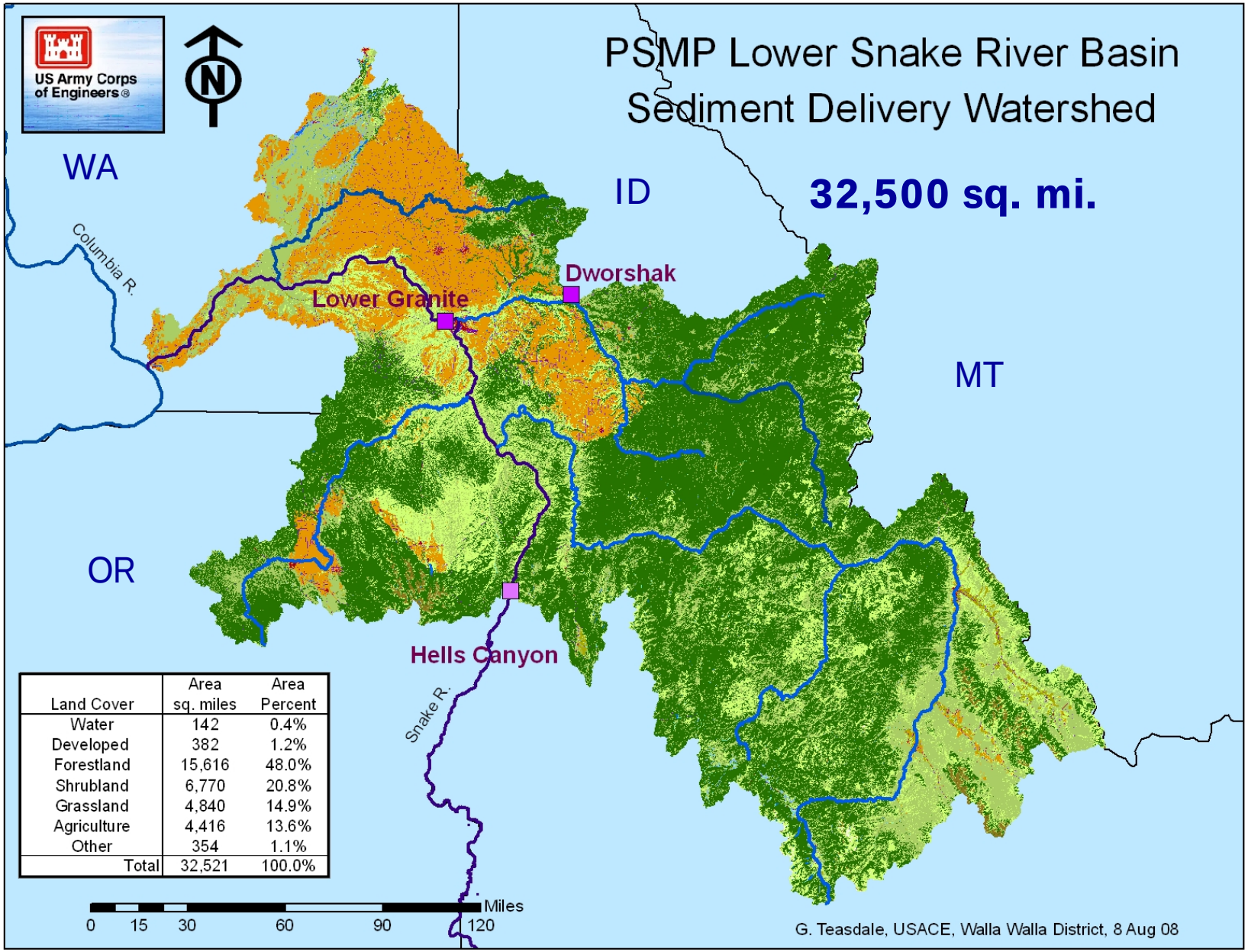
Lower Snake Basin PSMP

Confluence Hydraulic Modeling

and

Sediment Yield Analysis

November 6, 2008


US Army Corps of Engineers®
PSMP Lower Snake River Basin
Sediment Delivery Watershed
32,500 sq. mi.
WA
ID
MT
OR
Columbia R.
Snake R.
Dworshak
Lower Granite
Hells Canyon
Land Cover | Area sq. miles | Area Percent
Water | 142 | 0.4%
Developed | 382 | 1.2%
Forestland | 15,616 | 48.0%
Shrubland | 6,770 | 20.8%
Grassland | 4,840 | 14.9%
Agriculture | 4,416 | 13.6%
Other | 354 | 1.1%
Total | 32,521 | 100.0%
0 15 30 60 90 120 Miles
G. Teasdale, USACE, Walla Walla District, 8 Aug 08

PSMP Authorized Objectives

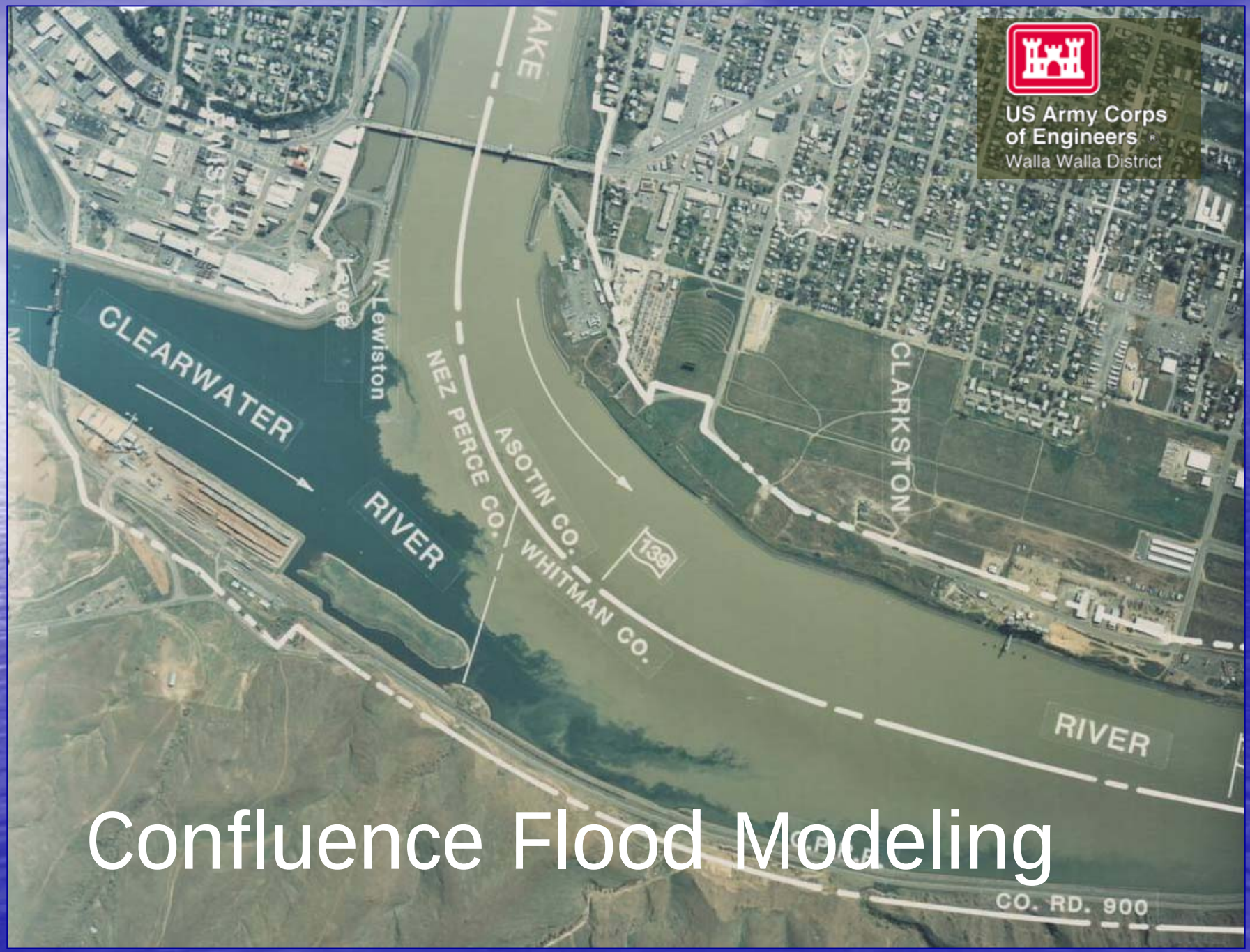
- To maintain the authorized navigation channel and certain publicly owned facilities, including recreation, navigation, and water supply, in the lower Snake River and McNary reservoirs for the next 20 year; and

- To maintain the flow conveyance of the Lower Granite Reservoir for the remaining economic life of the project (through 2074).

US Army Corps of Engineers
Walla Walla District

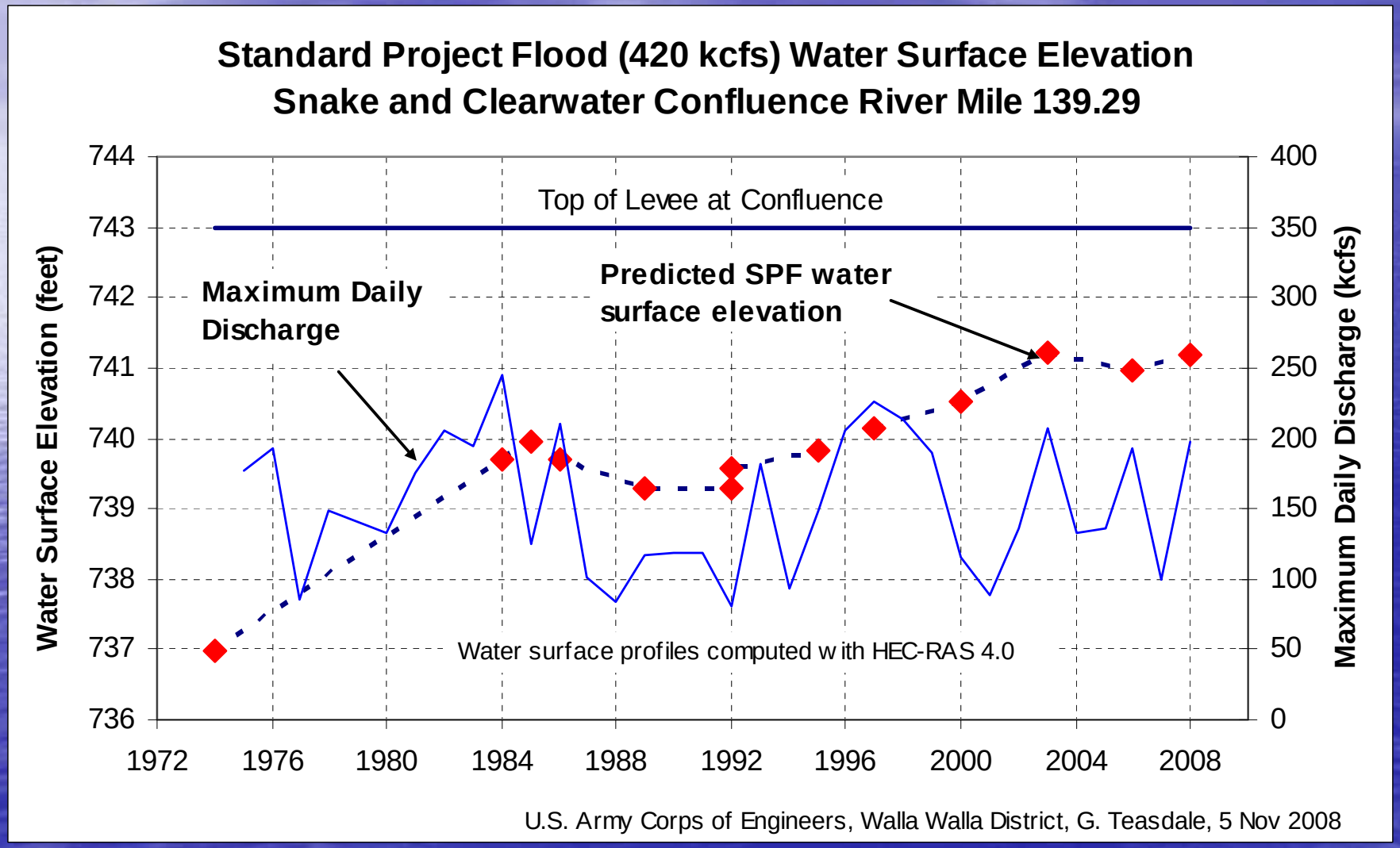
PSMP Analyses

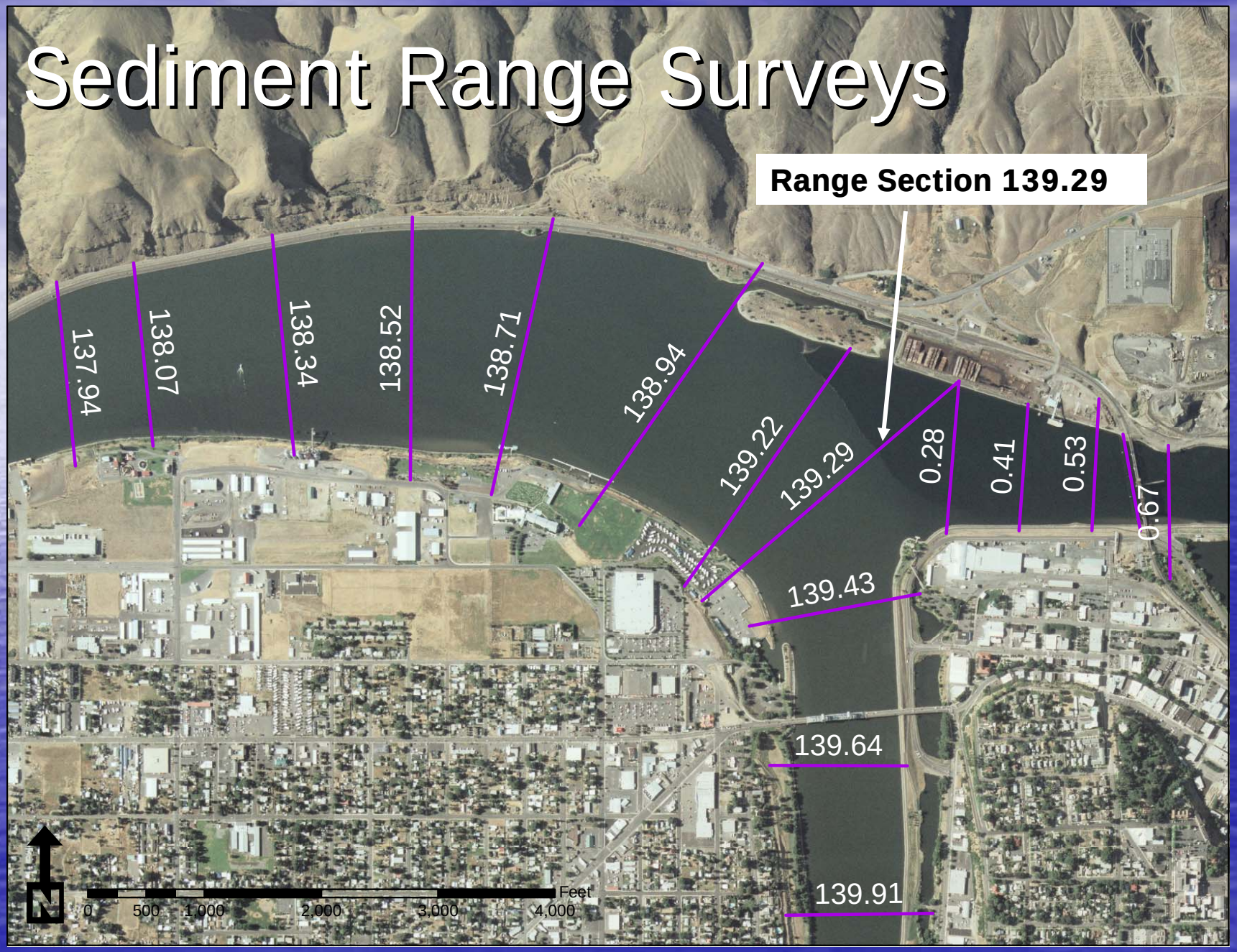
- Confluence Sediment Transport and Hydraulic modeling
- Reanalysis of the Probable Maximum Flood
- Evaluate Watershed Sediment Yield
- Examine Sediment Management Measures
- Lewiston Levee Risk Assessment
- In-Water Disposal Site Bathymetry
- Upland Disposal Site Evaluation
- Alternative Upland Disposal Methods

