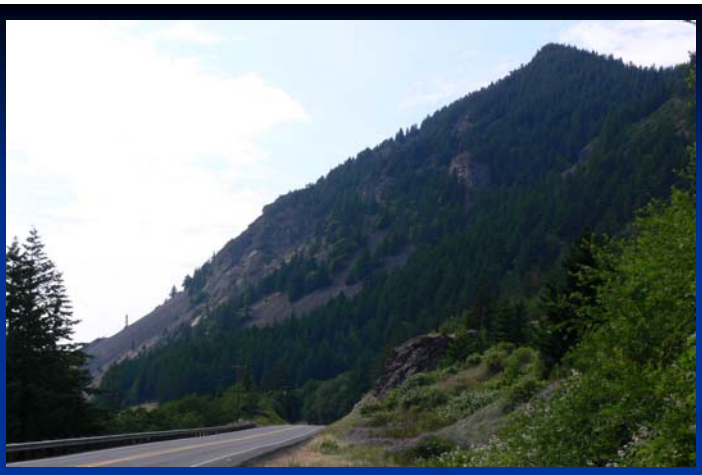


Preliminary Master Planning for the Camp Arrowhead Site of the Columbia River Council Unit of the Girl Scouts of America – Focus on Landslide Hazard Assessment

Julia Grothaus Vea, Alison Miller, Becca VandeWalle

Camp Arrowhead Location

- Included in the Columbia River Gorge National Scenic Area
- Nestled between Wind and Dog Mountains
- Neighbor to the Gifford Pinchot National Forest

Existing Facilities

- Main Lodge & Commercial Kitchen
- Unit Houses & Cabins
- Semi-primitive Camping Areas
- 3 Birdhouse Structures (Wooden Tents)
- Swimming Pool & Nearby Lake

Camp Arrowhead History

- In operation for approximately 60 years
- Currently in minimal use due to a failed water system
- The Columbia River Council is preparing to retrofit and reprogram the property

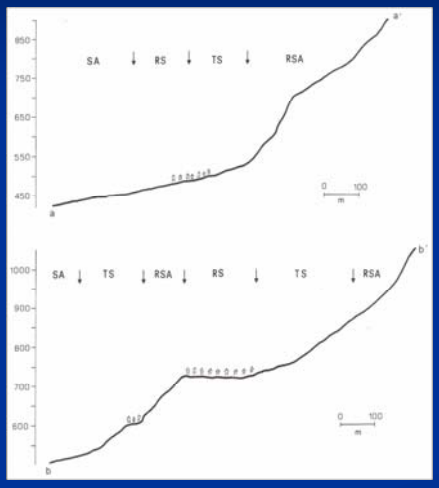
Girl Scouts' Planning Needs

- Site Suitability
- Wildfire Risk Assessment
- **Landslide Hazard Assessment**

Landslide Warning Signs

- Springs, seeps, or saturated ground in areas that have not typically been wet before.
- New cracks or unusual bulges in the ground.
- Soil moving away from foundations.
- Broken water lines and other underground utilities.
- Leaning trees.
- Sunken or down-dropped road beds.
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content).
- Sudden decrease in creek water levels though rain is still falling or just recently stopped.

Landslide Zonation



- RSA: Rock Source Area
- TS: Talus Slope
- RS: Run-Out Slope
- SA: Safe Area

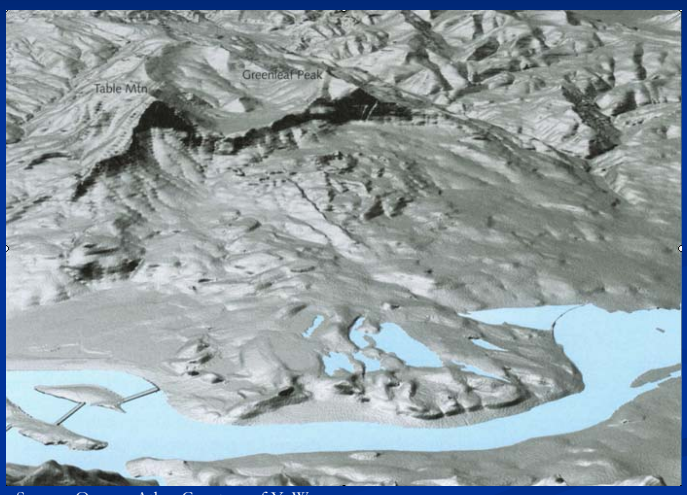
Source: Leonardo Ermini et al.
Geomorphology 2005

History of Landslides near Study Area

- Eagle Creek Formation tips southward.
- Wind Mountain is eroded vent of diorite.
- From Table Mountain to Dog Mountain are massive landslides
  - Bridge of the Gods (circa 1650 to 1750)
  - Collins Point (circa 1800)

Significance of Resolution

LiDAR: Table Mountain & Bridge of the Gods Landslide



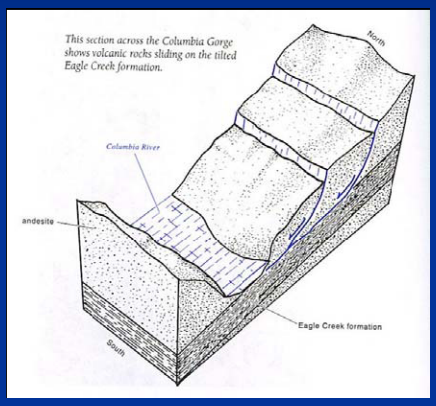
Source: Oregon Atlas, Courtesy of Y. Wang

Assumptions

- Future landslides will have the same causal factors as past landslides.
- Study area exposed to approximately the same earthquake risk.
- Study area is within one major geologic complex with the same subsurface layer orientation.
- Study area has low variation in precipitation.
- Only relatively static factors considered.

