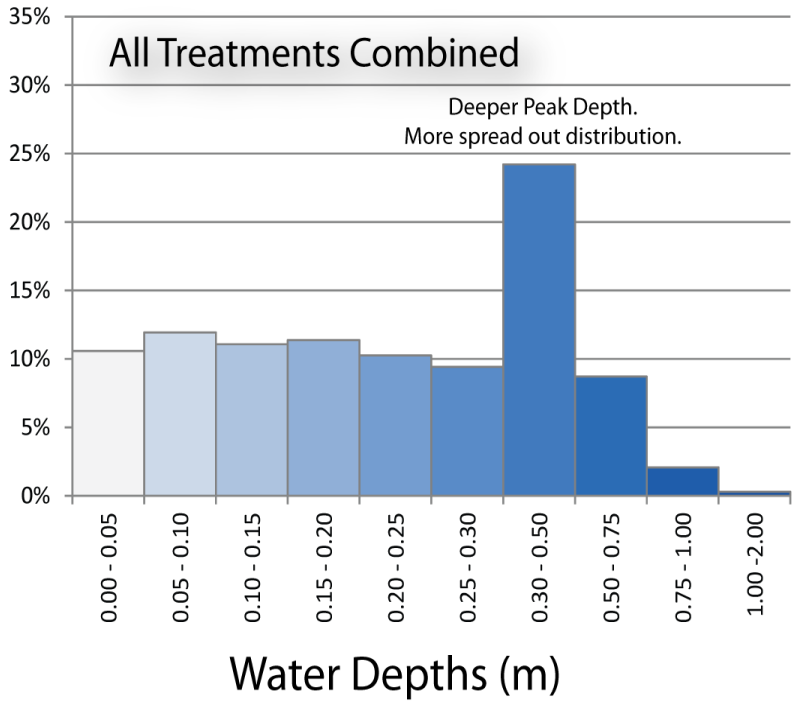




C

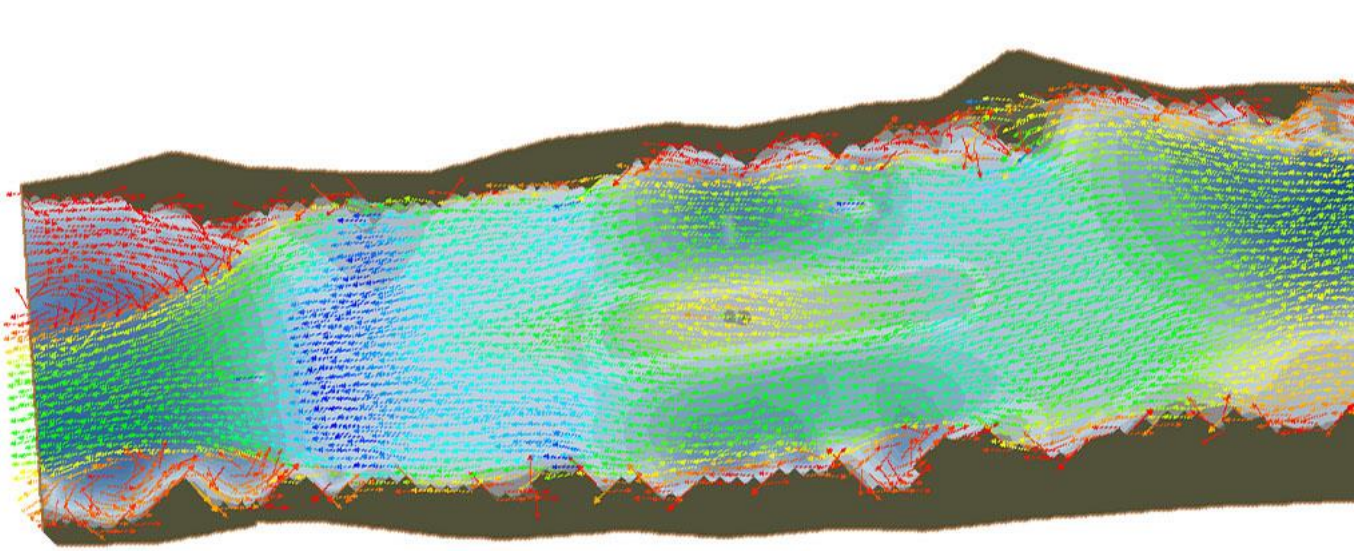


B



TOPO SUPPORTS: HYDRAULIC MODELS

- Can be 1D, 2D or 3D….



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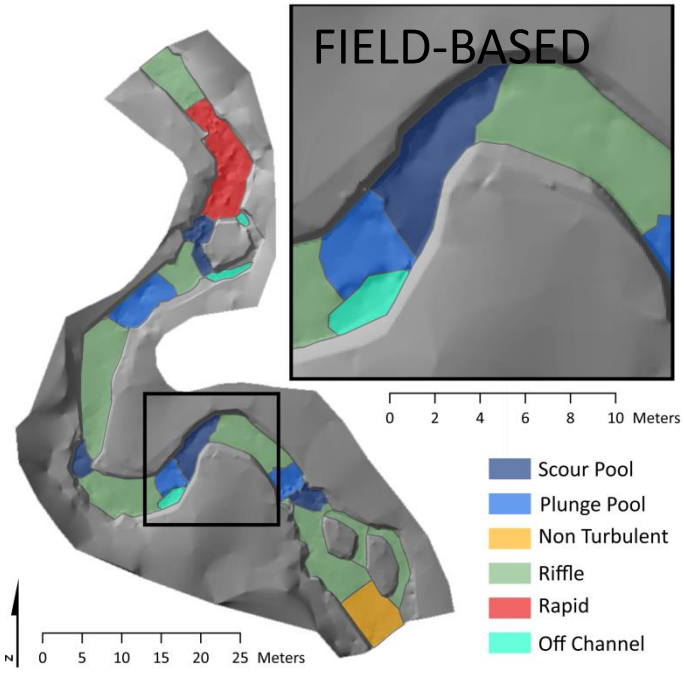
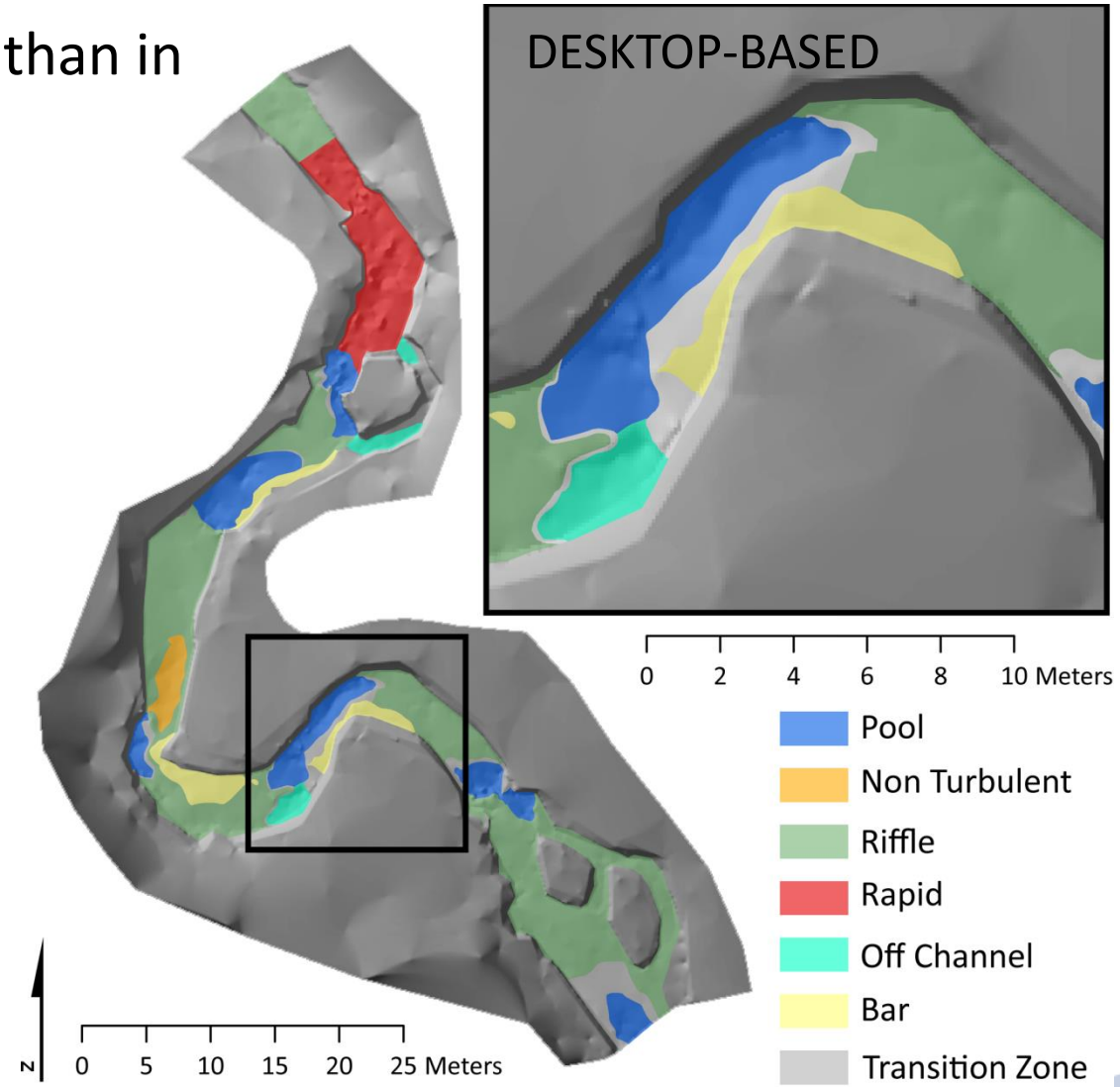
GEOMORPHOLOGY?

