Evaluating Sediment Production from Watersheds at La Plata Mine

20 May 2014
Advances in Geomorphic Reclamation at Coal Mines
Albuquerque, NM

Nicholas Bugosh, GeoFluv - Parma, OH

And

Edward Epp, BHP Billiton, New Mexico Coal Company-Farmington, NM

The Problem

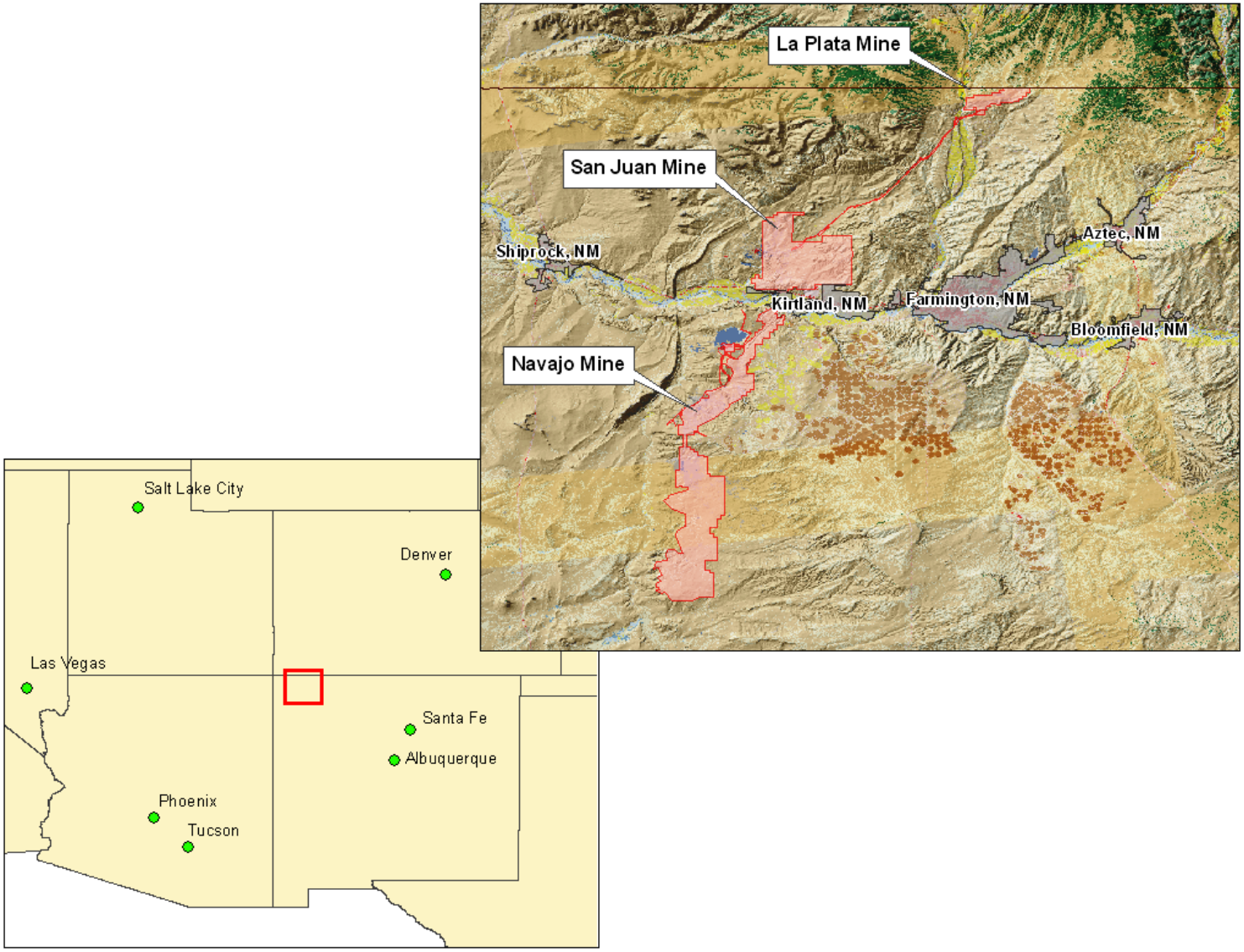
- Quantify sediment production as tons/acre
- Conduct study over years, make a tons/acre/year sediment production estimate
- Quantify the difference in sediment production values among various subwatershed types:
  - Natural - N7
  - GeoFluv with topdressing - MV5
  - GeoFluv with good vegetation - WV3
- Help decision making: storm runoff discharge monitoring duration, when bond release criteria are satisfied, etc.

Background

- How does *GeoFluv*™ landform design work? Asks: What would be a stable, "mature" natural landform?

