Evaluation of Geomorphic Reclamation Performance and Models in the Southwestern United States

M. Stone, J. Stormont, E. Epp, C. Byrne, S. Rahman, R. Powell, W. Rider, and S. Perkins

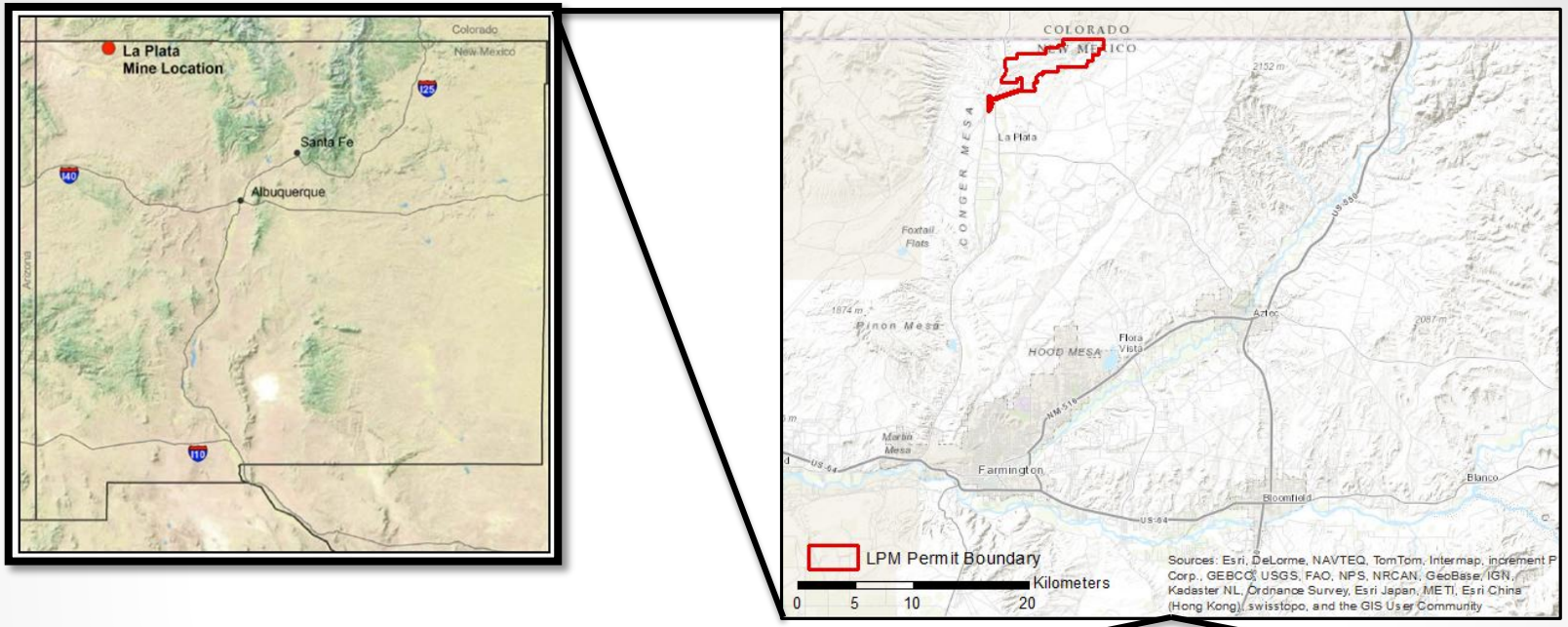
Presented by Colin Byrne, June 5th, 2013

2013 Joint Conference
2nd Wyoming Reclamation and Restoration Symposium and
30th Annual Meeting of the American Society of Mining & Reclamation

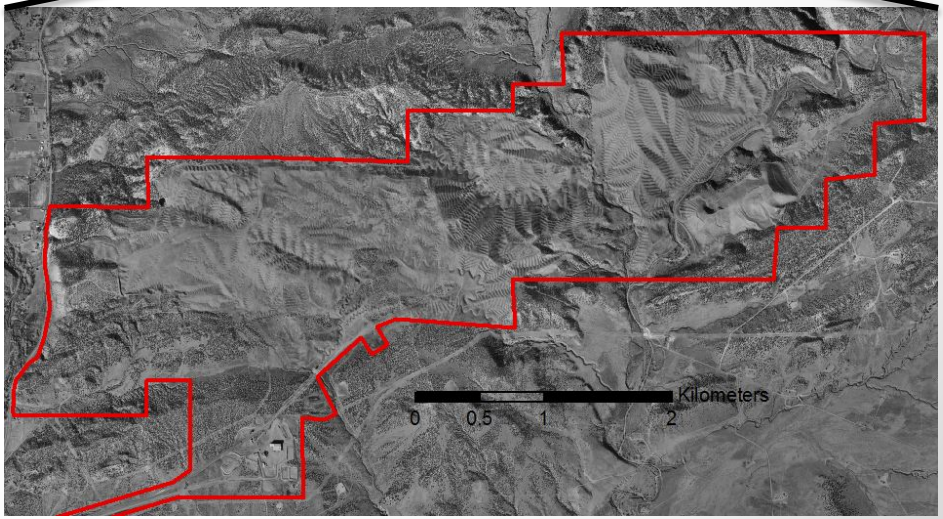
Study Background

- 2 year study began in August 2012
- Funded by Office of Surface Mining
- Working in collaboration with BHP-Billiton
  - La Plata Mine
- Results and Conclusions will be developed as research continues

La Plata Mine, New Mexico



- Open pit mine that produced coal until 2002
- Over 800 hectares in size
- Approx. 6000 ft elevation
- Approx. 12 inches of annual precipitation
- Reclaimed using GeoFluv™ approach



Objectives

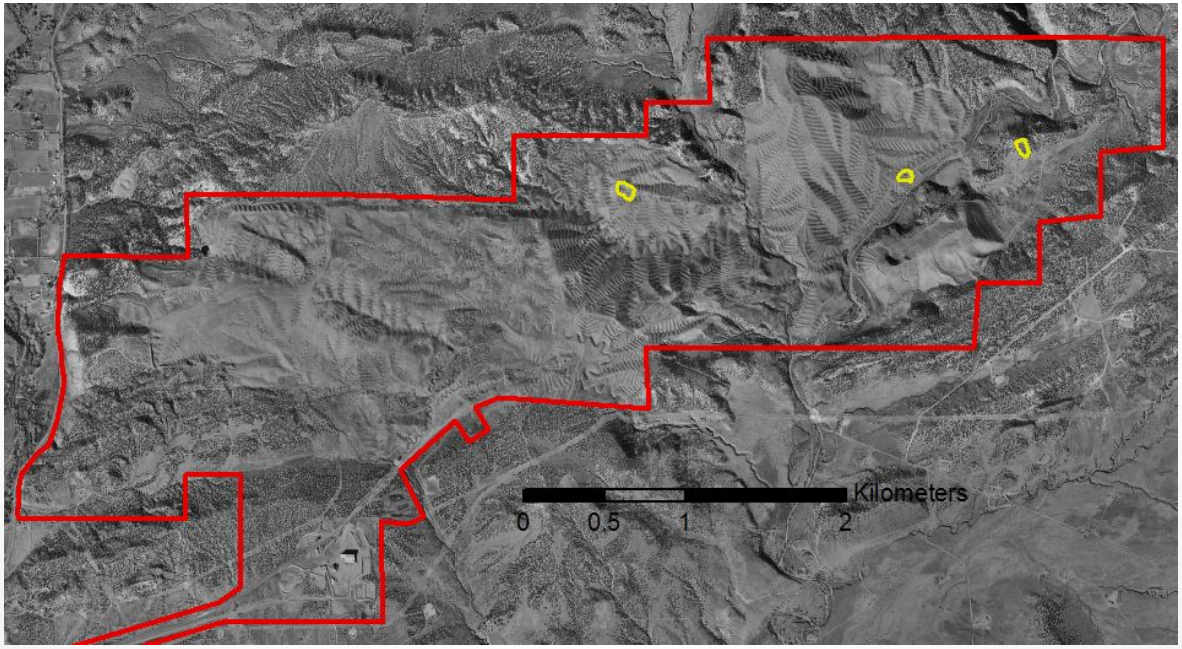
1. Evaluate the effectiveness of geomorphic reclamation at producing conditions that closely mimic those found in natural analog basins and channels

