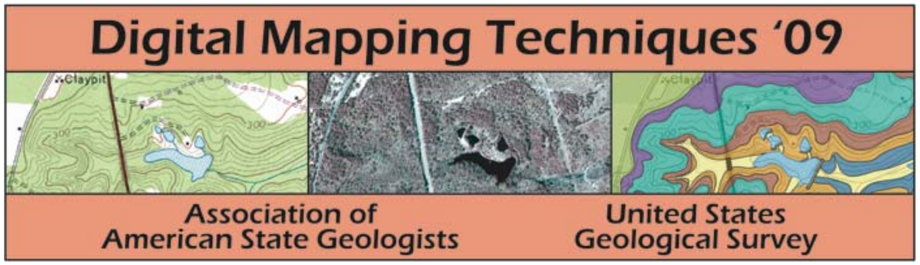


The following was presented at DMT'09
(May 10-13, 2009).

The contents are provisional and will be
superseded by a paper in the
DMT'09 Proceedings.

See also earlier Proceedings (1997-2008)
http://ngmdb.usgs.gov/info/dmt/

Desktop Screening Analysis for Wind Farm Siting

DMT 2009

Morgantown, WV

Mark Zellman, Chris Hitchcock, Ranon Dulberg, David Slayter
William Lettis & Associates, Inc.

Overview

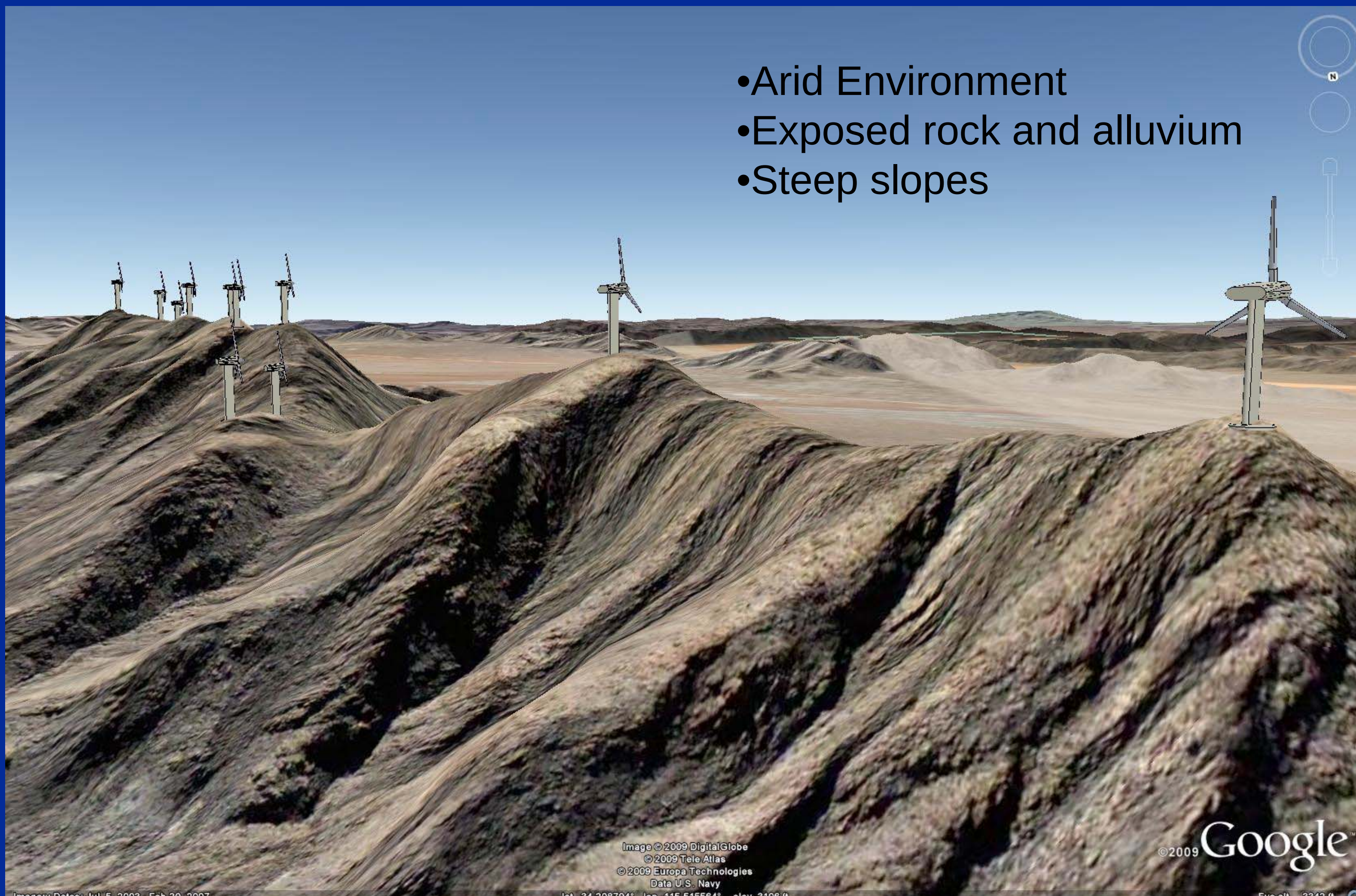
- Screening study for the siting of two wind farms
  - Mojave Desert, California
  - Coastal California
- Delivery
  - General geologic conditions
  - Rippability
  - Estimated cut volumes