- Input Parameters:
  - Post-Mining 3D Ground Surface
  - 3D Ground Surface Surrounding Project
  - Bankfull and Floodprone Precipitation, Runoff Coefficient, etc.
  - Drainage Density, Ridge to Head of Channel Distance, etc.
  - And many others

BHP Billiton - La Plata Mine Study Site

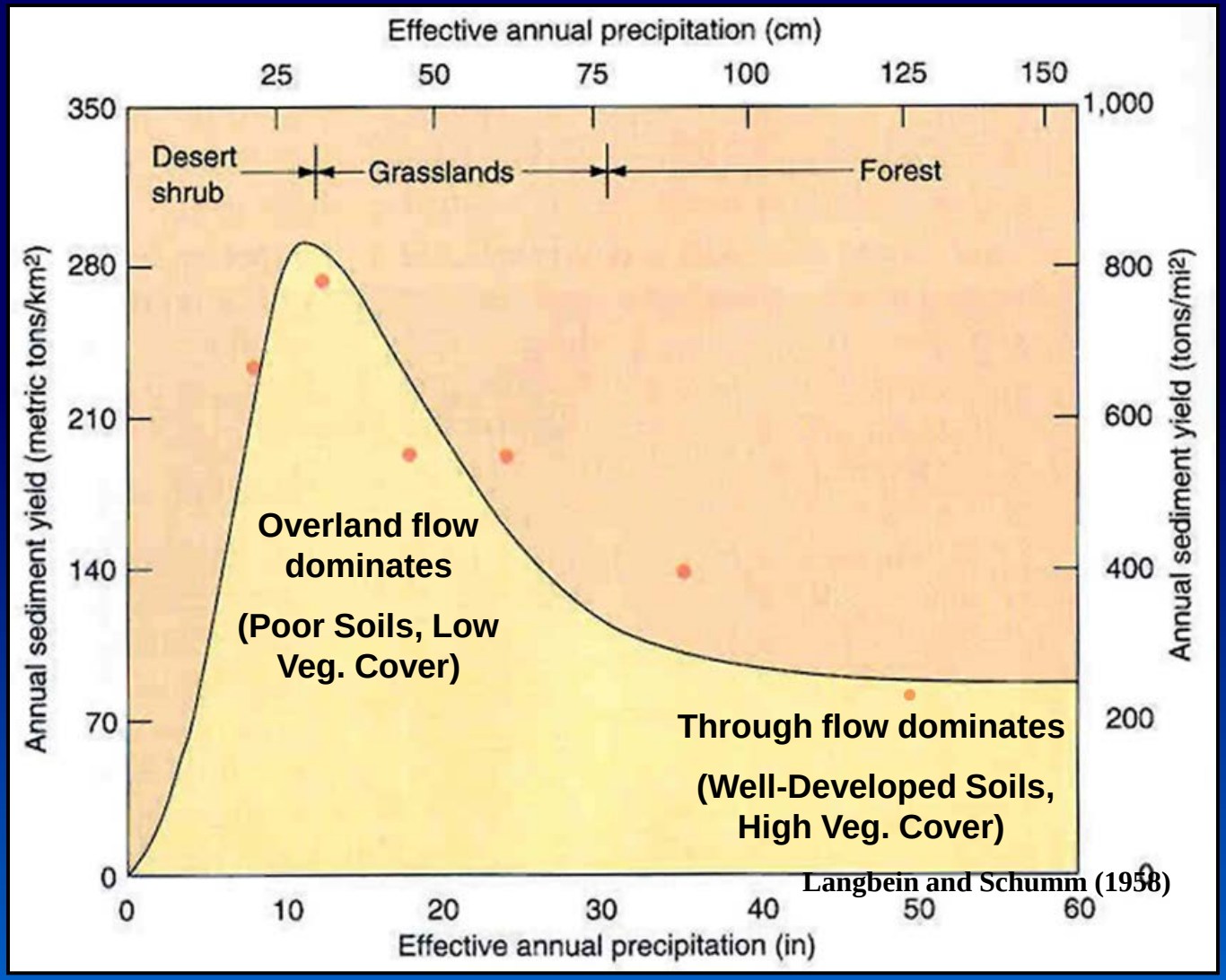


La Plata Mine Environment

- Elevations: ~ 1,795 to 1,892 m (5,890 - 6,210 ft)
- Annual precipitation: 30.5 to 35.6 cm (12 - 14 in)
- Thin and sandy soils, bedrock crops out regularly
- Vegetation sparse: bunch grasses, forbes, stands of piñon pine and juniper
- High, semi-arid, highly erosive terrain

Precipitation, Vegetation, and Soil Type Control Sediment Yield:

Sediment Yield *DECREASES* With Increasing Precipitation



Langbein and Schumm (1958)

* Graph Derived From 94 Stream Monitoring Stations Grouped in Precipitation Classes. Similar Results from 163 Sediment Pond Surveys

Natural TSS Values

- McDermott Arroyo:
  - ephemeral channel
  - 360 km^2 (139 mi^2) watershed area
  - 8 September 2005 TSS samples average 42,650 mg/L
- Values are typical for higher-order native ephemeral channel values
- First order ephemeral channel 660 mg/L