2. Assess the effectiveness of watershed models in informing the geomorphic reclamation process
   - Water Erosion Prediction Project (WEPP)
   - Sediment, Erosion, Discharge by Computer Aided Design (SEDCAD)

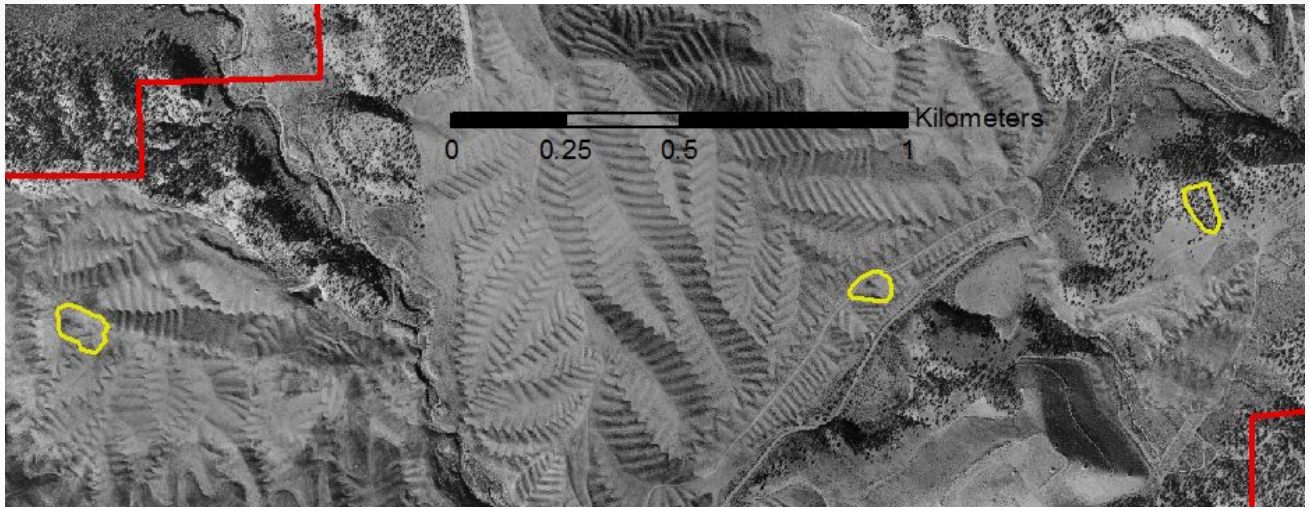
3. Investigate the long-term stability of reclaimed land including the impacts of extreme events

Selection of Watersheds

- Three watersheds selected due to similarities in slope, aspect, and size
  - Well Vegetated Reclaimed Site
  - Moderately-Vegetated Reclaimed Site
  - Undisturbed Natural Site
- Watersheds sit within 2.5 km of one another



Selection of Watersheds



Moderately Vegetated Reclaimed Watershed

Well Vegetated Reclaimed Watershed

Undisturbed Natural Watershed

Objective 1

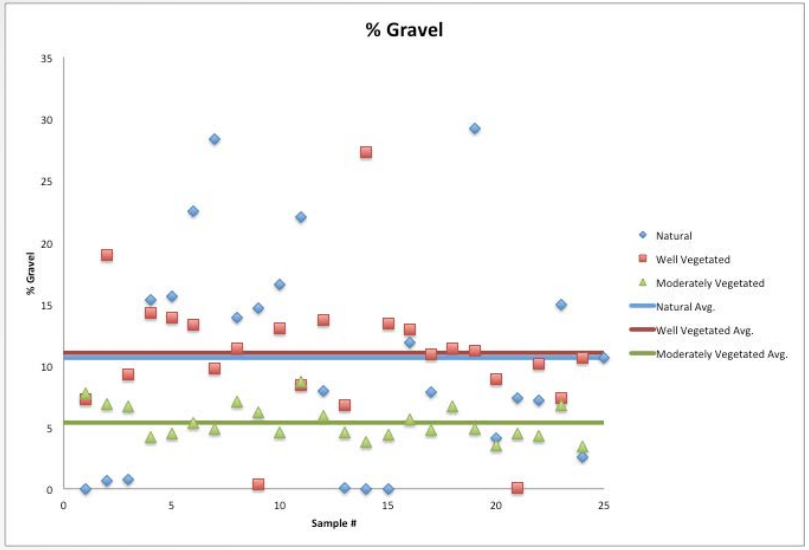
- Evaluate the effectiveness of geomorphic reclamation at producing conditions that closely mimic those found in natural analog basins and channels