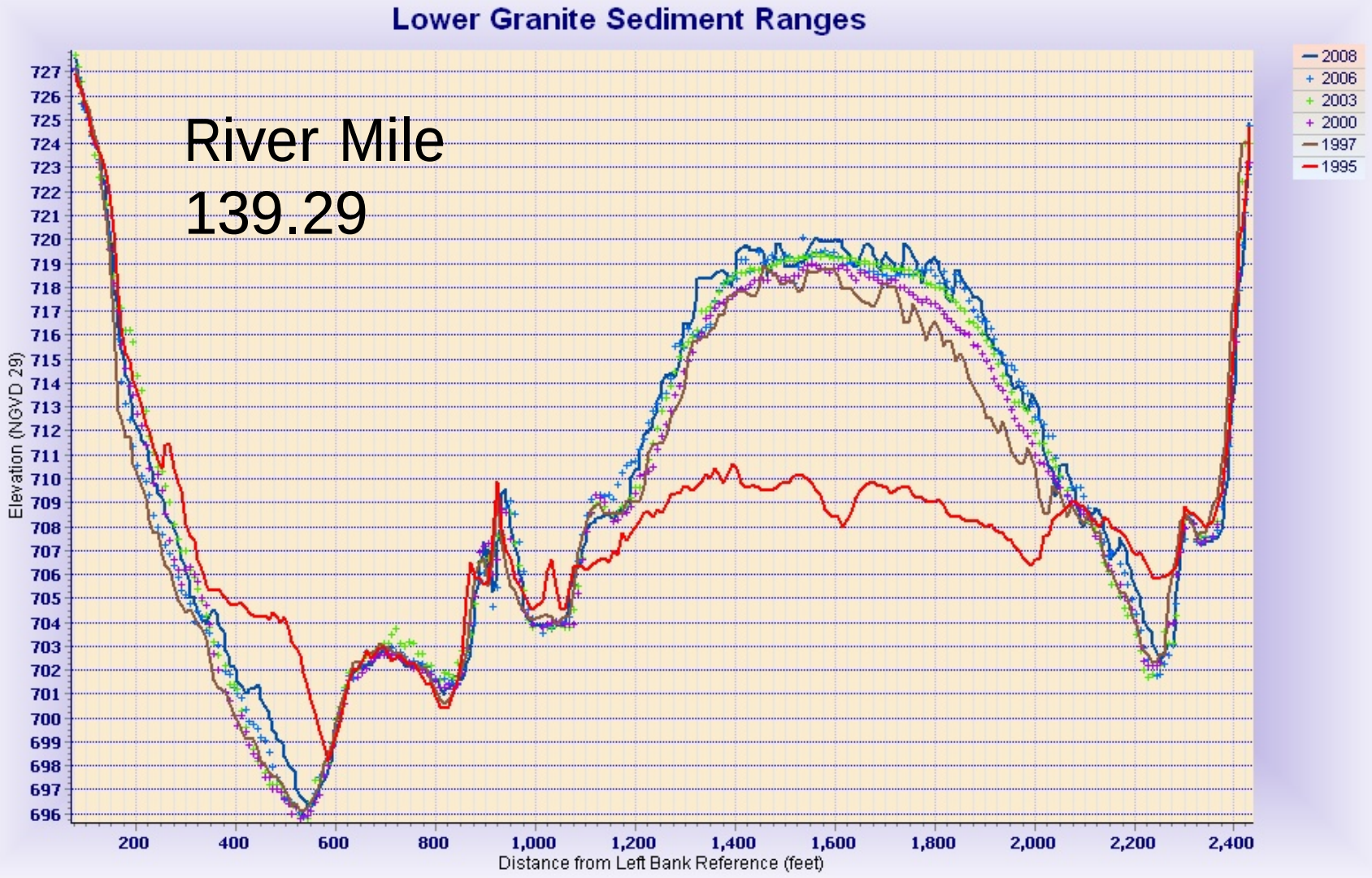


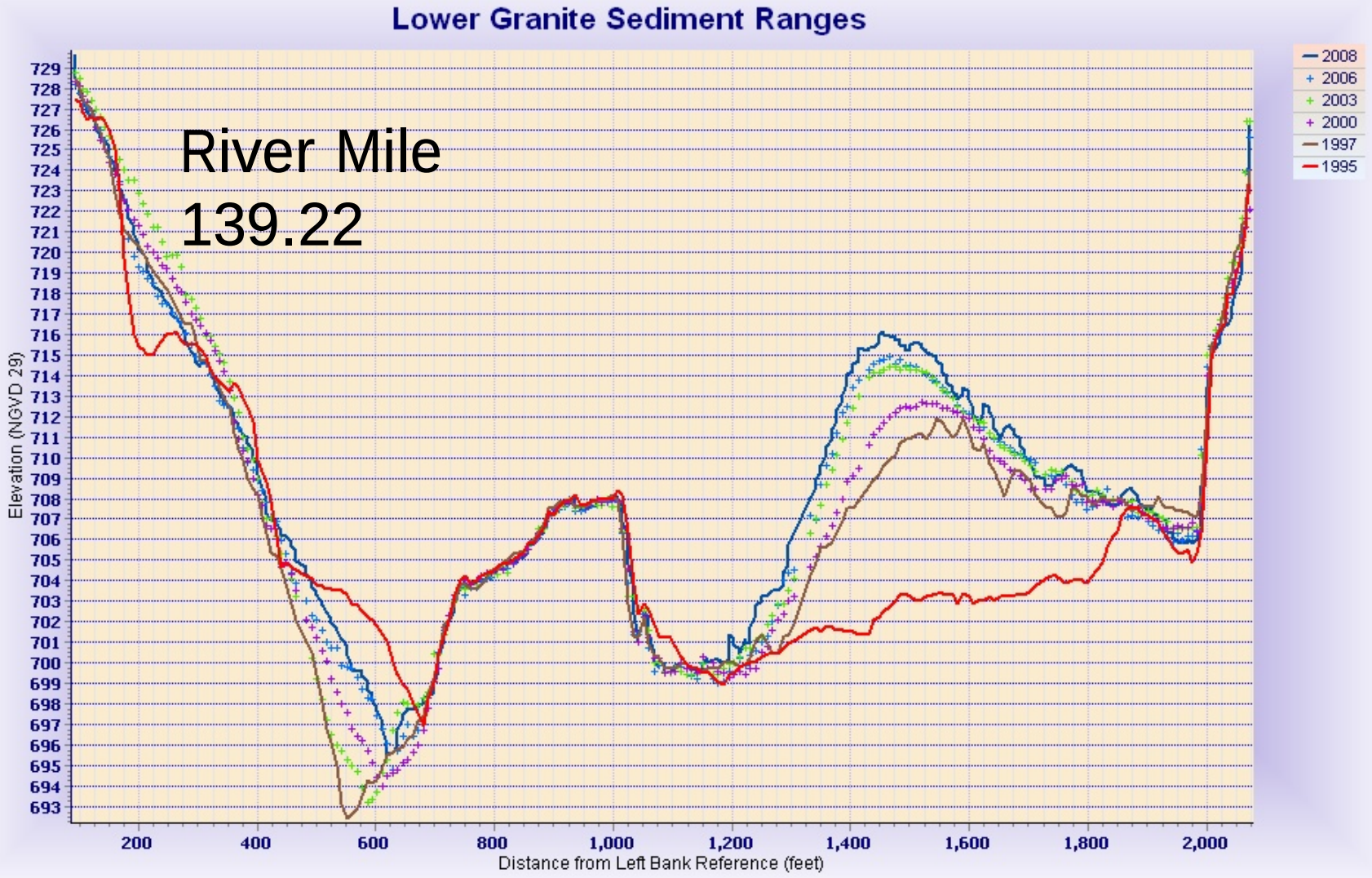
Confluence Flood Modeling

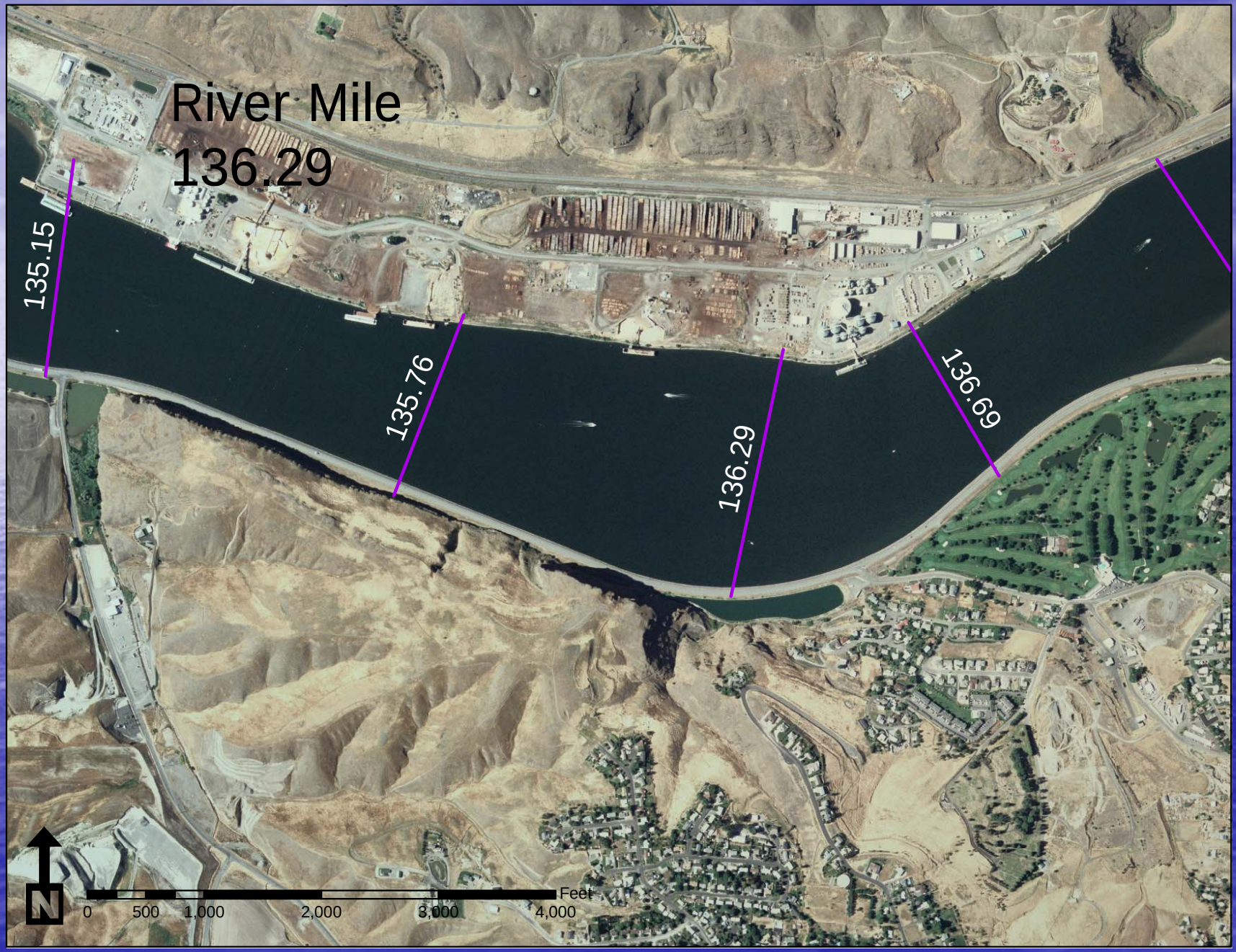
Standard Project Flood Modeling

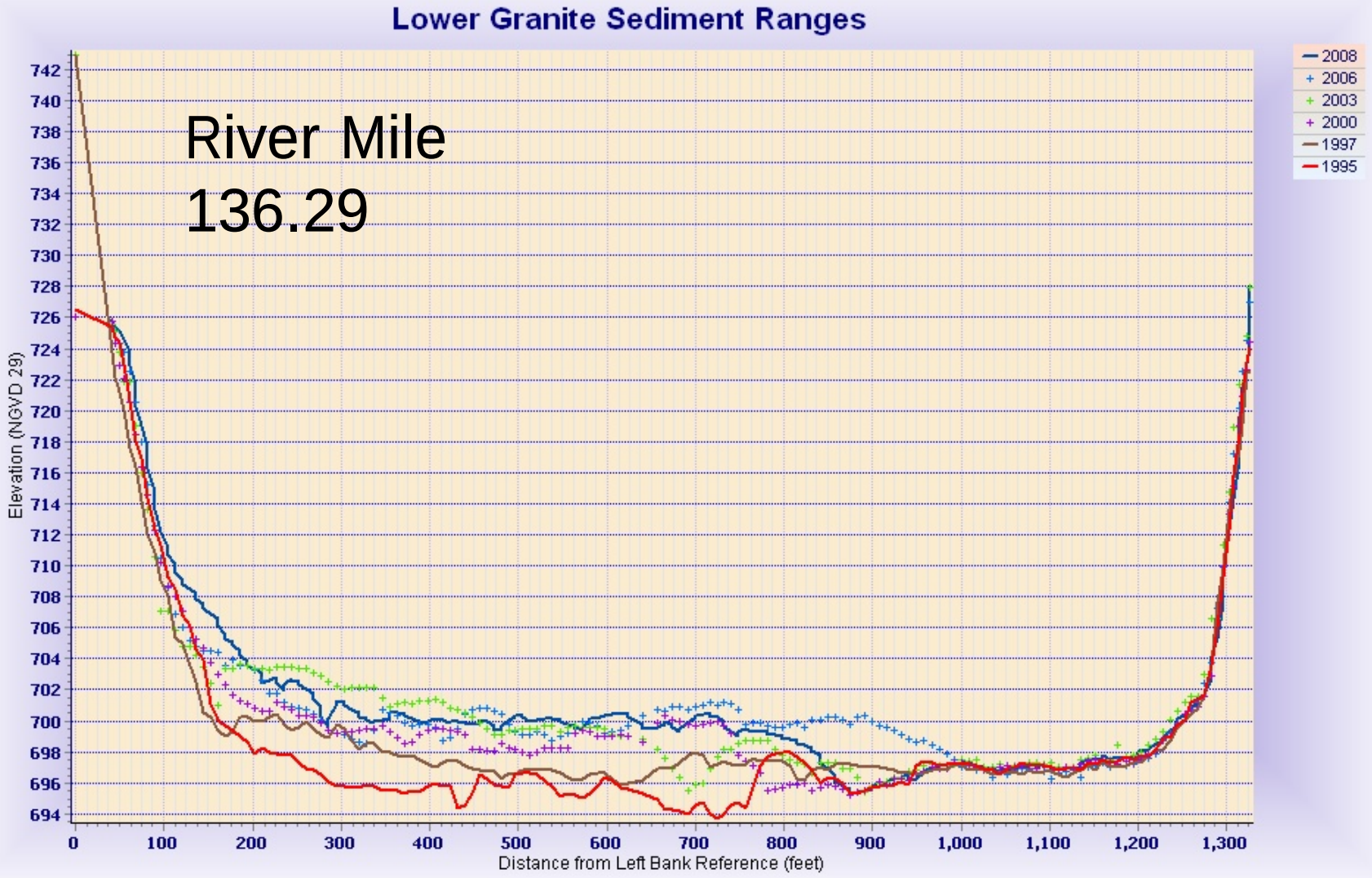


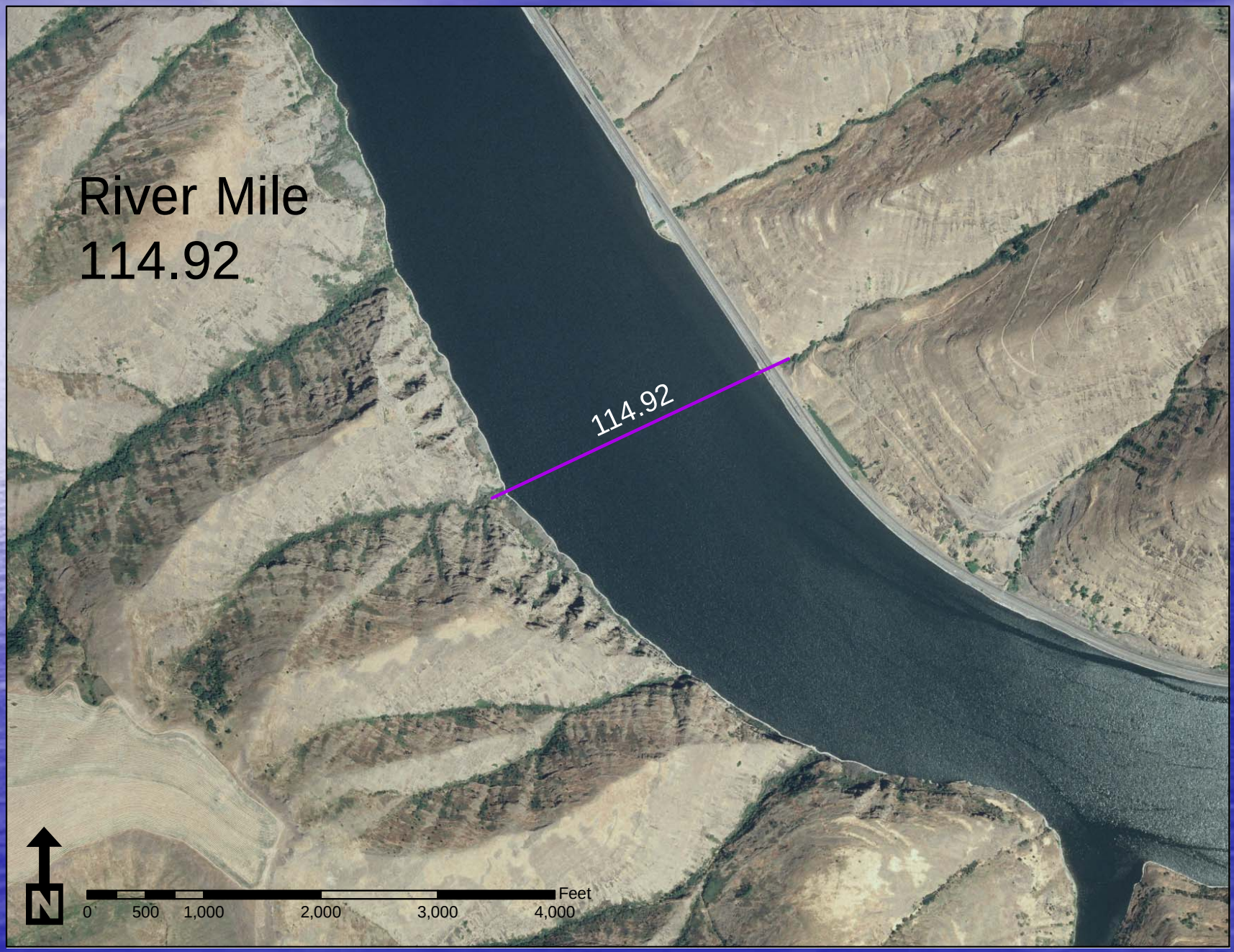

Sediment Range Surveys
Range Section 139.29
137.94
138.07
138.34
138.52
138.71
138.94
139.22
139.29
0.28
0.41
0.53
0.67
139.43
139.64
139.91
N
0
500
1,000
2,000
3,000
4,000
Feet