Previous Erosion and Sediment Monitoring

- ~ 6 precipitation events / year generate discharge
- Events typically during the night and early morning
- Representative sampling *during* storms is difficult
- Runoff drains to ponds, sediment collects
- Evaluations of observable erosion *are* possible after every storm

Qualitative Erosion Monitoring (NM MMD)

‘several other rains totally approximately 78 millimeters (3 in) within one week’

‘underground mine shut down due to flooding. . .had to send in scuba diver’

***‘only one noticeable erosion feature* …which occurred on the steepest slope and was predicted in the design’**

‘no need to complete any stabilization of this one minor feature’

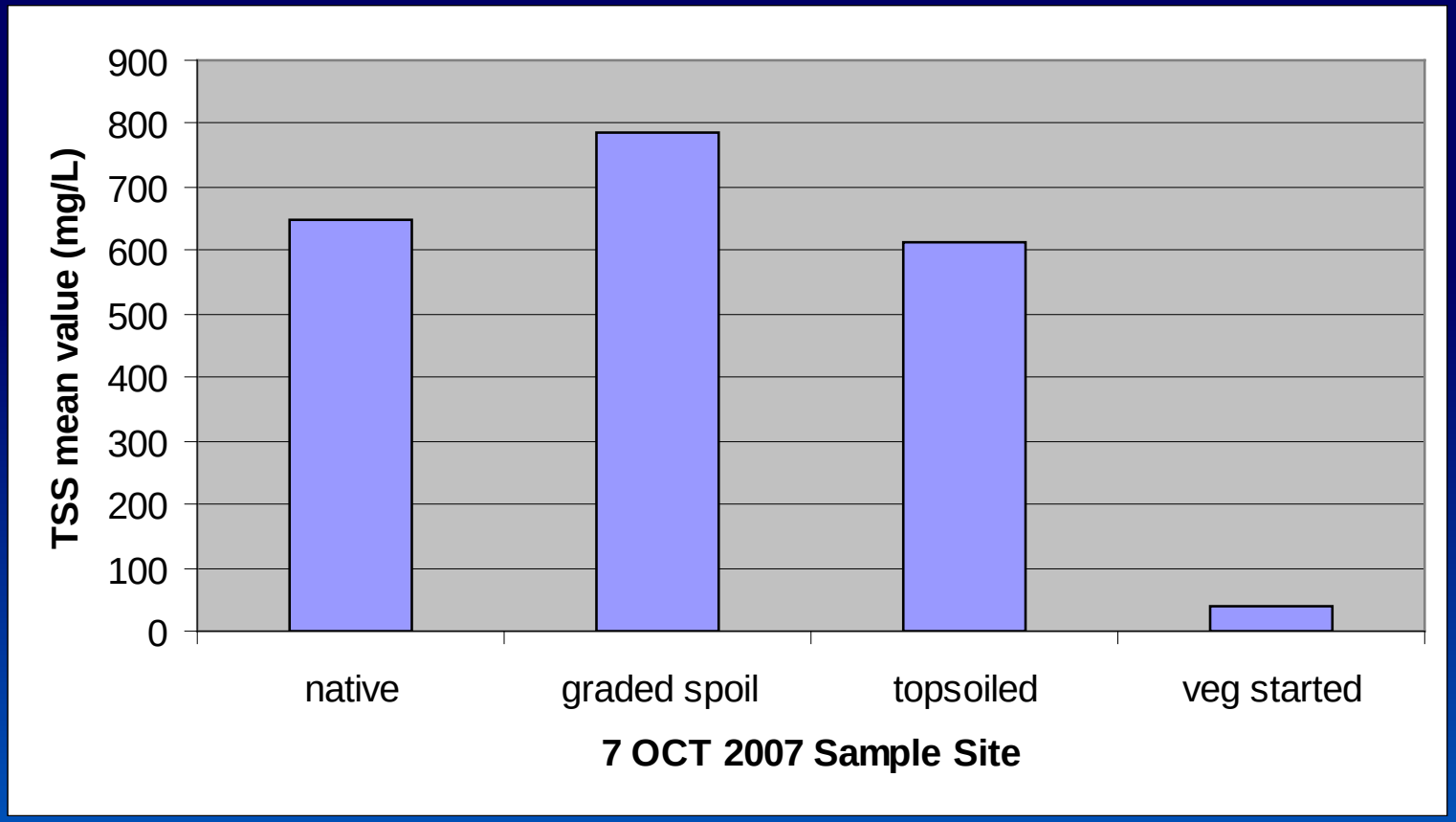
‘All of the drainage channels…stable with minor scouring and deposition occurring as predicted and designed’

‘The most remarkable result was that the impounded water resulting from the rain event was clear. *This is the first time I have witnessed clear water coming off reclaim in 18 years of inspecting’*

17 Sept 2002 Cottonwood reclamation west storm surge basin as Inspector Robert Russell saw it

Previous Erosion and Sediment Monitoring

Storm Water: Total Suspended Sediment at Native and GeoFluv-designed sites



Previous Erosion and Sediment Monitoring

- **Results strongly suggested GeoFluv-designed landform with topsoil cover can control erosion sufficient to meet water quality goals**
- **Did not tell the *soil volume or mass* involved**
- **Did not directly quantify actual sedimentation**
- **Did give some indication of the erosion control benefit of this geomorphic approach**
- **‘Topsoiled and re-vegetated’ TSS values *were* order of magnitude < ‘native’ sample**

Project Setup

Compared *actual* sediment production from constructed GeoFluv designs to adjacent undisturbed-by-mining, native lands and studied the results.

