An Overview of Quantum Spatial

quantum SPATIAL
AN NV5 COMPANY

Presented by: Tim Marcella

Who is this guy anyway?




Quantum Spatial, an NV5 company

NV5
Delivering Solutions
Improving Lives

WHO IS N5?
NV5 is a provider of engineering and consulting services to public and private sector clients, delivering solutions through five business verticals:

THE NV5 VERTICALS

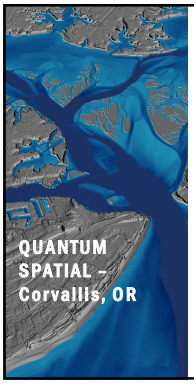
1. Construction Quality Assurance
2. Infrastructure engineering and support services
3. Energy
4. Program Management
5. Environmental Solutions

Large Geographical Footprint

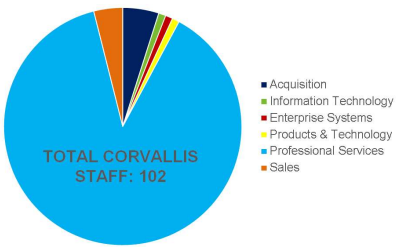
550 employees

9 offices in North America

Key acquisition assets located throughout the country supplemented by the largest partner network in the world



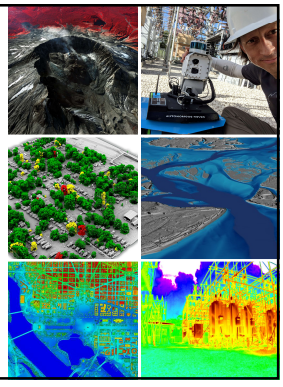
Unprecedented Experience, Expertise, and Service



Core Capabilities

- Terrestrial lidar
- Topobathymetric lidar
- Mobile lidar
- Multispectral imagery
- Hyperspectral imagery
- Thermal infrared
- Forestry and Land Cover/Land Use Analytics
- eGIS services

Clockwise from upper left: multispectral imagery, autonomous remote sensing inspection system (ARIS), topobathymetric lidar, thermal infrared, terrestrial lidar, hyperspectral imagery.

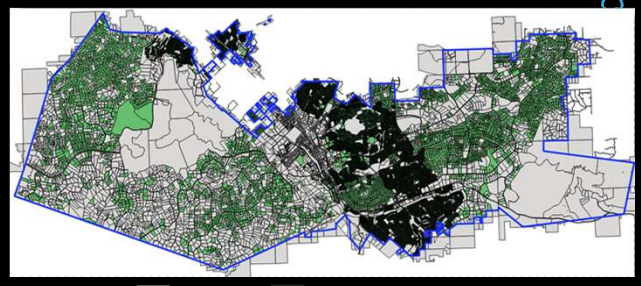


WHO WE SERVE
End Market Segmentation

Federal | State & Regional | Commercial

California Urban Retail Water Suppliers Landscape Area Estimates

Example of a Water District and Parcels



Water District | Original Parcels | Filtered Residential Parcels

eCognition Segmentation Objects of Similar Spectral Signatures are Intersected with Parcel Data

Model output of classified objects. Errors by model will be re-classified (flipped) by editors which are then used to tune up all water district objects.

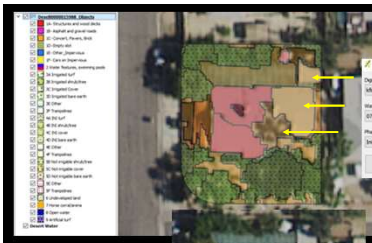
Tune up model with editor information until > 90% error rate

Model is tuned-up with editor adjustments district wide

Total area of irrigated, irrigable, and not-irrigated land is calculated for each parcel

CADWR Classification (Updated 10/30/2019)