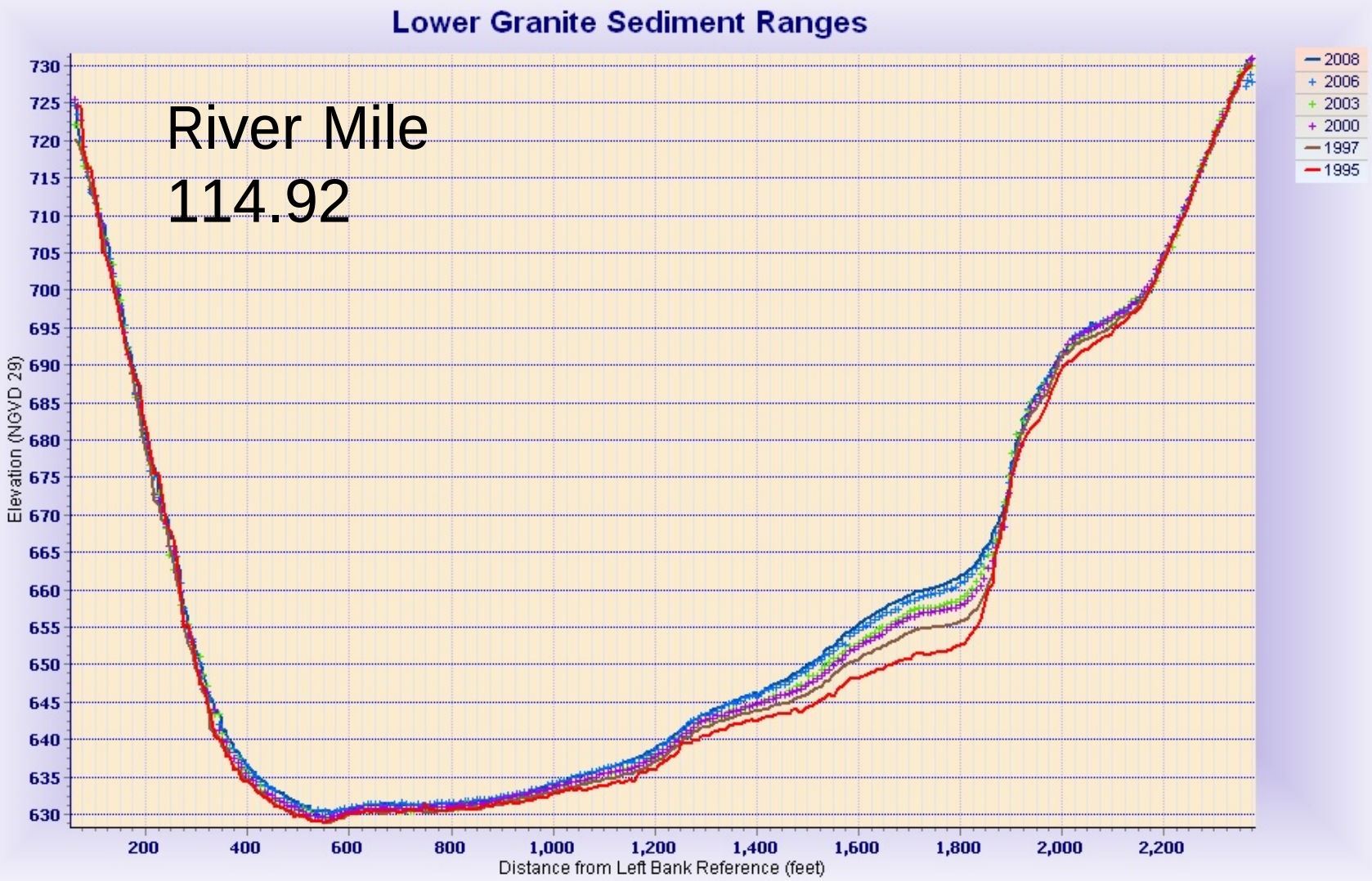

Lower Granite Sediment Ranges
River Mile
139.29
2008
2006
2003
2000
1997
1995
Elevation (NGVD 29)
727
726
725
724
723
722
721
720
719
718
717
716
715
714
713
712
711
710
709
708
707
706
705
704
703
702
701
700
699
698
697
696
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Distance from Left Bank Reference (feet)


Lower Granite Sediment Ranges
River Mile
139.22
2008
2006
2003
2000
1997
1995
Elevation (NGVD 29)
729
728
727
726
725
724
723
722
721
720
719
718
717
716
715
714
713
712
711
710
709
708
707
706
705
704
703
702
701
700
699
698
697
696
695
694
693
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Distance from Left Bank Reference (feet)

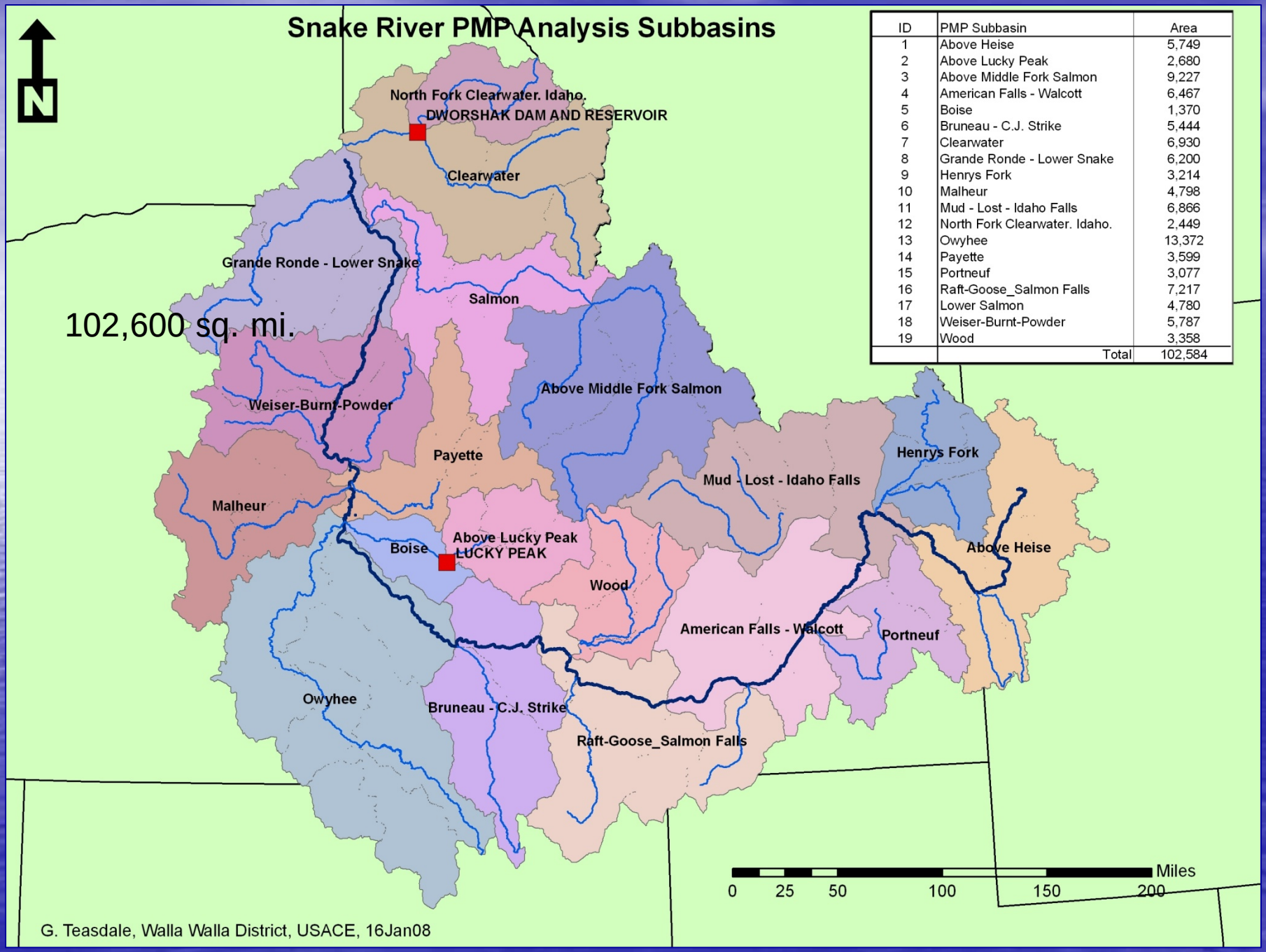

River Mile
136.29
135.15
135.76
136.29
136.69
N
0
500
1,000
2,000
3,000
4,000
Feet


Lower Granite Sediment Ranges
River Mile
136.29
2008
2006
2003
2000
1997
1995
Elevation (NGVD 29)
742
740
738
736
734
732
730
728
726
724
722
720
718
716
714
712
710
708
706
704
702
700
698
696
694
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
Distance from Left Bank Reference (feet)


River Mile
114.92
114.92
N
0
500
1,000
2,000
3,000
4,000
Feet

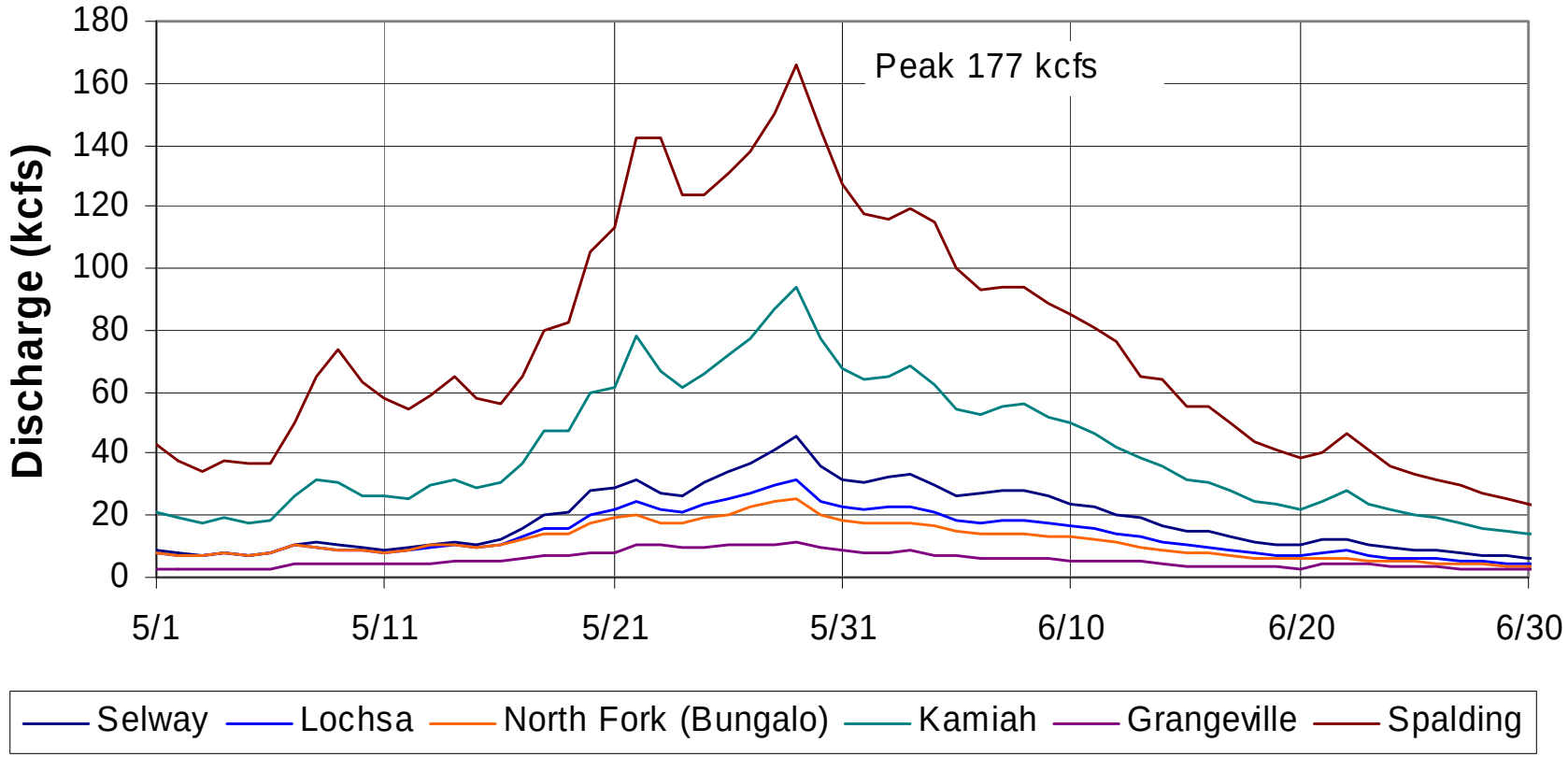

Lower Granite Sediment Ranges
River Mile
114.92
Elevation (NGVD 29)
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
Distance from Left Bank Reference (feet)
2008
2006
2003
2000
1997
1995

Snake River PMP Analysis Subbasins



ID	PMP Subbasin	Area
1	Above Heise	5,749
2	Above Lucky Peak	2,680
3	Above Middle Fork Salmon	9,227
4	American Falls - Walcott	6,467
5	Boise	1,370
6	Bruneau - C.J. Strike	5,444
7	Clearwater	6,930
8	Grande Ronde - Lower Snake	6,200
9	Henrys Fork	3,214
10	Malheur	4,798
11	Mud - Lost - Idaho Falls	6,866
12	North Fork Clearwater. Idaho.	2,449
13	Owyhee	13,372
14	Payette	3,599
15	Portneuf	3,077
16	Raft-Goose_Salmon Falls	7,217
17	Lower Salmon	4,780
18	Weiser-Burnt-Powder	5,787
19	Wood	3,358
	Total	102,584

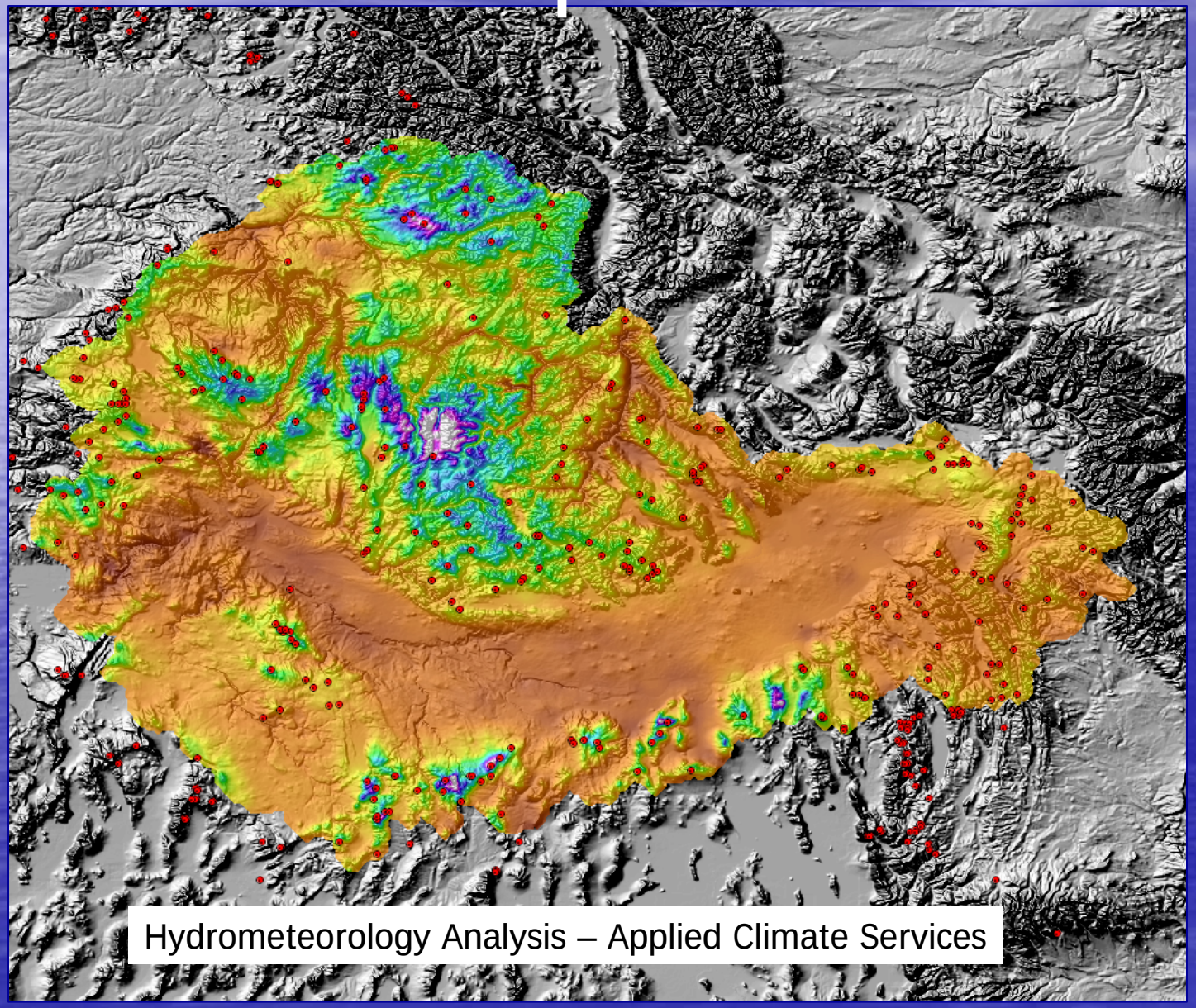
Clearwater Basin 1948 Flood



PMP/PMF Analysis

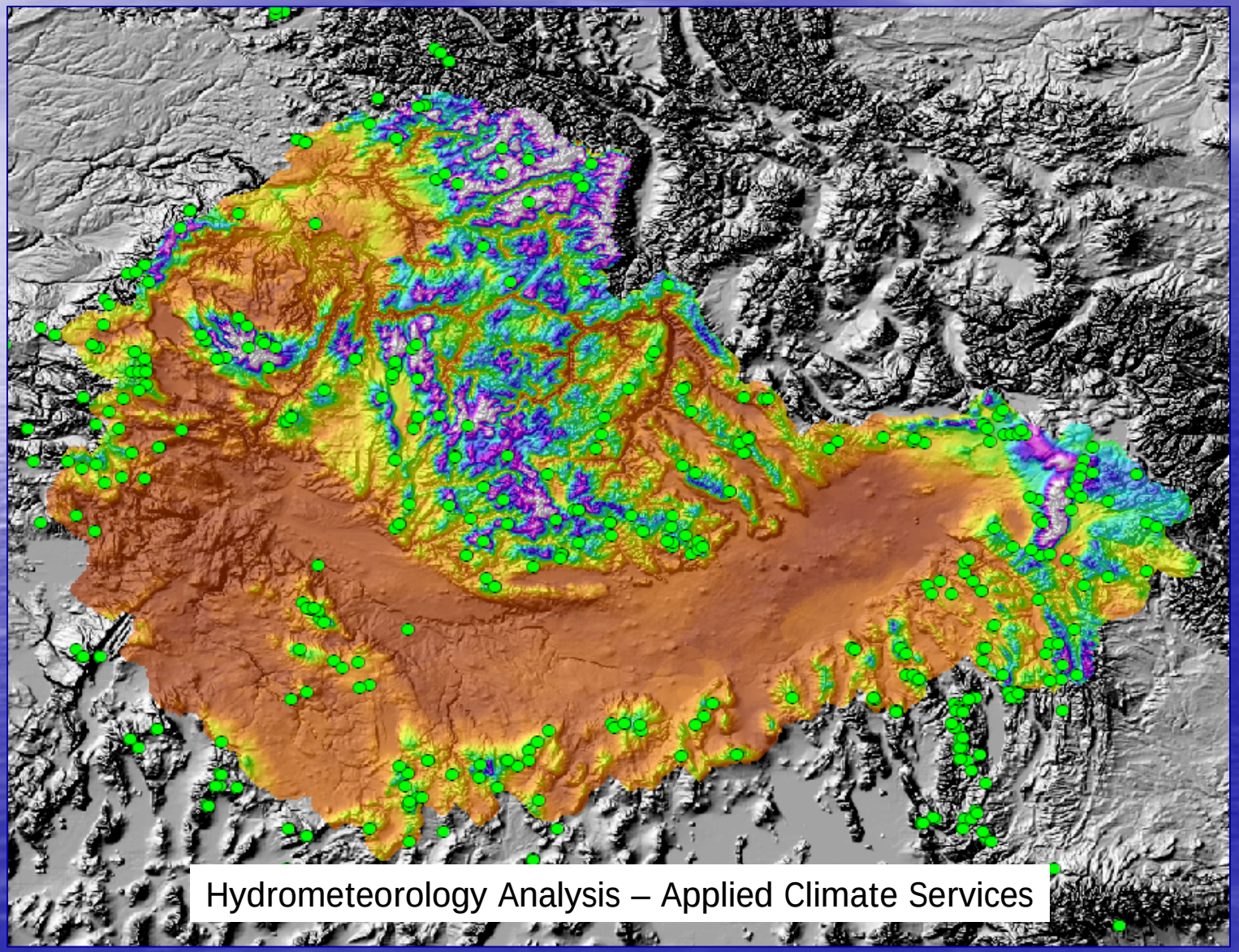
- Probable Maximum Precipitation (PMP)
  - Contract: Meteorological analysis, Applied Climate Services, George Taylor
  - Hydrology Section: historic flood and snowmelt analysis, final synthesis of PMP results
- Probable Maximum Flood (PMF)
  - Hydrology Section: Initial model development, final modeling
  - Contract: Subbasin and river model processing, McMillen Engineering