- The study of landforms (e.g. geomorphic units) and the processes that shape them?
  - The landform bit we can describe as a snapshot (status)
  - The processes play out over time (trend)
- What processes specifically?
  - Erosion and Deposition

DERIVE HABITAT UNITS FROM TOPO & WD

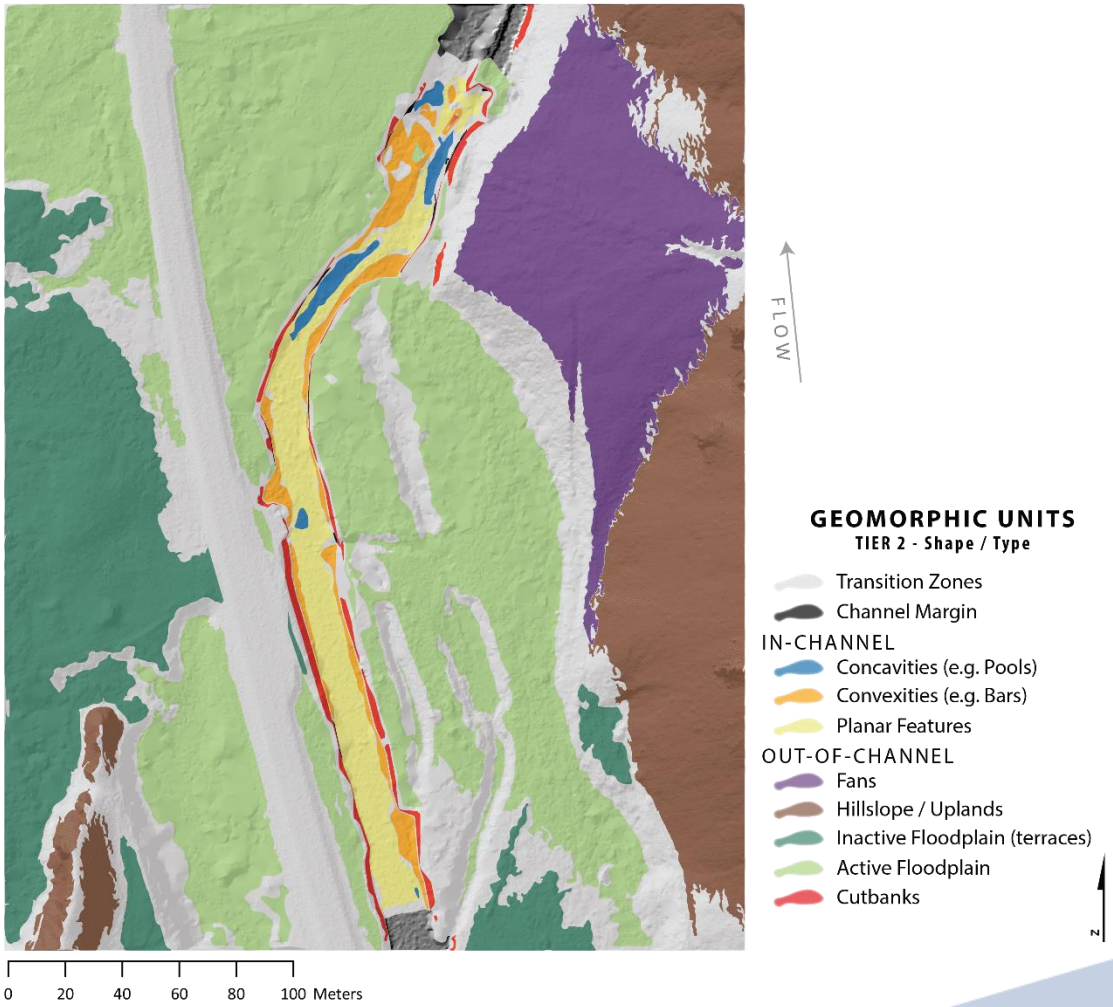
- More refined boundaries than in field alone
- Transitions emerge as important…





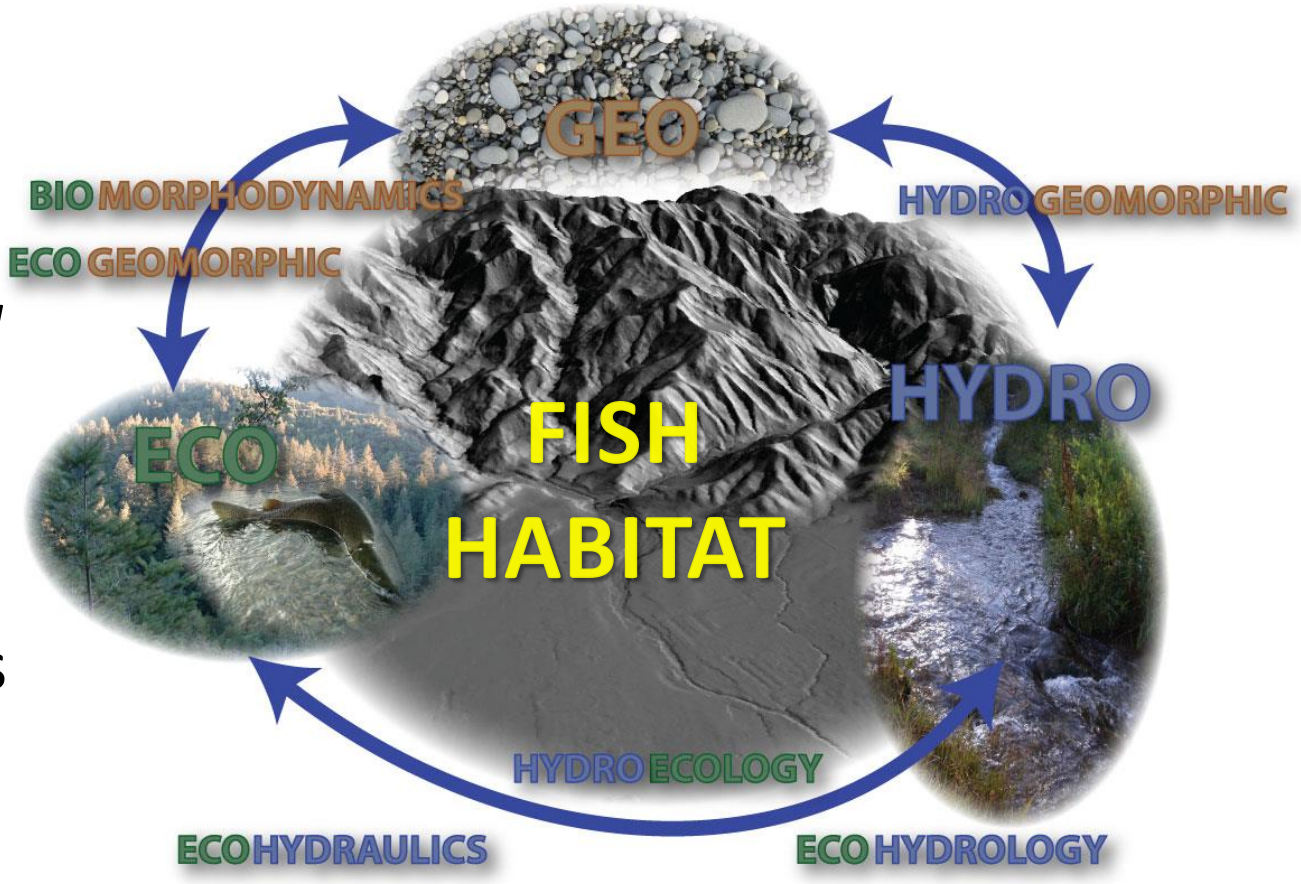
GUT - BLENDING WITH REMOTE SENSING

- Using CHaMP topography to derive in-channel geomorphic units & LiDaR to Derive out of-channel geomorphic units - GUT



DYNAMIC STREAMS = HEALTHY ECOSYSTEMS

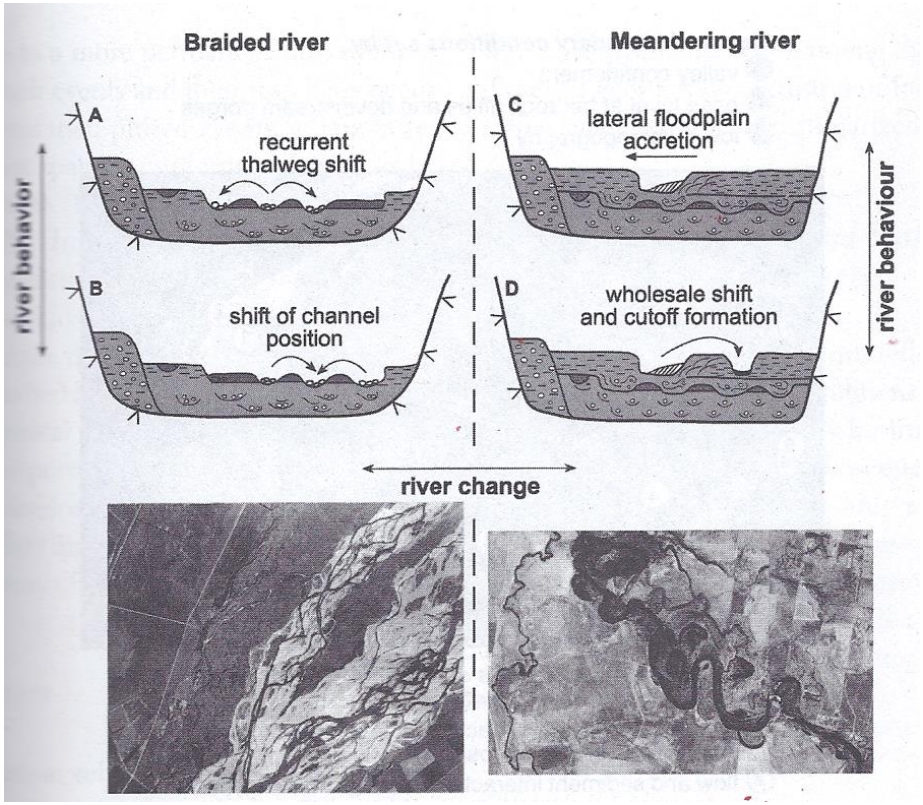
- We *believe* this…
- Lots of cool studies *showing* feedbacks and links…
- We *know* that heterogeneity is linked to dynamism



- How do we *monitor* and describe such dynamics?

WAYS A RIVER CAN ADJUST LOCALLY

- Adjustments (Erosion/Deposition)
  - Channel morphology
    - Channel Size
    - Channel Shape
  - Bed Character
  - Planform
  - Arrangement of geomorphic units

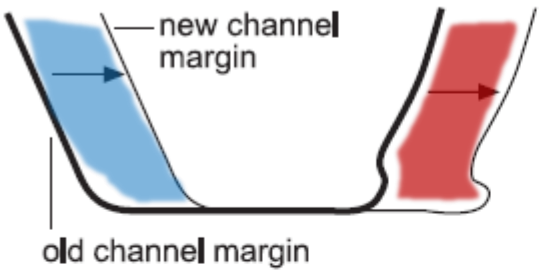


- An adjustment is not a *change* in river type!
- "River *behavior* equates to adjustments around a characteristic assemblage of geomorphic units"