Study includes test subwatersheds that are differentiated as:

- **Native (undisturbed by mining) – N7**
- **GeoFluv design with topdressing and poor to moderate vegetation MV5**
- **GeoFluv design with topdressing & significant vegetation establishment – WV3**

Project Setup

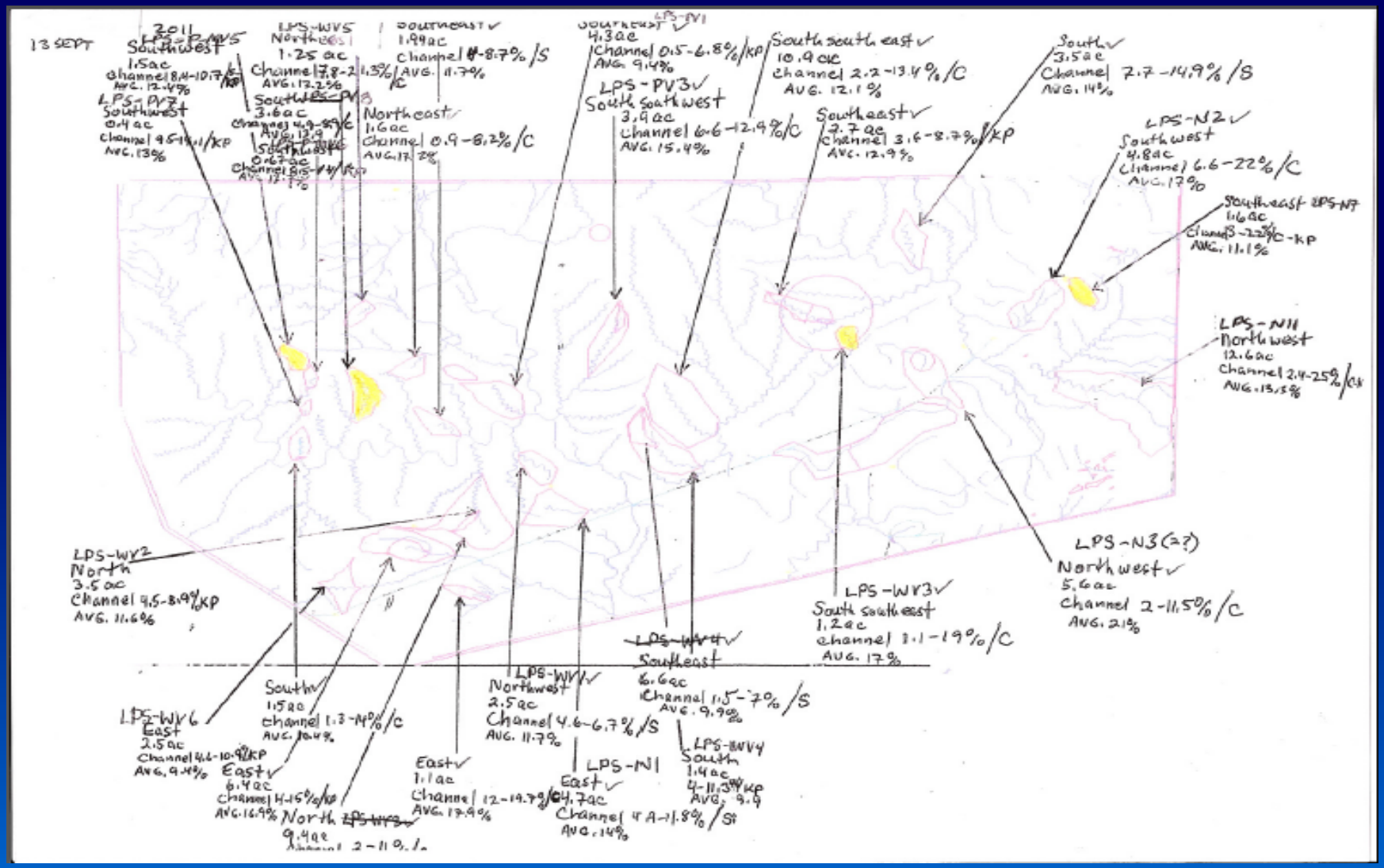
- Compare actual sediment production from constructed GeoFluv designs to adjacent undisturbed-by-mining, native lands

  Located Three Watersheds with Similar:

  - Area (acres) – N7 1.6 MV5 1.5 WV3 1.2
  - Aspect – N7 SE MV5 SW WV3 SSE
  - Avg slope (%) – N7 11.1 MV5 12.4 WV3 17.0
  - Range in slope – N7 3-22 MV5 8.4-10.7 WV3 1.1-19
  - Channel profile – N7 C KP MV5 S WV3 C

Project Setup

Many Sites Were Compared in Adjacent Areas



Project Setup

N7 - Native Subwatershed Site

Project Setup

MV5 - GeoFluv design with topdressing and poor to moderate vegetation

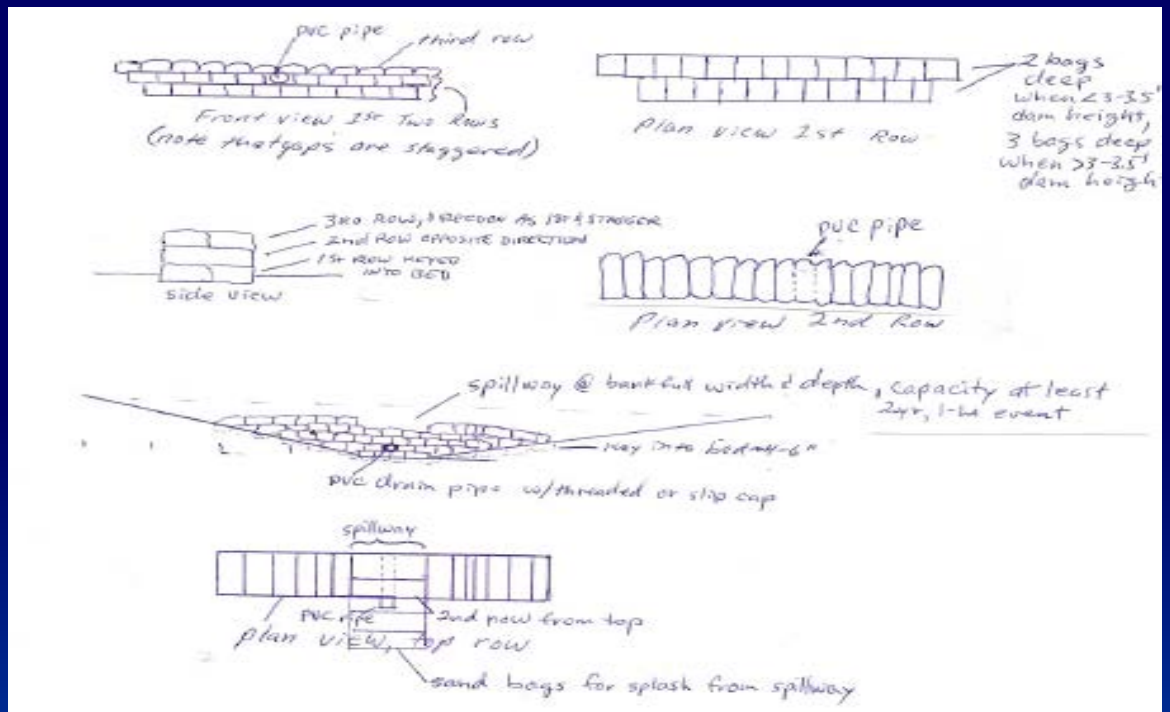
Project Setup

WV3 GeoFluv design with topdressing & significant vegetation establishment –

Project Setup

Construction Specifications:

Design Temporary Sediment Pond Around Bankfull Storm Event



Valley Pond Report LPS-WV3 1.2acres

```
Top of dam elevation: 5920.5000
Top of dam width: 2.0000
Out slope percent grade: 90.91, slope ratio: 1.10
Interior slope percent grade: 90.91, slope ratio: 1.10

Lower left grid corner : 414244.65,2180388.19
Upper right grid corner: 414444.65,2180668.19
X grid resolution: 10, Y grid resolution: 14
X grid cell size: 20.00, Y grid cell size: 20.00

Pond Earthwork Volumes
Total fill: 3,140.9 C.F., 116.33 C.Y.

Pond Storage Volumes
Water Elev    Storage(AcreFt)   (C.Y.)    (C.F.)    Area(Acre)
5918.26       0.04727           76.3      2059.3    0.041
```

- 3.8 ft dam height (spillway) stores 0.04 acre-ft
- 4.0 ft dam height stores 0.08 acre-ft (topography)

Project Setup

Dedicated meteorological station plus recording precipitation gauges in each study subwatershed