	Class	Description
Not Irrigable	1A (11)	Structures and decks (houses, garages, sheds, decks, swing sets, solar panels on a structure).
	1B (12)	Roads (gravel and asphalt). *Do not use this class in rock landscape beds - this would be (5C).*
	1C (13)	Concrete, pavers, and brick (sidewalks and empty pools).
	1D (14)	Empty slot
	1E (15)	Other objects: (retention walls, fences, boulders, rocks, tennis courts, solar panels on the ground) or movable objects presumably on impervious surfaces (garbage bins, umbrellas, patio furniture, shade tarps, trampolines).
	1F (16)	Vehicles or tractors on roadways or driveways.
Irrigated	2A (21)	Pools (inset or above ground), hot tubs, koi ponds, man-made water features > 64 sq feet fountains.
	3A (31)	Lawn (>60% healthy growth), smooth in texture can be lush green pasutres that are lawnlike
	3B (32)	Shrubs/Trees/Vegetation healthy growth *(large enough to cast shadows)*.
	3C (33)	Ground Cover between class 3 vegetation: landscaping mulch & rock, or coarse grasses *(doesn't cast shadows)*
	3D (34)	Bare earth between irrigated plantings or orchards *(rarely used, most commonly SD)*.
	3E (35)	Vehicles, tractors, or other movable objects (garbage bins, umbrellas, tarps on vehicles or boats) presumably on 3 irrigated landscapes.
	3F (36)	Trampolines presumably on 3 vegetation
Irrigable	4A (41)	Lawn (> 40% browning, water stressed grass, but has evidence of past irrigation). Should be smooth in texture *(if coarse would be 4C)*.
	4B (42)	Shrubs/Trees/Vegetation adjacent to 4 classes, or water stressed *(large enough to cast shadows)*
	4C (43)	Ground Cover between class 4 vegetation: landscaping mulch & rock, or coarse grasses *(doesn't cast shadows). (If planting beds are 10% or less planted even if healthy)*
	4D (44)	Bare earth between irrigated plantings or orchards *(rarely used, most commonly SD)*.
	4E (45)	Vehicles, tractors, or other movable objects (garbage bins, umbrellas, tarps on vehicles or boats) presumably on 4 irrigable landscapes.
	4F (46)	Trampolines presumably on 4 vegetation
Not Irrigated	5A (51)	Empty slot
	5B (52)	Shrubs/Trees/Vegetation typically native, not planted in rows, or any prior evidence of irrigation *(casts shadows)*
	5C (53)	Ground Cover: generally native grasses, pasture lands that are puffy or textured in appearance *(doesn't cast shadows). Planting bed with rock-mulch, but no plants.*
	5D (54)	Bare earth very smooth in texture. Can be dirt roads, cleared earth around newly constructed homes, abandoned urban lots, corrals etc.
	5E (55)	Vehicles, tractors, or other movable objects (garbage bins, umbrellas, tarps on vehicles or boats) on 5 non-irrigated landscape.
	5F (56)	Trampolines presumably on class 5
Other	6	** Class NOT used while digitizing parcels. Vector layer that represents the undeveloped lands mask (in context of irrigation). Any areas deemed not irrigated by humans, they can be abandoned urban lots, native landscape, trees, grasses, and wetlands.
	7	** Class NOT used while digitizing parcels. Horse Corrals and Arenas (Irrigated) Usually round or oval. These areas are irrigated to keep dust down. Generally smooth soil texture, signs of watering.
	8A (81)	Open Water: Ocean coastline, lakes, rivers, or retention ponds.
	9A (91)	Artificial Turf (Homogenous color, smooth texture) See directions for checking NIR imagery (red = grass; purple or burgundy = artificial turf)



Flipping objects to improve model classification. In this picture the roof was read in the model as concrete, so the polygons are flipped to ((11) = Structure) by the editor using the GUI. Level 1 is irrigation, while Level 2 is cover type. Entering 11 in the GUI is equal to (1A).

When assessing irrigation level, determine if the water district is wet or dry?

6/2013 (Dry)

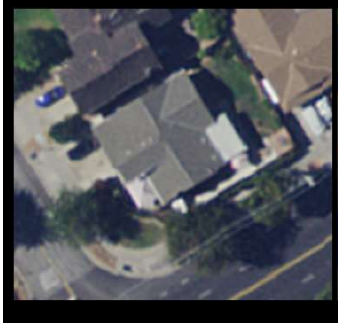
3/2015 (Wet)

If water district looks dry and lawn is 50/50 green/browning you may lean towards a 3 class, rather than a 4 class.

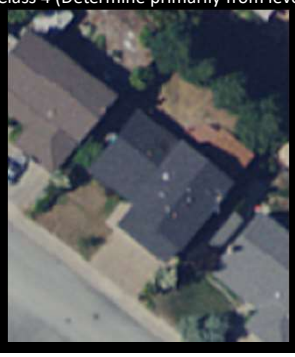
Assessing Fairfield Water District - Dry means we may pull slightly green grass yards into the 3 irrigation class and not the 4 class

Surrounding turf is what generally identifies hydrozone class to use

Class 3 (Determined primarily from level of lawn watering)



Class 4 (Determine primarily from level of lawn watering)



Class 5: Bare earth and ground cover

Bare Earth and Horse Corrals (HC in California are irrigated by law)

Class 5 - Native grasslands and trees (with 4B from other side of fence)

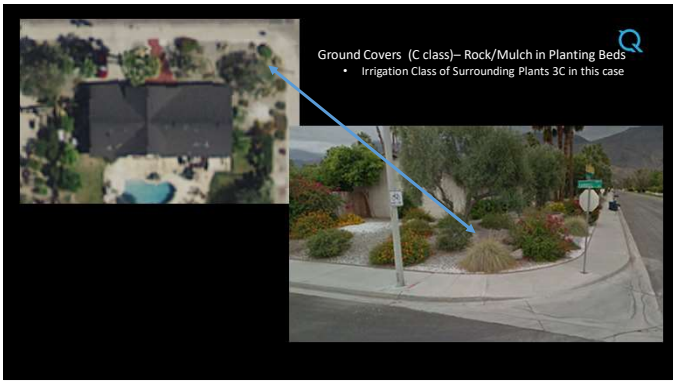
Watch for non-native canopy around house that is not class 5

Class 5: Not-Irrigated (from an irrigation stand point this land has never been irrigated)

Hydro-zone delineation: Fences, barriers, and planting beds can create separation between irrigation statuses. This rule can assist in digitization, but may not be applicable depending on the parcel.