ADJUSTMENTS TO CHANNEL SHAPE

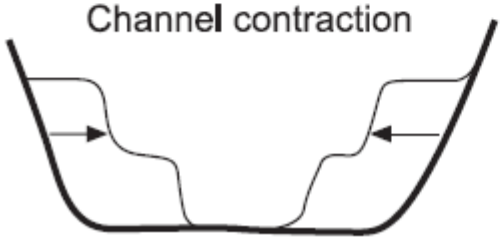
Lateral adjustment proceses

Lateral migration



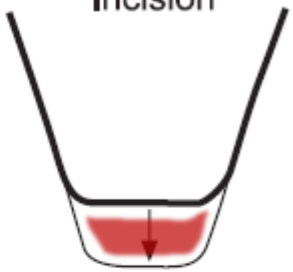
Channel expansion

Channel contraction

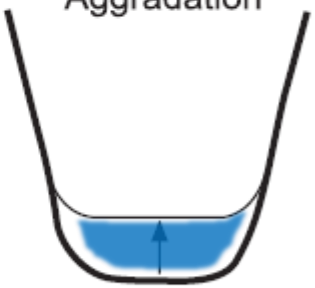


Vertical adjustment proceses

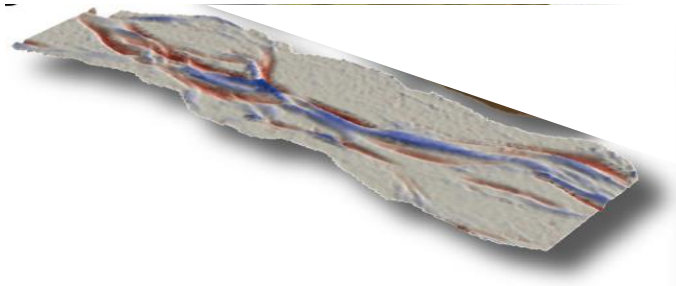
Incision



Aggradation



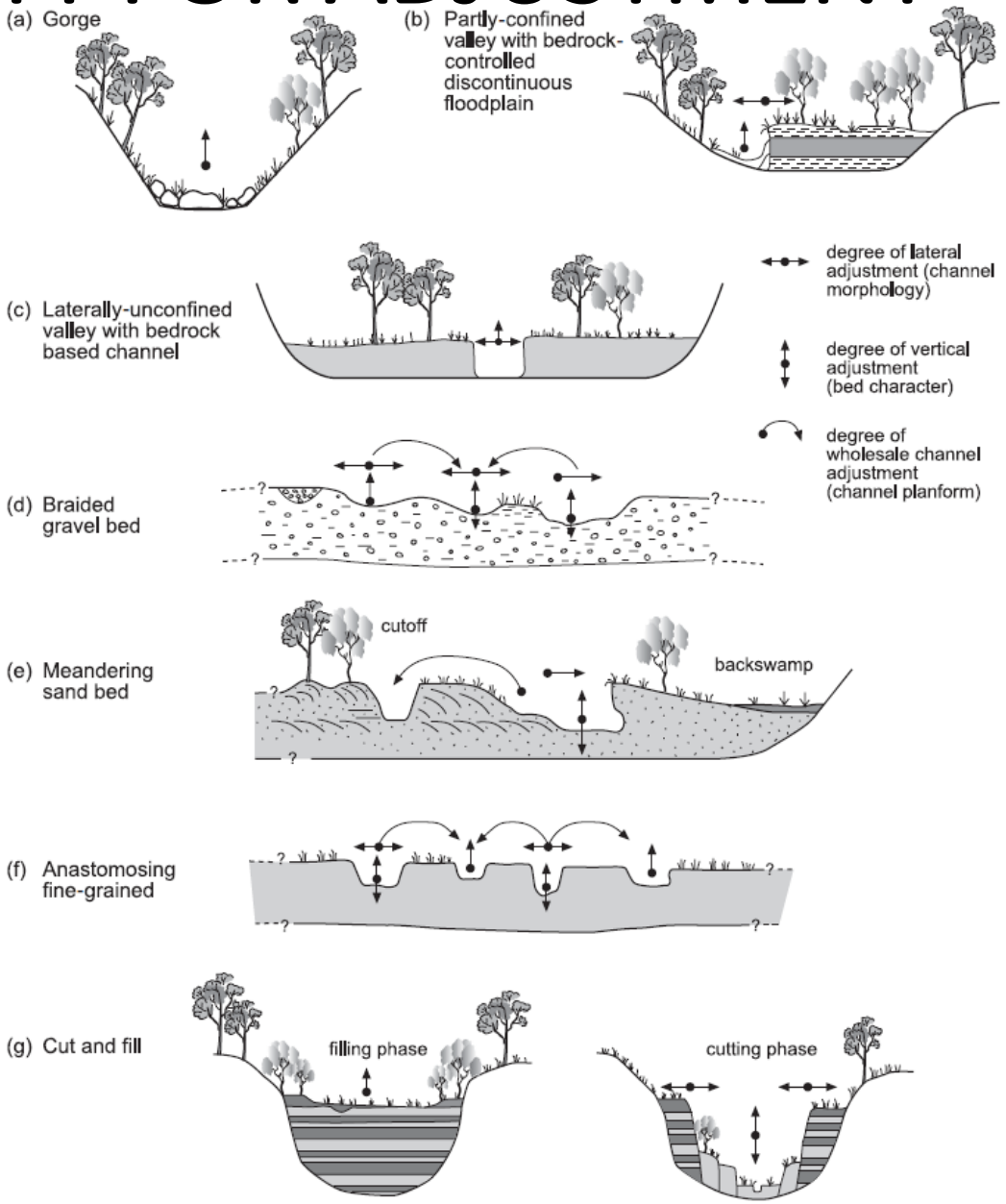
- Geomorphologists have lots of special names for things…
- Basically, all expressions or special cases of erosion or deposition



From Brierley & Fryirs (2005)

NATURAL CAPACITY FOR ADJUSTMENT

- Plausible limits on what adjustments are possible
- Geomorphic context matters
  - Confinement
  - Sediment Supply
  - Flow Regime
  - Vegetation
  - Land use
  - History

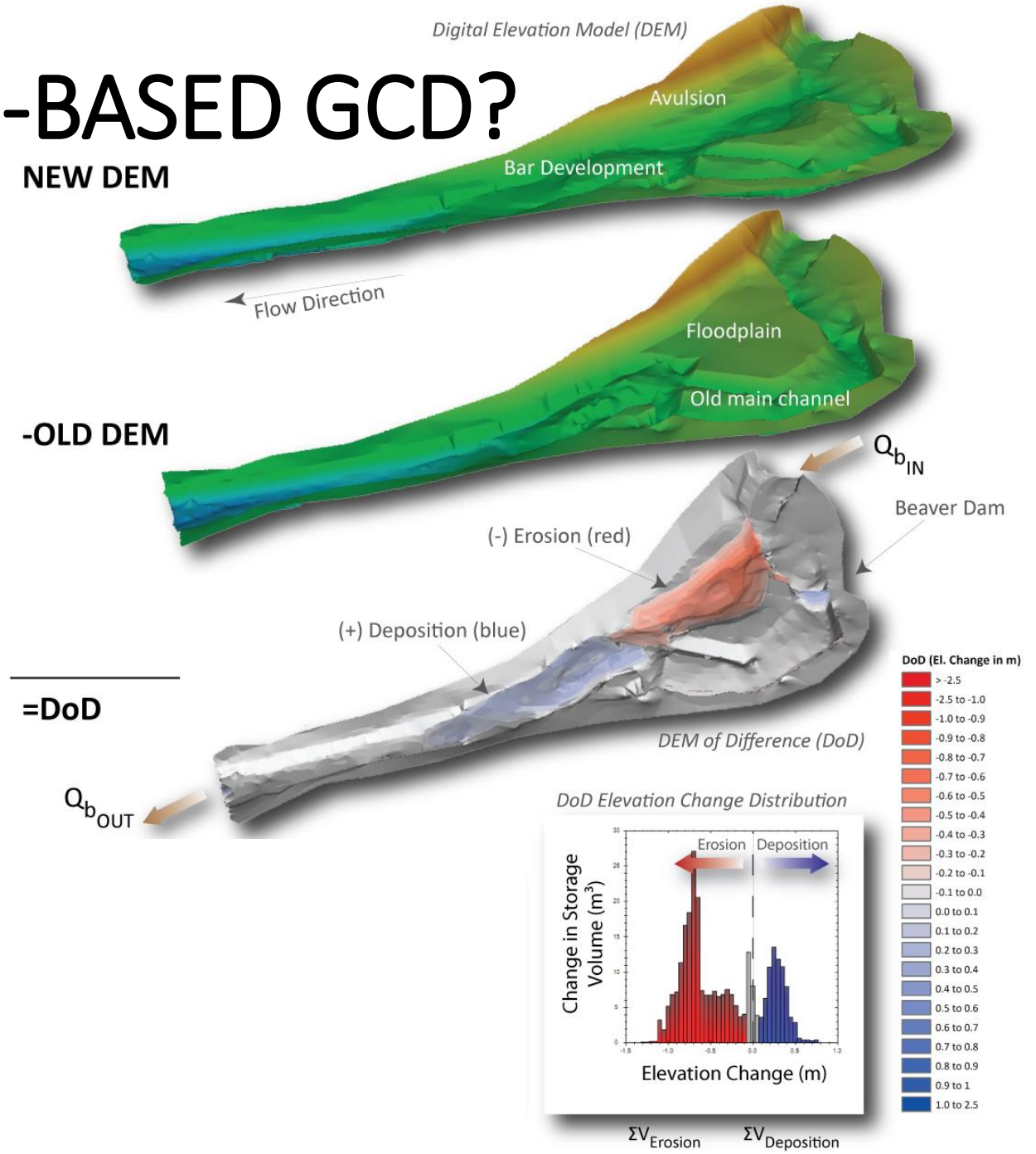


From Brierley & Fryirs (2005)

WHAT IS DEM-BASED GCD?

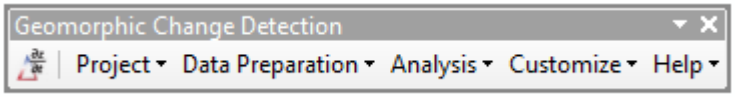
A little background…

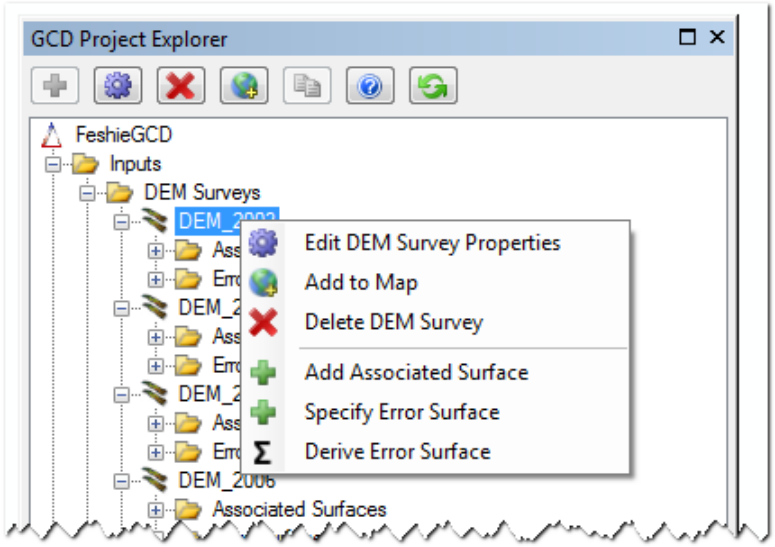
- DEM -> digital elevation model
- GCD -> geomorphic change detection
- Of everything that CHaMP measures, GCD is one of most sensitive to the quality of the data and influences like crew variability