Project Setup

Site Layout: survey + reference stakes

Project Setup

Example: Completed WV3

Challenges

Precipitation run on into Study Site

Challenges

Seepage Through Impoundment

Challenges

Top of Stakes Immersed by Pooled Water

Challenges

Frost Heave

Results: N7 Sediment

First event

Results: MV5 Sediment

First event

Results: WV3 Sediment

First event

Calculations

	A	B	C	D	E	F	G	H	I	J	K	L
1	Site	fill (cy)	cut (cy)	import vol (cy)	density (t/cy)	tons	area	tons/ac	period (days)	period (yrs)	T/ac/yr	
2					1.3545							
3	N7 120518-131025	7.32	0	7.32	1.3545	9.91494	1.6	6.196838	525	1.44	4.31	natural land
4	N7 120518-131025E	7.32	0.68	6.64	1.3545	8.99388	1.6	5.621175	525	1.44	3.91	natural land
5	N7 120518-131025E	7.32	0	7.32	1.3545	9.91494	1.6	6.196838	525	1.44	4.31	natural land
6	MV5 120518-131025	2.48	0.01	2.47	1.3545	3.345615	1.5	2.23041	525	1.44	1.55	GeoFluv reclamation with no vegetation
7	MV5 120518-131025E	5.52	0.01	5.51	1.3545	7.463295	1.5	4.97553	525	1.44	3.46	GeoFluv reclamation with no vegetation
8	MV5 120518-131025E	5.52	0	5.52	1.3545	7.47684	1.5	4.98456	525	1.44	3.47	GeoFluv reclamation with no vegetation
9	WV3 120518-131025	4.78	0	4.78	1.3545	6.47451	1.2	5.395425	525	1.44	3.75	GeoFluv reclamation with good vegetation
10	WV3 120518-131025E	3.13	1.11	2.02	1.3545	2.73609	1.2	2.280075	525	1.44	1.59	GeoFluv reclamation with good vegetation
11	WV3 120518-131025E	3.13	0	3.13	1.3545	4.239585	1.2	3.532988	525	1.44	2.46	GeoFluv reclamation with good vegetation
12												
13	N7 120518-120917	2.5	0.86	1.64	1.3545	2.22138	1.6	1.388363	122	0.33	4.15	natural land
14	N7 120518-120917	2.5	0	2.5	1.3545	3.38625	1.6	2.116406	122	0.33	6.33	natural land
15	N7 120518-120917E	2.5	0.8	1.7	1.3545	2.30265	1.6	1.439156	122	0.33	4.31	natural land
16	N7 120518-120917E	2.5	0	2.5	1.3545	3.38625	1.6	2.116406	122	0.33	6.33	natural land
17	MV5 120518-120917	1.28	0.1	1.18	1.3545	1.59831	1.5	1.06554	122	0.33	3.19	GeoFluv reclamation with no vegetation
18	MV5 120518-120917	1.28	0	1.28	1.3545	1.73376	1.5	1.15584	122	0.33	3.46	GeoFluv reclamation with no vegetation
19	MV5 120518-120917E	1.32	0	1.32	1.3545	1.78794	1.5	1.19196	122	0.33	3.57	GeoFluv reclamation with no vegetation
20	MV5 120518-120917E	1.23	0.07	1.16	1.3545	1.57122	1.5	1.04748	122	0.33	3.13	
21	MV5 120518-120917E	1.23	0	1.23	1.3545	1.666035	1.5	1.11069	122	0.33	3.32	
22	WV3 120518-120917	3.48	0.58	2.9	1.3545	3.92805	1.2	3.273375	122	0.33	9.79	GeoFluv reclamation with good vegetation
23	WV3 120518-120917	3.48	0	3.48	1.3545	4.71366	1.2	3.92805	122	0.33	11.75	GeoFluv reclamation with good vegetation
24	WV3 120518-120917E	0.32	0.19	0.13	1.3545	0.176085	1.2	0.146738	122	0.33	0.44	GeoFluv reclamation with good vegetation
25	WV3 120518-120917E	0.32	0	0.32	1.3545	0.43344	1.2	0.3612	122	0.33	1.08	GeoFluv reclamation with good vegetation
26												
27	N7 120518-130509	3.82	0.61	3.21	1.3545	4.347945	1.6	2.717466	356	0.98	2.79	natural land
28	N7 120518-130509	3.82	0	3.82	1.3545	5.17419	1.6	3.233869	356	0.98	3.32	natural land
29	N7 120518-130509E	3.82	0.61	3.21	1.3545	4.347945	1.6	2.717466	356	0.98	2.79	natural land
30	N7 120518-130509E	3.82	0	3.82	1.3545	5.17419	1.6	3.233869	356	0.98	3.32	natural land
31	MV5 120518-130419	1.26	0.03	1.23	1.3545	1.666035	1.5	1.11069	336	0.92	1.21	GeoFluv reclamation with no vegetation
32	MV5 120518-130419	1.26	0	1.26	1.3545	1.70667	1.5	1.13778	336	0.92	1.24	GeoFluv reclamation with no vegetation
33	MV5 120518-130419E	1.31	0	1.31	1.3545	1.774395	1.5	1.18293	336	0.92	1.29	GeoFluv reclamation with no vegetation
34	MV5 120518-130419E	1.31	0	1.31	1.3545	1.774395	1.5	1.18293	336	0.92	1.29	GeoFluv reclamation with no vegetation
35	WV3 120518-130409	1.12	3.47	-2.35	1.3545	-3.18308	1.2	-2.65256	326	0.89	-2.97	GeoFluv reclamation with good vegetation
36	WV3 120518-130409	1.12	0	1.12	1.3545	1.51704	1.2	1.2642	326	0.89	1.42	GeoFluv reclamation with good vegetation
37	WV3 120518-130409E	1.08	0.41	0.67	1.3545	0.907515	1.2	0.756263	326	0.89	0.85	GeoFluv reclamation with good vegetation
38	WV3 120518-130409E	1.08	0	1.08	1.3545	1.46286	1.2	1.21905	326	0.89	1.36	GeoFluv reclamation with good vegetation
39												
40												
41												
42	N7 study period	4.31										