100 Year Precipitation



Hydrometeorology Analysis – Applied Climate Services

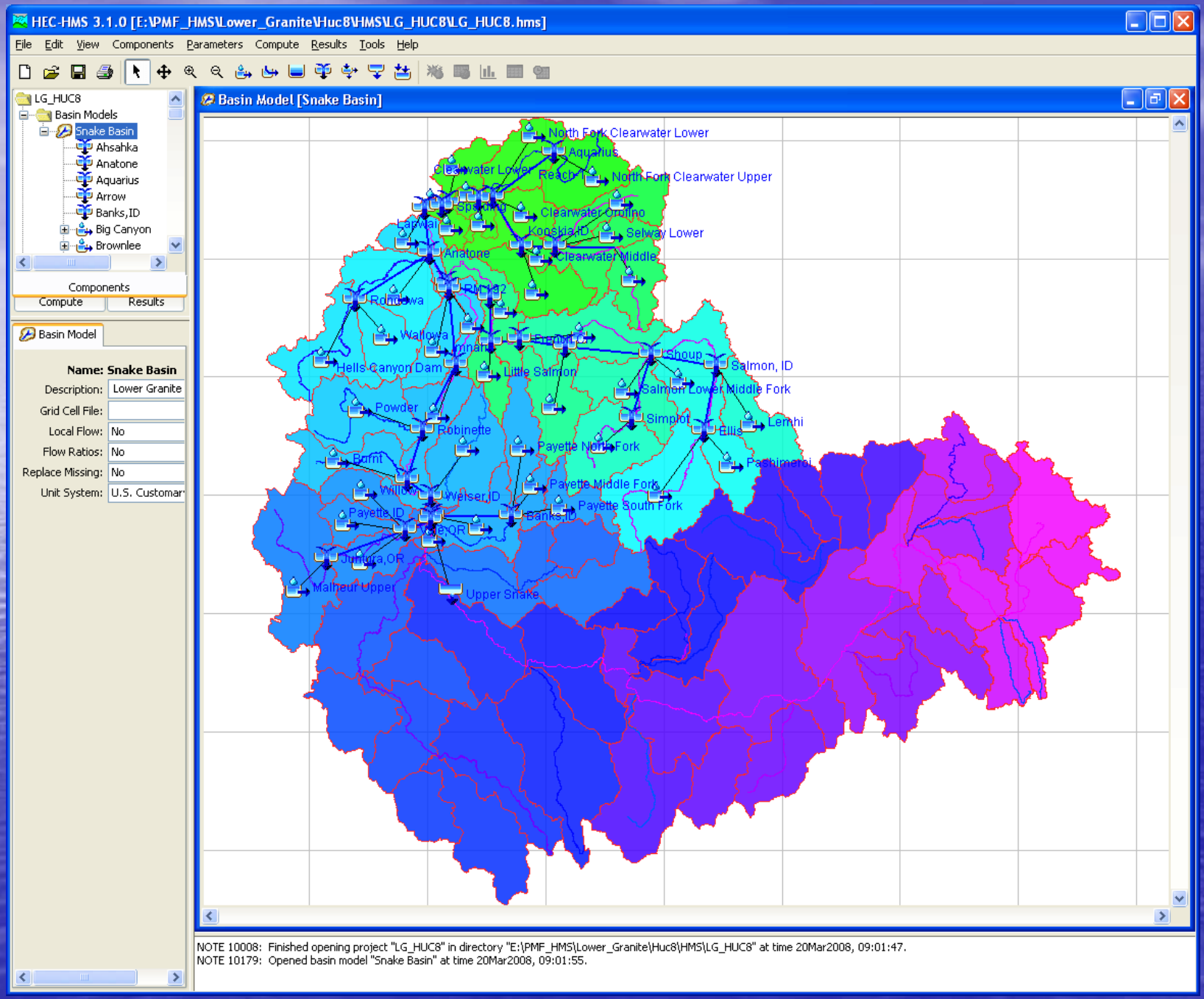
100 Year Snow Water Equivalent



Hydrometeorology Analysis – Applied Climate Services

Hydrologic Modeling

- HEC-HMS
- HEC GeoHMS
- Individual subbasin models
- Aggregated basin model
- Transparency of analysis


HEC-HMS 3.1.0 [E:\PMF_HMS\Lower_Granite\Huc8\HMS\LG_HUC8\LG_HUC8.hms]
File Edit View Components Parameters Compute Results Tools Help
LG_HUC8
Basin Models
Snake Basin
Ahsahka
Anatone
Aquarius
Arrow
Banks,ID
Big Canyon
Brownlee
Components
Compute
Results
Basin Model
Name: Snake Basin
Description: Lower Granite
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Unit System: U.S. Customar
Basin Model [Snake Basin]
North Fork Clearwater Lower
Aquarius
Clearwater Lower
Reach
North Fork Clearwater Upper
Clearwater Orofino
Kooskia,ID
Selway Lower
Clearwater Middle
Anatone
Robinette
Wallowa
Hells Canyon Dam
Little Salmon
Shoup
Salmon, ID
Salmon Lower Middle Fork
Simplot
Lemhi
Ellis
Pashimeroi
Powder
Robinette
Payette North Fork
Burnt
Payette Middle Fork
Payette South Fork
Weiser,ID
Banks,ID
Payette,ID
Ontario,OR
Malheur Upper
Upper Snake
NOTE 10008: Finished opening project "LG_HUC8" in directory "E:\PMF_HMS\Lower_Granite\Huc8\HMS\LG_HUC8" at time 20Mar2008, 09:01:47.
NOTE 10179: Opened basin model "Snake Basin" at time 20Mar2008, 09:01:55.

US Army Corps of Engineers®

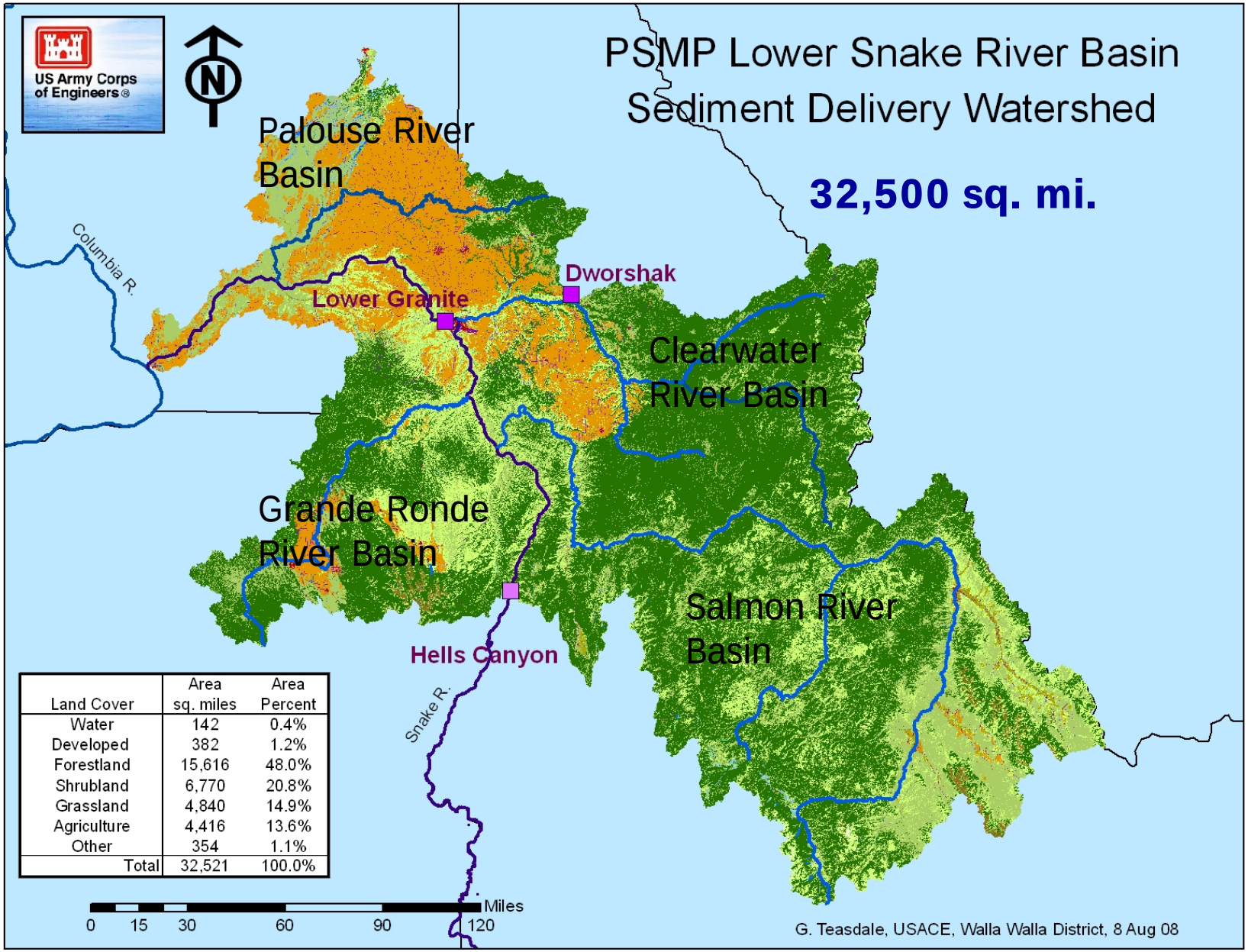
NRCS Natural Resources Conservation Service

Lower Snake Basin Sediment Yield Assessment

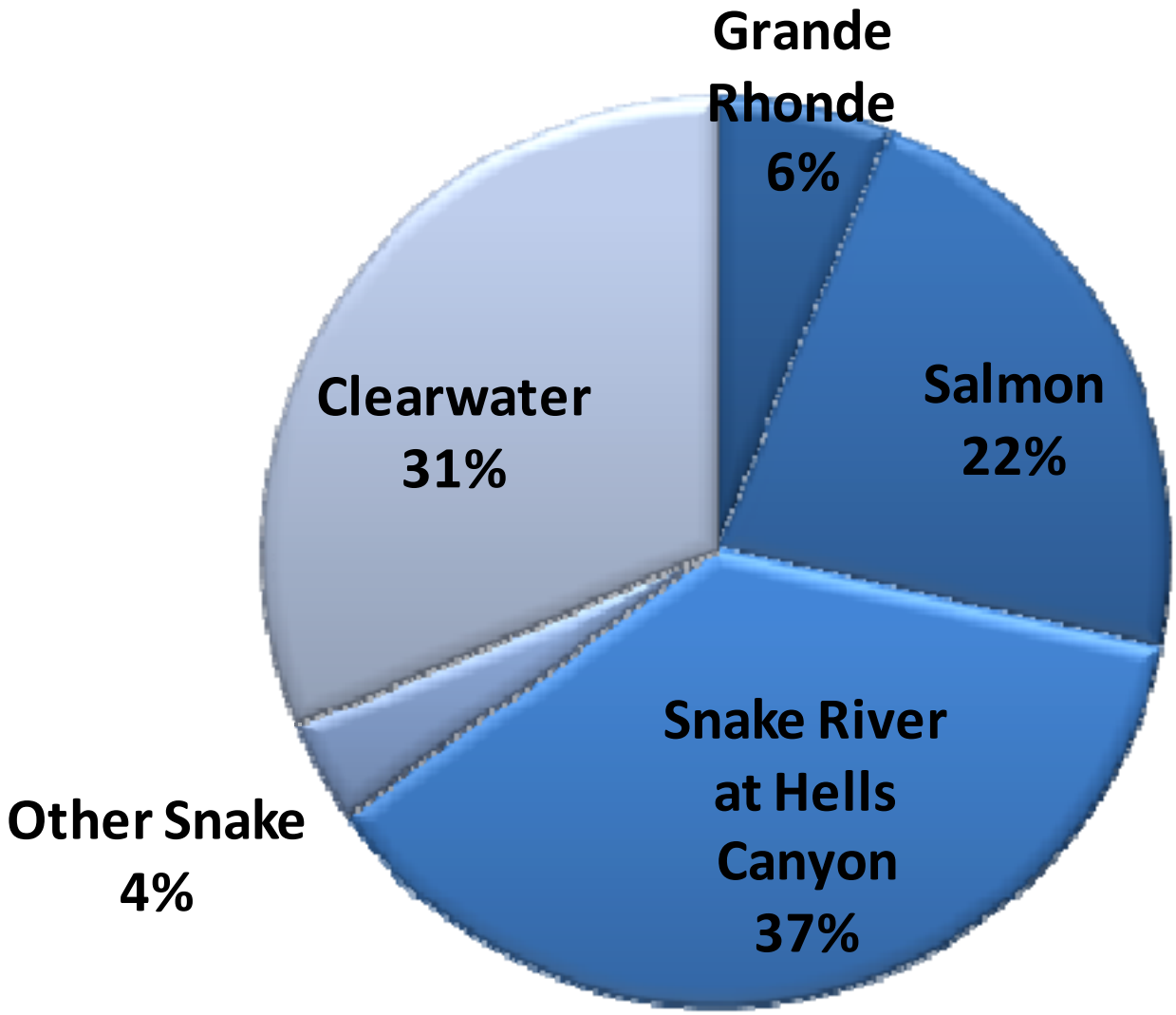
October 16, 2008

USGS science for a changing world

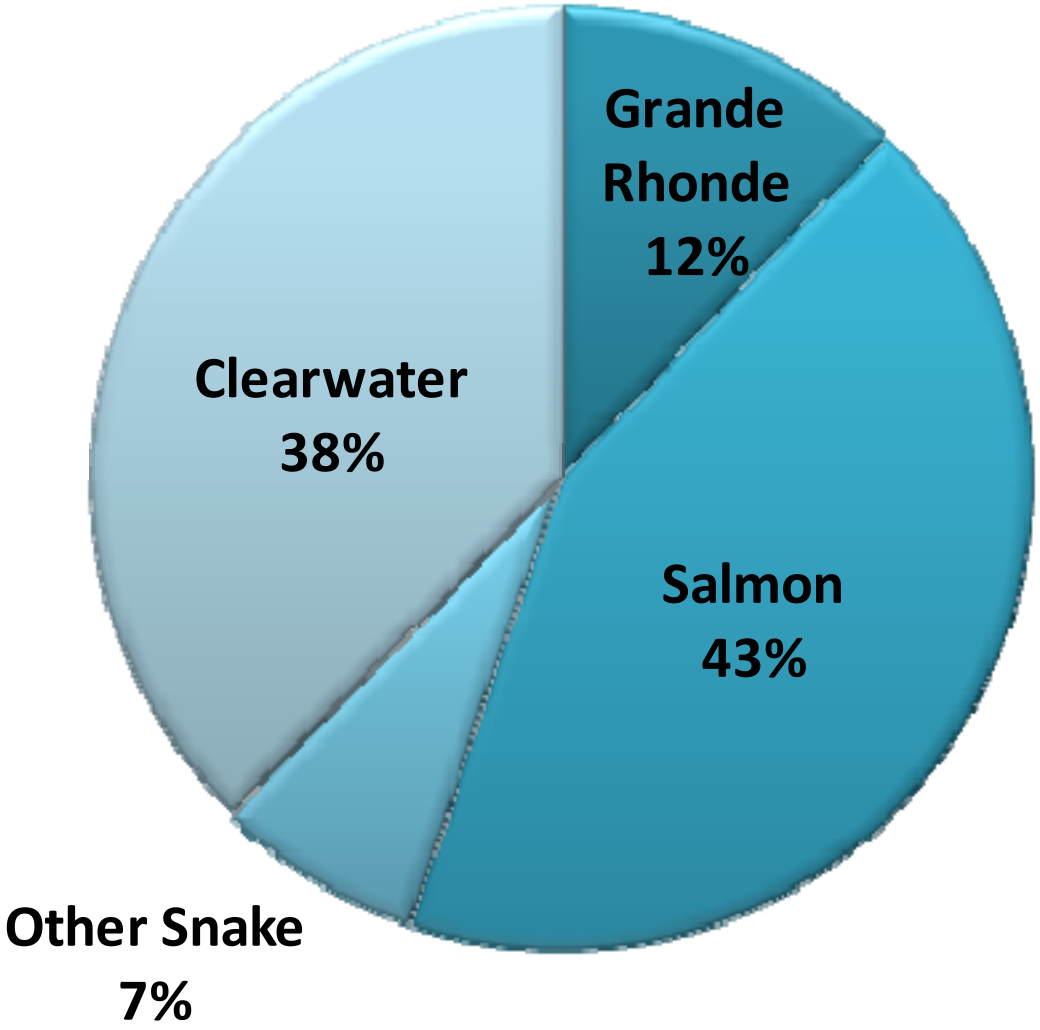
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE