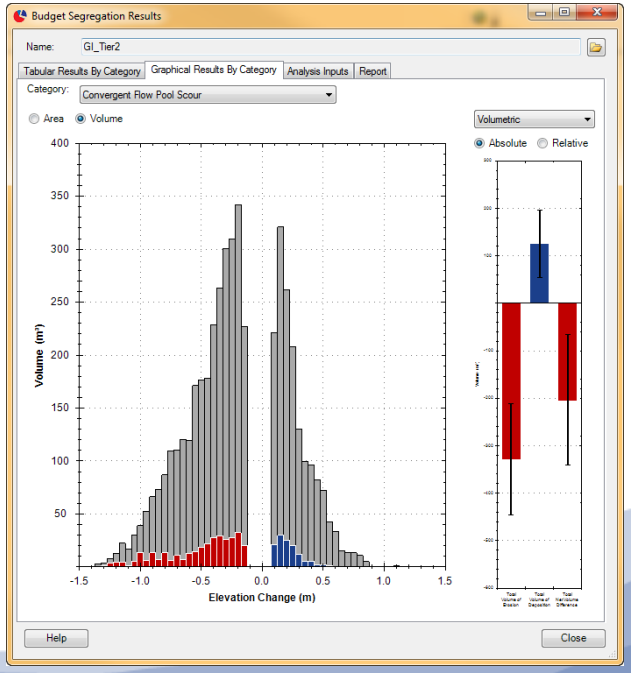


GCD RUNS AUTOMATICALLY ON CM.ORG

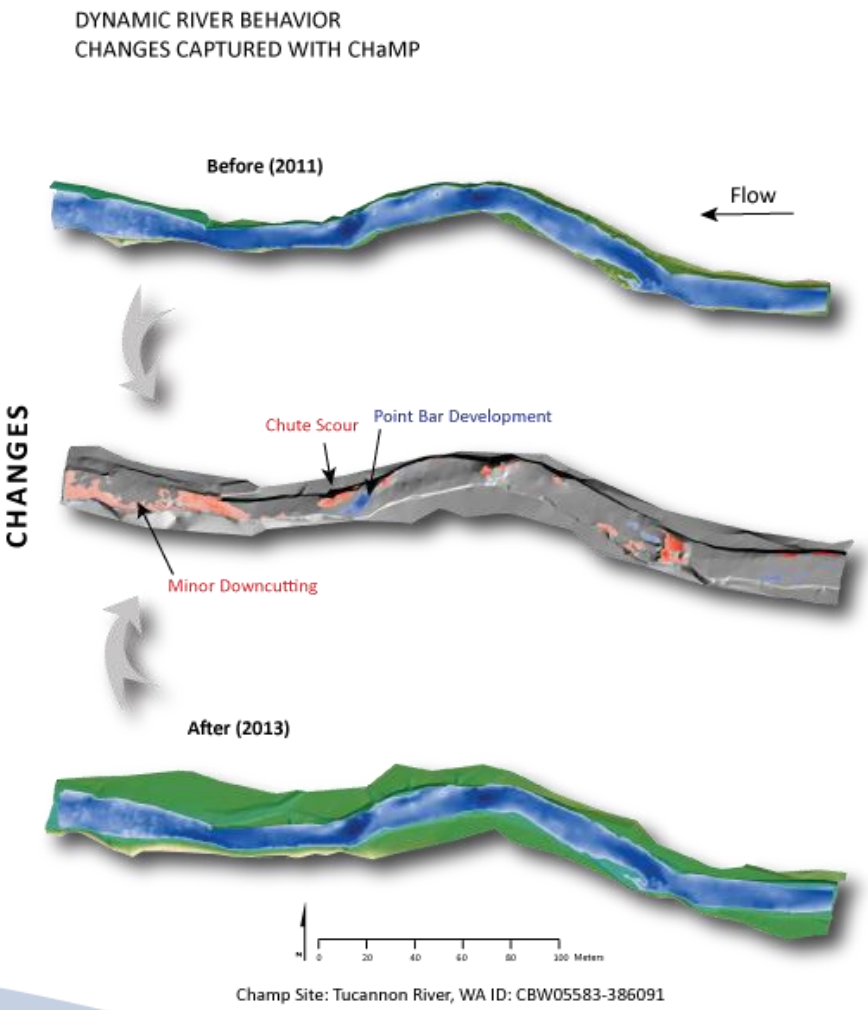
- GCD Projects Run Centrally
- Detailed DoD output map & reports
- Summary Results for:
  - Bankfull Union of Surveys
  - By Channel Units
- You can download *.gcd file to:
  - Visualize output
  - Perform additional analysis



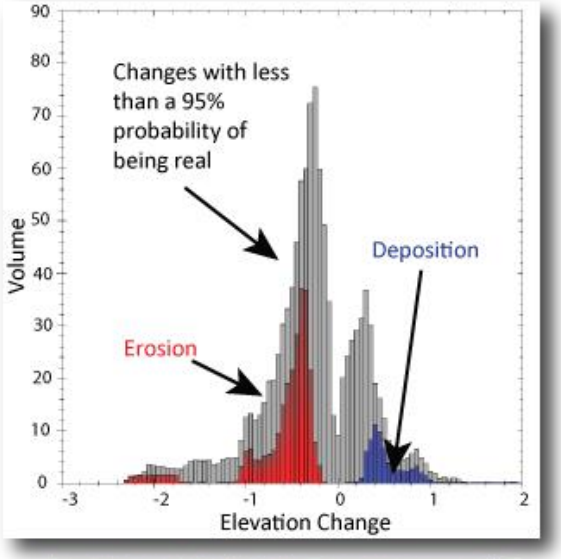




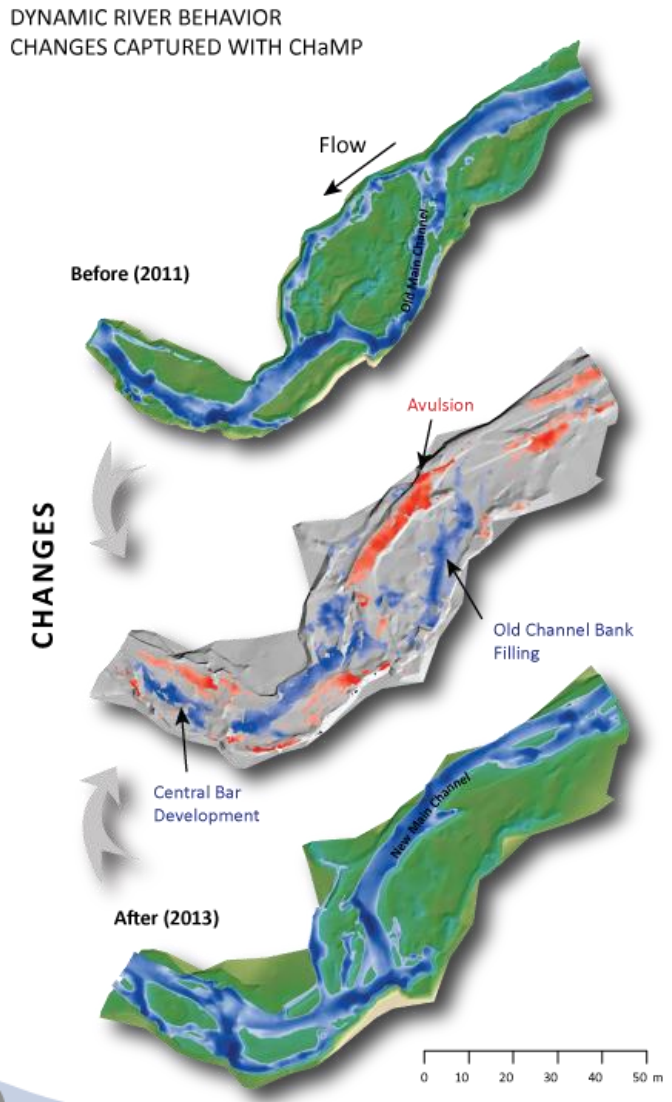
GCD TO DESCRIBE BEHAVIOR… IN A POOR CONDITION VARIANT

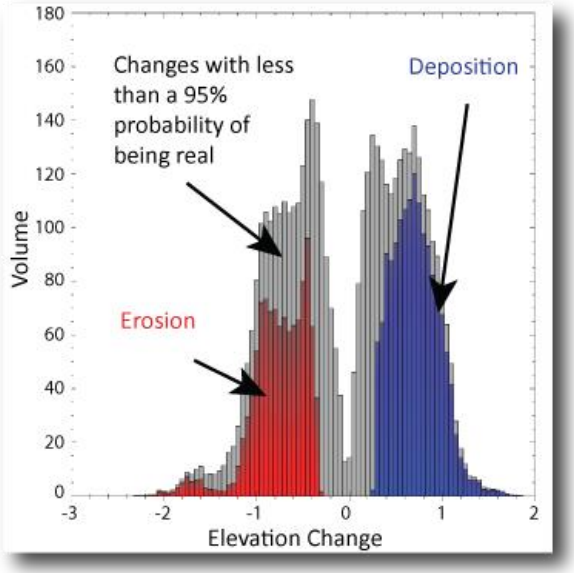


Champ Site: Tucannon River, WA ID: CBW05583-386091



GCD TO DESCRIBE BEHAVIOR… IN A GOOD CONDITION VARIANT





Champ Site: Tucannon River, WA ID: CBW05583-481459

IN A PERFECT WORLD…

- The signal (the change we're trying to detect) is much greater than our noise….

$$\frac{\partial z}{\partial t} >> \delta(z)$$

- In many instances, the noise is of similar magnitude to our noise…

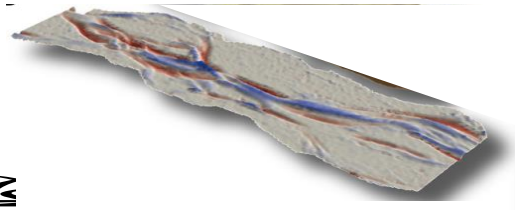
$$\frac{\partial z}{\partial t} \approx \delta(z)$$

- Better in places where vertical changes are large!

Surface Noise:

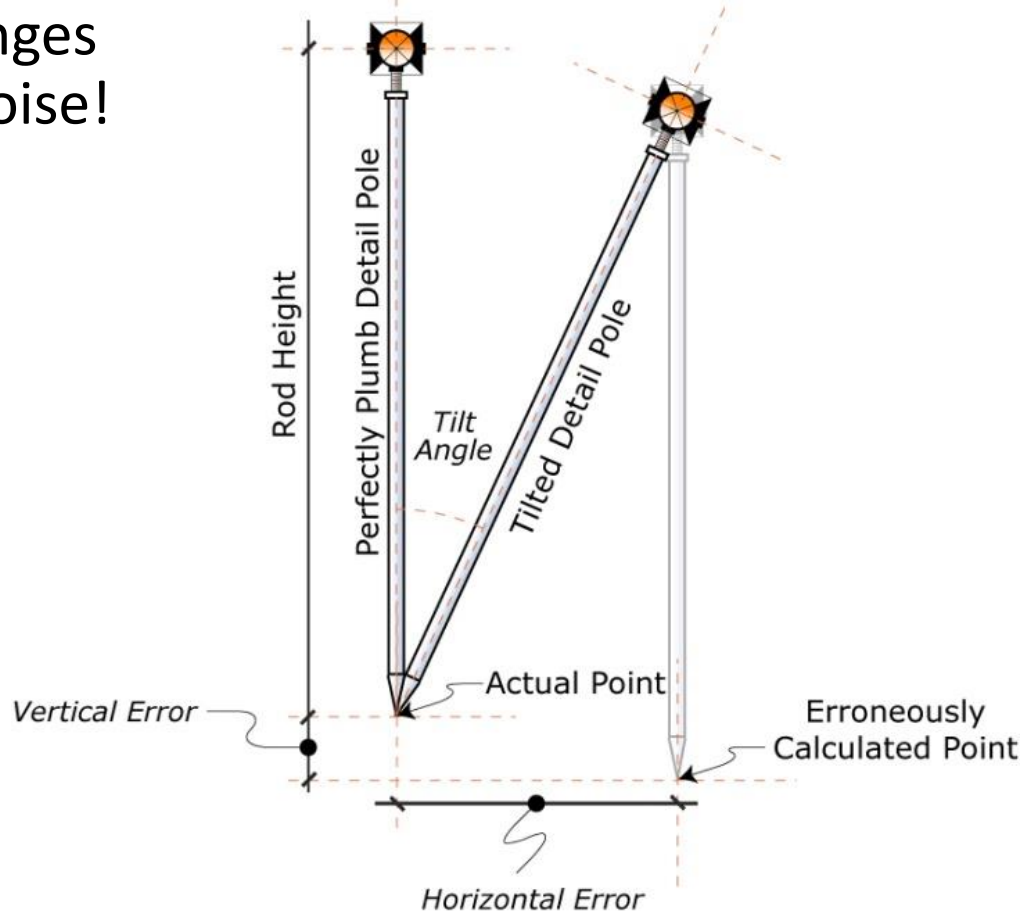
- LiDaR : +/- 10 to 25 cm (14 to 36 cm $_{min}$LoD)
- Total Station: +/- 2 to 10 cm (3 to 14 cm $_{min}$LoD)

SO PAY ATTENTION….