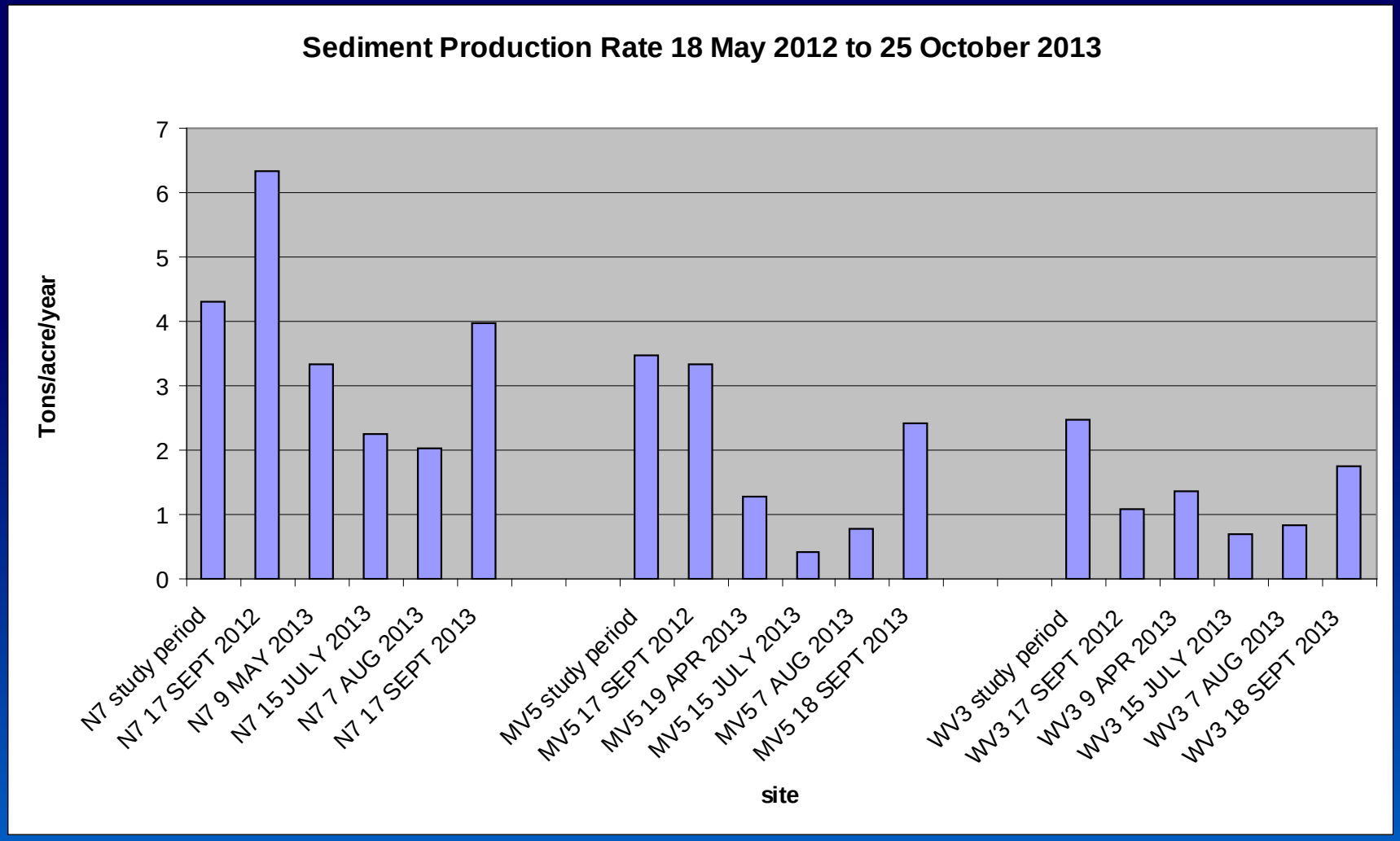
Sediment Production Rate 18 May 2012 to 25 October 2013