Gravel and asphalt can be difficult to tell from concrete and ground cover

Use NIR which shows textures of gravel and tan of cover better, along with smooth concrete



Ground Covers (C class)– Rock/Mulch in Planting Beds

- Irrigation Class of Surrounding Plants 3C in this case

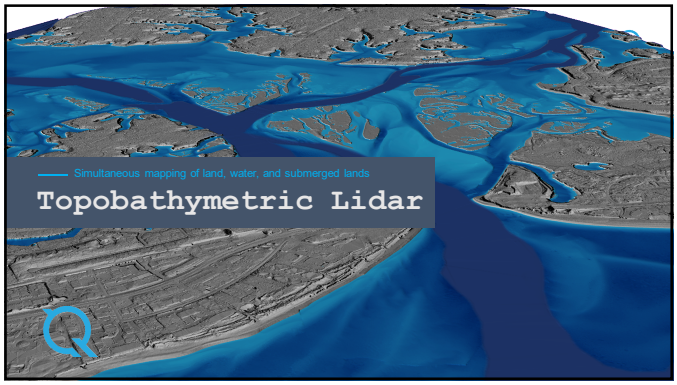
Planted Beds - If 10% or more is planted 3B & 3C, If less than 10% of bed is planted is 4B & 4C

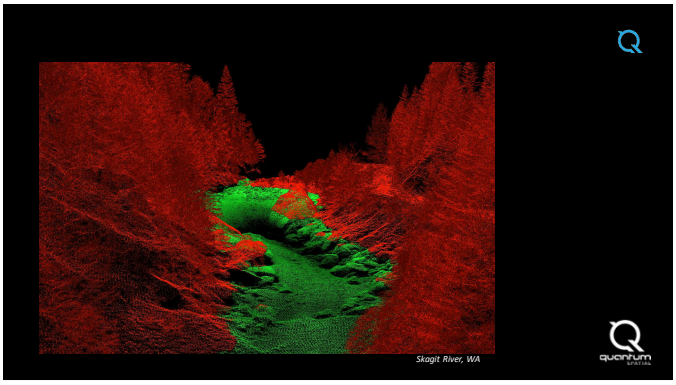
- If plants are dry or planted bed is highly xeric-scaped with succulents or cactus pull planted bed into 4B & 4C.

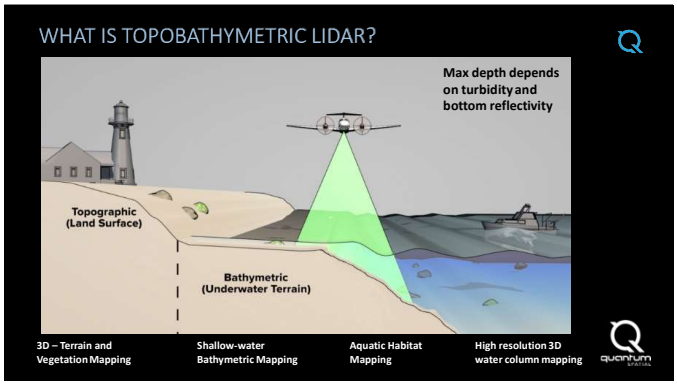
Planted Beds - If 10% or more is planted 3B & 3C, If less than 10% of bed is planted is 4B & 4C

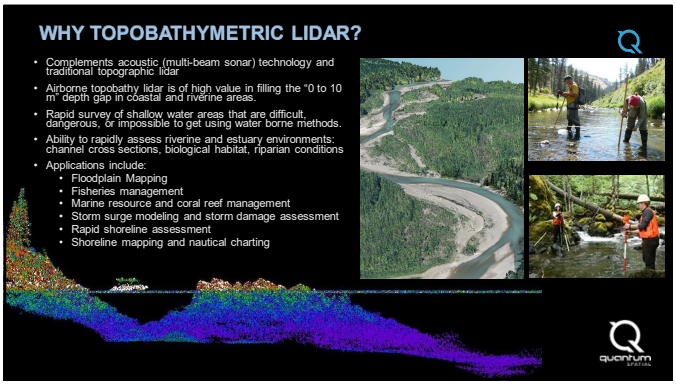
Orchards and Crops, surrounding cover:

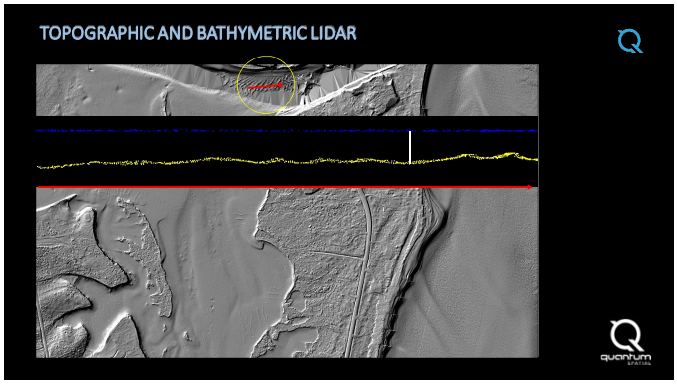
Trampolines are the F class cover type. The irrigation of trampolines are interpreted by the surrounding irrigation type. The trampolines in these 2 parcels would take on the 3F (36) because they are surrounded by irrigated lawn.