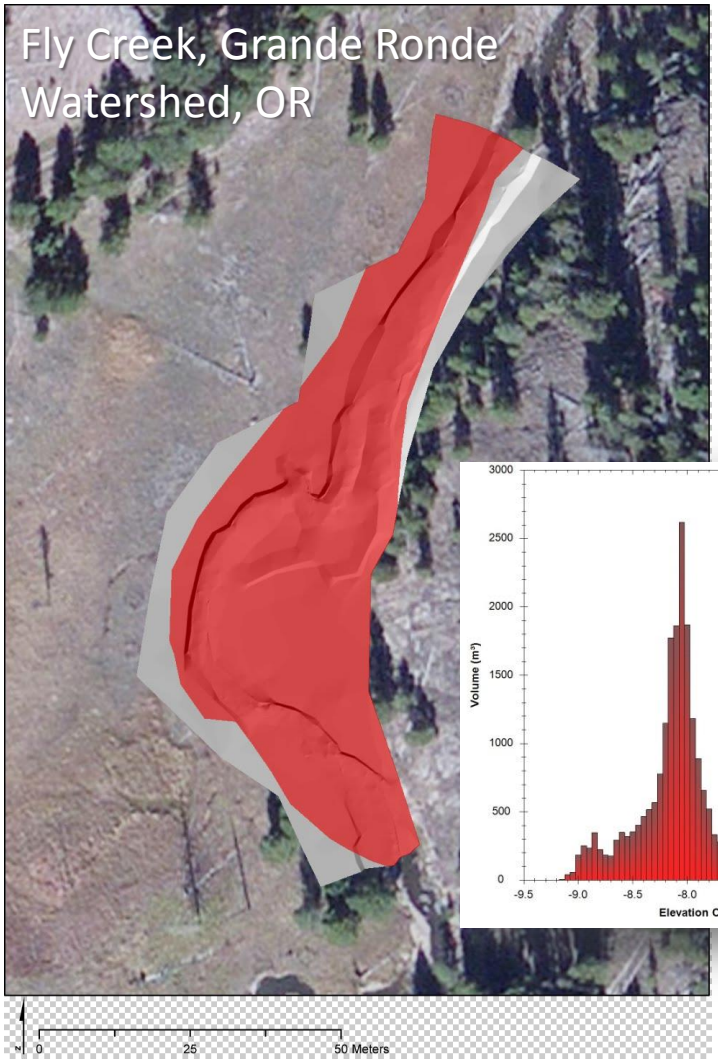
- How well you survey, determines our ability to detect real changes and distinguish these from noise!

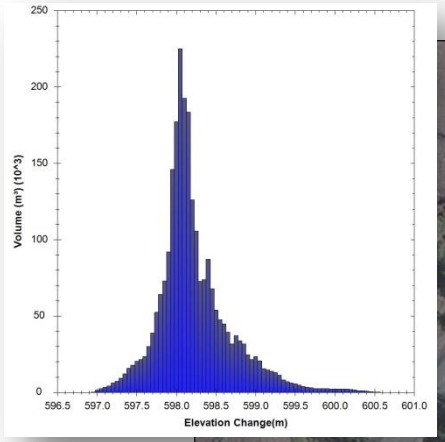
- Will it *really* matter?
- If you're not sure, ask!



© Wheaton (2008)

OBVIOUS DATUM PROBLEMS…





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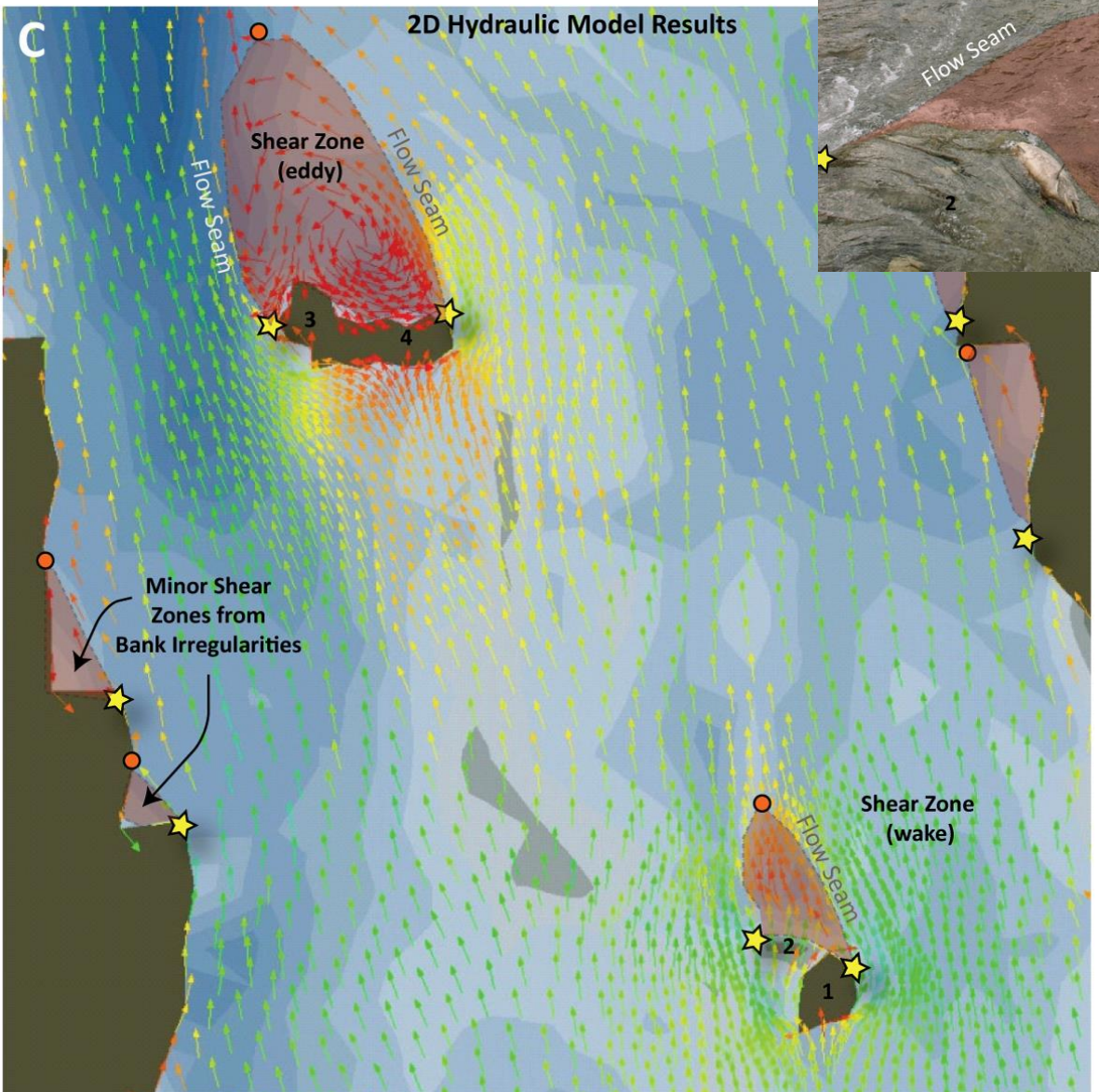
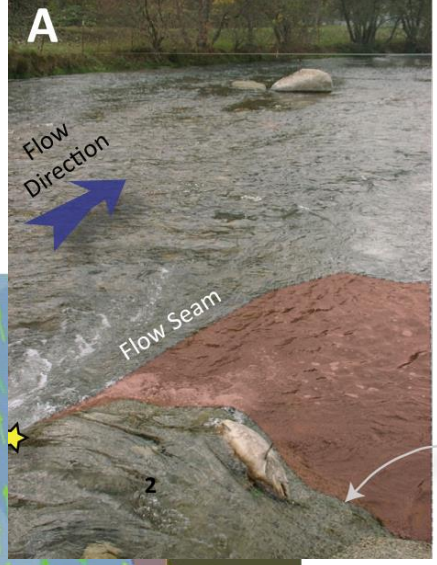
ENERGY REFUGIA & SHEAR ZONES

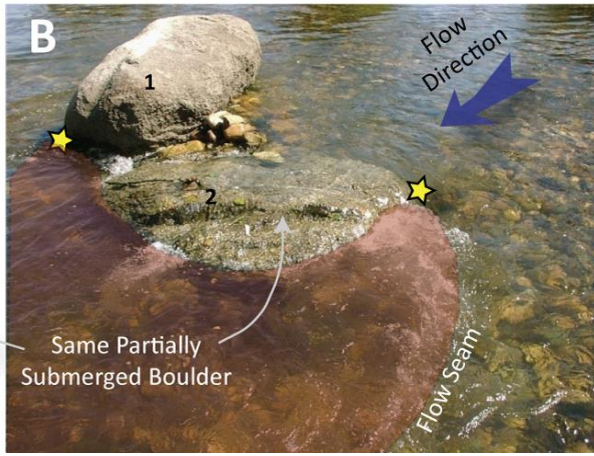




Flow Separation Point (AKA detachment point)

Reattachment Point

Shear Zone



THREE TYPES OF REFUGIA…

1. **Predation** Refugia – (Cover) Protection from Predation
2. **Energy** Refugia - Resting Areas (i.e. shear zones)
3. **Thermal** Refugia – Get away from the mean!

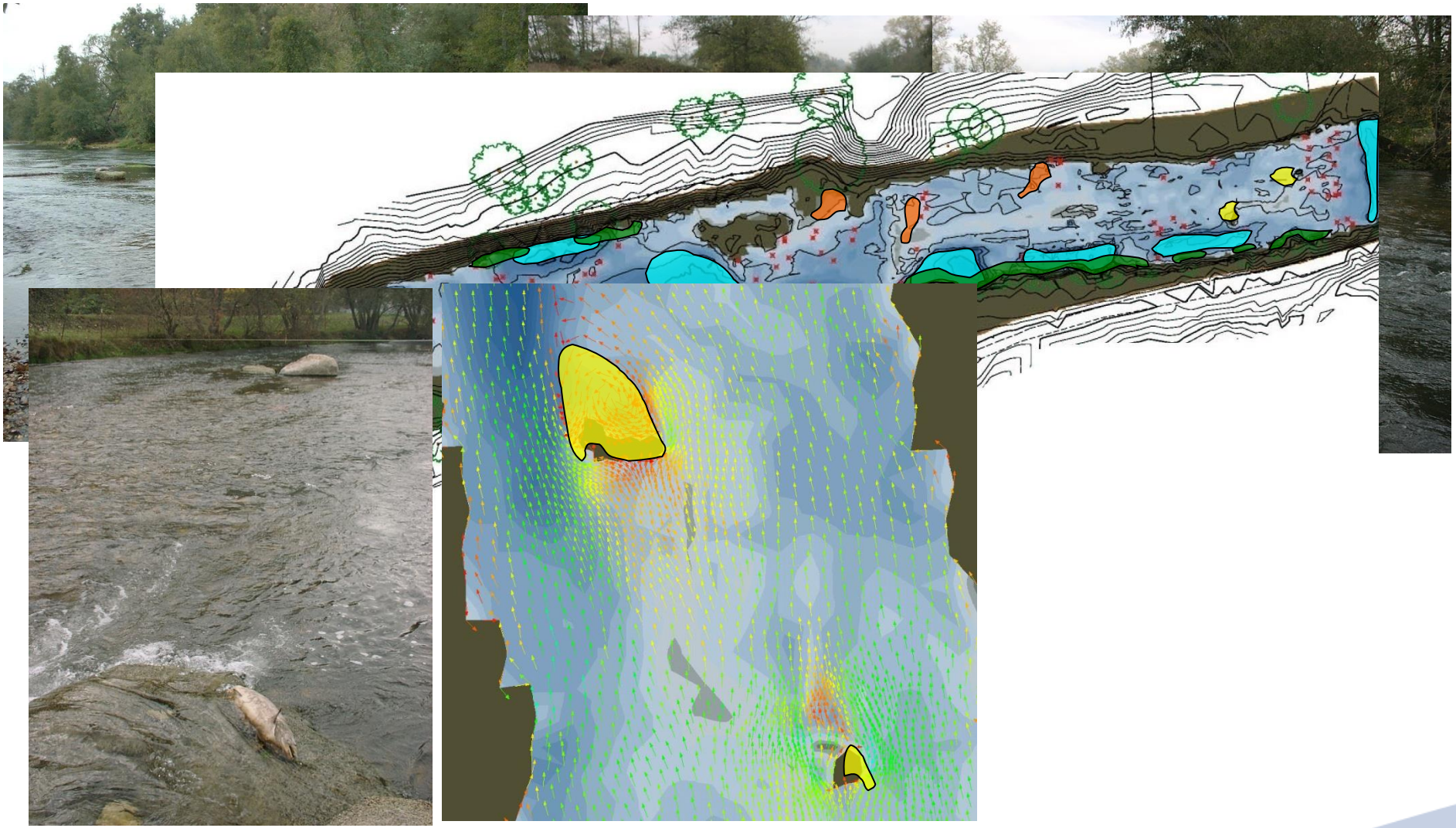
Predation Refugia from:

- Bank Vegetation
- LWD
- Boulders
- Deep Pools

Energy Refugia from Shear Zones induced by:

- Irregular Banks
- LWD
- Boulders
- Bed Forms

DEFINING HABITAT HETEROGENEITY - REFUGIA



IS HETEROGENEITY IMPORTANT TO A SPAWNING FEMALE SALMON?

Habitat Heterogeneity is usually assumed to support species diversity (assumed to be good).

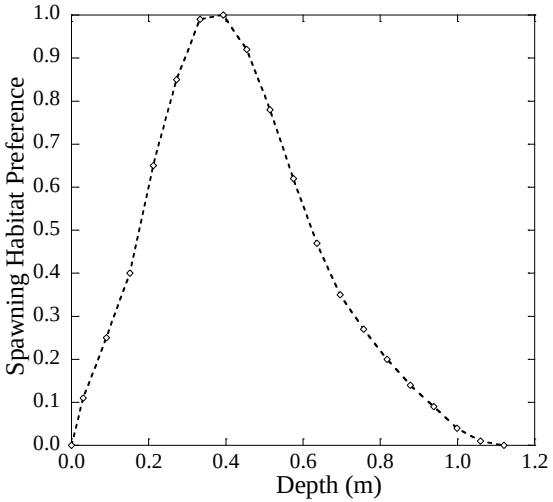
What are specific ecological benefits of habitat heterogeneity to spawning salmonids?

BONNEVILLE POWER ADMINISTRATION

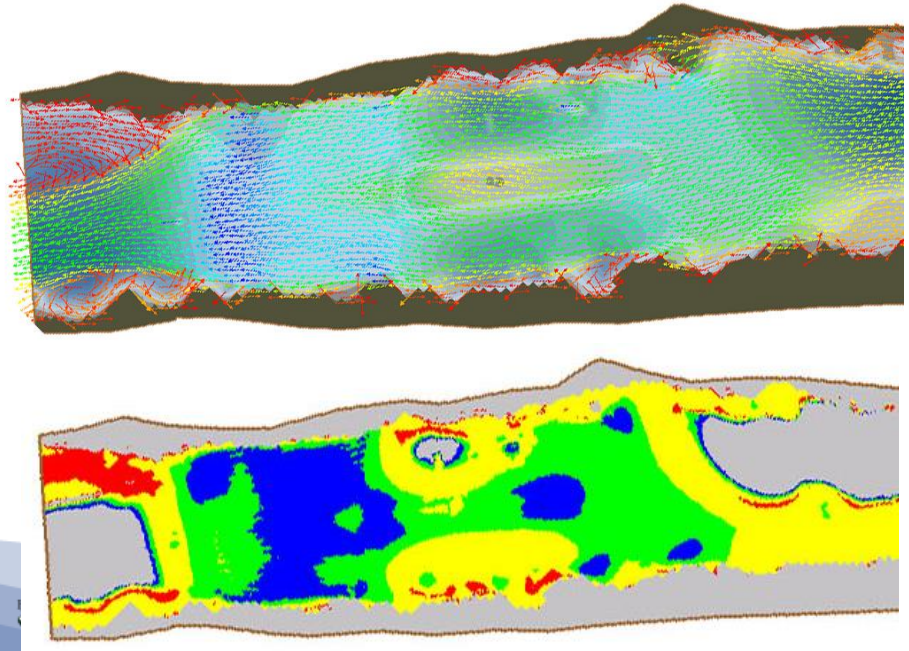
ISEMP

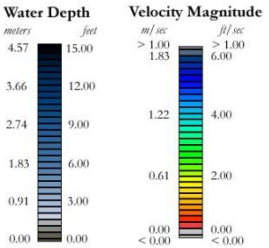
CHaMP

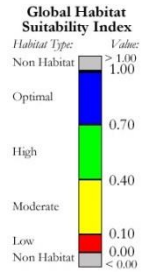
FISH HABITAT MODELS…

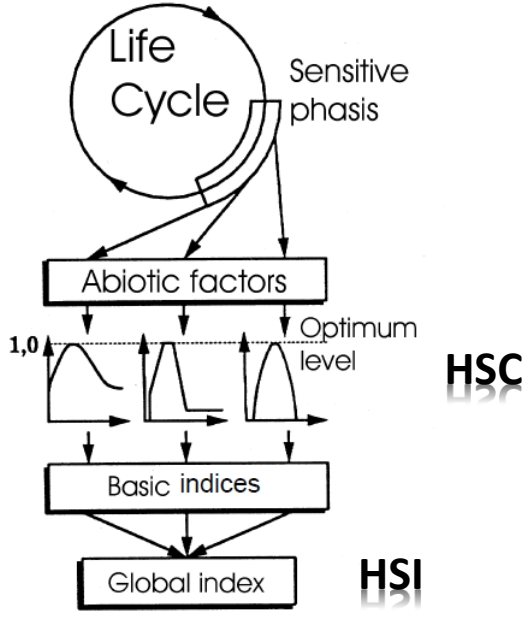


- Pete will talk to us about two different flavors of FHM (there are many more)
  - Net Rate of Energy Intake (NREI) – Summer Juvenile
  - Habitat Suitability Index (HSI) – Adult Spawners









Building a classical fish *preferendum* model

From LeClerc (2005)

CHaMP | Columbia Habitat Monitoring Program

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PRODUCTS

More strategic improvement actions could save millions through more realistic investment in actions more likely to work!

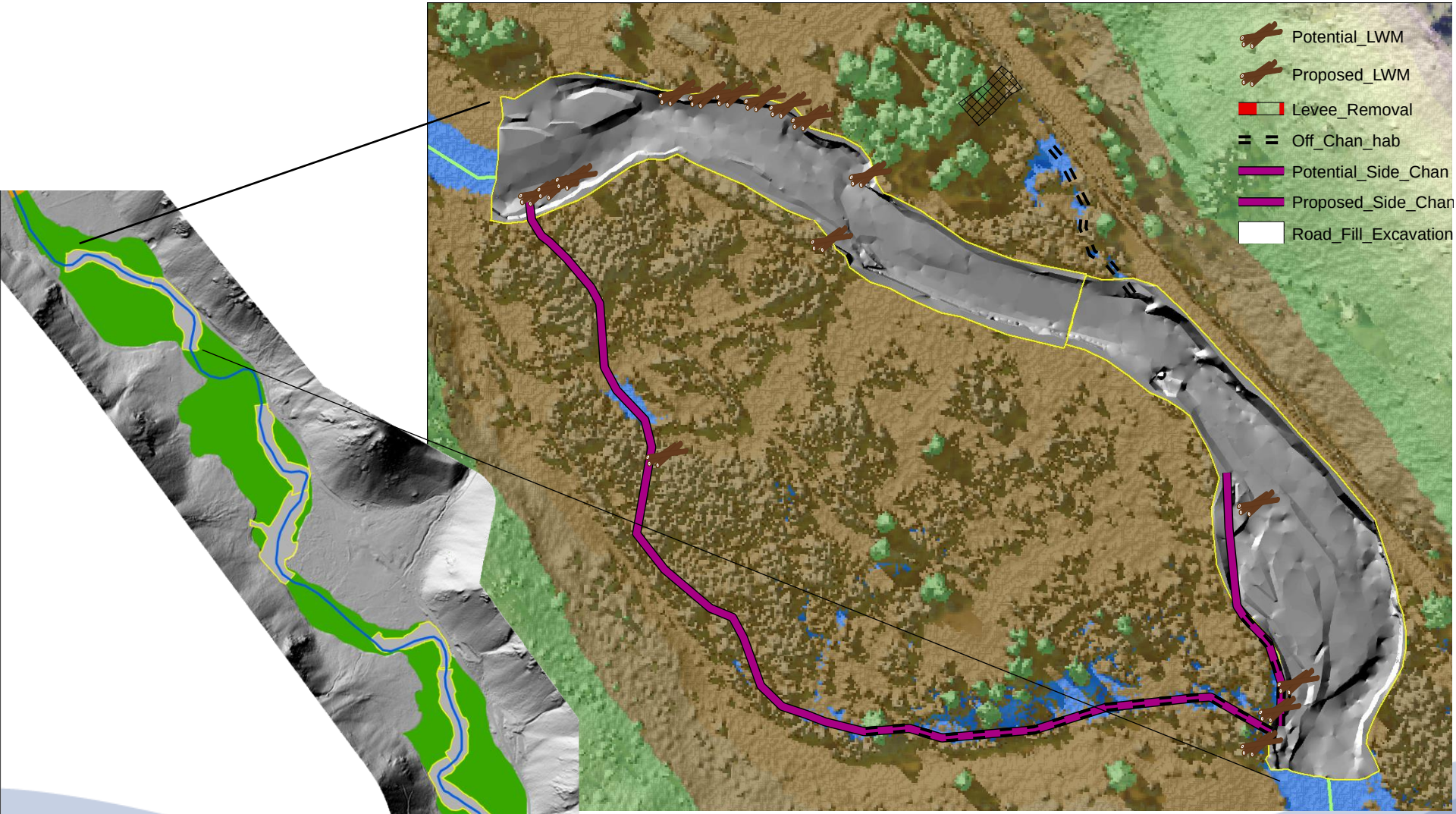
SUMMARY PRODUCTS

- Can be directly produced from CHaMP/ISEMP

- Can be better *informed* by CHaMP/ISEMP/AEM
- Still requires expert and stakeholder input (e.g. Atlas)