Which data layers and why?

Aspect



- Underlying geologic deposits are in layers tipped toward the south

Which data layers and why?

GPS

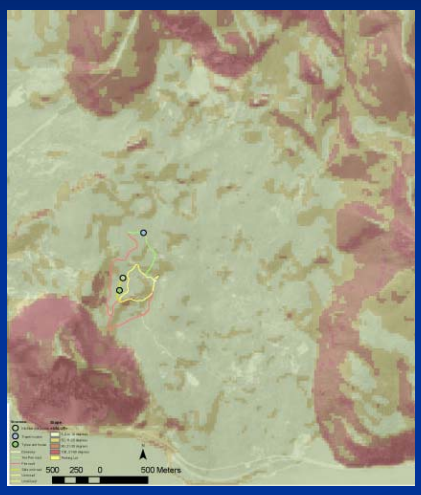
DATA COLLECTION

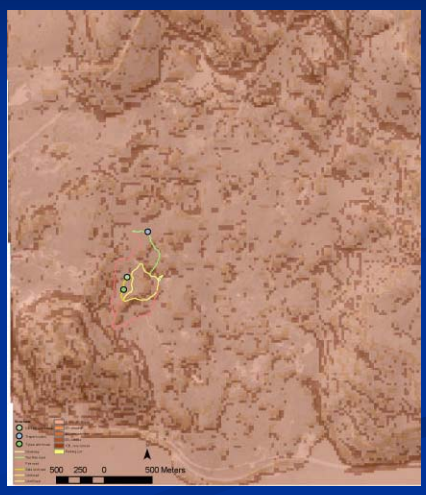
- Roads on Girl Scout Site
- Observations of landslide indicators for validation

Methodology

- GPS Data Collection
- Aerial Photography Interpretation/Digitizing
- Reprojecting
- Resampling
- Rasterizing
- Normalized Factors and Weights
- Multiple Criteria Evaluation

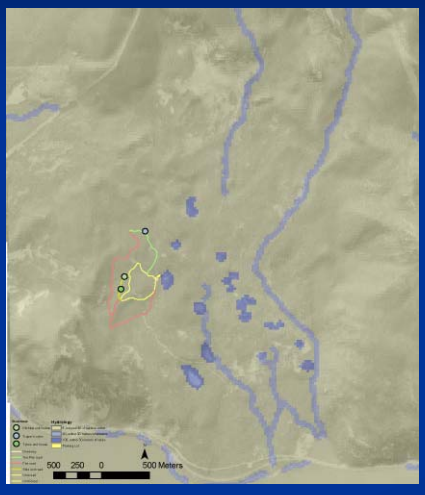
Slope and Profile Curvature





Plan Curvature and Aspect

Hydrology and Tree Canopy

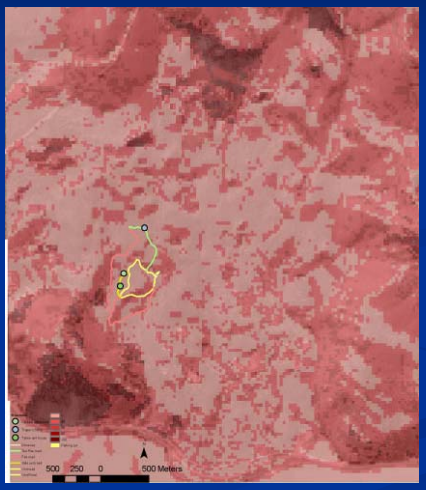


Elevation Factors and Landslides

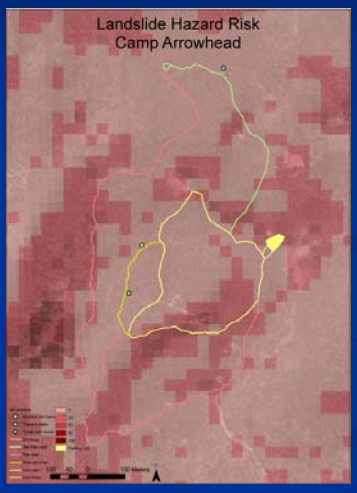
Multi-Criteria Weights

INPUT	PERCENT
Slope	35%
Profile Curvature	25%
Plan Curvature	20%
Aspect	20%
Elevation Factors (datasets derived from elevation)	**50%**
Active Landslides	25%
Tree Canopy	12.5%
Hydrology	12.5%

Landslide Hazard Risk



Landslide Hazard at Camp Arrowhead



Conclusions

- The model within the Camp Arrowhead site gave higher landslide hazard risk ratings at three of the four observer landslide indicator areas.
- Without a finer resolution DEM (LiDAR), site specific recommendations are very limited.

Improvement/Further Study

- LiDAR (~1m DEM)
- Published geologic landslide data, georeferenced
- Soils Data, Complete SSURGO data
- Better hydrology data and hydrological modeling for subsurface impacts
- Slope Reconstruction of known landslides for statistical testing of factors
- Expert Input

Data Sources

- Girl Scouts – Columbia River Council (Background Information)
- USGS (10m DEM)
- USFS (Tree Canopy)
- Terraserver USA (Digital Orthorectified Quarter Quadrangles)
- Columbia River Gorge NSA (Vector Data)
- Oregon Geospatial Clearinghouse (Context Map)
- Washington State Geospatial Data Archive (Context Map)
- Field GPS Data (Trimble GeoXT)

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