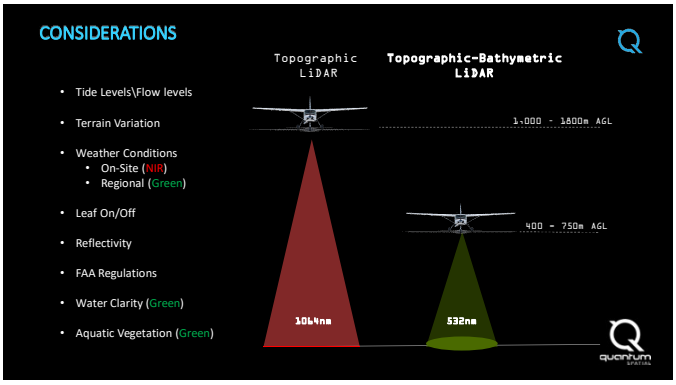

Simultaneous mapping of land, water, and submerged lands
Topobathymetric Lidar


Skagit River, WA


WHAT IS TOPOBATHYMETRIC LIDAR?
Max depth depends on turbidity and bottom reflectivity
Topographic (Land Surface)
Bathymetric (Underwater Terrain)
3D – Terrain and Vegetation Mapping
Shallow-water Bathymetric Mapping
Aquatic Habitat Mapping
High resolution 3D water column mapping

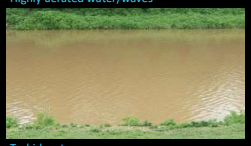

WHY TOPOBATHYMETRIC LIDAR?
Complements acoustic (multi-beam sonar) technology and traditional topographic lidar
Airborne topobathy lidar is of high value in filling the "0 to 10 m" depth gap in coastal and riverine areas.
Rapid survey of shallow water areas that are difficult, dangerous, or impossible to get using water borne methods.
Ability to rapidly assess riverine and estuary environments: channel cross sections, biological habitat, riparian conditions
Applications include:
Floodplain Mapping
Fisheries management
Marine resource and coral reef management
Storm surge modeling and storm damage assessment
Rapid shoreline assessment
Shoreline mapping and nautical charting


TOPOGRAPHIC AND BATHYMETRIC LIDAR


CONSIDERATIONS
Tide Levels\Flow levels
Terrain Variation
Weather Conditions
On-Site (NIR)
Regional (Green)
Leaf On/Off
Reflectivity
FAA Regulations
Water Clarity (Green)
Aquatic Vegetation (Green)
Topographic LiDAR
Topographic-Bathymetric LiDAR
1,000 - 1800m AGL
400 - 750m AGL
1064nm
532nm

Where will shallow water topo-bathymetric sensors have problems?

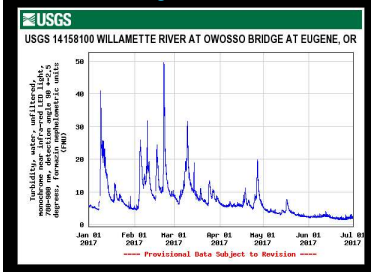
Highly aerated water/waves

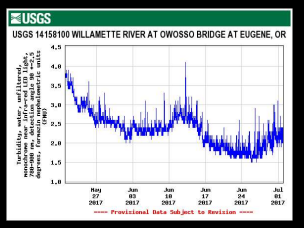


Turbid water

Heavy aquatic vegetation

Turbidity

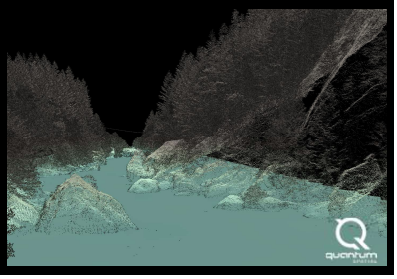




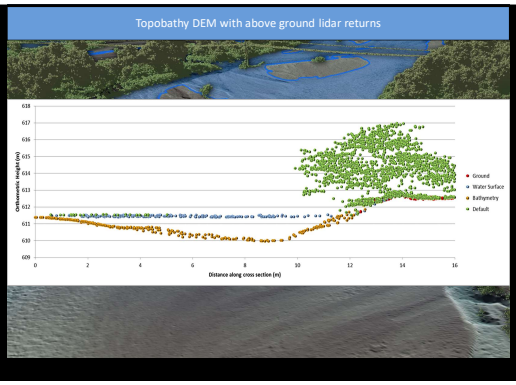
FACTORS IMPACTING PERFORMANCE

Relies on the propagation of green laser pulses through the water to reflect from the river bottom, and then to make the return trip back through the water to receivers in the aircraft.