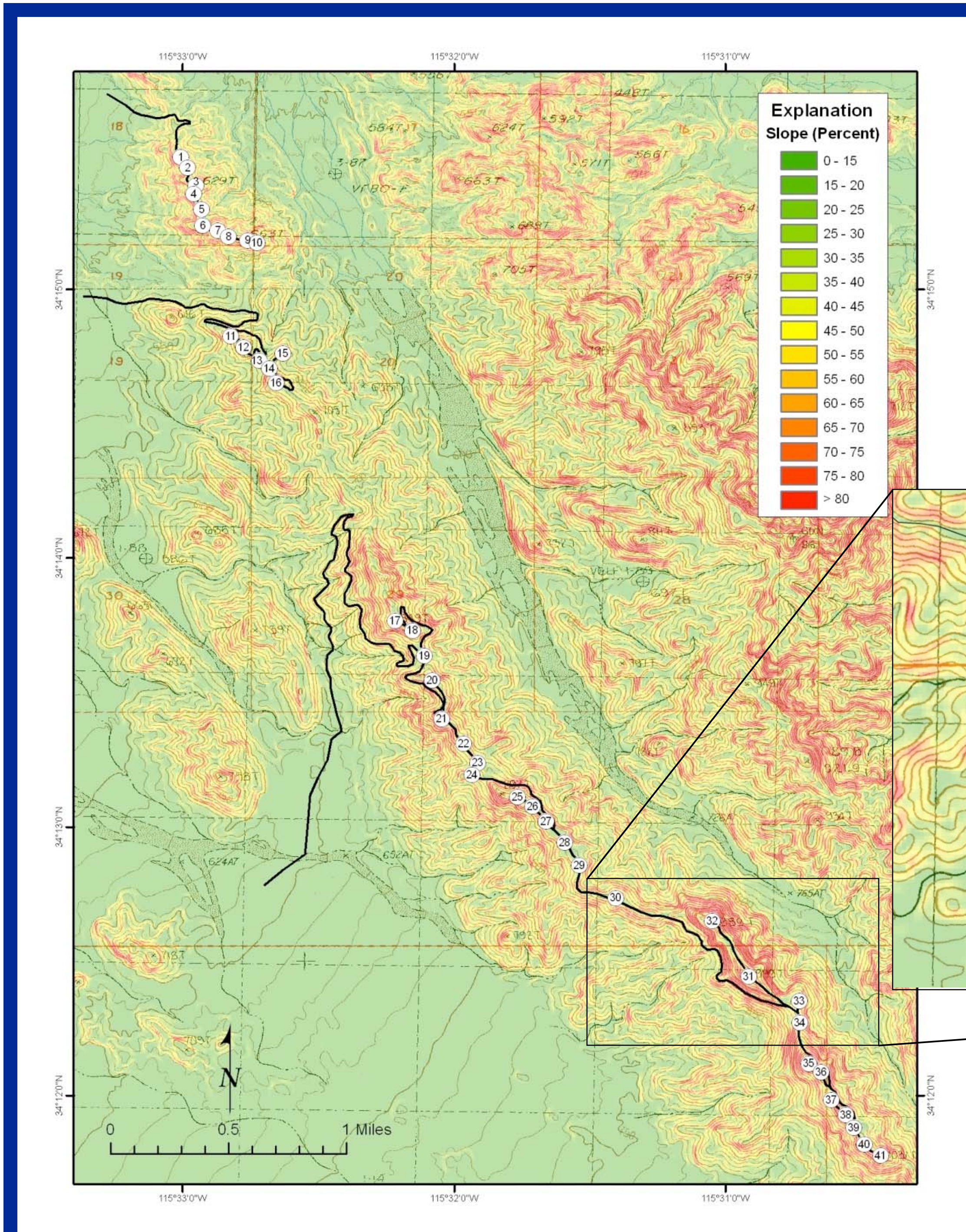
Data

- **CAL-ATLAS Geospatial Clearinghouse**
- http://www.atlas.ca.gov/download.html
    - 1:24,000 Digital Raster Graphics (DRGs)
    - Imagery (DOQ's, NAIP)
- **San Luis Obispo County**
- http://midnight.calpoly.edu/gis/data/slo_county/geology/Geology/Geology.htm
    - SLO County geology
- **National Resources Conservation Service (NRCS)**
- http://www.nrcs.usda.gov
    - Soil Survey Geographic Database (SSURGO)
- **USGS**
    - **National Map Seamless Server**
    - http://seamless.usgs.gov/index.php
        - 10-meter National Elevation Dataset (NED)
    - **Western Earth Surface Process Team**
    - http://geomaps.wr.usgs.gov/socal/index.html
        - California 1:100,000 geology