US Army Corps of Engineers®
PSMP Lower Snake River Basin
Sediment Delivery Watershed
32,500 sq. mi.
Palouse River Basin
Columbia R.
Dworshak
Lower Granite
Clearwater River Basin
Grande Ronde River Basin
Salmon River Basin
Hells Canyon
Snake R.
Land Cover | Area sq. miles | Area Percent
Water | 142 | 0.4%
Developed | 382 | 1.2%
Forestland | 15,616 | 48.0%
Shrubland | 6,770 | 20.8%
Grassland | 4,840 | 14.9%
Agriculture | 4,416 | 13.6%
Other | 354 | 1.1%
Total | 32,521 | 100.0%
0 15 30 60 90 120 Miles
G. Teasdale, USACE, Walla Walla District, 8 Aug 08

Water Inflow to Lower Granite



Sediment Bearing Water Inflow to Lower Granite



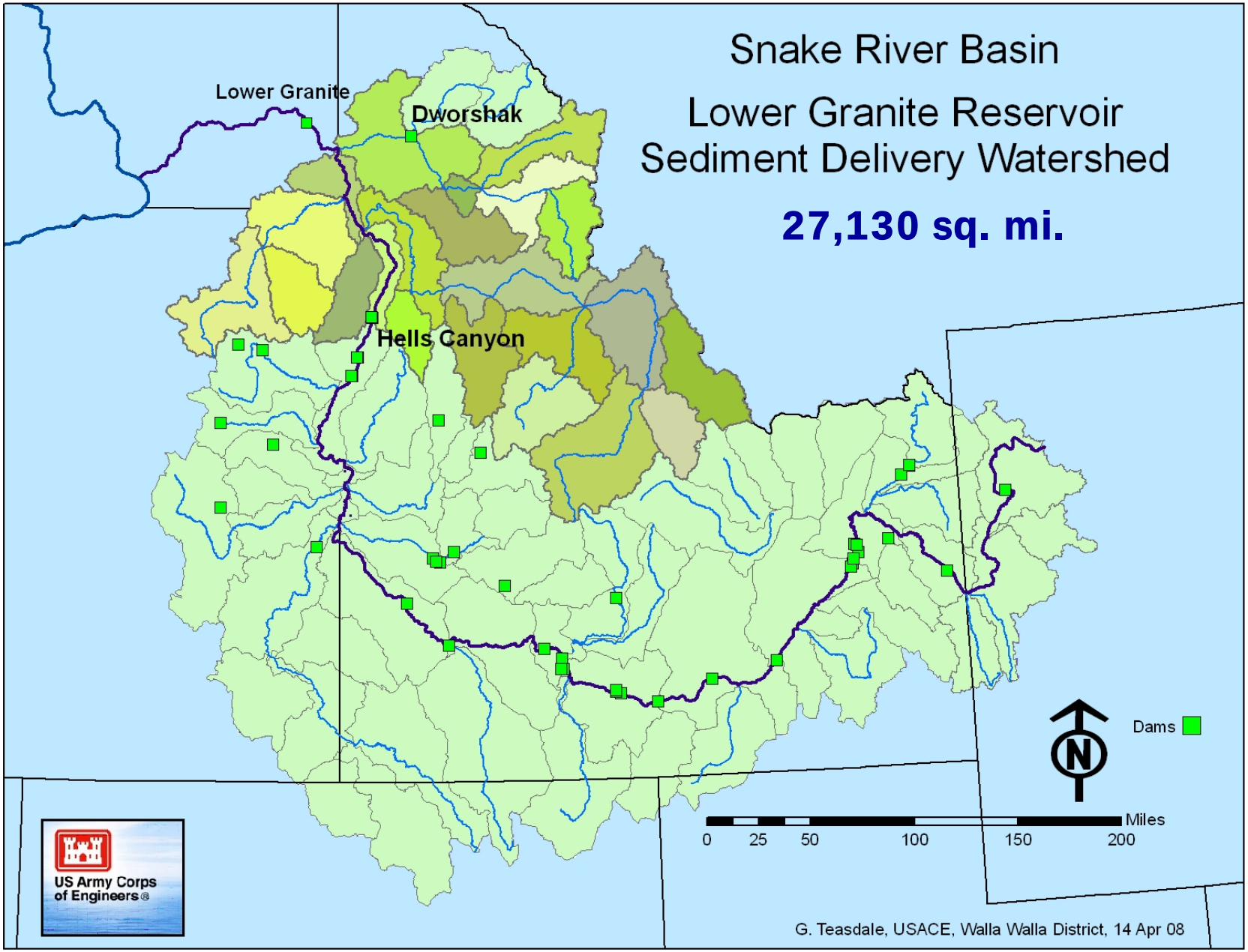
PSMP EIS Sediment Yield

- Assess and model sediment yield of the lower Snake River basin
- Forecast sediment delivery to the lower Snake Reservoirs
- Predict future maintenance dredging needs
- Identify the primary sources and trends in sediment delivery
- Determine where reductions in sediment delivery can be made

Multiple Approaches to Sediment Yield Analysis

- Sediment Range Surveys
- Sediment load measurement
- Evaluation of stream geomorphology and sediment transport
- Sediment yield modeling
- High resolution remote sensing

How does climate change alter sediment yield?


Snake River Basin
Lower Granite Reservoir
Sediment Delivery Watershed
27,130 sq. mi.
Lower Granite
Dworshak
Hells Canyon
Dams
N
Miles
0
25
50
100
150
200
US Army Corps of Engineers®
G. Teasdale, USACE, Walla Walla District, 14 Apr 08

Lower Granite Range Survey Sediment Accumulation

Sediment Range Year	Range Survey Volume Snake mcy	Range Survey Volume Clearwater mcy	Dredged Material mcy	Accumulated Dredge Vol mcy	Total Volume mcy	Percent of Total Accumulated	Cumulative Volume mcy
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	11.78	0.50	0.00	0.00	12.28	16.42%	12.28
1977	14.21	0.62	0.00	0.00	2.55	3.41%	14.83
1979	15.17	0.49	0.00	0.00	0.82	1.10%	15.65
1982	19.06	0.73	0.26	0.26	4.39	5.87%	20.05
1983	25.23	0.74	0.01	0.26	6.18	8.26%	26.23
1984	29.15	0.96	0.00	0.26	4.14	5.53%	30.36
1985	28.40	0.69	0.00	0.26	-1.02	-1.36%	29.35
1986	33.73	0.99	0.45	0.71	6.08	8.13%	35.43
1989	39.32	0.55	0.87	1.58	6.02	8.05%	41.45
1992	40.11	0.22	0.48	2.06	0.94	1.25%	42.39
1995	44.42	0.21	0.00	2.06	4.30	5.75%	46.69
1997	56.61	0.73	0.03	2.09	12.74	17.03%	59.43
2000	64.46	0.94	0.12	2.21	8.17	10.92%	67.60
2003	70.28	0.91	0.00	2.21	5.80	7.75%	73.40
2006[1]	72.05	0.00	0.55	2.76	1.41	1.89%	74.81

Total Sediment Accumulation 74.8 million cubic yards (57.2×10^6 m^3)

Lower Granite Sediment Accumulation

Lower Granite Sediment Accumulation (1974-2006)		
Period	Cumulative Volume mcy	Mean Annual Accumulation mcy/yr
1974 - 1982	20.05	2.51
1983 - 1992	42.39	2.23
1993 - 2000	67.60	3.15
2001 - 2006	74.81	1.20

No apparent increase or reduction in annual sediment accumulation with time, but the 1997 flood was extraordinary and may have delivered “legacy” sediment stored in channel margins.

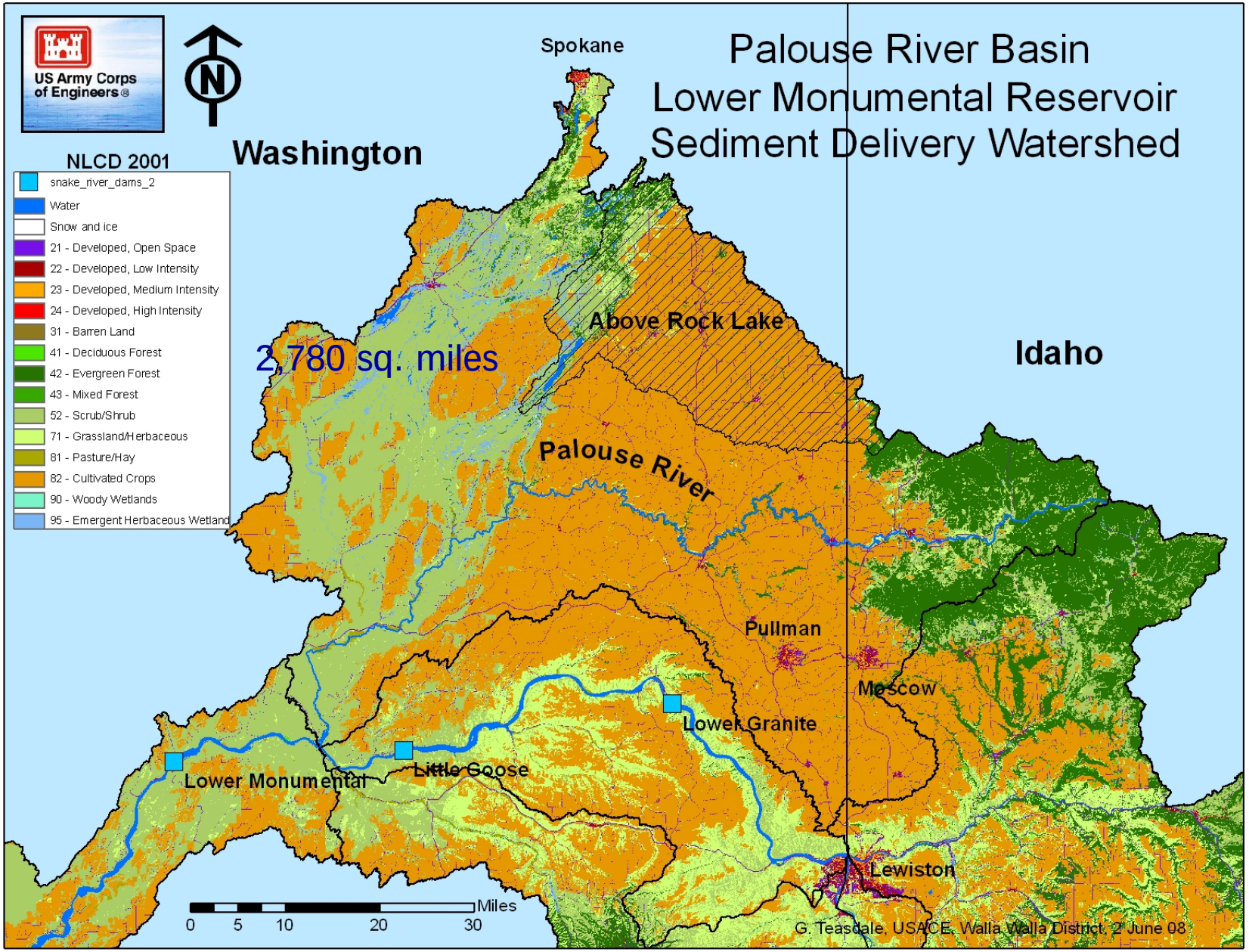
Sediment Yield by Accumulation

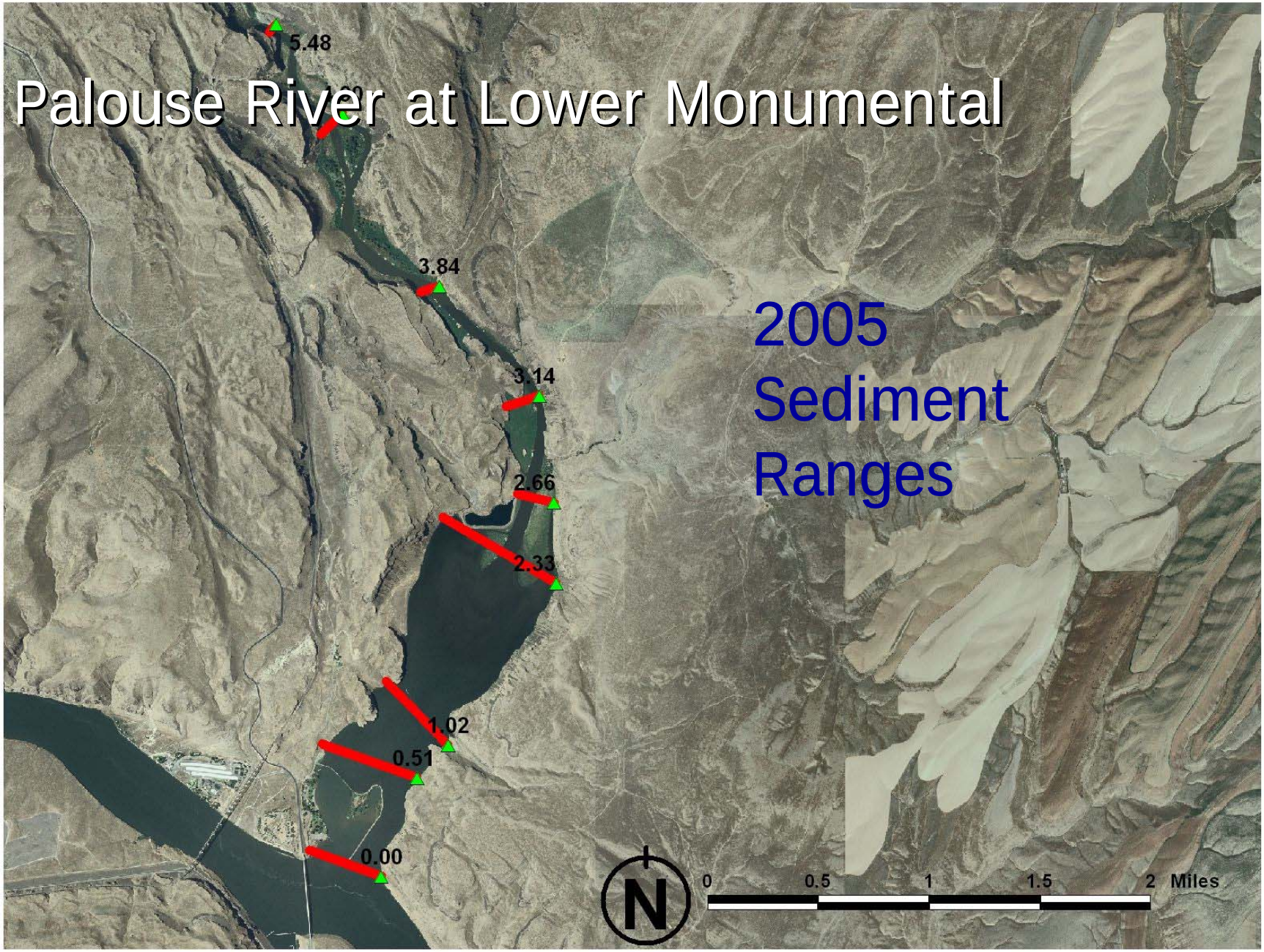
$$\text{Average Annual Sediment Volume} = \frac{74.8\ \text{mcy}}{32\ \text{yr}} = 2.34\ \frac{\text{mcy}}{\text{yr}}$$

$$\text{Average Annual Sediment Volume} = 2.34\ \frac{\text{mcy}}{\text{yr}} \times \frac{1}{0.90}\ \text{trap eff.} = 2.60\ \frac{\text{mcy}}{\text{yr}}$$

$$\text{Sediment yield, } S_V = 2.60\ \frac{\text{mcy}}{\text{yr}} \times 70\ \frac{\text{lb}}{\text{ft}^3} \times \frac{27 \times 10^6\ \frac{\text{ft}^3}{\text{mcy}}}{2000\ \frac{\text{lb}}{\text{ton}}} \times \frac{1}{27{,}130\ \text{mi}^2} \times \frac{1\ \text{mi}^2}{640\ \text{ac}}$$

$$\text{Sediment Yield, } S_V = 0.14\ \frac{\text{ton}}{\text{ac} \cdot \text{yr}}$$


US Army Corps of Engineers
Palouse River Basin
Lower Monumental Reservoir
Sediment Delivery Watershed
Spokane
Washington
Idaho
NLCD 2001
snake_river_dams_2
Water
Snow and ice
21 - Developed, Open Space
22 - Developed, Low Intensity
23 - Developed, Medium Intensity
24 - Developed, High Intensity
31 - Barren Land
41 - Deciduous Forest
42 - Evergreen Forest
43 - Mixed Forest
52 - Scrub/Shrub
71 - Grassland/Herbaceous
81 - Pasture/Hay
82 - Cultivated Crops
90 - Woody Wetlands
95 - Emergent Herbaceous Wetland
2,780 sq. miles
Above Rock Lake
Palouse River
Pullman
Moscow
Lower Granite
Little Goose
Lower Monumental
Lewiston
Miles
0 5 10 20 30
G. Teasdale, USACE, Walla Walla District, 2 June 08


