

# Topographic Mapping RTK GPS Standard Operating Procedures

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## Purpose/Objective:

Ground-based topographic mapping using real time kinematic global positioning system (RTK GPS) is a useful tool for collecting high resolution elevation data at the landscape level. RTK GPS is mobile, collects data quickly, and measures elevation within an accuracy of 1 – 5 cm.

To tie vegetation community structure to elevation throughout the study site, vegetation surveys can be completed in conjunction with topographic mapping. See Vegetation Survey section for methods.

## Site map preparation

Prepare site map with gridlines at the desired resolution for mapping the site. For example, we typically record RTK elevation points every 25 meters along transects spaced 50 meters apart (25 x 50 m grid). Transects are stratified from high to low elevations. Transect positioning is based on individual marsh characteristics (i.e. accessibility, channel location, etc.). Marshes should have an equal number of elevation points per unit area. For larger sites, transects may be spaced further apart to increase field efficiency. Gridlines are created in ArcGIS and can be uploaded to some RTK GPS as CAD files.

## Field mapping

### Field Equipment:

RTK GPS loaded with gridlines  
Site map with gridlines

### Field Methods:

RTK elevation points are taken at evenly spaced distances (i.e. 25 m) along transects stratified from high to low elevations. To navigate to each measurement point, the technician uses the CAD gridline file uploaded to the RTK GPS map. If there is not a gridline



Figure 1. RTK GPS elevation survey points (bottom) and interpolated digital elevation model (DEM; top).

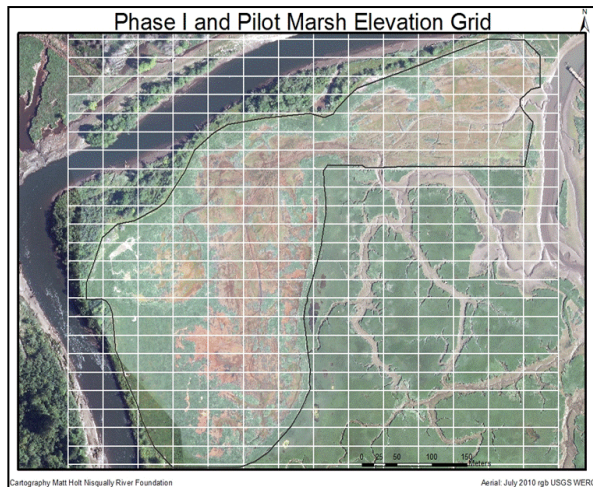


Figure 2. RTK GPS survey grid (25 x 50 m) for Phase I and Pilot restoration sites, Nisqually estuary. Elevation points were collected at each grid intersection using RTK GPS.



Figure 3. Mapping Phase II restoration site with RTK GPS, Nisqually estuary.

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file available, the technician paces between points and uses the RTK map to establish relatively straight and parallel transect lines. Small marsh features such as channels and interior levees are not mapped. Channels are digitized using ArcGIS and photos.

### Creating a Topographic Map in Arc GIS

#### Data Preparation

Upload RTK elevation points into ArcGIS. For each site, levee points are excluded. For the sites with randomly collected elevation points, points are excluded when they were clumped (<10m apart). For a pair of close points, the point with the highest 3D error is removed.

The points are then randomly divided into 2 subsets, 70% for a test model and 30% for validation. Hawth's tools is used to select a random subset of points (Sampling Tools->Random Selection within Subsets).

The distance among all points at a site are calculated with the Point Distance tool (Analyst Tools->Proximity->Point Distance). This can also be done by using the Measure tool between the two furthest points. This distance is used in calculating the lag size and number. Following an ERSI rule of thumb: lag size\*lag # < 1/2 maximum distance among points. If you leave the Lag # to the default 12, then dividing the maximum distance between points by 24 will give you the Lag number.

#### Ordinary Kriging

Two kriging interpolations are modeled for each site, one with 70% of the points, which were tested with the remained 30%, and one with all points included.

#### Model Settings

Open the Geostatistical Wizard within Geostatistical Analyst, chose the Kriging method, select the point layer and attribute you want to interpolate (ortho height).

Step 1. No transformations were performed, click next.

Step 2. Select the Exponential model. Turn on anisotropy, which assumes a trend in the data. Set lag # to between 9 and 12, with lag size varying among sites depending on the maximum distance. Lag # can be optimized by minimizing the root-mean-square value provided in the internal cross-validation of geospatial analyst (click Next twice to get to the cross-validation screen).