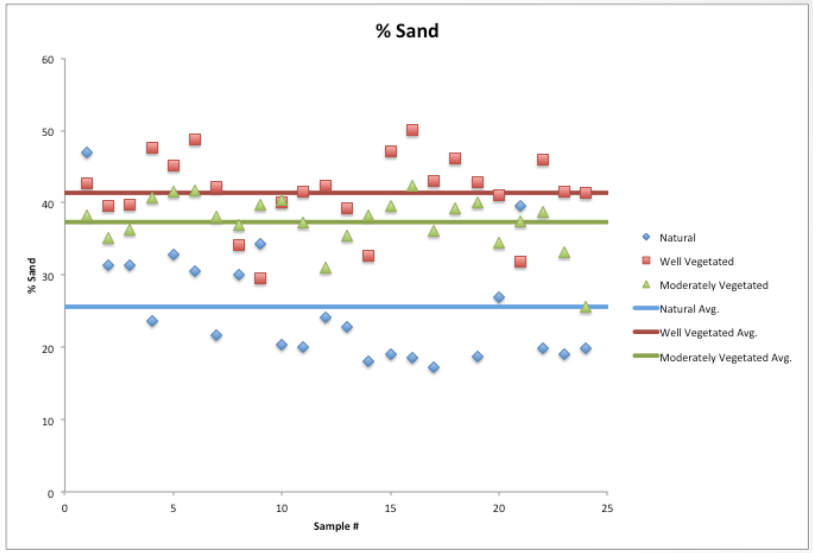
Field Sampling

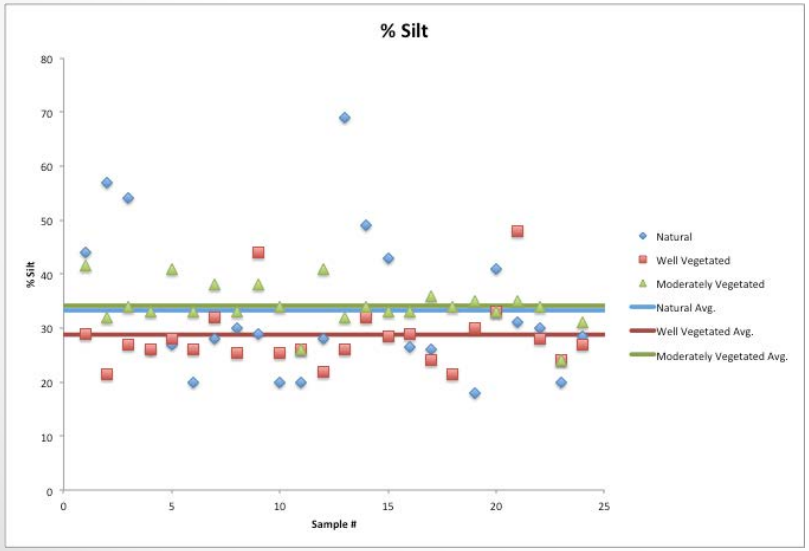
- In situ soil measurements
  - Temperature
  - Moisture content
  - Vegetation
- Disturbed soil sampling
  - Particle size distribution
  - Specific gravity
  - Organic matter
  - Cation exchange capacity
- Undisturbed soil sampling
  - Saturated hydraulic conductivity
  - Water retention curves
- Check-dams installed
- V-notch weirs installed

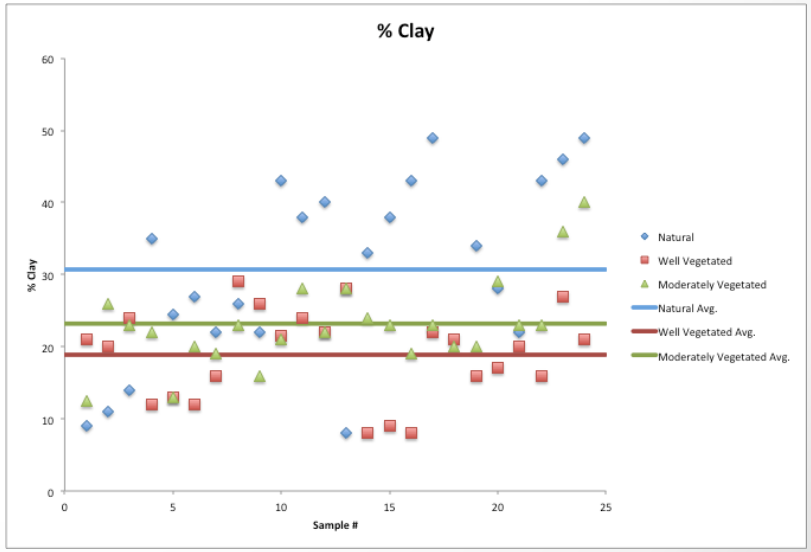
Field Sampling

Field Site Soil Characteristics

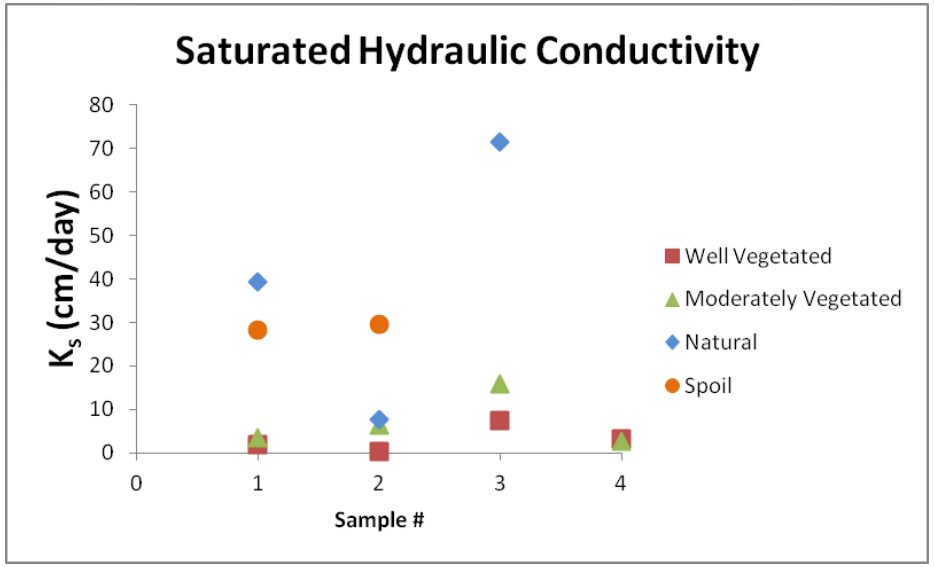


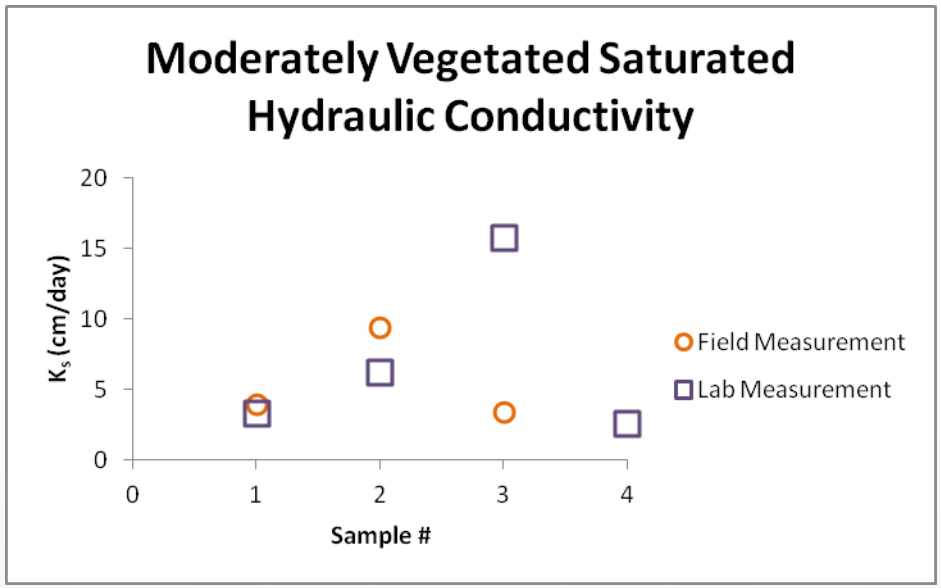






Field Site Soil Characteristics





Objective 2

- Assess the effectiveness of watershed models in informing the geomorphic reclamation process
  - How well do the models predict runoff and erosion totals from sites?
  - How much field collected data is necessary to produce reasonable results?