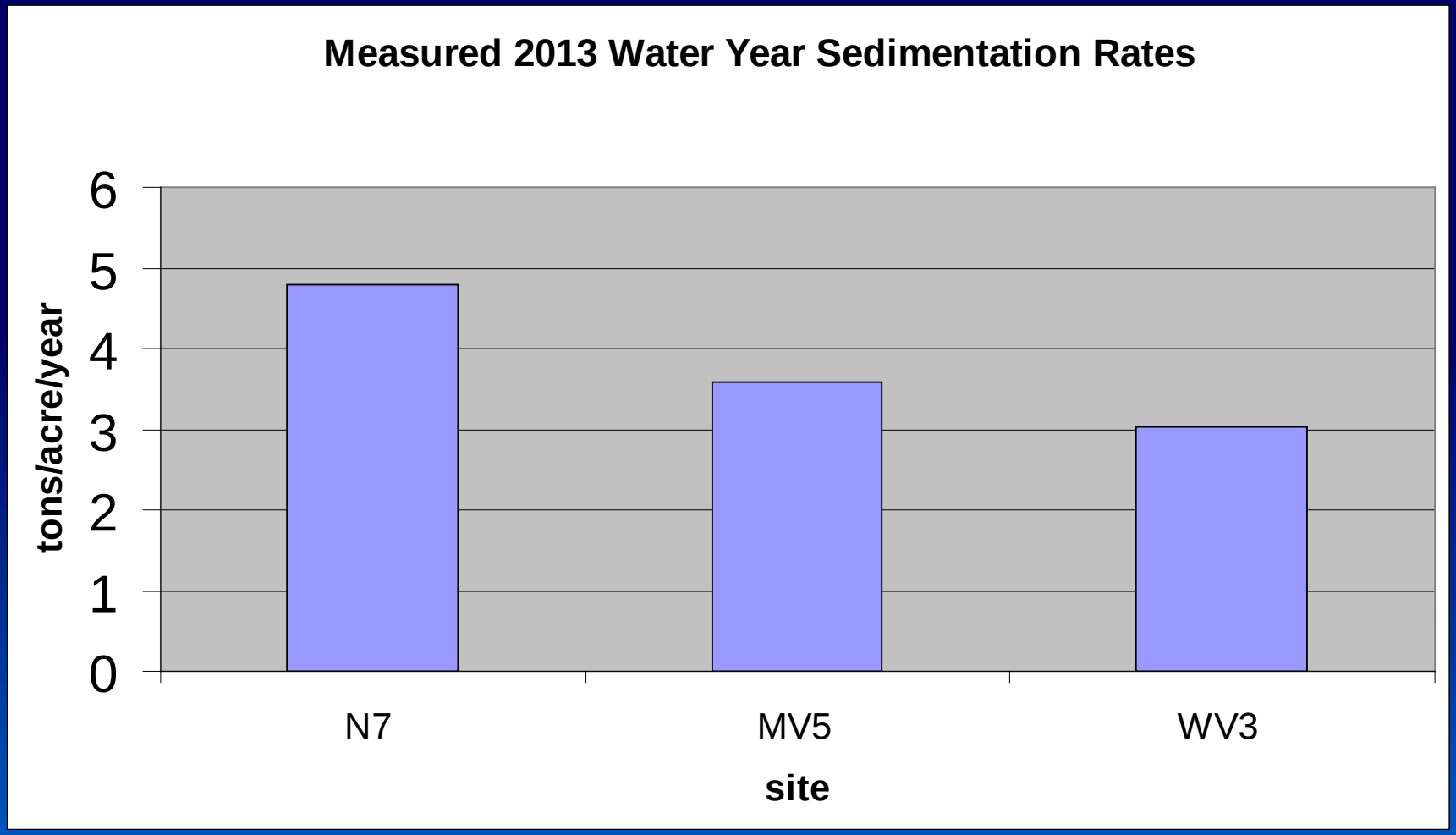
Sheet1 Sheet2 Sheet3

Ready

Variability in Rates Over Time

Relative Trend Similar




Measured 2013 Water Year Sedimentation Rates
tons/acre/year
6
5
4
3
2
1
0
N7
MV5
WV3
site

Conclusions

- Conduct study over years, make a tons/acre/year sediment production estimate
  - N7: 4.79 t/ac/yr
  - MV5: 3.58 t/ac/yr
  - WV3: 3.02 t/ac/yr
- Quantify the difference in sediment production values among various subwatershed types:
  - GeoFluv with topdressing MV5 - 25 percent less than natural N7
  - GeoFluv with good vegetation WV3 - 37 percent less than natural N7

Conclusions

Help decision making: storm runoff discharge monitoring duration, when bond release criteria are satisfied, etc.

- **Rehabilitation sediment discharge is less than natural, monitoring not needed**
- **Bond release criteria related to erosion and sedimentation are satisfied**

Recommendations for Future Study

- Increase number of sites
- Study other site types
- Conduct studies in other regions
- Study the effects of storm intensity and duration
- Develop slope, area, aspect relationships
- Develop monitoring period relationships

Thank You

There is something new happening in landform design.

It's the future. It's natural.

Be a part of it.

GeoFluv™

bhpbilliton
resourcing the future

Water & Earth Technologies, Inc.
Water Resources and Environmental Consulting
1225 Red Cedar Circle, Suite A Fort Collins, CO 80524 (970) 225-6080

Carlson®