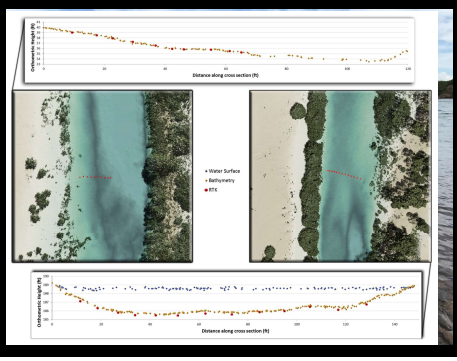
- Refraction at air/water interface
- Bubbles and breaking waves
- Optical properties of the water column
  - Absorption
  - Scattering
- Characteristics of the river bottom
  - Morphology
  - Color
  - Vegetation



Topobathy DEM with above ground lidar returns



ACCURACY



KLAMATH RIVER PROJECT GOALS

Project Stakeholders: USGS, KRRC, NOAA, Yurok Tribe, AECOM/GMA, USACE

Goals:

- Engineering design and survey for reservoirs.
- Pre-dam removal foundational data set for river.
- Quantitatively measure geomorphic evolution and physical response.

Data Elements:

- Airborne Topobathy LiDAR
- 4-Band Imagery
- Sonar Reservoirs (GMA/GDS)
- Sonar River (USACE)

TOPOBATHY LIDAR DATA COLLECTION

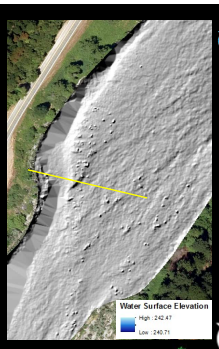
Riegl VQ-880-G Topobathy sensor:
- ✓ Green (532 nm) & NIR (1064 nm)
- ✓ High Pulse Rate (up to 550 kHz)
- ✓ Beam Divergence (0.7 mR)
- ✓ Short pulse length (1.5 ns)
- ✓ 1.5 Secchi Depth for bright ground

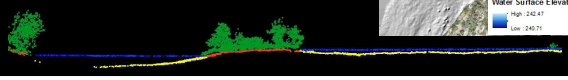
Bell Long Ranger Helicopter:
- ✓ Fly safely at 400m AGL in extreme terrain

Acquisition Parameters:
- ✓ Flight speed: 40-50 knots
- ✓ Pulse Rate: 245 kHz
- ✓ Pulse Density: 20 ppms (single swath)
- ✓ Swath Width = 291 meters
- ✓ Overlap = 30-50%

PROCESSING CONSIDERATIONS

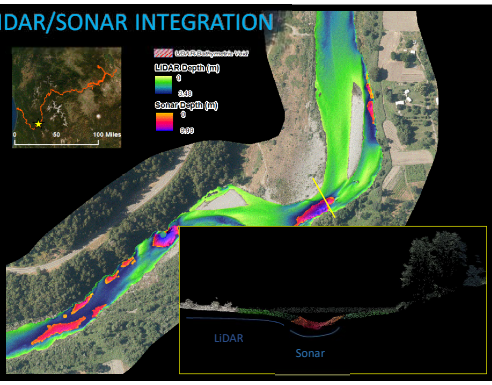
- Helicopter acquisition
- Circular scanner
- Water surface modeling
- Breaklines
- Sonar Integration
- Changing landscape





TOPOBATHY LIDAR RESULTS

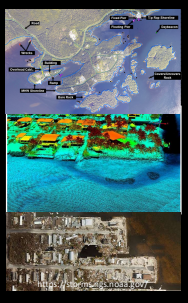
LIDAR/SONAR INTEGRATION

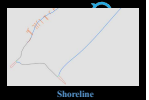


Florida Keys Project

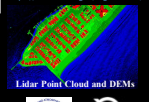
NOAA's Coastal Mapping Program

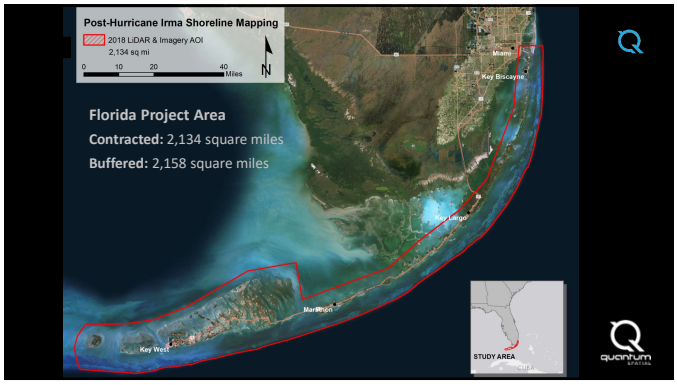
- Define the National Shoreline and nearshore elevation data
- NOAA nautical charts
- Other important applications:
  - Used in defining the United States' territorial limits
  - Coastal resource management
  - Storm surge and coastal flooding modeling
  - GIS analysis
  - Benthic habitat mapping
- Coastal Intelligence and Resiliency…
- Emergency Response