Water Erosion Prediction Project (WEPP)

- Development by the USDA began in 1985 to expand upon the Universal Soil Loss Equation (USLE)
  - USLE – gives annual erosion predictions
  - WEPP – spatial and temporal information about erosion and deposition on a hillslope or watershed

Applications of WEPP

- Agricultural Sites
- Forested Sites
- Rangeland Sites
- **Geomorphic Reclamation Sites at La Plata Mine**

WEPP Overview

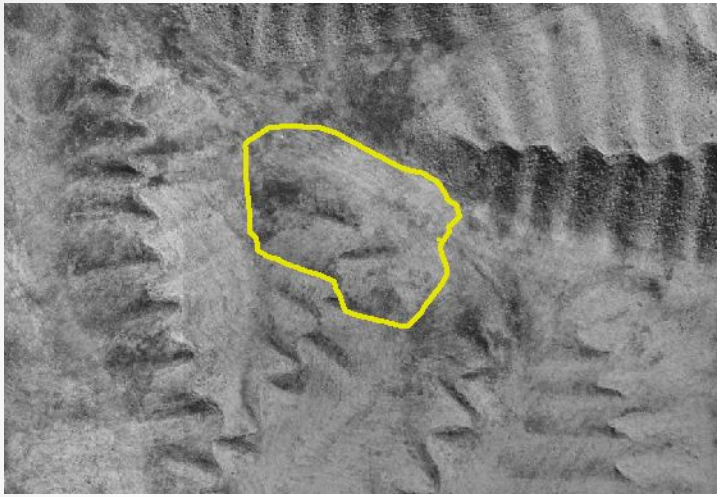
Model Inputs

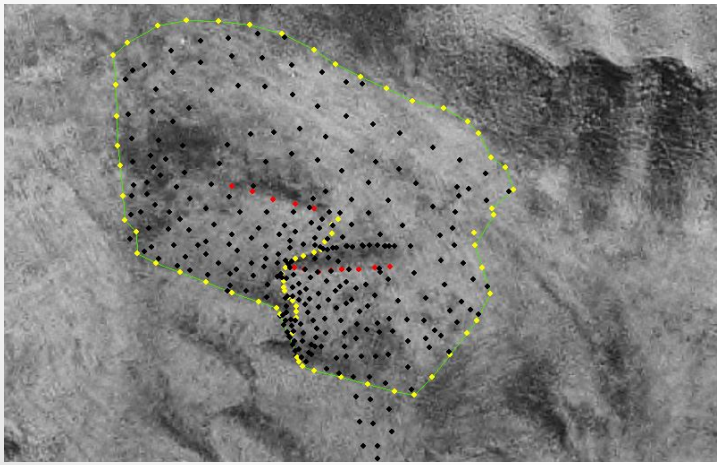
- Define the Topography
  - Hillslope
  - Watershed
    - Channels, hillslope, impoundments, outlets
- Climate data
- Soil data
- Vegetation management

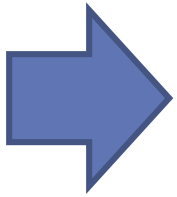
Model Output (annual basis)

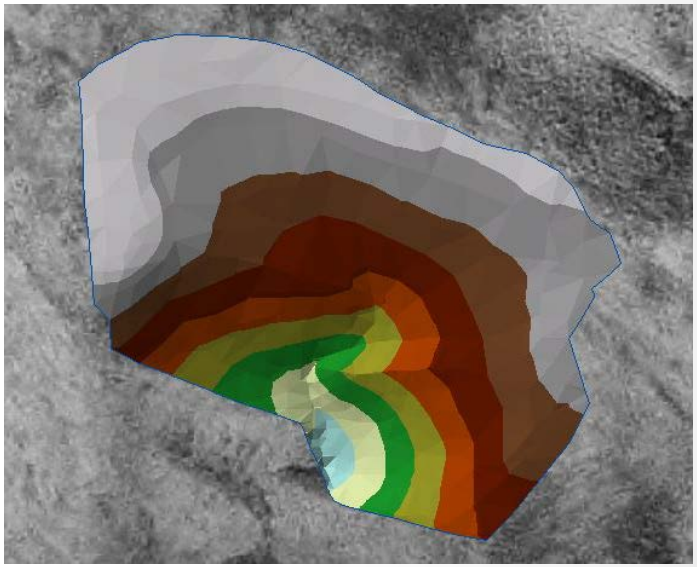
- Runoff Volumes and Hydrographs
- Sediment yields
- Characteristics of Eroded Sediment