Site 1

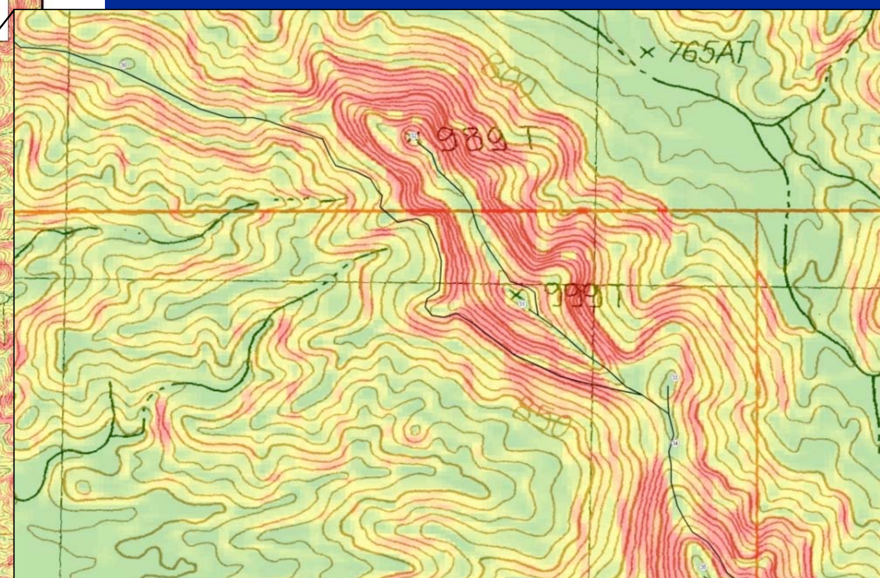
- Arid Environment
- Exposed rock and alluvium
- Steep slopes