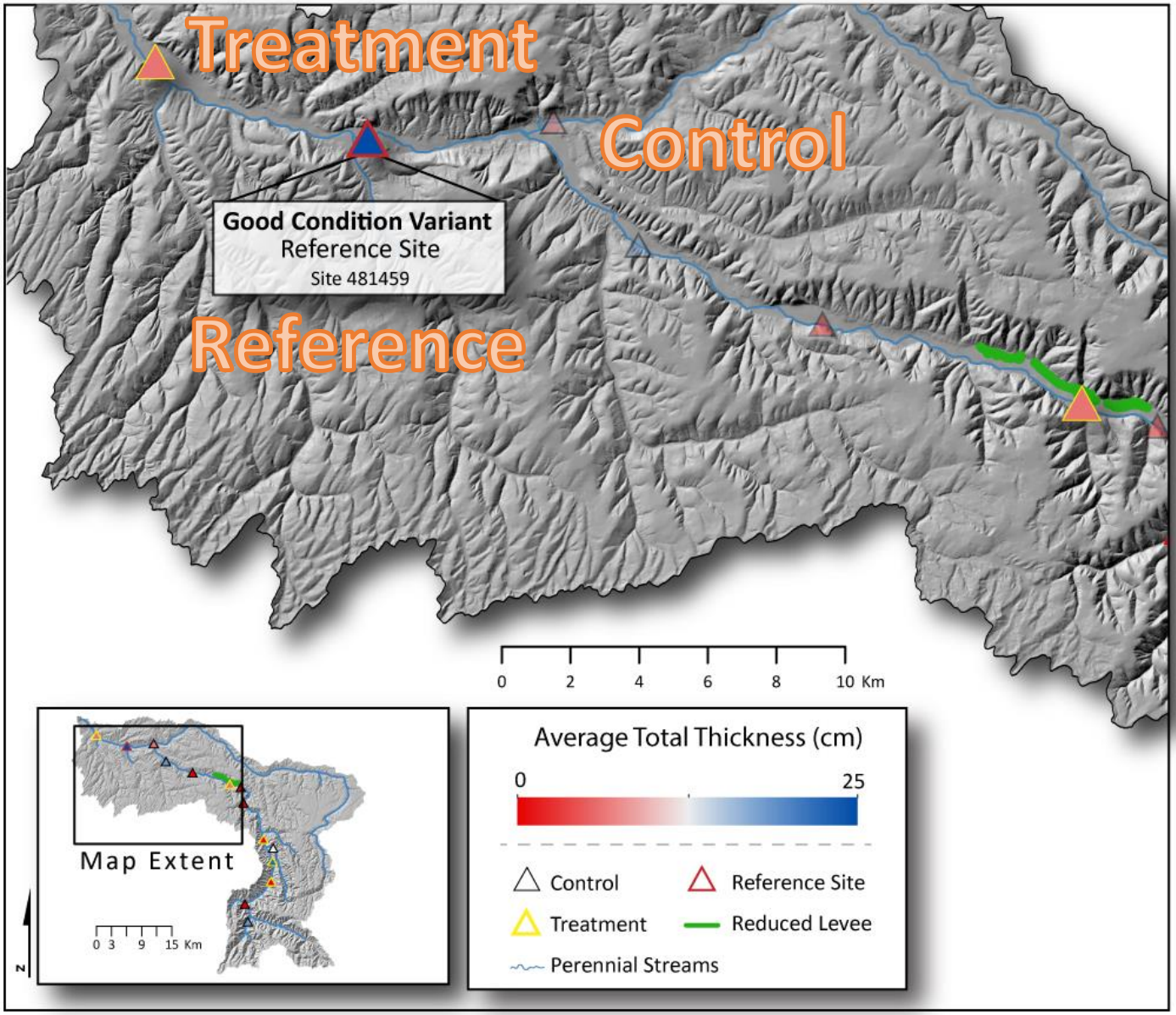
- Can be better *informed* by CHaMP/ISEMP/AEM
- Still requires expert designers…

CHAMP DATA CAN BE USED AS BASEMAP & BASELINE FOR DESIGN



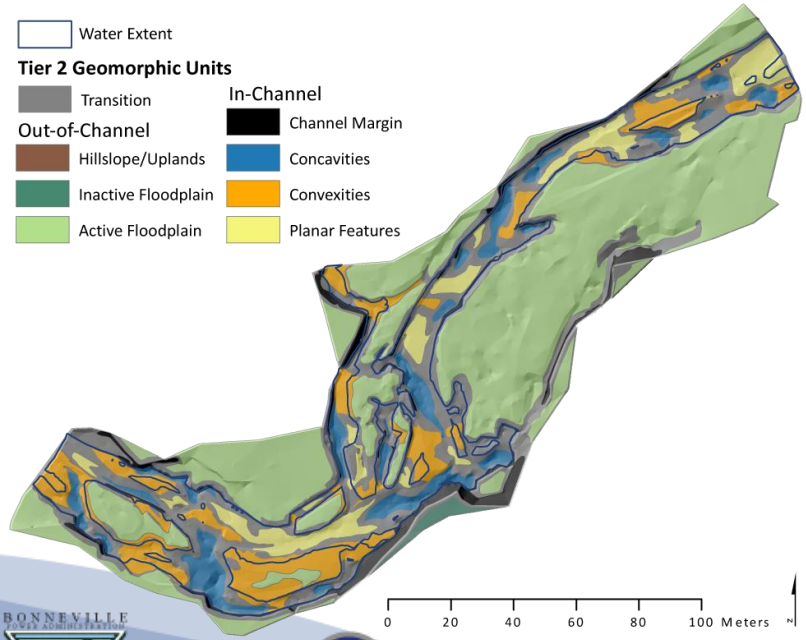
From Steve Fortney (Terraqua)

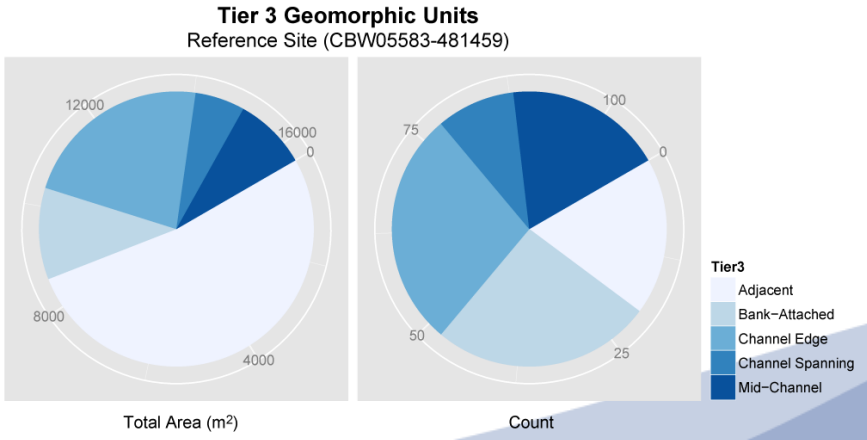
USING CHAMP SITES AS ANALOGS



ANALOGS FOR DESIGN

- Multi-threaded channel with diverse range of habitat serving critical functions for salmonids at various life stages
- The regular turn-over of this habitat is maintained by dynamic behavior (regular erosion and deposition).





CHaMP | Columbia Habitat Monitoring Program

OUTLINE

HOW DO YOU ACCOUNT FOR FISH HABITAT WITH A TOTAL STATION?

I. Background

II. Painting a Picture of Habitat – Topographically

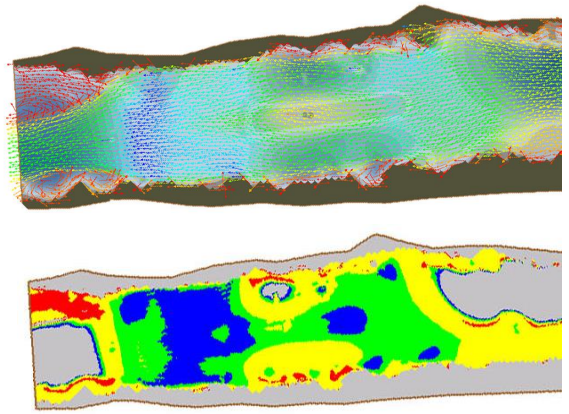
III. Quantifying Habitat – From Topography
   I. Hydraulics
   II. Geomorphology
   III. Fish Habitat

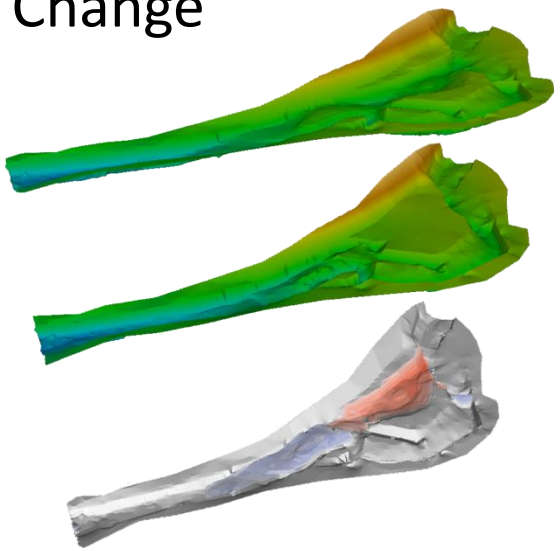
IV. Some Other Useful Byproducts of Topography

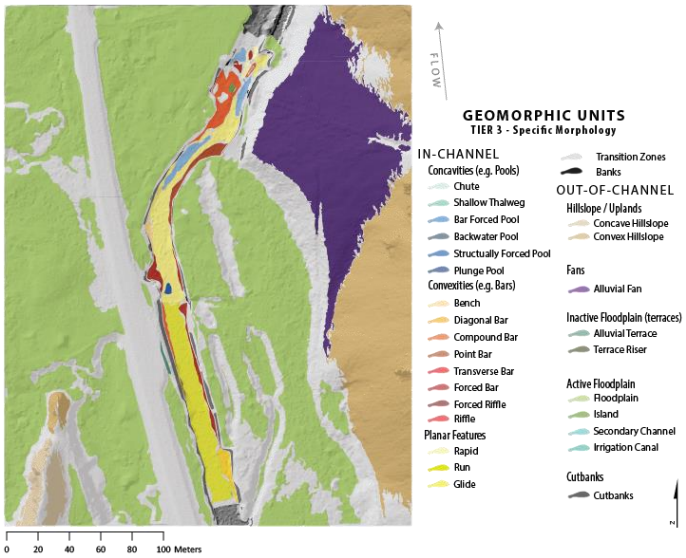
V. Take Homes

SO… PAINTING QUANTITATIVE PICTURES

- From Topographic Snapshot
  - Habitat Units
  - Habitat Heterogeneity
  - Hydraulic Models
  - Ecohydraulic Models
- Multiple Topos
  - Geomorphic Change Detection

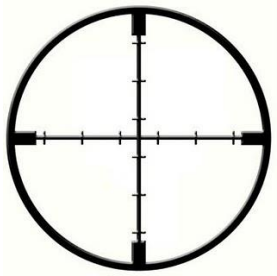






2 PERSON CREW…

- **Who's the artist?**



Dumb end of a stick?