Delineation of Watersheds

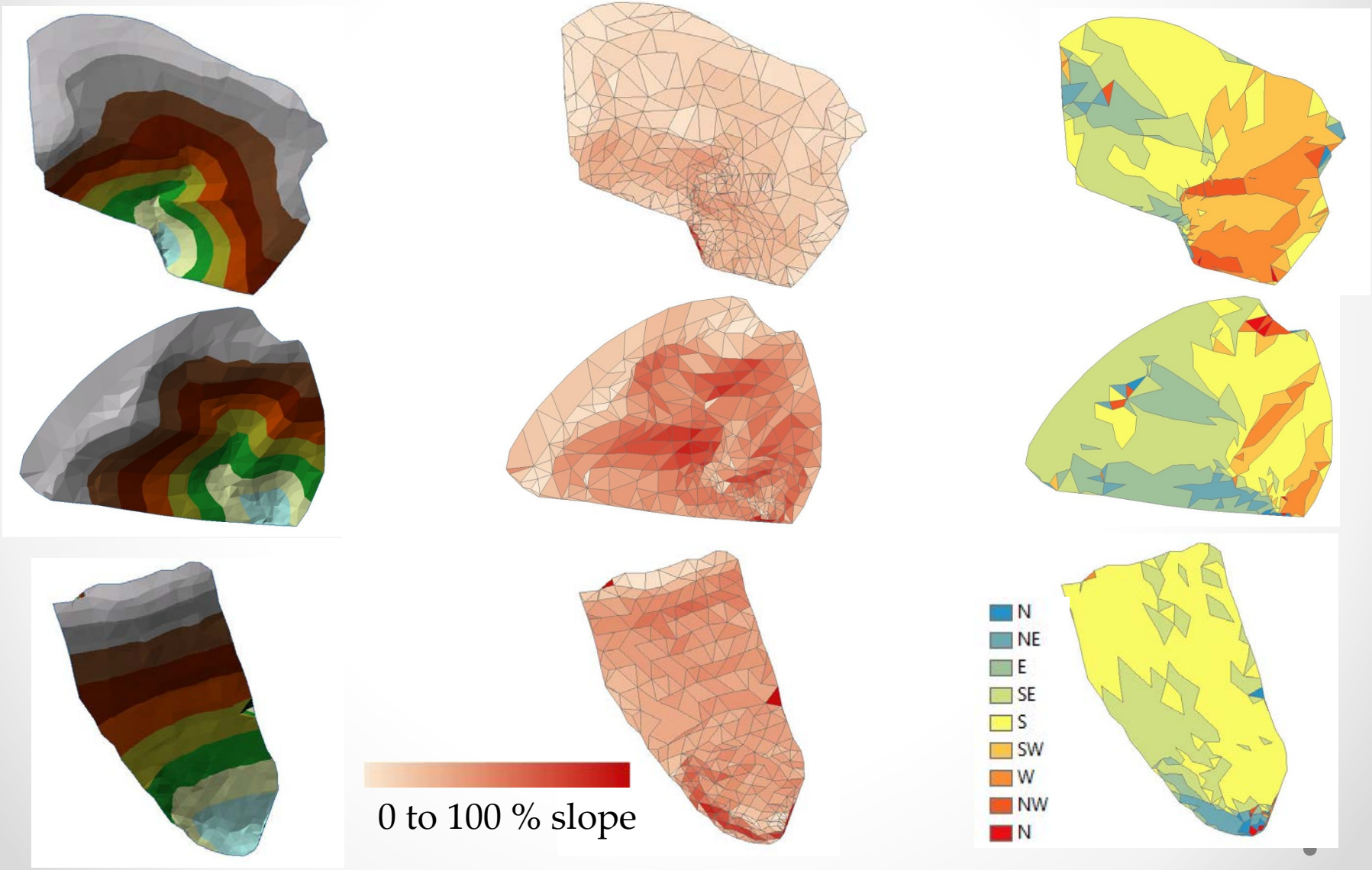




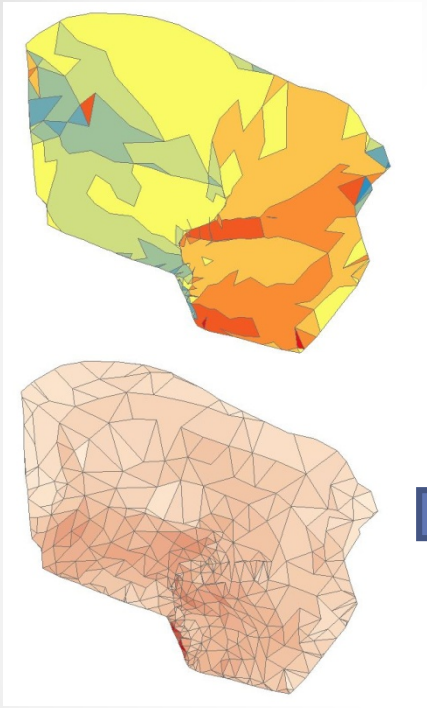


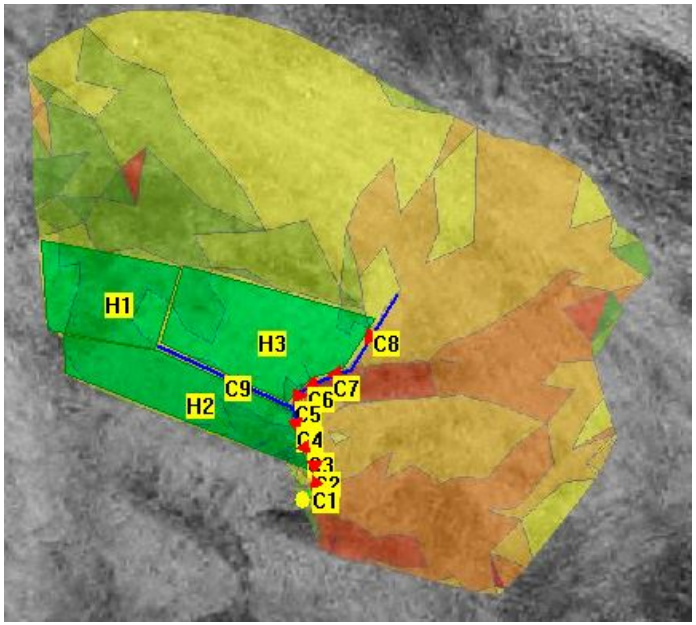


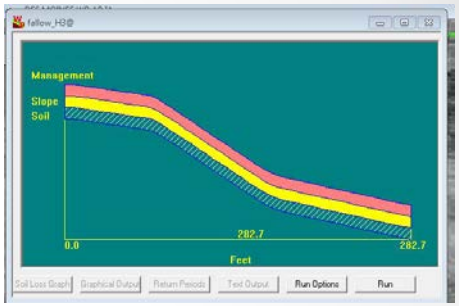
Study Watersheds at La Plata Mine

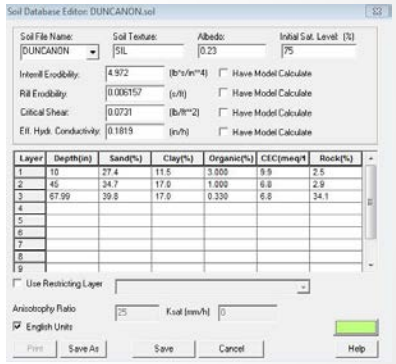


Importing Watersheds to WEPP Model







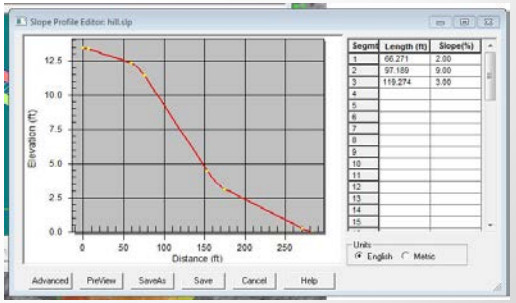


with correction for gravel soil (MV)

	11T	12T	13T	21T	22T	23T	31T	32T	33T	41T	42T	43T
Sand	39.3283	37.7014	37.8349	40.501	42.4084	41.9219	39.0116	38.1055	41.3646	41.2998	38.6637	30.9245
Silt	45.5038	32.2284	35.3698	35.4906	43.4555	35.9029	39.9579	36.0601	39.9787	35.6394	27.9299	44.6334
Clay	15.1679	30.0752	26.7953	24.0084	14.1261	22.1753	21.0305	25.8342	18.6567	23.0608	33.4064	24.4421
	Loam	Clay Loam	Clay Loam	Loam	Loam	Loam	Loam	Loam	Loam	Loam	Clay Loam	Loam

with correction for gravel (WV)

	11T	12T	13T	21T	22T	23T	31T	32T	33T	41T	42T	43T
Sand	43.9051	43.8272	41.5656	52.7421	50.0581	53.2526	43.459		48.7952	42.5287	43.2314	45.5388
Silt	31.2837	25.3086	29.7685	30.9218	28.4553	29.9885	37.1397		25.1004	28.7356	27.8384	24.3337
Clay	24.8112	30.8642	28.6659	16.3361	21.4866	16.1476	19.4013		26.1044	28.7356	28.9301	30.1275
	Loam	Clay Loam	Clay Loam	Sandy Loam	Loam	Sandy Loam	Loam		Sandy Clay Loam	Clay Loam	Clay Loam	Sandy Clay Loam



Defining Hillslopes

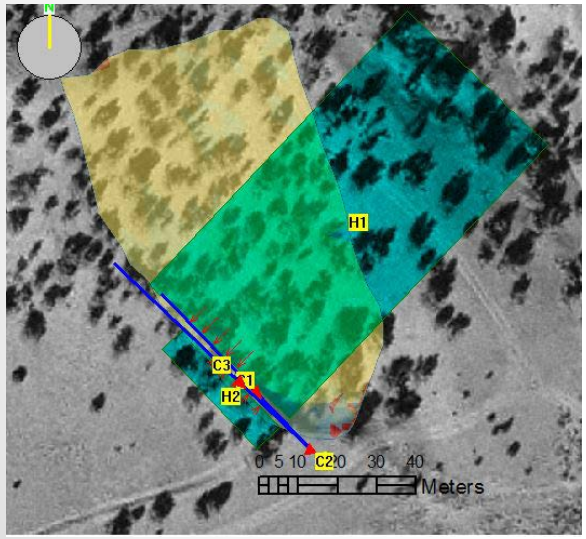
Hillslope defined by cross-section taken in Arc-GIS