Step 3. The number of neighbors included depends on how many points were at a site. For small sites, 5 neighbors are included, medium sized sites have 10, and large sites have 25. A minimum of 2 neighbors are always included. The default sector type should be left alone (four sector with 45

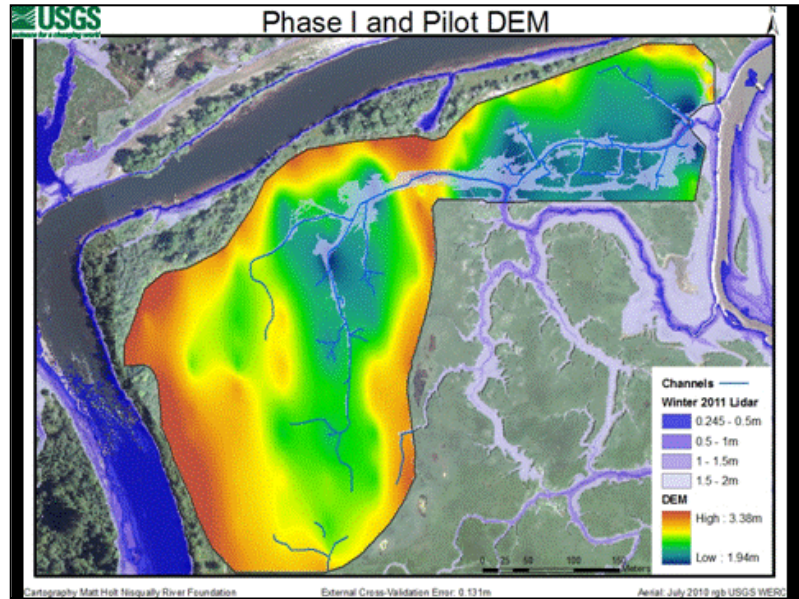


Figure 4. Digital elevation model (DEM) of Phase I and Pilot restoration sites, Nisqually estuary. Channels are delineated and aerial LiDAR is shown for channels.

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degree offset). The more neighbors included into the model, the more uniform the predicted surface will be as anomalous high or low points will be smoothed out. This is desirable for relatively flat places (marshes) but not so for heterogeneous terrain (mountains). Experiment with different number of neighbors and compare the root-mean-square value to determine the optimum number.

Step 4. Examine the root-mean-square value, lower is better. Click Finish to create the predicted surface. Save the output as a raster (right click on layer->Data->Export to Raster). Change the cell size to the chosen resolution of your study and then clip to the outline mask of the study site. The 'Spatial Analyst->Extraction->Extract by Mask' tool also works to clip a raster, and seems to be better at lining up the raster cells across layers. In the original output, you can go back to examine the parameters of the model (Right-click->Method Properties)

### External Cross-Validation

The krig model made with the 70% of points is converted to a raster and then extracted (using the Extract to Points tool) to the subset of 30%. The absolute value of the difference between predicted heights from the model and the ortho heights is averaged, providing a metric of model accuracy.

After verifying the model accuracy with external cross-validation, rerun the model with all points, using the same parameters.

### Vegetation Surveys

Vegetation data can also be collected in conjunction with topographic mapping. These data can be used to create vegetation maps of the study site and analyze shifts in vegetation communities based on elevation gradients. Point intercept, quadrat or pore-water salinity data can be collected based upon monitoring needs.

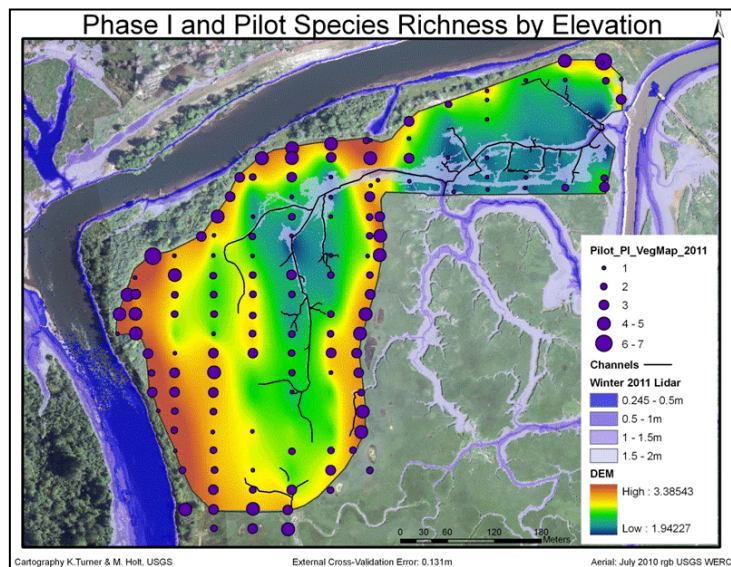


Figure 5. Phase I and Pilot digital elevation model overlain with proportional points indicating vegetation species richness.