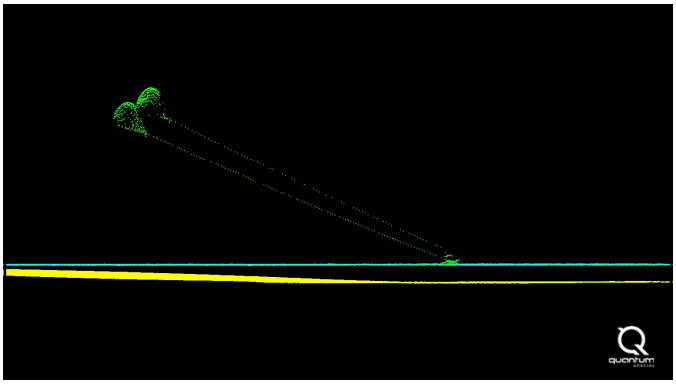




https://coast.noaa.gov/digitalcoast/



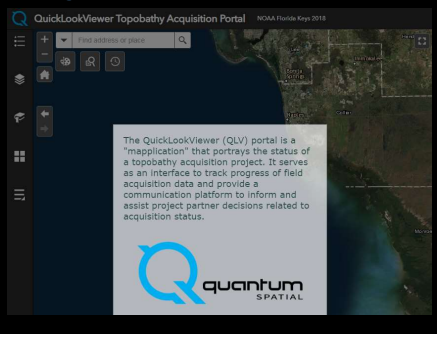




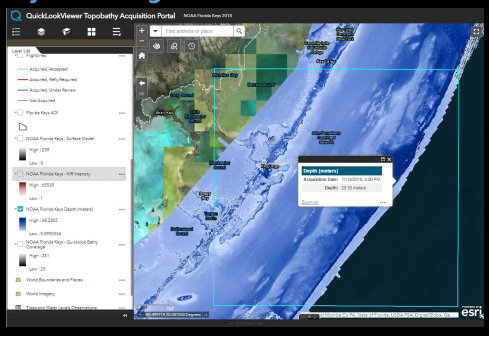
Florida Keys - Acquisition Summary

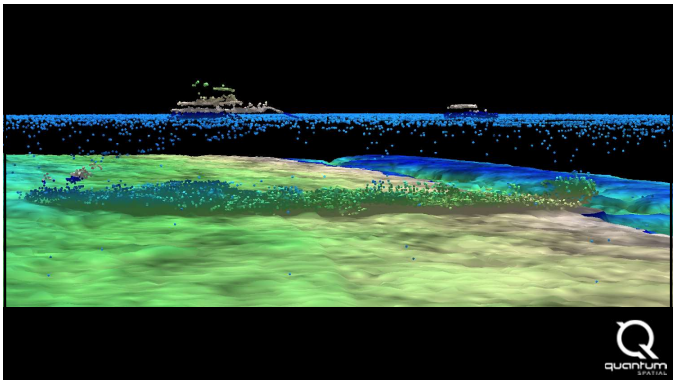
- 16,537 flight line miles
- 1388 flight lines
- 696 Flight hours
- 2.9 days of turn time!
- Reflew 40.5% of lines due to turbidity
- First Flight 11/19/2018
- Last Flight 3/23/2019
- 3 Riegl Sensors
  - VQ-880-G, VQ-880-GH, VQ-880-GII

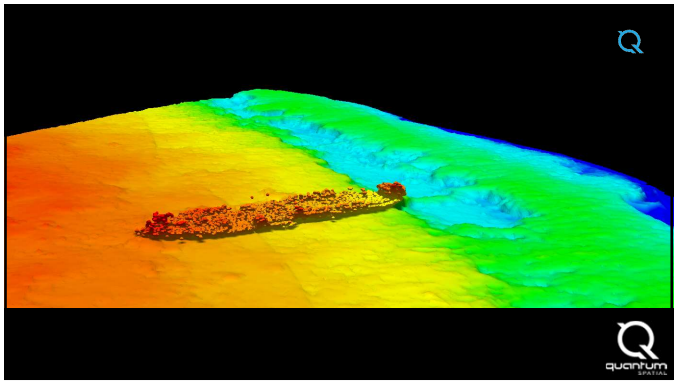
Project Management Portal



Project Management Portal







DC NHD Project Objectives

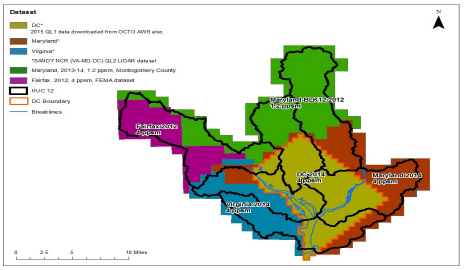
1. Complete and standardize the District's portion of local resolution National Hydrography Dataset (NHD) for all HUC-12 watersheds that cover the District.
   - Existing District NHD/WBD is based on old data, and is incomplete and discontinuous.
2. Update and standardize local resolution NHD/WBD for all HUC-12 watersheds that cover the District.
3. Integrate the Combined Sewer Overflow (CSO) networks into updated NHD/WBD to ensure storm water flow paths are captured and documented.