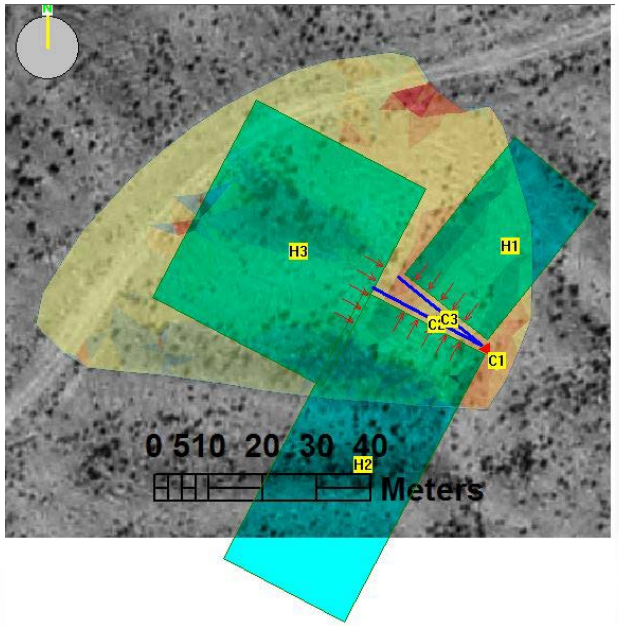
Hillslope defined by 10 equidistant slope points

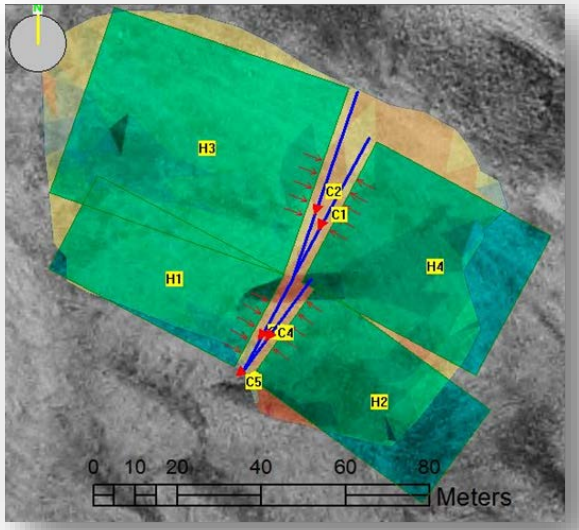
Hillslope defined by simplified S-shape using average slope

WEPP Watershed Approaches

- Natural, Well Vegetated, & Moderately Vegetated
  - Cross-section Hillslope
  - 10 slope points Hillslope
  - Simplified S-shape Hillslope





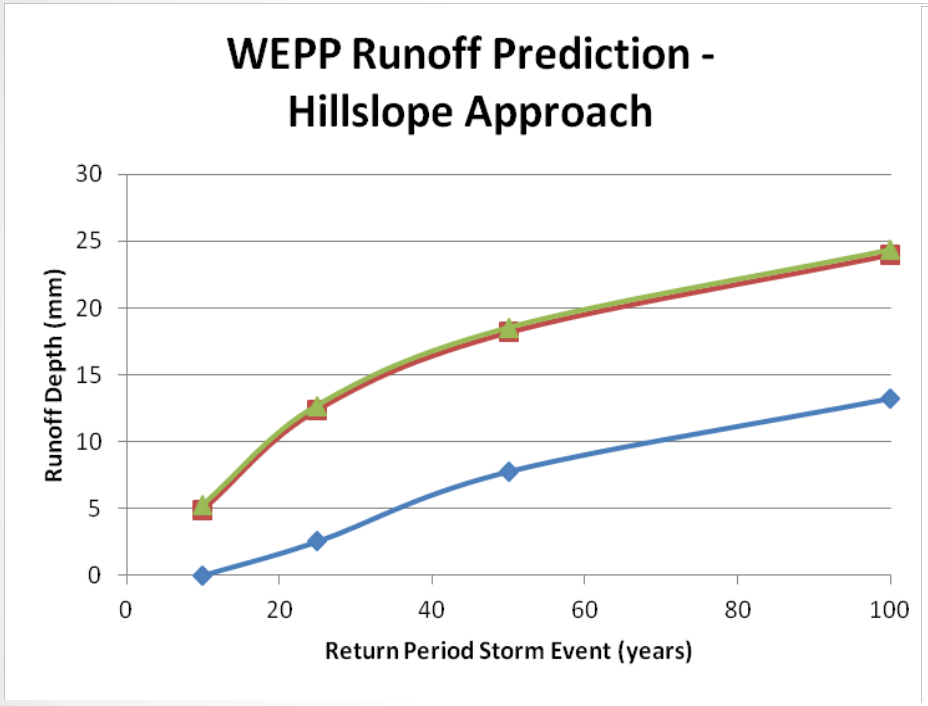


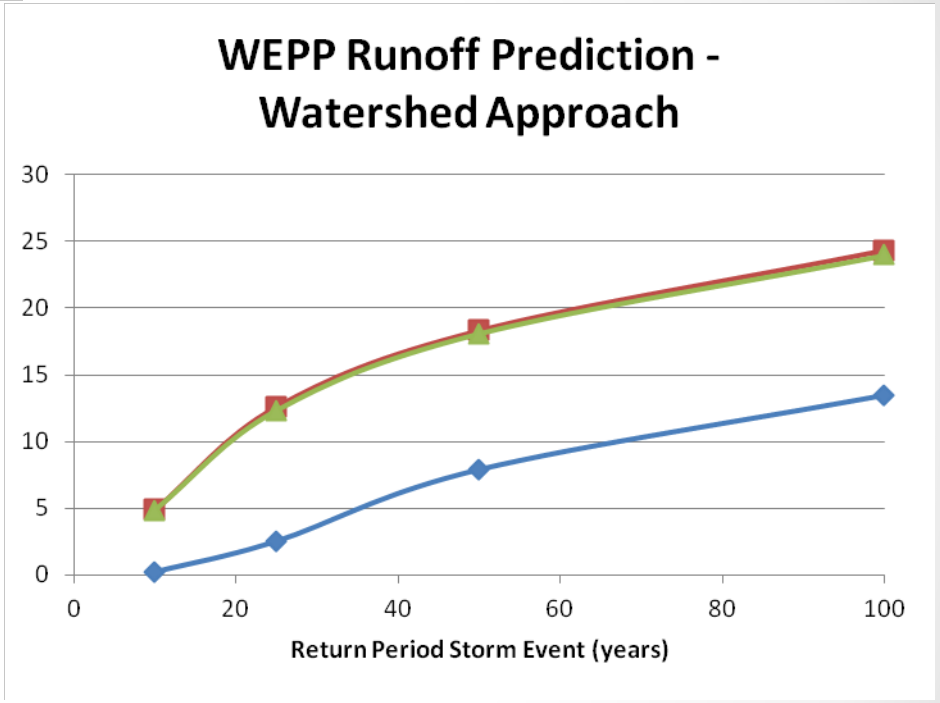
Initial WEPP Results

Average Depth of Eroded Sediment (mm) assuming 1.5 g/cc				
	Storm Frequency (years)			
Well Vegetated	10	25	50	100
Profile Hillslope	70.05	245.27	425.53	658.67
10 point Hillslope	0.08	0.25	0.38	0.51
Simplified Hillslope	0.04	0.16	0.26	0.36
Watershed - Profile	0.45	1.33	2.13	2.99
Watershed - 10 point	0.03	0.12	0.19	0.27
Watershed - S simplified	0.03	0.10	0.17	0.23

- WEPP model unable to handle the complexities of the cross-sectional description of the hillslope