Palouse River at Lower Monumental
5.48
3.84
3.14
2.66
2.33
1.02
0.51
0.00
2005
Sediment
Ranges
N
0
0.5
1
1.5
2 Miles

Palouse River Sediment Accumulation

Palouse River Sediment Accumulation Volume (1969-2005)		
Period	Cumulative Volume mcy	Mean Annual Accumulation mcy/yr
1969-1973	4.18	1.04
1973-1984	11.57	1.05
1984-1994	3.09	0.31
1994-2005	5.18	0.47
Average	24.02	0.67

$$\text{Sediment yield}, S_L = 0.47 \frac{\text{mcy}}{\text{yr}} \times 70 \frac{\text{lb}}{\text{ft}^3} \times \frac{27 \times 10^6 \frac{\text{ft}^3}{\text{mcy}}}{2000 \frac{\text{lb}}{\text{ton}}} \times \frac{1}{2{,}780\ \text{mi}^2} \times \frac{1\ \text{mi}^2}{640\ \text{ac}}$$

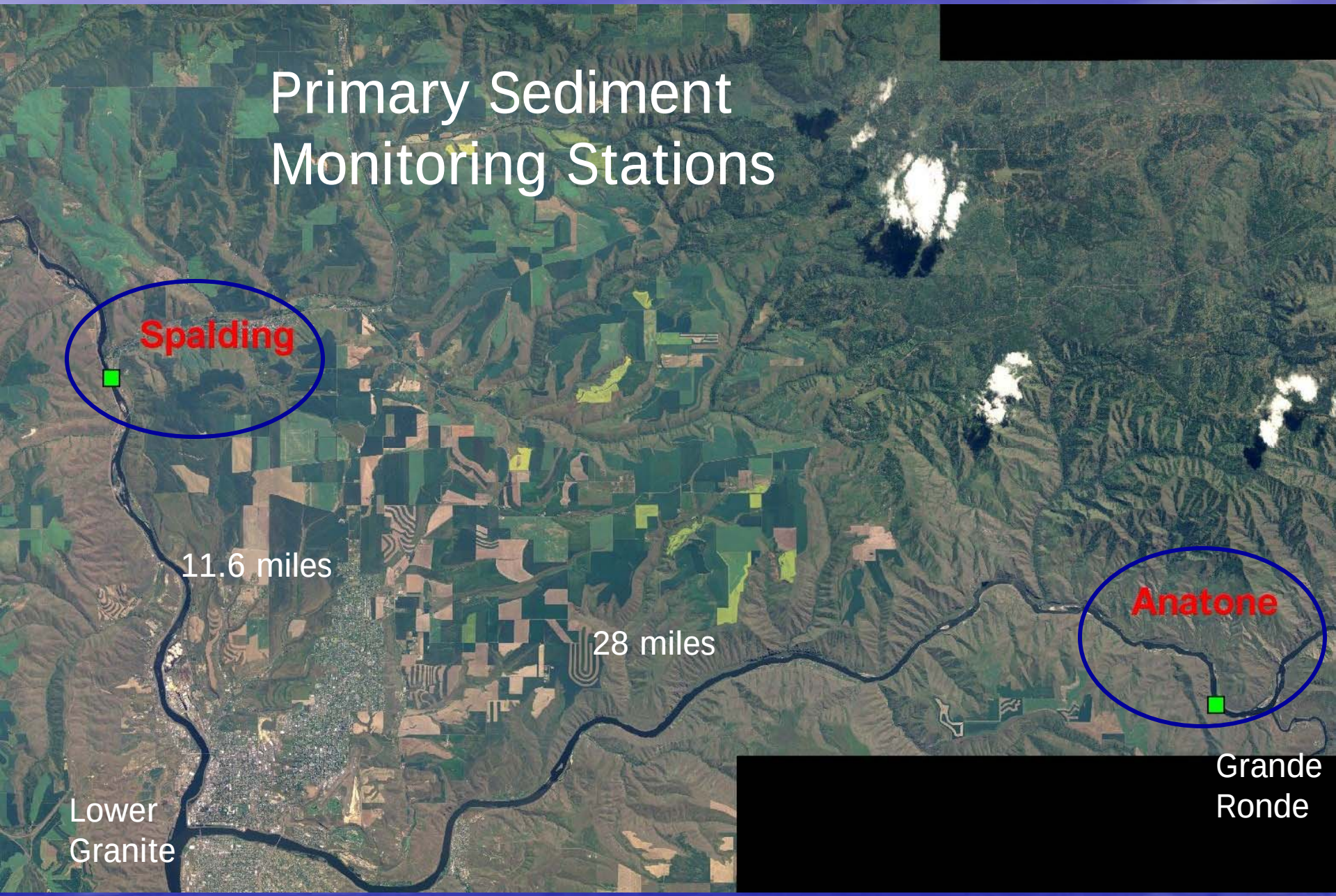
$$\text{Sediment yield}, S_L = 0.25 \frac{\text{ton}}{\text{ac} \cdot \text{yr}}$$

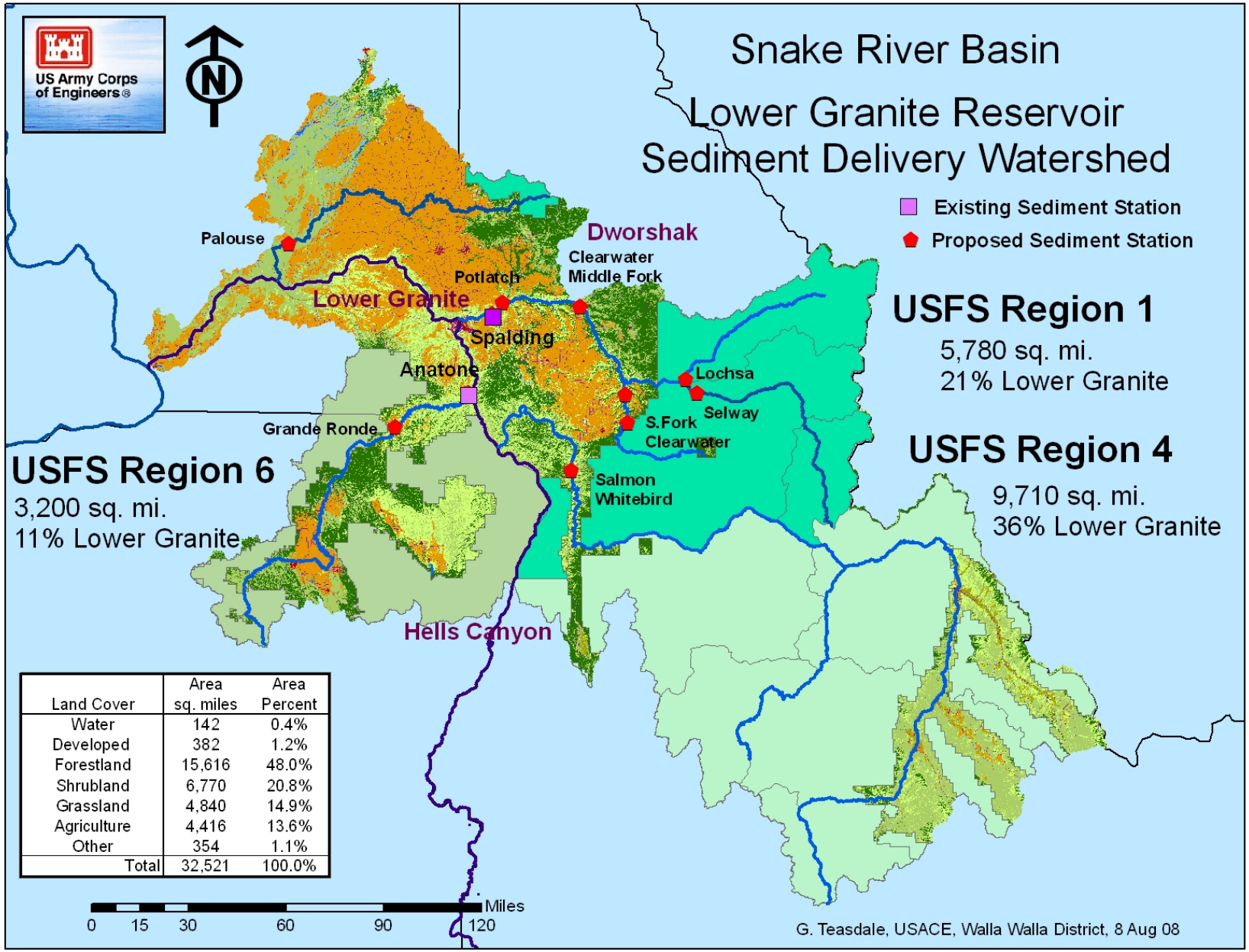
Measurement of Sediment Load

- Repeat the USGS 1970's Investigation
- Conventional Sampling
- Continuous measurement with electronic instrumentation
- Primary stations on the Snake and Clearwater
- Proposed stations on main tributary rivers
- Began March 2008

Measurement of Sediment Load Snake and Clearwater Rivers

- U.S Geological Survey – Idaho Water Science Center
- Conventional manual suspended sediment and bedload
- Continuous load from calibrated electronic surrogate technology
- Suspended sediment is a priority


Primary Sediment
Monitoring Stations
Spalding
11.6 miles
28 miles
Anatone
Lower
Granite
Grande
Ronde



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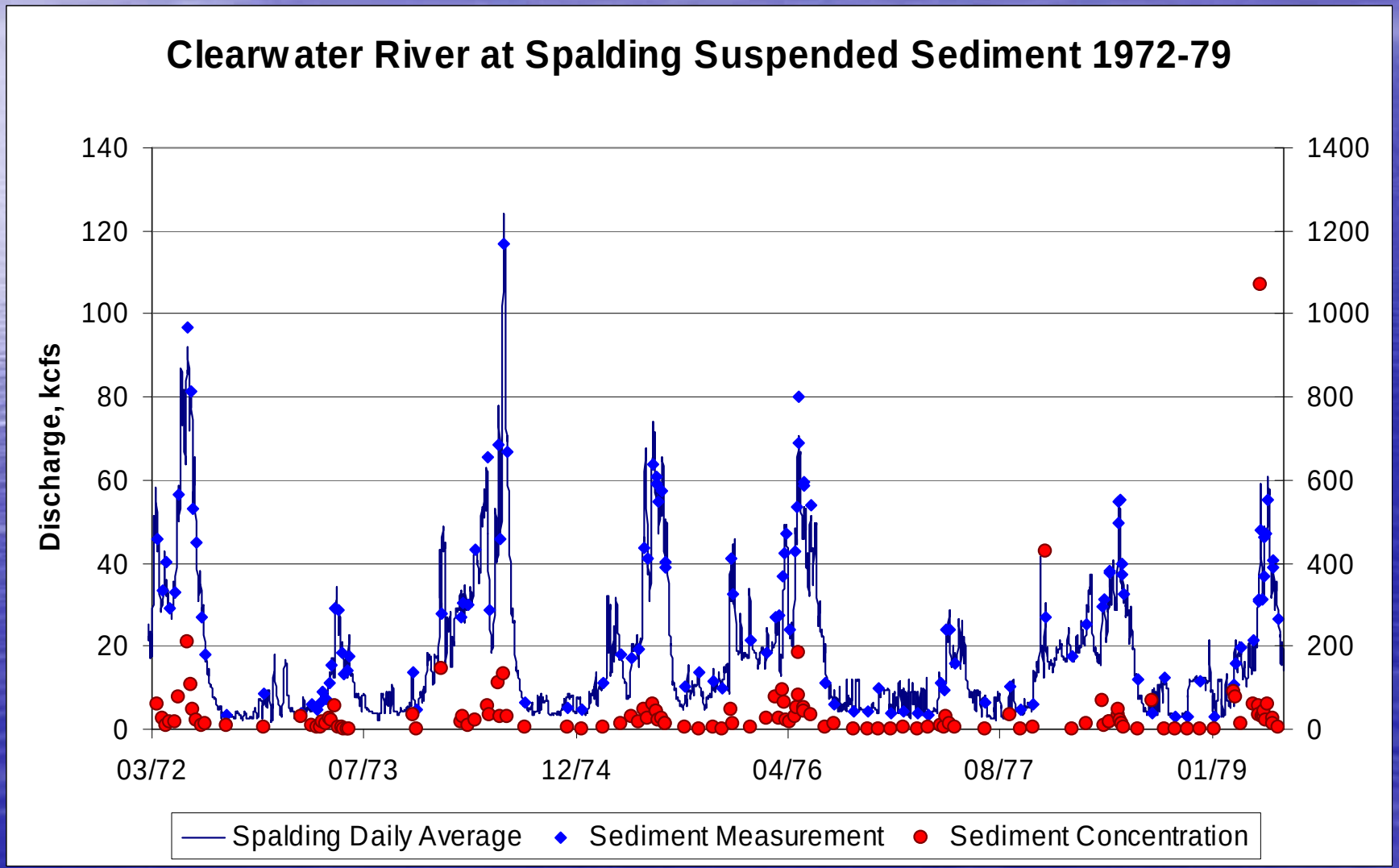
Shrubland	6,770	20.8%
Grassland	4,840	14.9%
Agriculture	4,416	13.6%
Other	354	1.1%
Total	32,521	100.0%

USGS Sediment Measurement 1972-1979

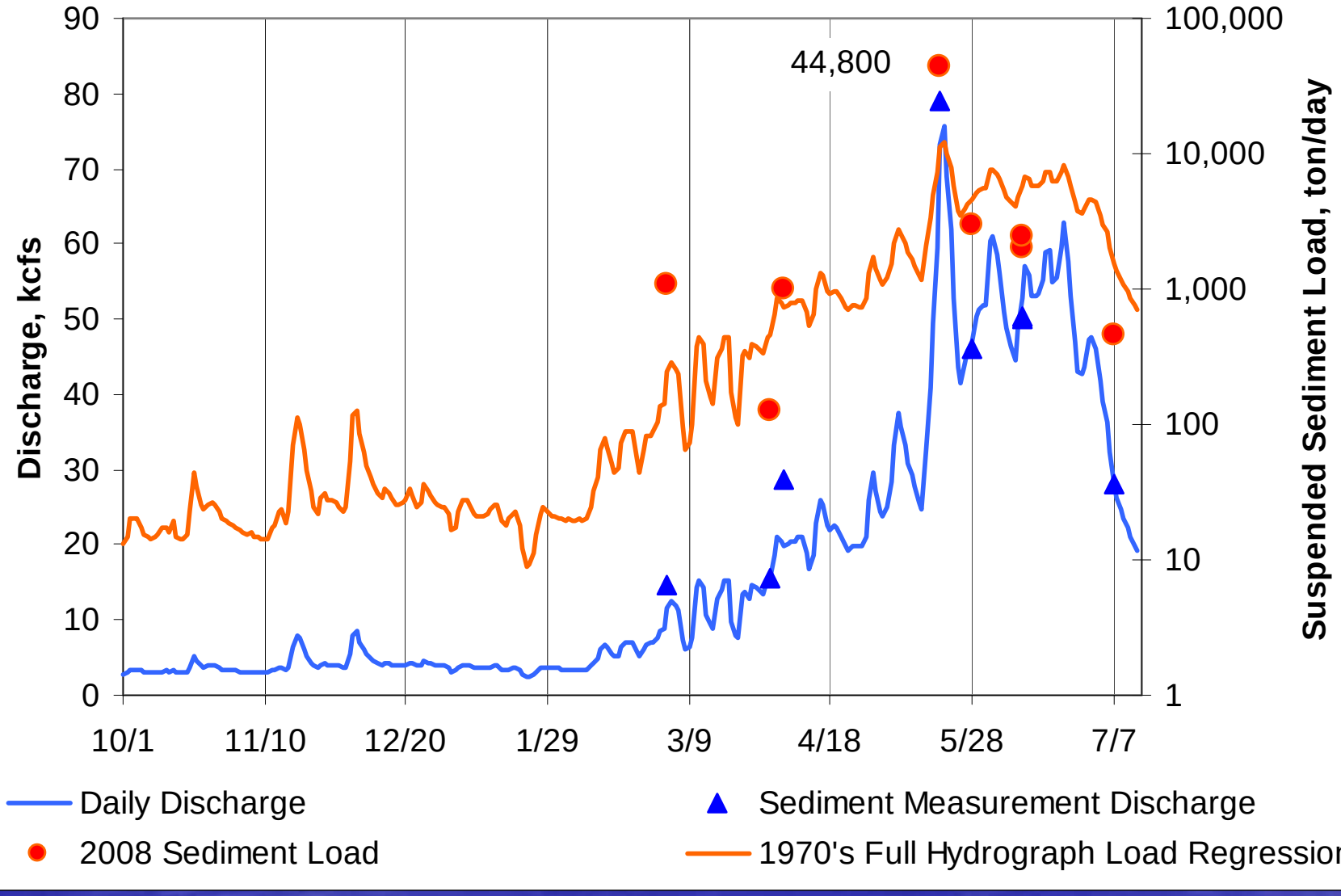


USGS 1970's Measured Sediment Load Open-File Report 80-690

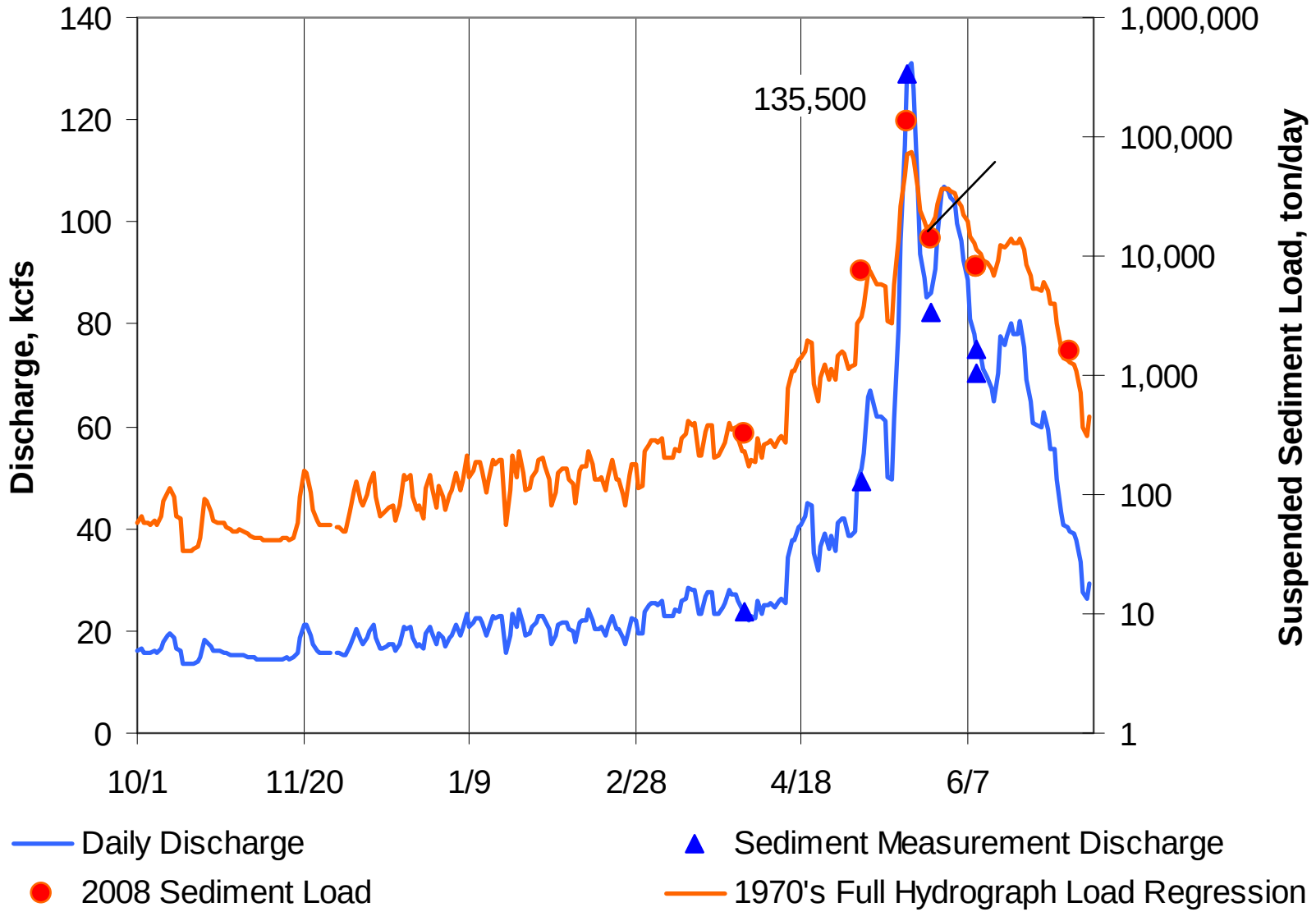
- Suspended Sediment and Bedload
- 1972 - 1979