Partners

- **USGS**
- **Washington DC**
  - **Planning and Reporting: Water Division**
  - **Office of Chief Technology Officer**
- **DC Water**

Source Data & AOIs

- USGS/publicly avaliable QL2 LiDAR
- Current NHD data
- Current CSO network
- 2013 DC-OCTO 6" ortho-image



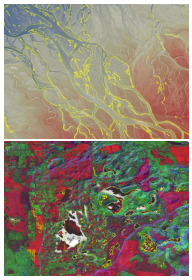
Task 1: Creating Local Resolution National Hydrography Dataset (NHD) for the District of Columbia

Waterbody Delineation

LiDAR derived breaklines will provide some of the boundaries, additional water delineation is required.

Object Based Image Analysis (OBIA)

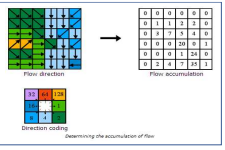
- LiDAR derived layers
  - Terrain descriptors
  - LiDAR descriptors
- Initial Segmentation
  - Homogenous objects (Slope, Intensity)
- Initial Classification
  - Finds known water (Native Density)
  - Finds known land (Slope)
- Contextual Classification
  - Iteratively classifies water
  - Spatial relationship to known water
  - Unknown areas (nDSM, GD)
- Consistent and Reproducible



Modeling Surface Flows

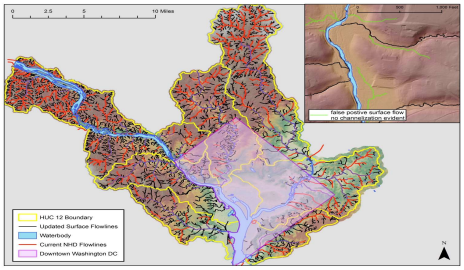
Run ArcHydro Routine → Examine the resulting stream definition for areas where flow appears artificially impeded → Create Hydro-Enforcement Breaklines → Enforce Breaklines in Model → Re-run Archydro Routine

1) Fill Sinks
2) Calculate Flow Direction Grid
3) Calculate Flow Accumulation Grid
4) Define Stream Definition Threshold



Automated Flowlines ready for manual QC and editing as necessary

Manual Edit and QC of Surface Flowlines



GOALS

- Ensure all streams stay in their channel.
- Manually correct if ground model was insufficient causing stream to deviate out of the channel.
- Remove false-positive streams with no channelization evident in the ground model.

Artificial Flow Paths

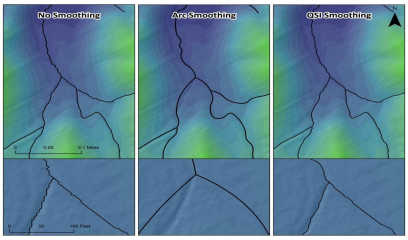
Centerline Generation

Automated process

- Rivers and Lakes
- Extracts elevation from LiDAR to enforce direction
- Ensures no peaks or sinks in flow
- Integrated seamlesly > snaps with line work outside of polygons
- Consistent and Reproducible

XYZ Smoothing of Surface Flowlines

Once Manual Review is complete, Network checks are run and data is XYZ smoothed using custom tools

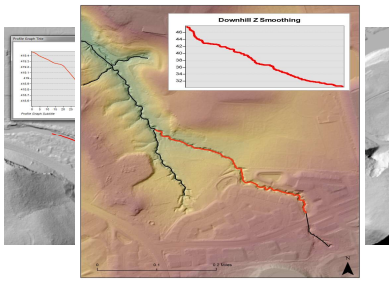


Z Values

-Extract values from LiDAR data

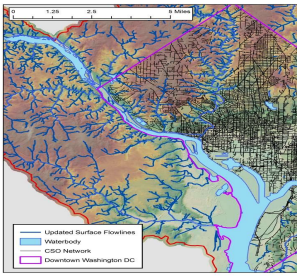
-Enforce downstream flow and line direction for all single flowlines/double line streams

-Assign single elevation for all lakes and reservoirs



Task 2: Integration of the CSO networks (rivers/streams, outfall) into the District portion of the NHD

Modeling CSO flows



CSO Networks are dynamic and complex!
Therefore…
It is important to establish the goal of the integration.

Should all features be retained?

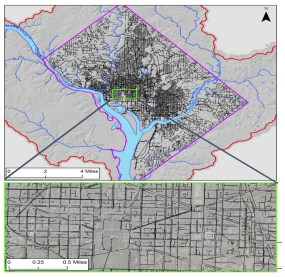
For DC's purposes ->YES
End Goal -> Trace inlets to all possible outlets and vice versa

For NHD Purposes and Framework ->NO
End Goal -> map *major* flow routes making sure all areas of the city are represented

Important CSO Considerations

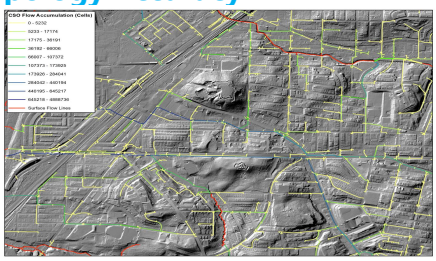
- **It is hard to portray and maintain an accurate and consistent representation of a CSO as they are inherently dynamic.**
- **Detailed locally supplied information is variable.**
- **The utility of an integrated network is highly dependent on the quality of the CSO network.**