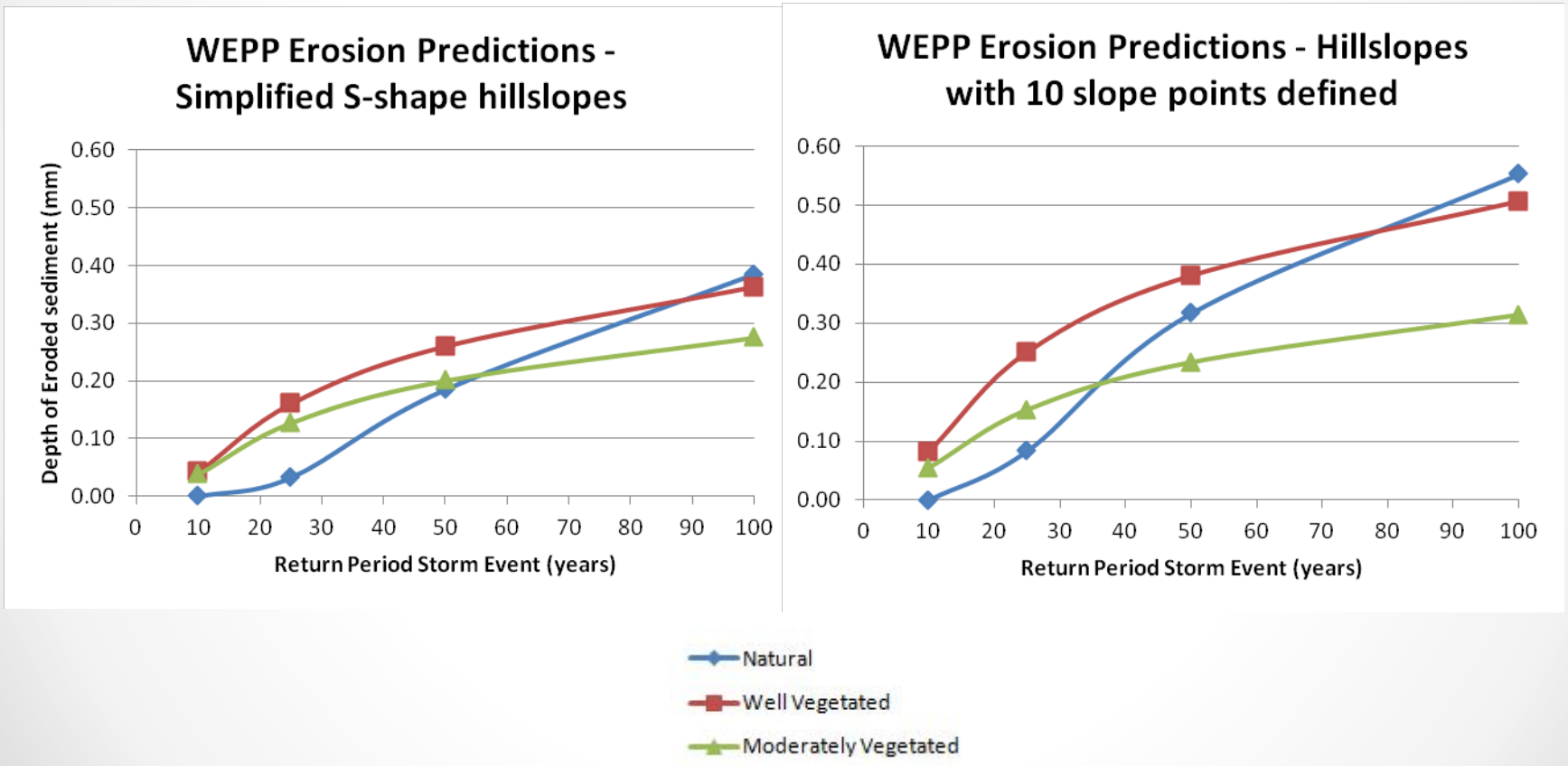
WEPP Runoff Prediction



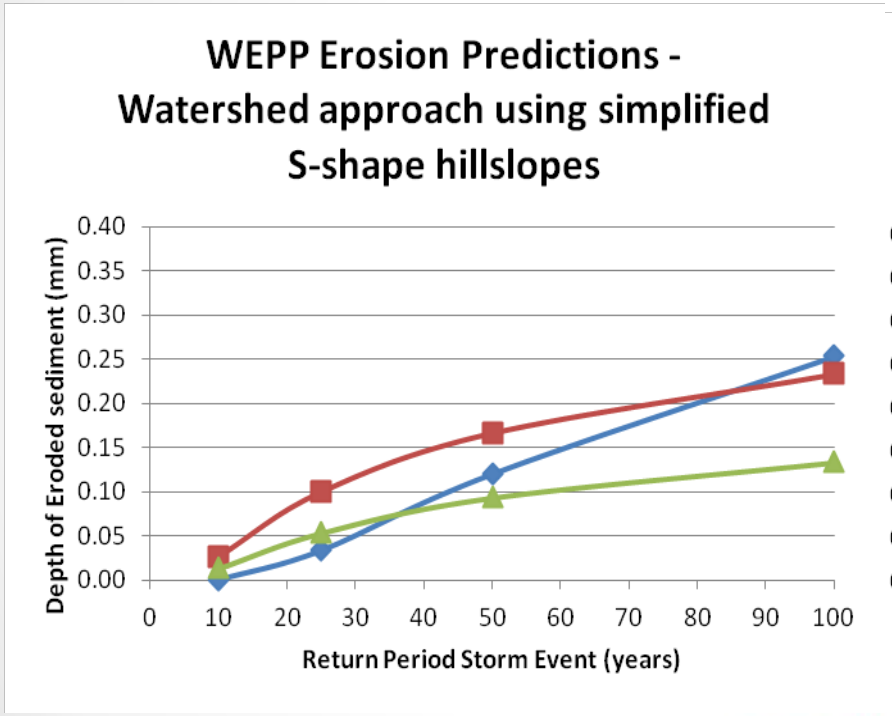


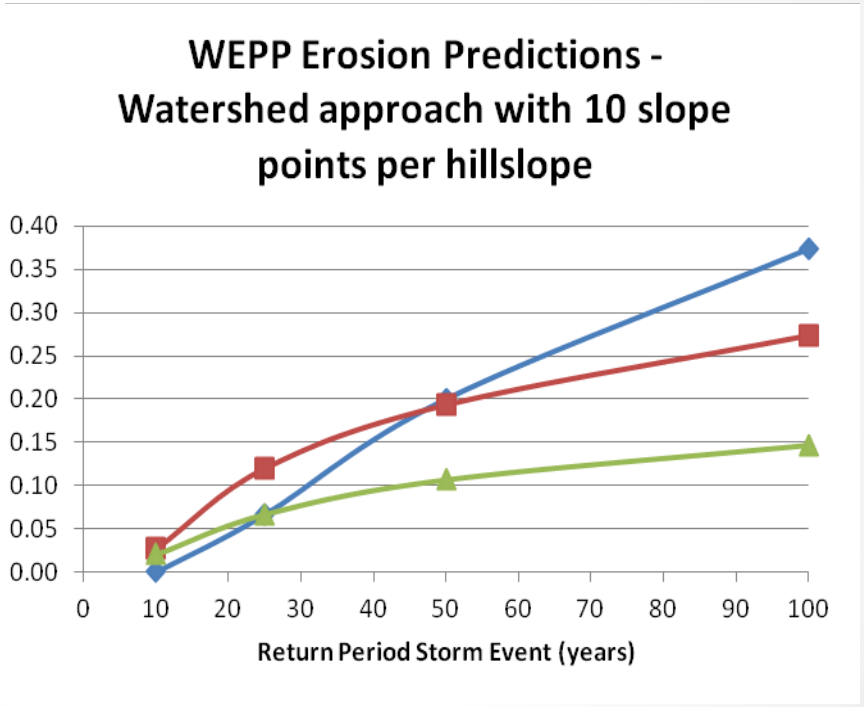
Natural
Well Vegetated
Moderately Vegetated