MAIN TAKE HOMES

- Topography helps us paint a quantitative picture of habitat
- Topography derivatives:
  - Habitat Units
  - Hydraulic Models
  - Habitat Suitability Models
- Repeat topography helps quantify processes that create, maintain & destroy habitat
- Useful not just in status & trend monitoring, but also restoration design and effectiveness monitoring

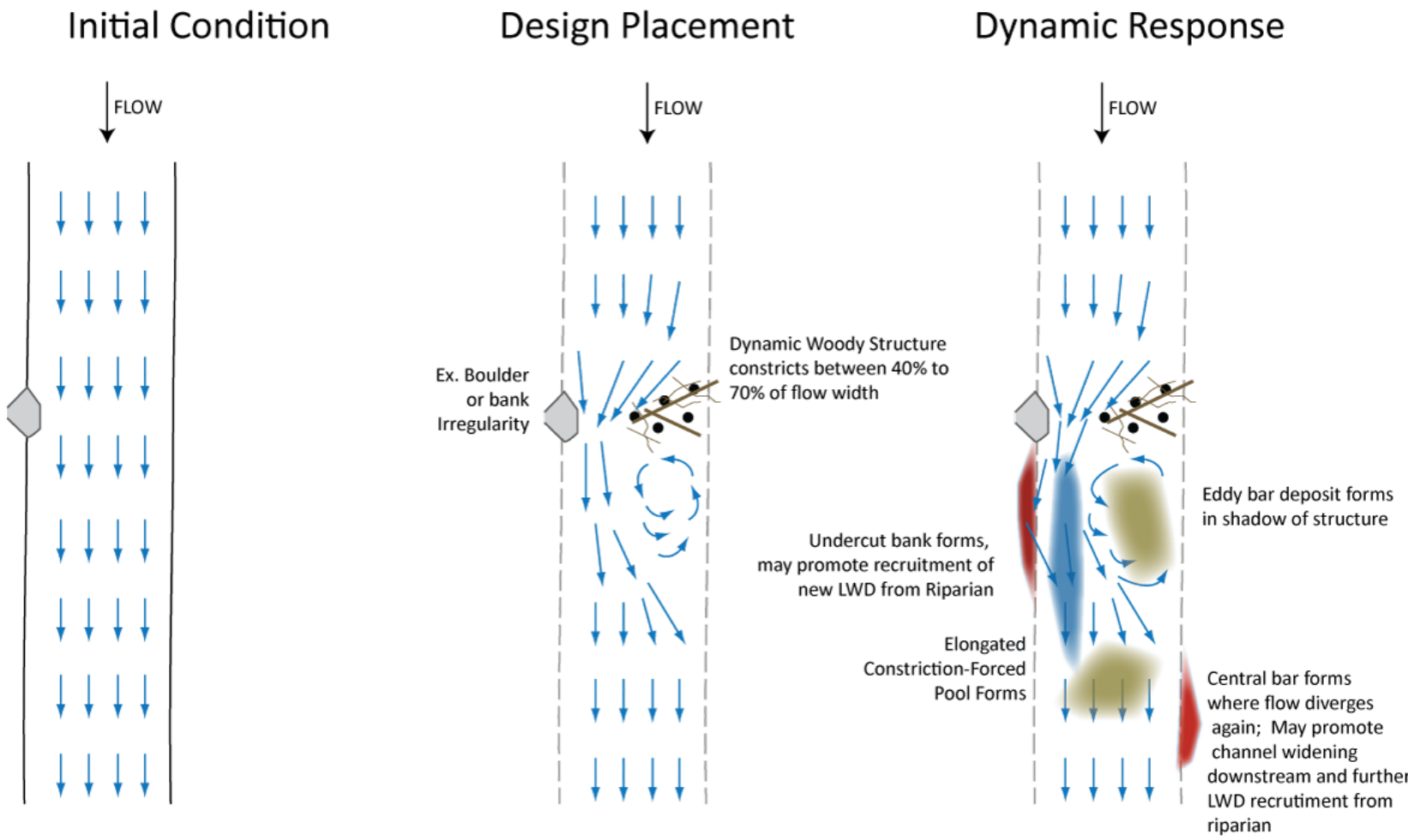
MANY PLACES IN CRB

- Riparian not all that bad… compared to some places
- Nothing like what it once was
- Habitat highly simplified
  - Armored
  - Few pools / Not much large wood
  - Few active bars

BONNEVILLE POWER ADMINISTRATION
ISEMP
CHaMP

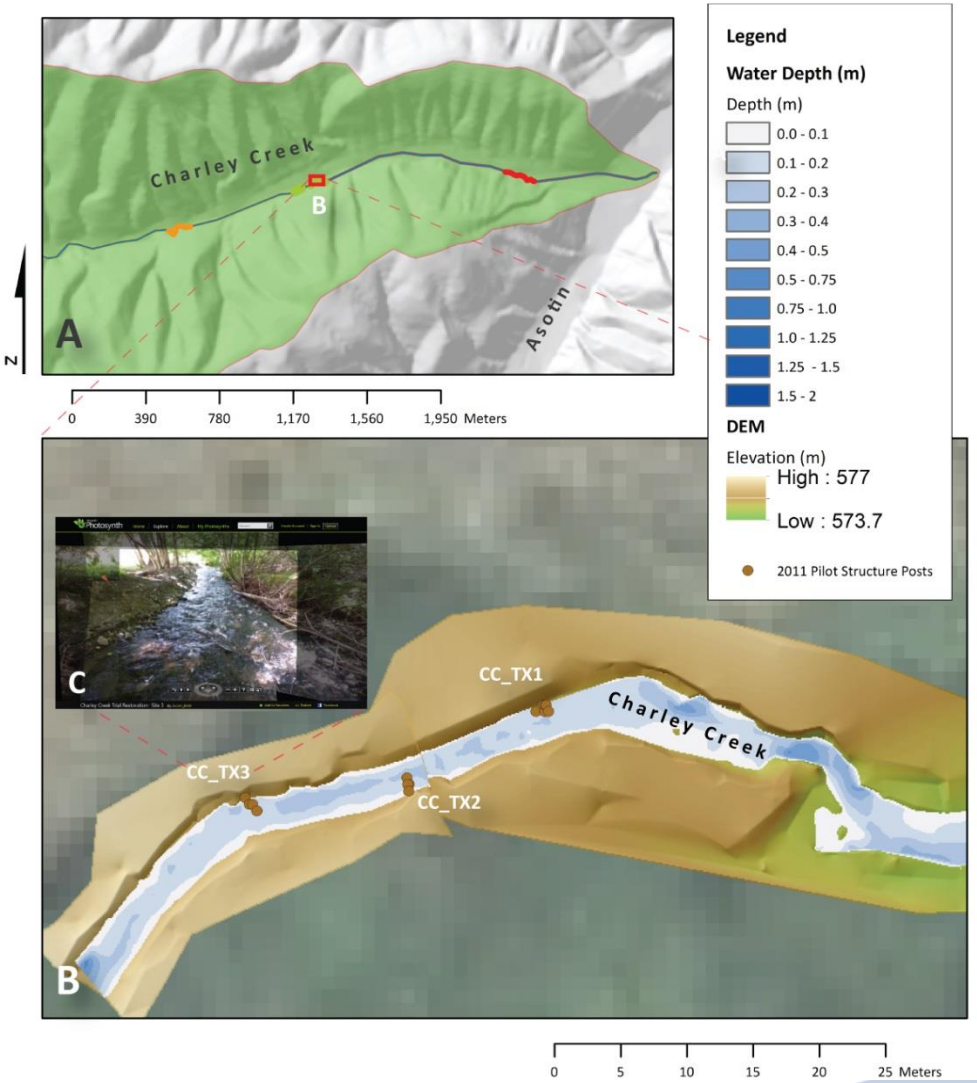
TYPICAL HDLWD STRUCTURES

SIMPLE PALS HYPOTHESIZED RESPONSE



PILOT OR AEM TESTING VS. DESIGN STAGE

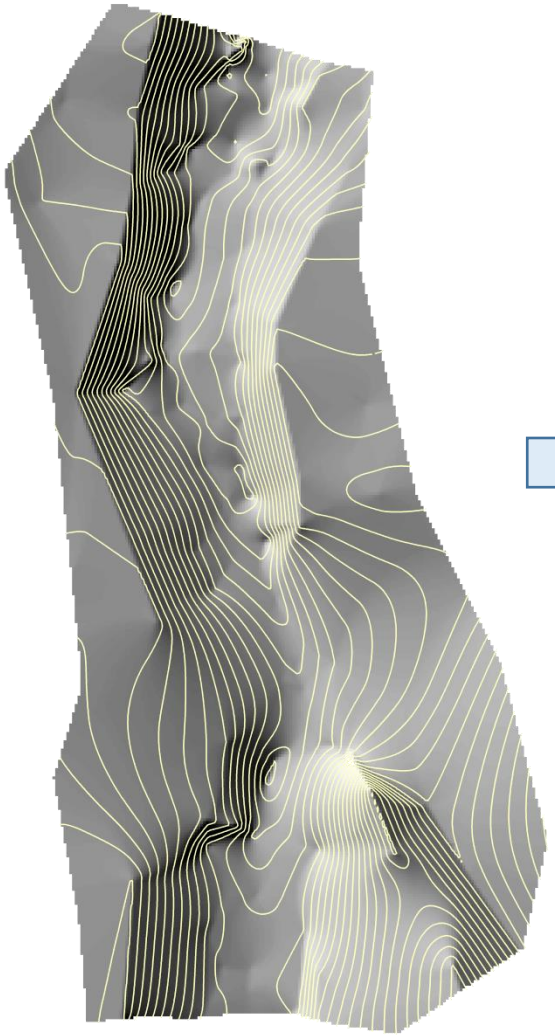
- Do we have to build it to test it?

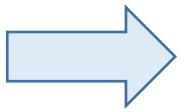


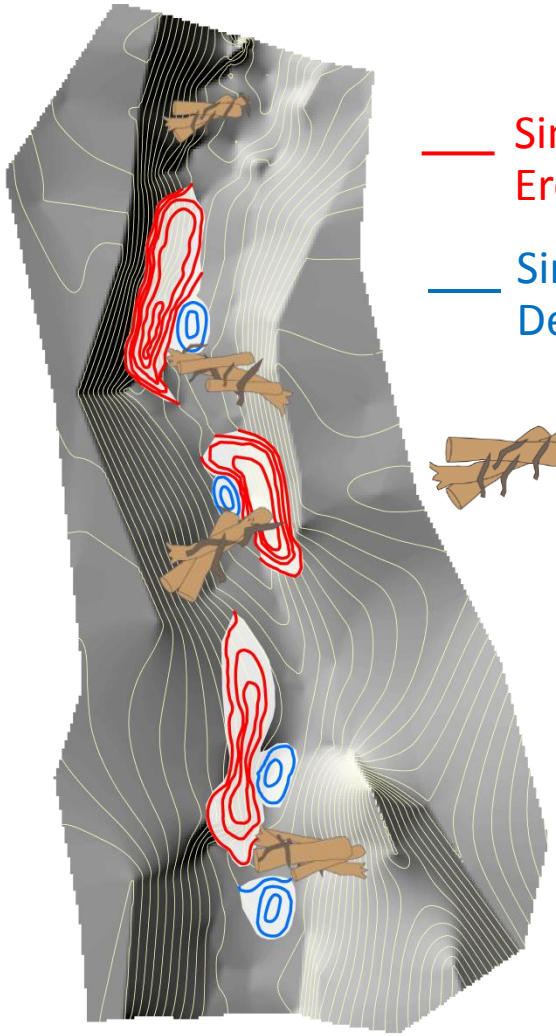
A DESIGN HYPOTHESIS TEST…

Existing Topography

Simulated Change







Simulated Erosion

Simulated Deposition

Wood Structures

DOES DESIGN PRODUCE INTENDED BENEFIT FOR FISH?