Year	Snake River at Anatone		Clearwater River at Spalding	
	ton/ac/yr	Percent	ton/ac/yr	Percent
1972	0.24	76%	0.22	24%
1973	0.02	87%	0.01	13%
1974	0.43	81%	0.30	19%
1975	0.17	82%	0.11	18%
1976	0.18	84%	0.10	16%
1977	0.002	45%	0.01	55%
1978	0.08	79%	0.06	21%
1979	0.04	68%	0.05	32%
All years	0.14	80%	0.11	20%

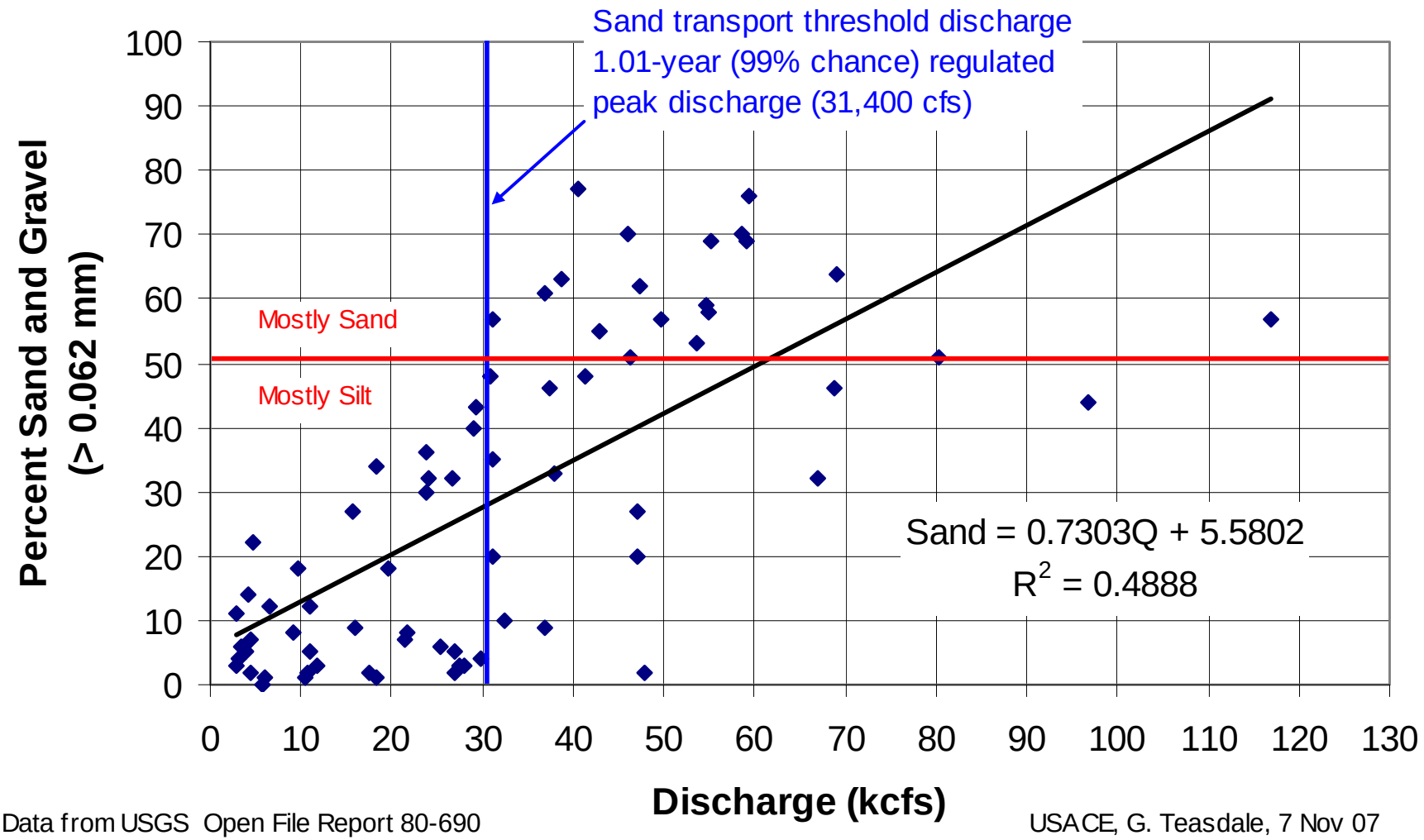
2008 Suspended Sediment Sampling
Clearwater River at Spalding



2008 Suspended Sediment Sampling
Snake River at Anatone



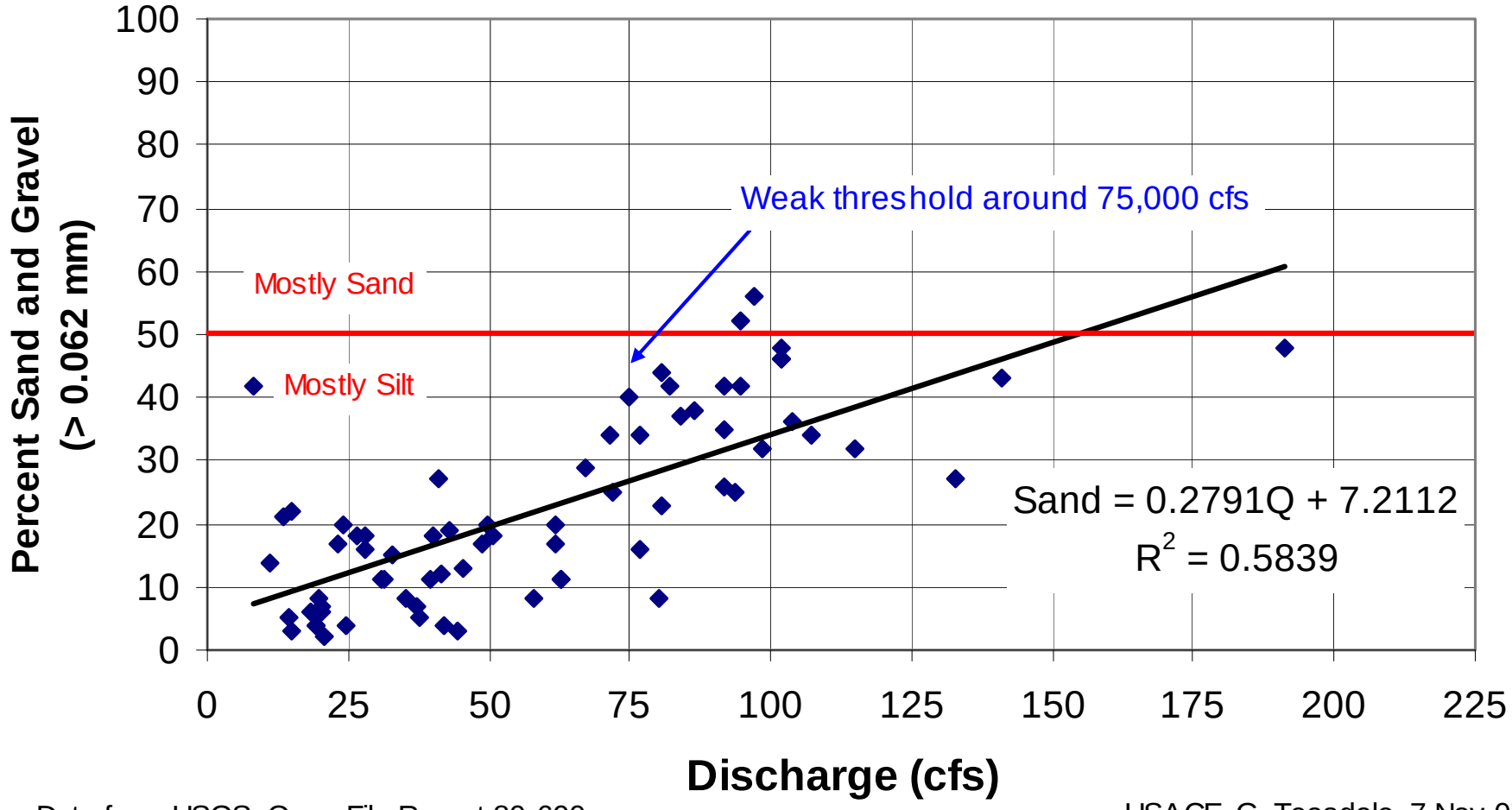
Clearwater River Suspended Sediment Load (1972-79)
Variation of Particle Size with Discharge



Data from USGS Open File Report 80-690

USACE, G. Teasdale, 7 Nov 07

Snake River Suspended Sediment Load (1972-79) Variation of Particle Size with Discharge



Data from USGS Open File Report 80-690

USACE, G. Teasdale, 7 Nov 07

Investigation of Dominant Sediment Sources

- Forestland
- Agricultural land
- River channel sediment
- Other

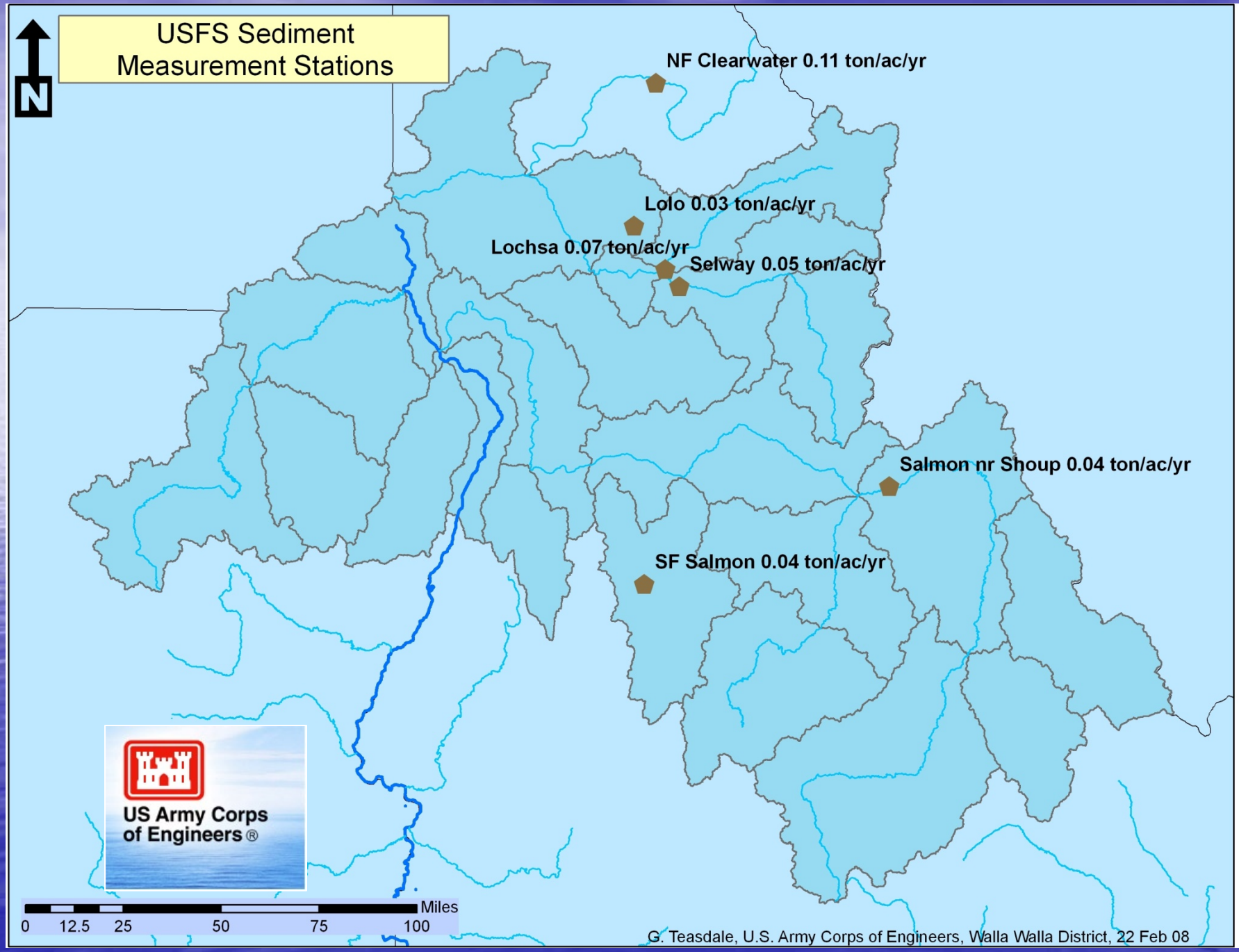
Forest Watershed Sediment Yield Assessment

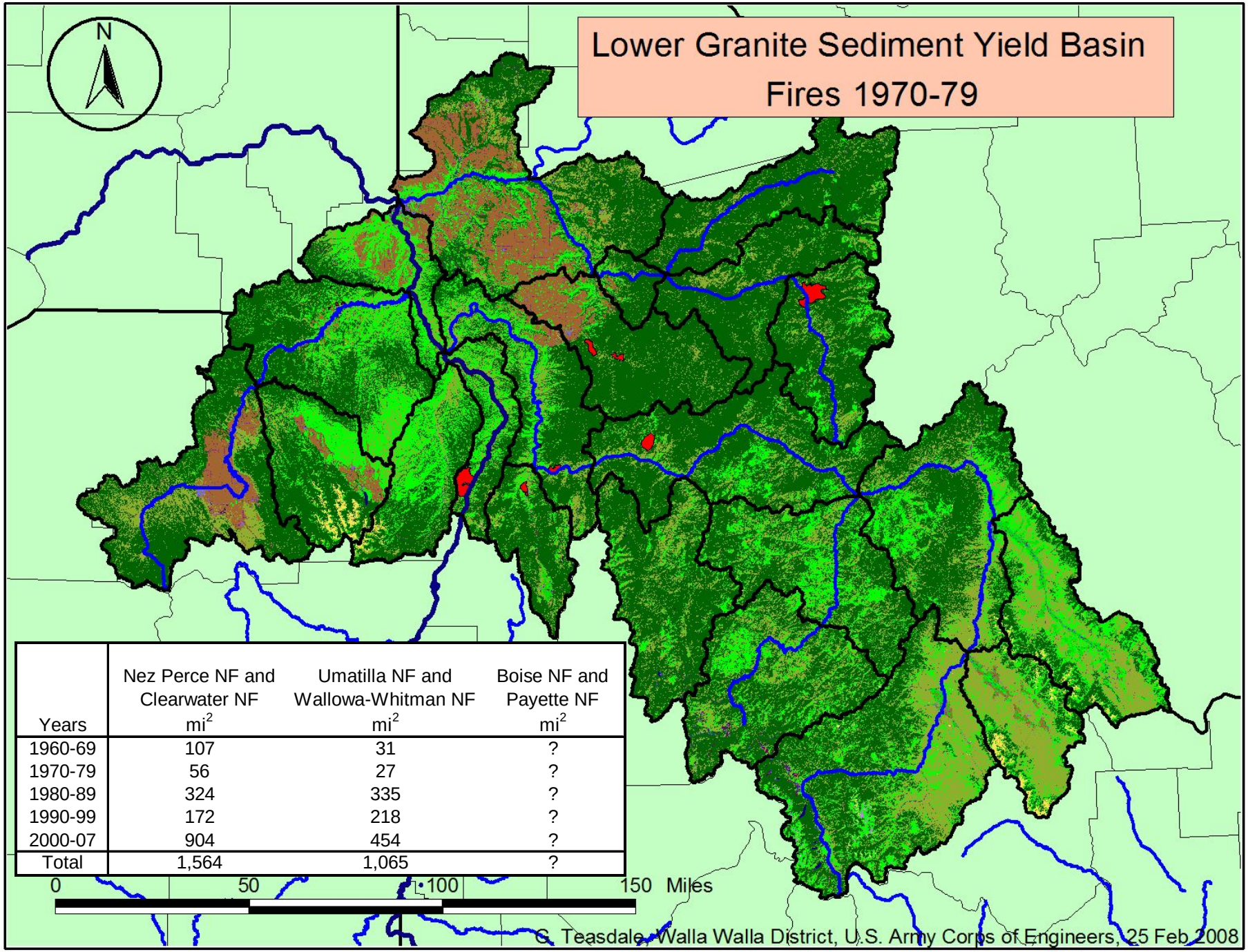
- Over 50% of the Lower Granite Basin is managed by the USFS
- Forest Service expertise and data
  - Direct monitoring
  - Watershed sediment yield modeling
  - Strong research capabilities