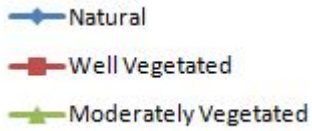
WEPP Erosion Prediction – Hillslope Approaches



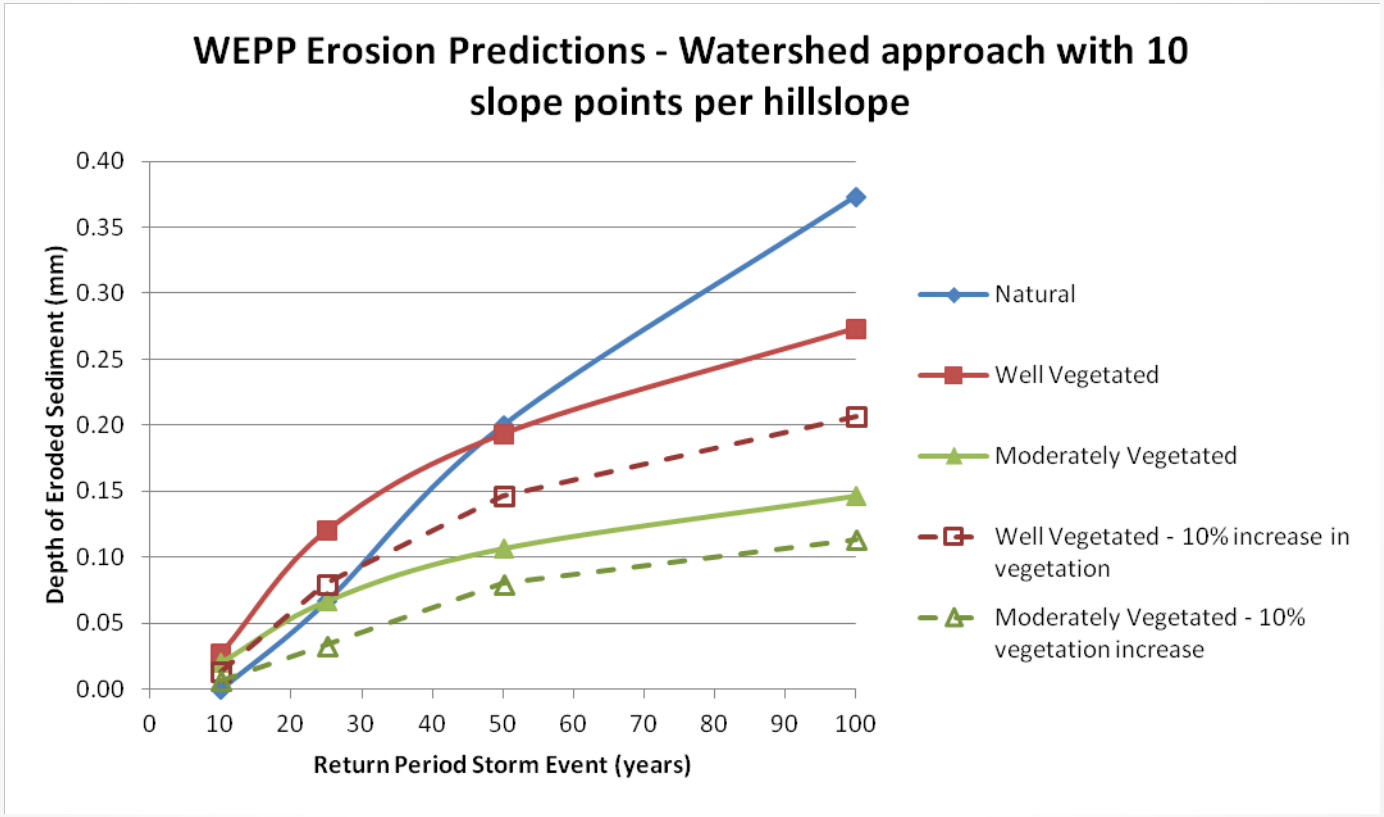
WEPP Erosion Prediction – Watershed Approaches





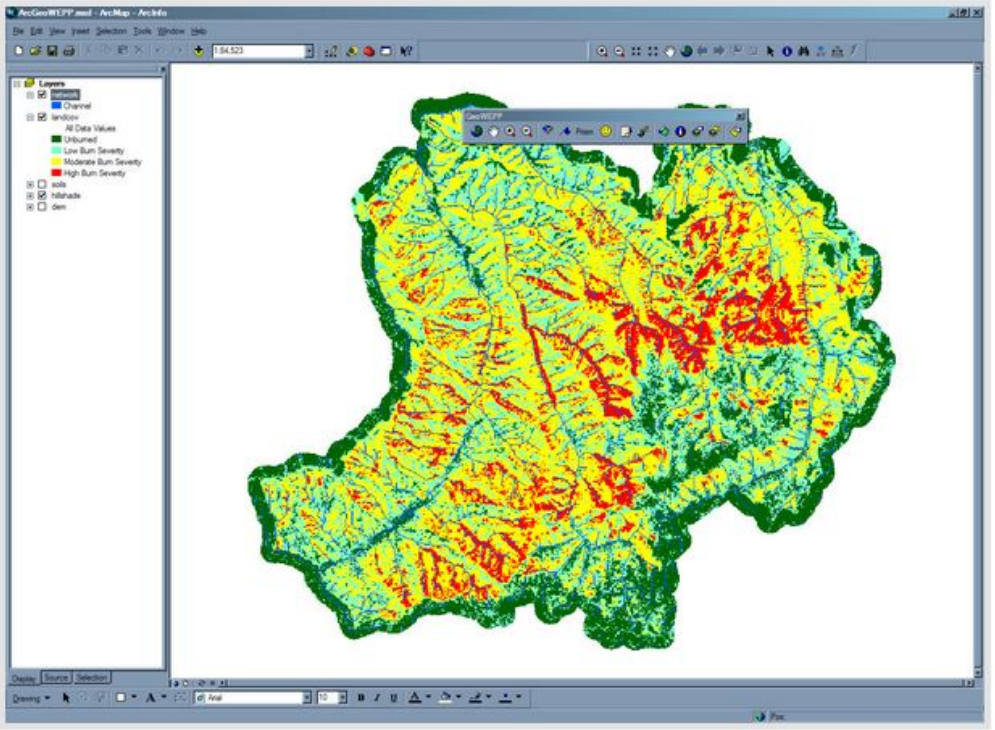


Effects of Increased Vegetation at Reclaimed Sites



Future Work

- Future research using GeoWEPP will aid in more accurate watershed delineation methods.
  - WEPP is limited to rectangular shaped hillslopes in addition to limited access points along channels



Objective 3

- Investigate the long-term stability of reclaimed land including the impacts of extreme events

Conclusions

- Early model runs hint that geomorphic reclamation sites are successful in producing erosion totals similar to natural basins
- WEPP hillslopes and watersheds can not be too complex, as the model will over predict sediment yields
- Check-dams and V-notch weirs should help to inform the accuracy of model predictions, as well as aid in calibration of model

Acknowledgements

THE UNIVERSITY of NEW MEXICO

Questions?