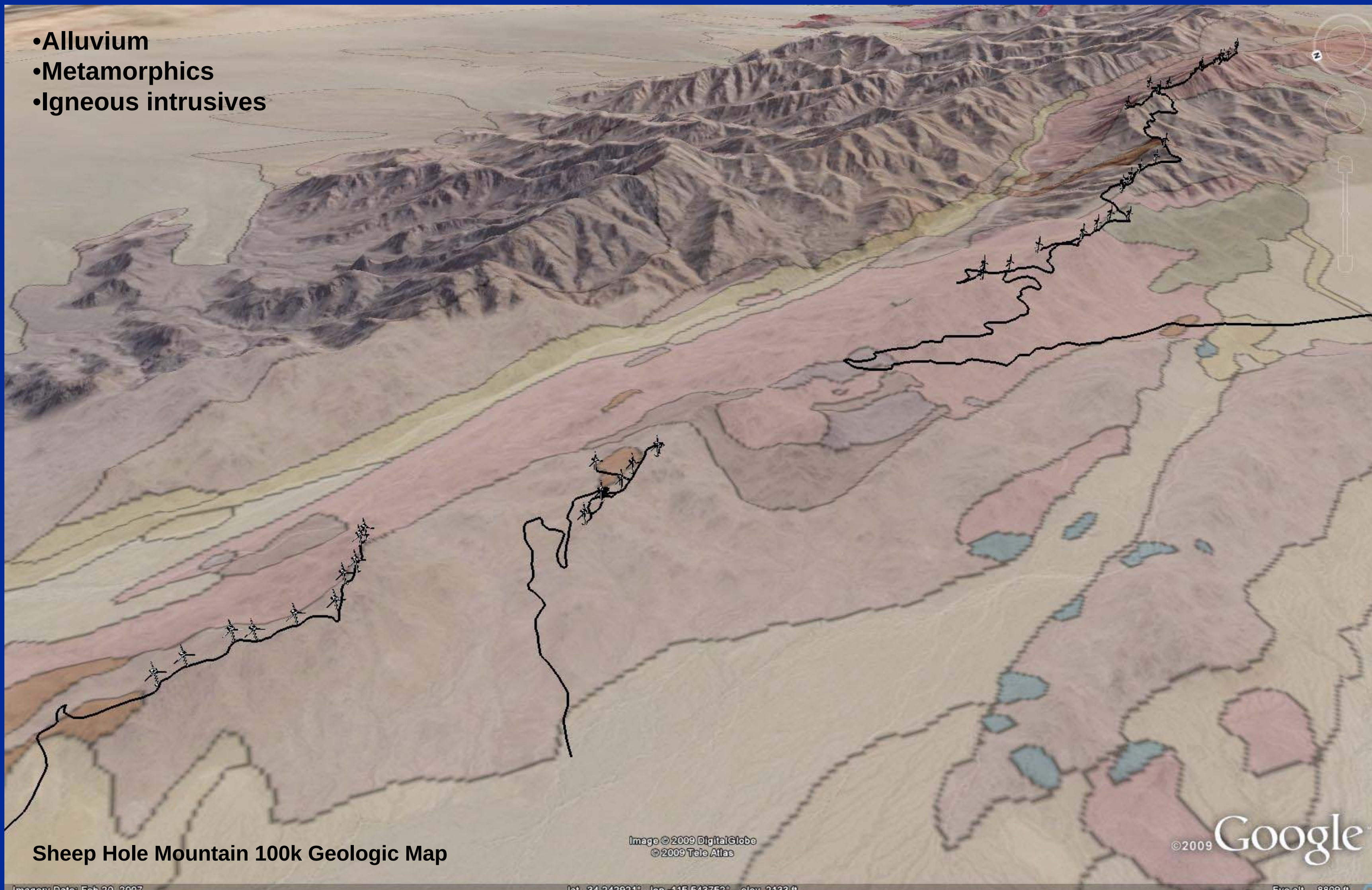


Roads

- Checked on a DRG/Slope map base
- 10m NED – Percent Slope

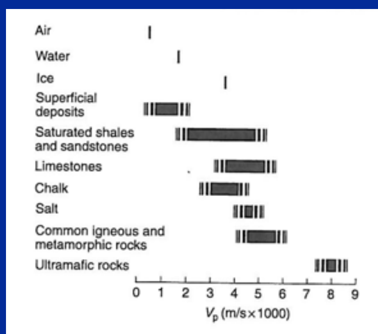


Site 1 Geology

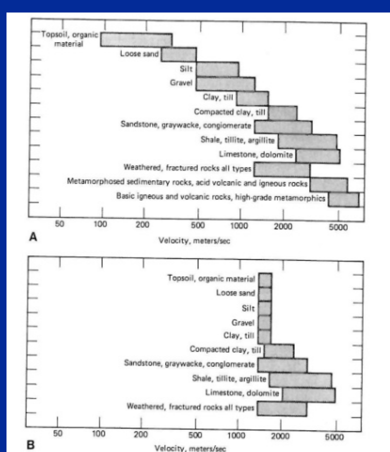


Rippability

- •Determine approximate P-wave velocity
- •Apply p-wave velocity to Caterpillar D9R Rippability Chart



Griffiths and King, 1988



Todd, 1980

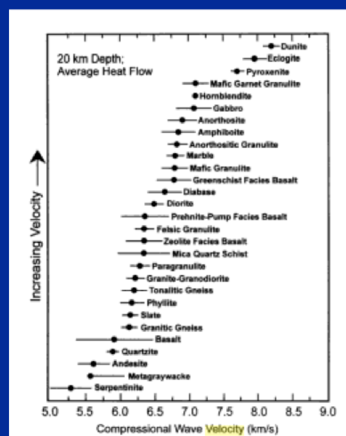
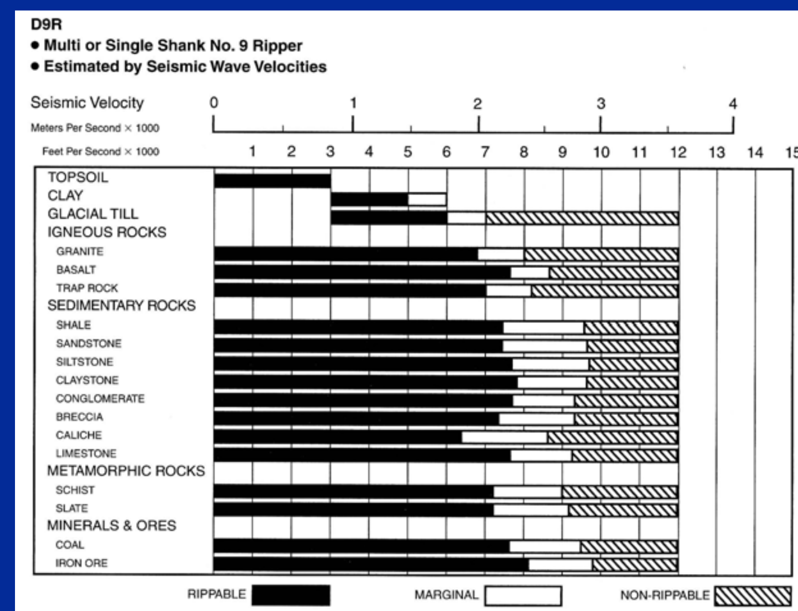


Figure 11.15 Average laboratory velocities for each rock type, at 20 km equivalent depth, and at a temperature of 309°C. Christensen and Mooney, 1995.