Examples of things to assess in a CSO network:
- **Network & Topology Accuracy**
- **Horizontal and Temporal Accuracy**
- **Z values**
- **Added attribution – completeness and utility**



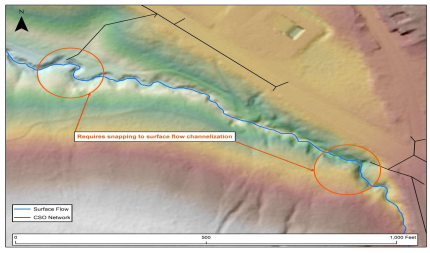
Network/Topology Accuracy

- **CSOs contain many XY crossings that may or may not represent a transfer of flow between the pipes.**
- **For correct flow accumulation need…**
  - **Accurate topology**
  - **Nodes only exist where flow is exchanged**
  - **Line direction correctly represents flowpaths**
- **Flow input only at inlets.**



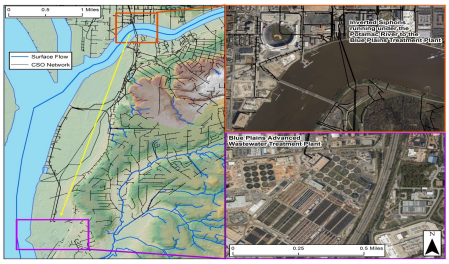
Horizontal/Temporal Accuracy

- **Spatial accuracy and maintenance frequency of the CSO Network are important**
  - **CSO Networks change over time**
- **Outfalls and inlets are not precisely aligned with surface channels**
  - **requiring extensions/snapping to surface flowlines**



Z Values

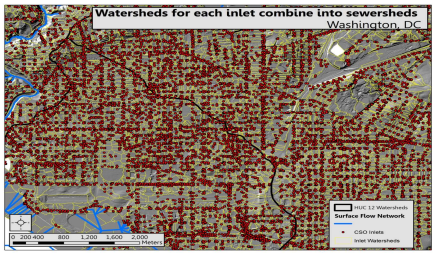
- **Surface Feature elevation known**
  - **Downhill flow can be enforced**
- **Underground elevations often unknown and may have pumps, siphons, and other features**
  - **Downhill flow can not be mapped easily**
- **Z values for CSO features**
  - **Will involve assumptions – assumptions need to be recorded**



Task 3: Creating Local Resolution Watershed Boundary Dataset (WBD) for all District Watersheds.

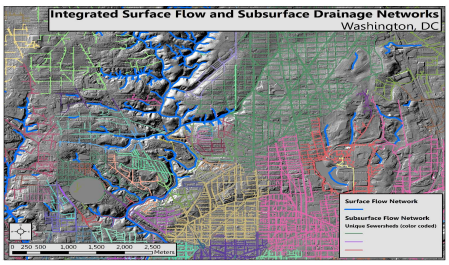
CSO Sewersheds: Inlet Basins

- Individual inlet catchments.
  - ~33k inlets in DC
- Snap inlets to Flow accumulation.
  - Minor offsets cause no flow.
- Not perfect
  - Noise is inherent in this fine-scale analysis.
  - Urban landscapes complex.



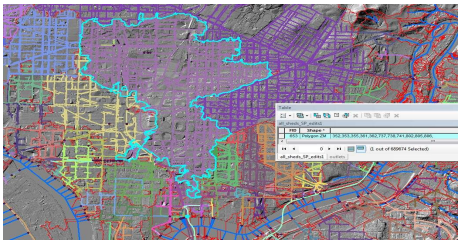
CSO Sewersheds: Network Basins

- Clustering of inlets
  - Based on unique combination of outlets.
- Trace outlets through the network.
  - Geometric dependency
- Surface flow to inlets
  - Individual basins for each inlet and surface flow line.



CSO Sewersheds: Network Basins

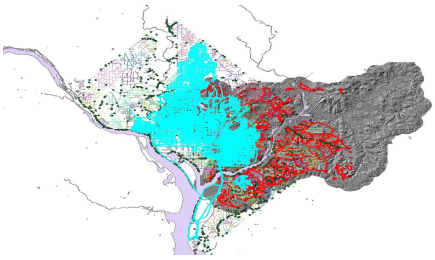
- Dissolve inlets basins to sewersheds
  - Based on unique combination of outlets.
- Manual cleaning/ QC
  - Snapping causes offsets.
  - Internal basins
- Questions of scale
  - Should sewersheds be further split.



Once water enters the CSO… Is it significant before it exits the CSO?

Watersheds and Sewersheds.

- Multiple outlet options.
  - Combined sewer and overflow pipes.
- Disconnected / multipart sheds.
  - When to separate?
  - When to merge?
- Appropriate scale?
  - Varying resolution of source datasets.



Watersheds and Sewersheds.

- CSO is predominant driver of hydro transport in urban landscapes.
- Can disagree with surface trends.
- *What is most a appropriate for WBD user needs?*