Christensen and Mooney, 1995

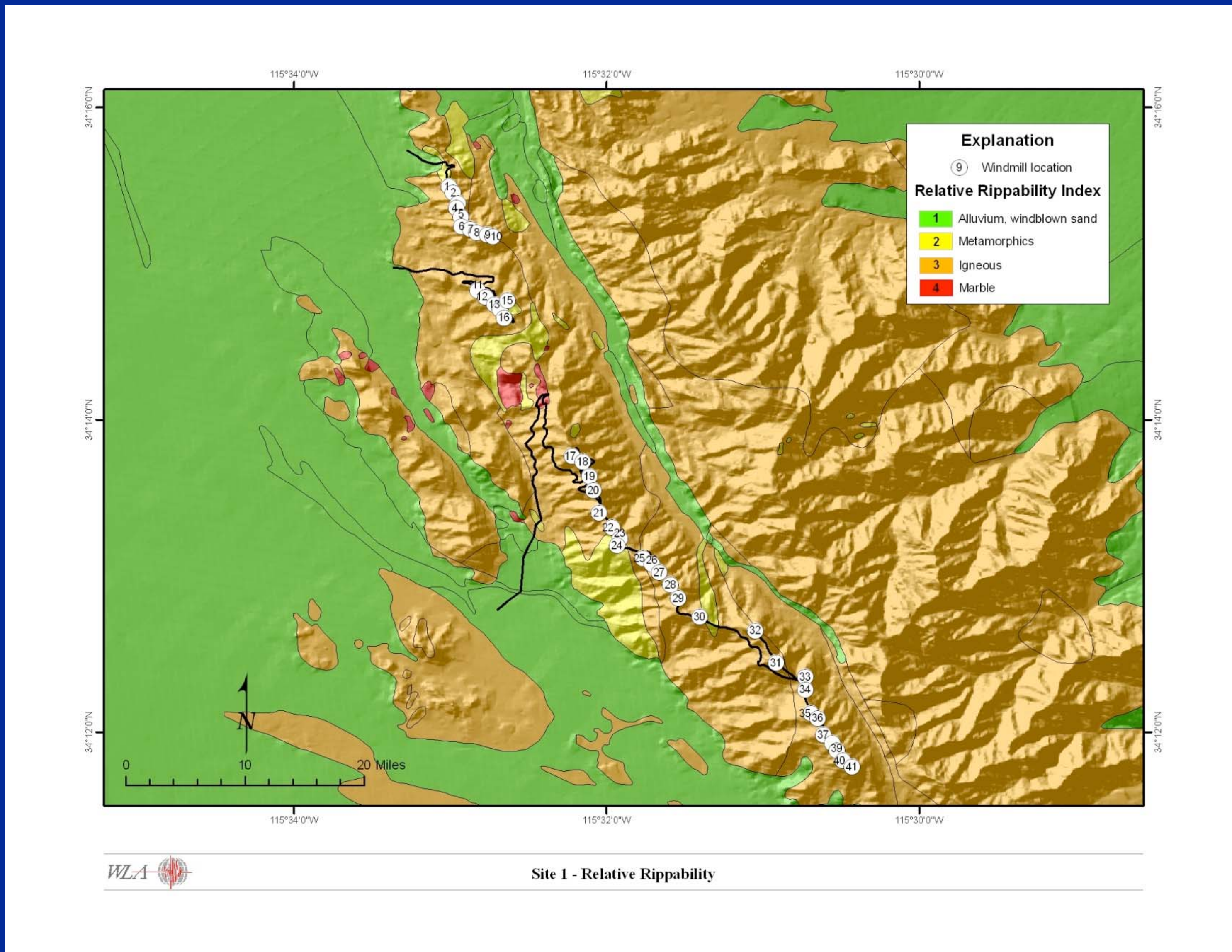


Rippability

TABLE 7-9: REVISED RIPPABILITY CLASSIFICATION [7]					
Parameters	Class 1	Class 2	Class 3	Class 4	Class 5
Uniaxial Tensile Strength (lbs/ft^2)	<41,800	41,800-125,400	125,400-209,000	209,000-313,500	>313,500
Rating	0-3	3-7	7-11	11-14	14-17
Weathering	Complete	Highly	Moderate	Slightly	None
Rating	0-2	2-6	6-10	10-14	14-18
Abrasiveness	Very low	Low	Moderate	High	Extreme
Rating	0-5	5-9	9-13	13-18	18-22
Spacing of Discontinuities (ft)	<0.197	0.197-0.984	0.984-3.3	3.3-6.6	>6.6
Rating	0-7	7-15	15-22	22-28	28-33
Seismic (Sound) Velocity (ft/sec)	1310-3610	3610-5250	5250-6235	6235-8200	>8200
Rating	0-6	6-10	10-14	14-18	18-25
Total Rating	<30	30-50	50-70	70-90	>90
Rippability Assessment	Easy	Moderate	Difficult	Marginal	Blast
Recommended Dozer	Light Duty	Medium Duty	Heavy Duty	Very Heavy Duty	None

Bieniawski, 1986

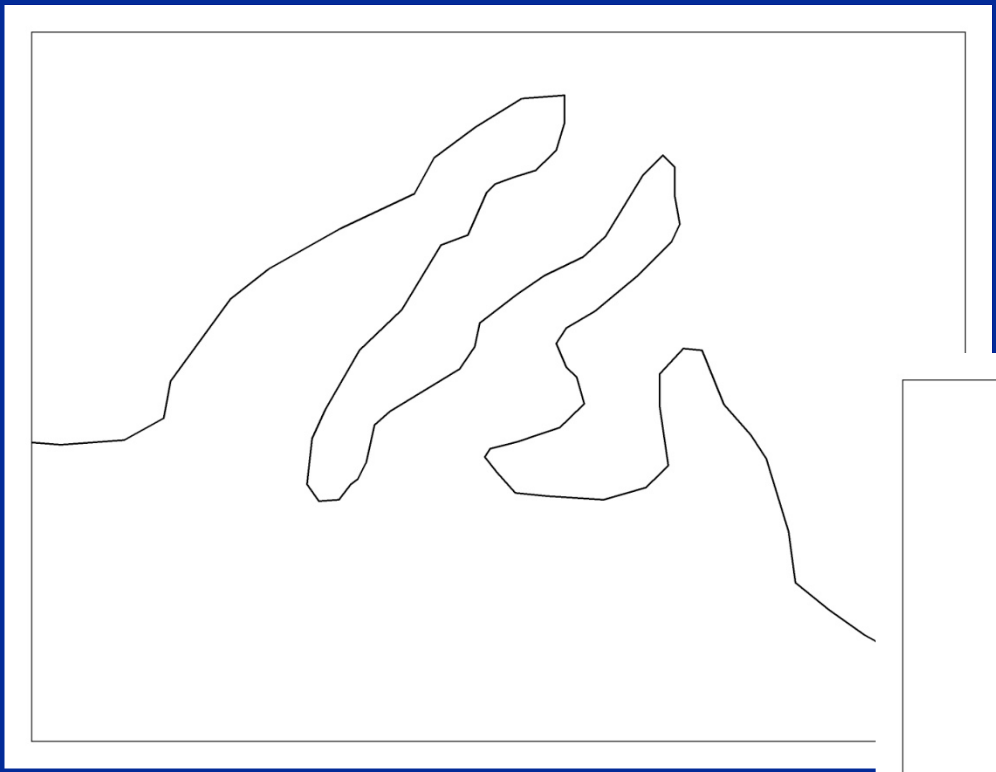
Rippability



Cut Volumes

- Slope values obtained from 10m NED
- Assuming width of 30’ for access road
- Assuming that all cuts are made along the slope
- Calculating approximate values

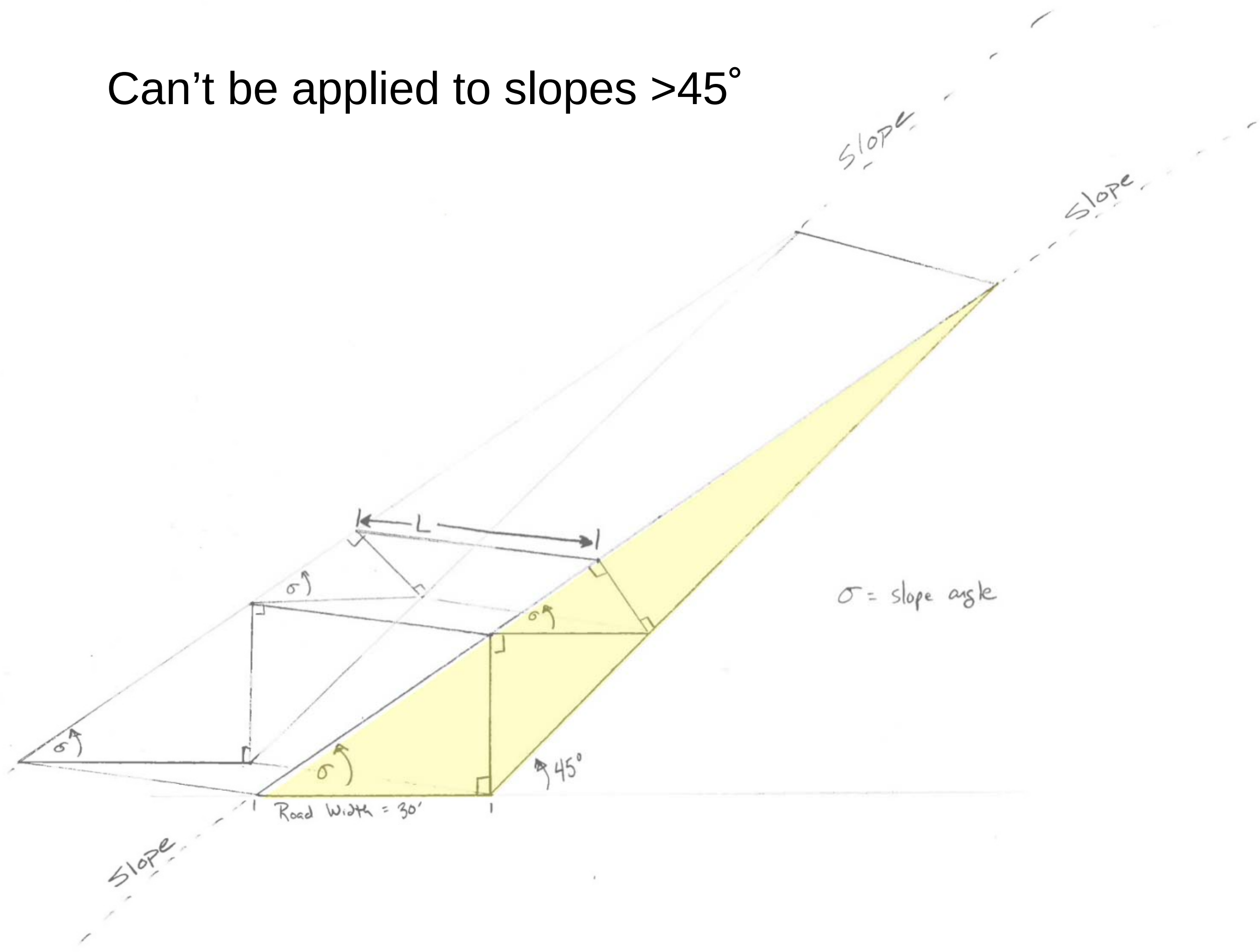
Cut Volumes - CHANGE



- •Create slope grid (degree) from 10m NED
- •Convert slope grid to shapefile
- •Select cells that intersect roads
- •Join slope polygons with rippability
- •Calculate cut volume for each cell

Cut Volumes

Can't be applied to slopes >45˚



Cut Volumes

Rock Type	Relative Ripability (1-4)	Velocity Range (km/sec)	Road Length (ft)	1:1 Cut Volume (yd^3)	1:2 Cut Volume (yd^3)
Tectonic Schist	4	6.0 - 6.7	18807.62	235905.41	139775.45
Older Alluvium	1	0.5 - 2.5	4326.09	9091.08	8112.71
Iron Granodiorite Gneiss	3	6.0 - 6.2	53608.72	543735.74	304268.09
Intrusive dacite	2	5.4 - 5.8	2244.05	69629.24	31898.15
Granite Pass Granite	3	6.0 - 6.2	12203.39	112837.99	75562.03
Danby Lake granite gneis	3	6.0-6.2	31370.18	489979.16	264438.38
Basalt in Iron Mountain	4	5.3 - 6.5	914.45	5739.65	4578.33
			123474.5	1466918.27*	807331.29**

Relative Rippability Index 1 = more rippable, 4 = difficult to rip / unrippable

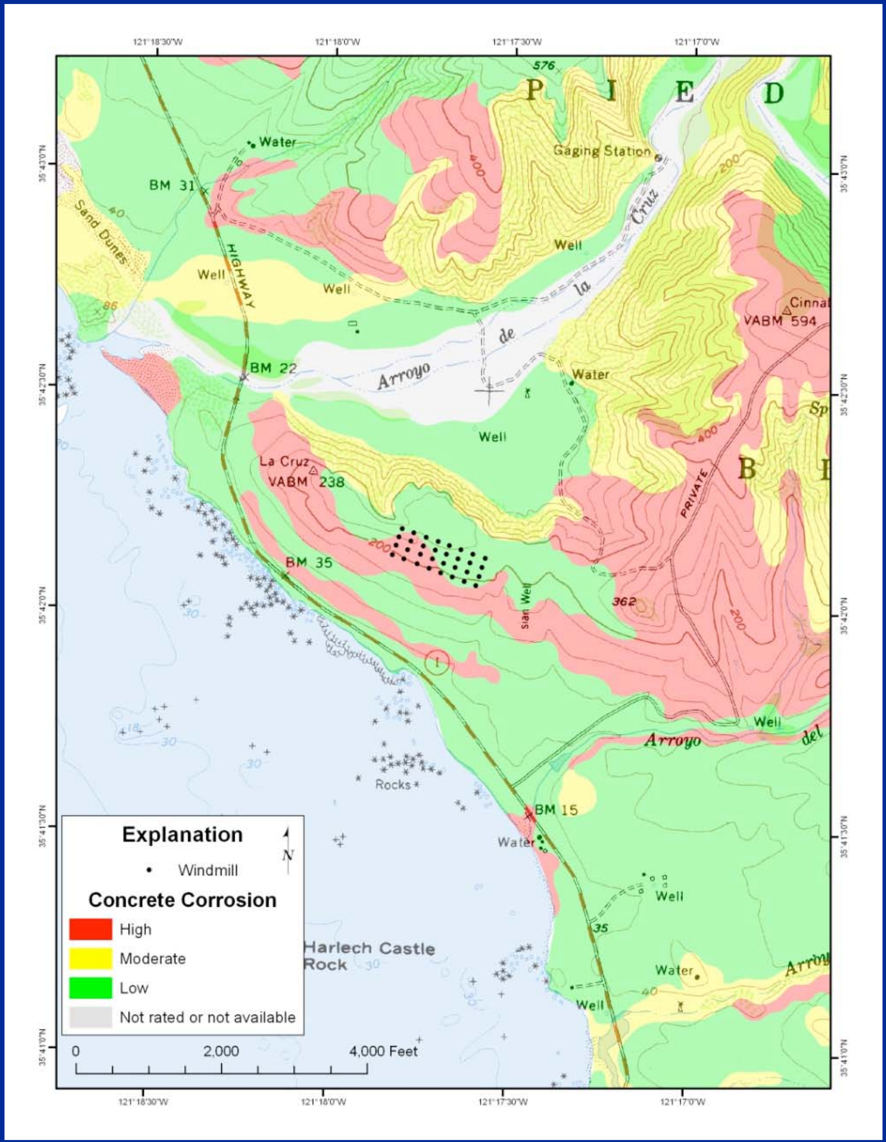
*Does not include volumes for areas where slope is greater than 45°

**Does not include volumes for areas where slope is greater than 63.44°

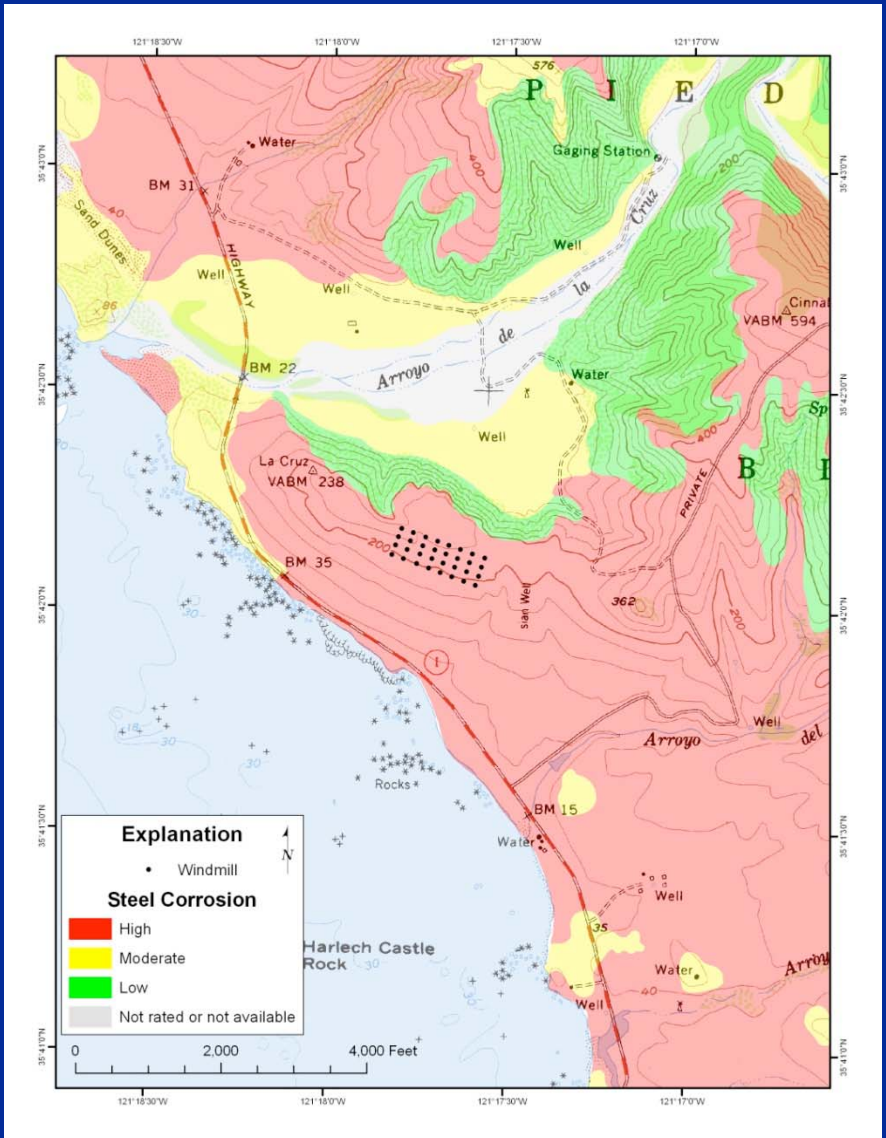
Site 2

- Coastal Region
- Soil site
- Gentle Slopes

Soil



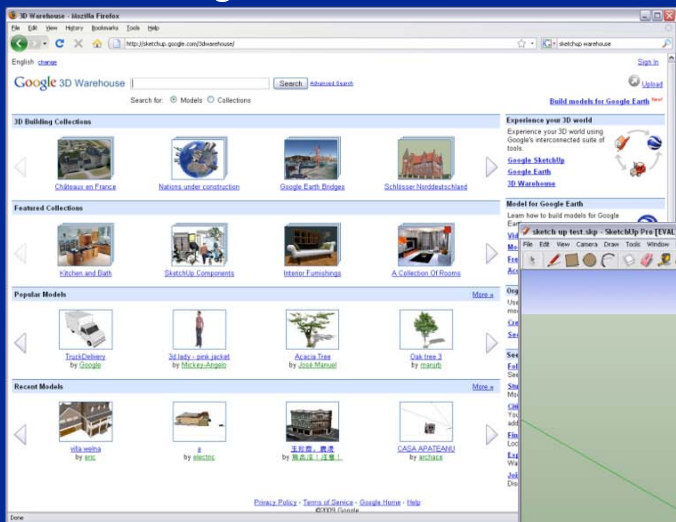
Explanation
Windmill
Concrete Corrosion
High
Moderate
Low
Not rated or not available
0
2,000
4,000 Feet



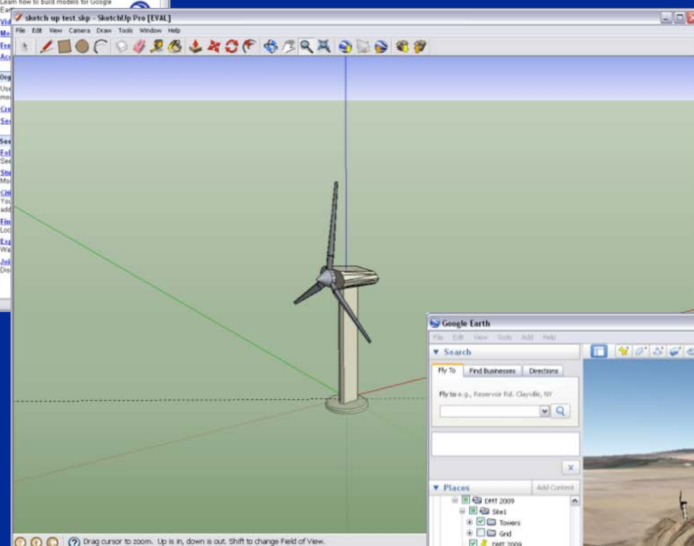
Explanation
Windmill
Steel Corrosion
High
Moderate
Low
Not rated or not available
0
2,000
4,000 Feet

Google Earth Models

Google 3D Warehouse



Google Sketch Up



Google Earth

Increasing Accuracy

- Higher Resolution Data
    - LIDAR
    - Air Photos
    - Geology
- Multi-spectral Data
- Field Checking
    - Weathering
    - Velocity measurements
    - Depth to bedrock

Conclusions

•Low budget / Quick turn-around projects which use free data are common

•When LIDAR is not available the “next best” data is being used for mapping projects

•High resolution elevation data important!

•Google Earth is a great tool for presenting data

•Measured P-Wave velocity data for common rocks, and depth to bedrock data would be would be of great use

Thanks!