Episodic Sediment Sources

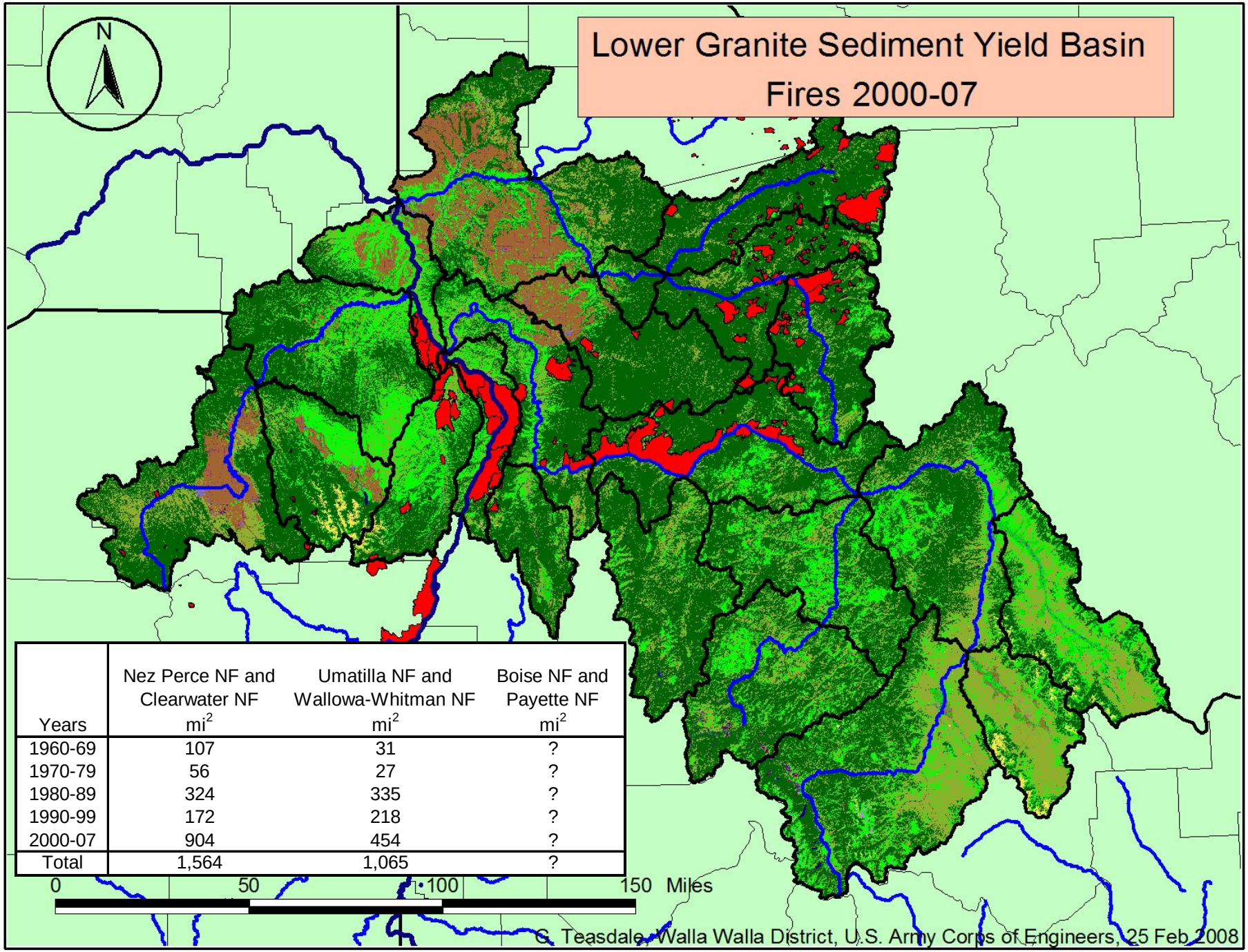
- Fires
- Landslides
- Forest practices
- Roads
- Other

Uncertain timing and magnitude


USFS Sediment Measurement Stations
N
NF Clearwater 0.11 ton/ac/yr
Lolo 0.03 ton/ac/yr
Lochsa 0.07 ton/ac/yr
Selway 0.05 ton/ac/yr
Salmon nr Shoup 0.04 ton/ac/yr
SF Salmon 0.04 ton/ac/yr
US Army Corps of Engineers®
Miles
0 12.5 25 50 75 100
G. Teasdale, U.S. Army Corps of Engineers, Walla Walla District, 22 Feb 08



Years	Nez Perce NF and Clearwater NF mi^2	Umatilla NF and Wallowa-Whitman NF mi^2	Boise NF and Payette NF mi^2
1960-69	107	31	?
1970-79	56	27	?
1980-89	324	335	?
1990-99	172	218	?
2000-07	904	454	?
Total	1,564	1,065	?



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US Army Corps of Engineers®

NRCS Natural Resources Conservation Service

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Sediment Yield from Agricultural and Mixed Land Use Watersheds

Mixed Land Cover – Land Use

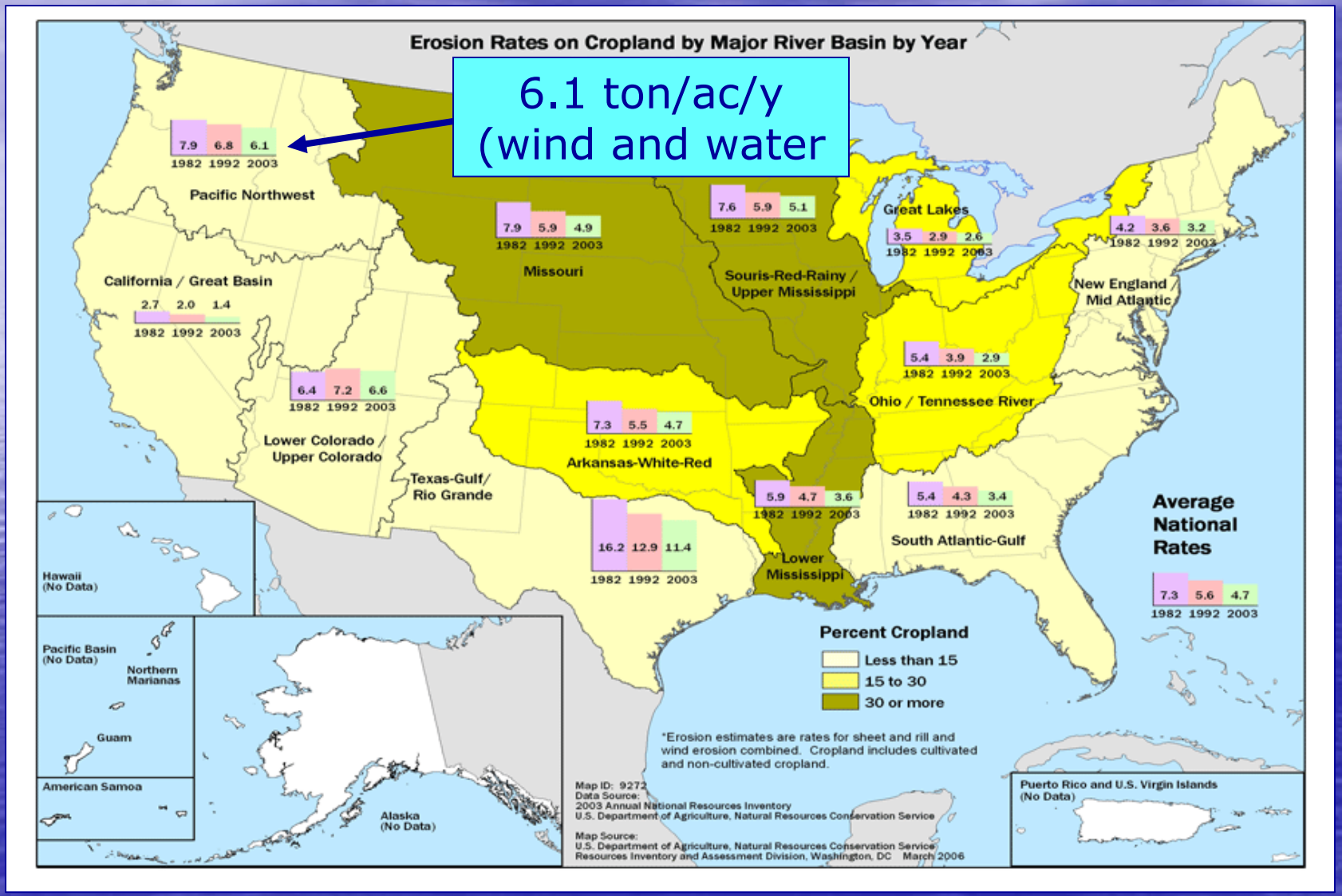
- Agricultural
  - Cultivated
  - Non-cultivated
  - Conservation Reserve Program (CRP)
- Forest
- Range
- Urban/Residential
- Transportation
- Industrial

Sediment Yield Assessments

- National Resources Inventory (NRI)
- Local NRCS Assessments
- Conservation Effects Assessment Project (CEAP)
- Total Maximum Daily Load Analysis (TMDL)

The Conservation Effects Assessment Project (CEAP) began in 2003 as a multi-agency effort to quantify the environmental benefits of conservation practices used by private landowners participating in selected U.S. Department of Agriculture (USDA) conservation programs.

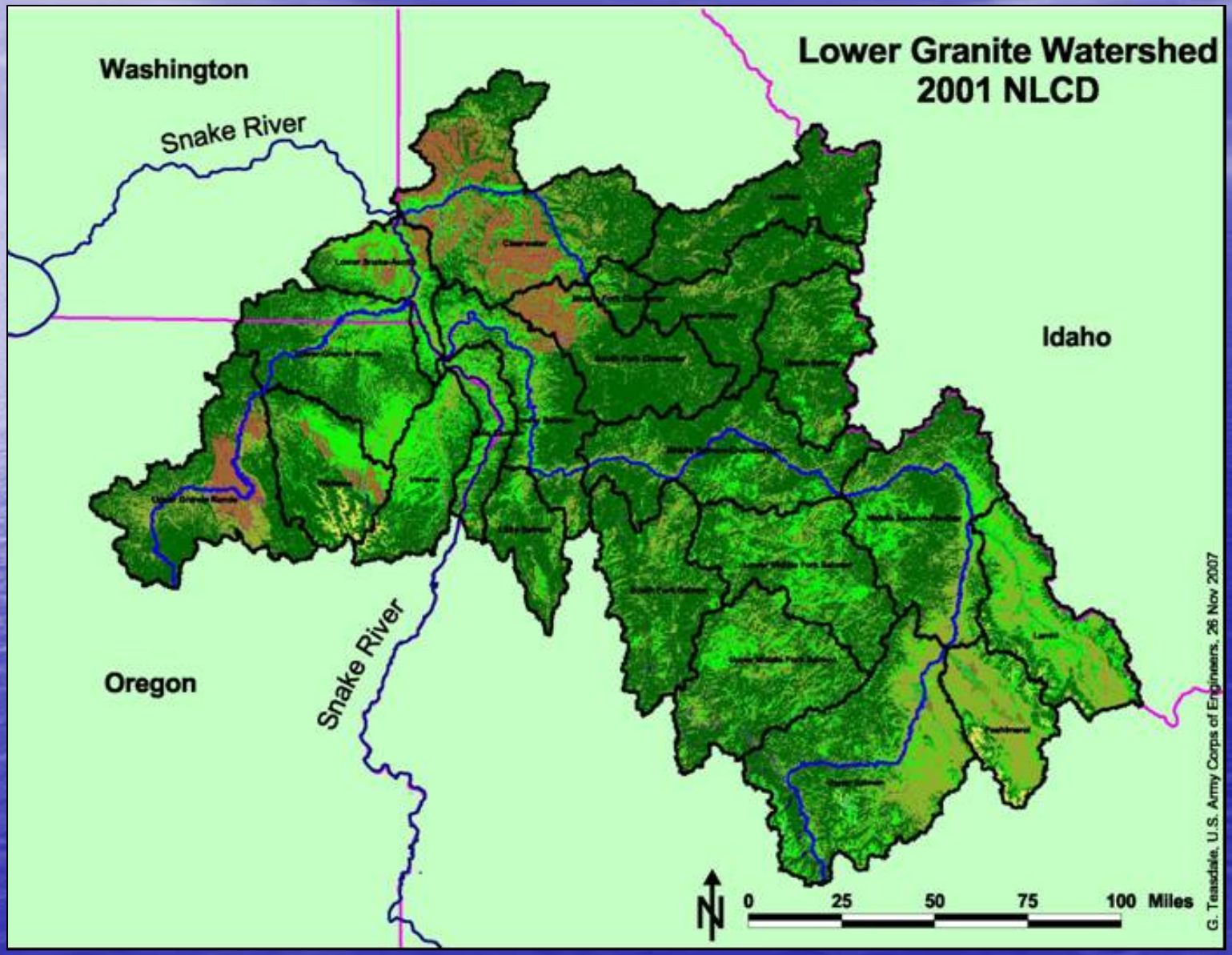
Cropland Erosion NRI 2003



Source: NRCS 2003 National Resources Inventory

Sediment Yield Modeling

Lower Granite Basin Sediment Management Model



Sediment Yield Modeling Approaches

- Physical process
  - WEPP
  - EuroSEM
- Physically based
  - Field scale: USLE/RUSLE
  - Watershed scale: SWAT, AGNPS
- Empirical
  - USEPA PLoad
- Statistical
  - USGS SPARROW (SPAtially Referenced Regressions On Watershed Attributes)

Field scale and small catchments

Watersheds and river basins

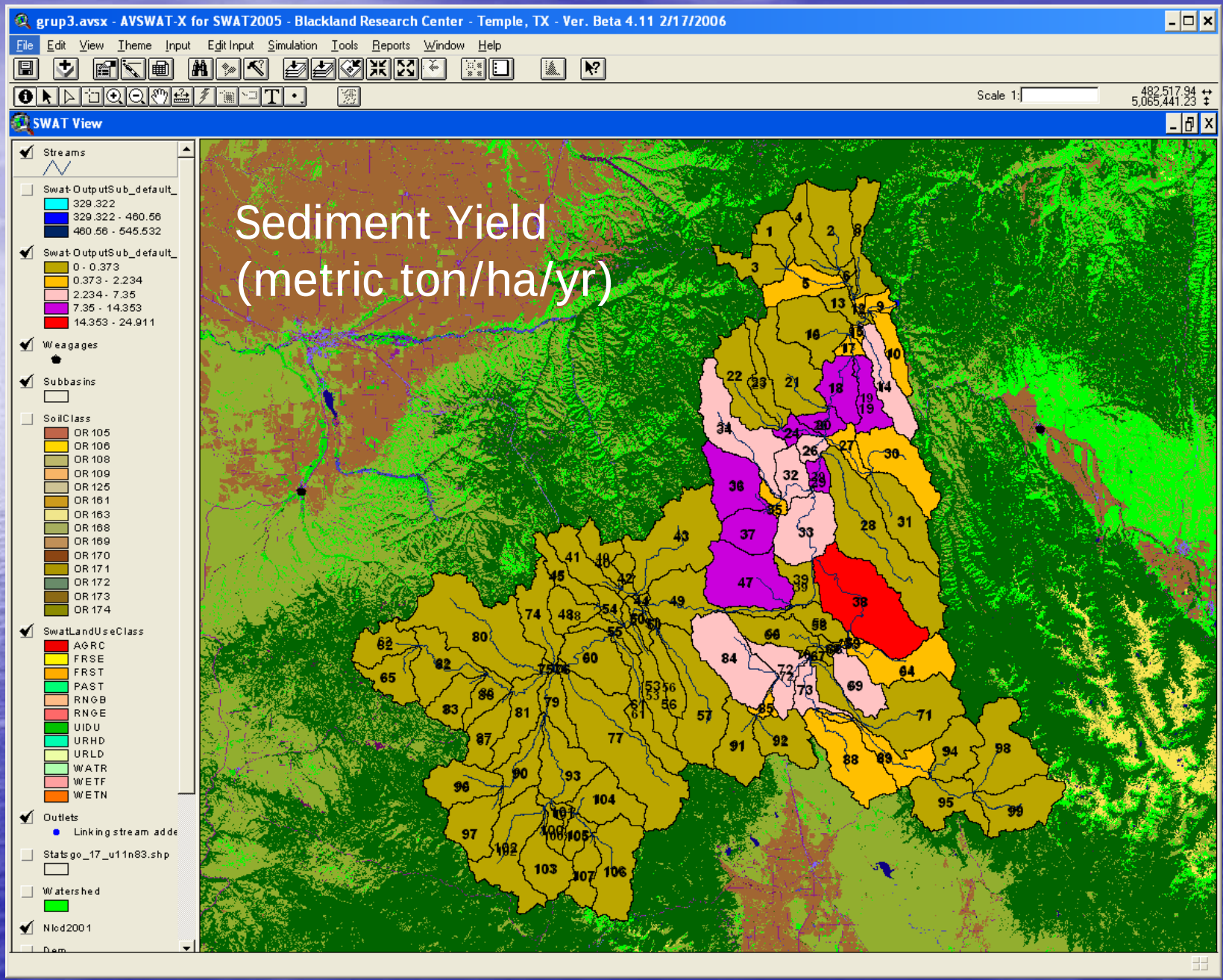
SWAT Model

- **S**oil and **W**ater **A**ssessment **T**ool
- 30 years of development
  - Jeff Arnold and J.R. Williams at ARS
  - Texas A&M

SWAT is a river basin, or watershed scale model developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time.

Input Datasets

- 1990 and 2001 National Land Cover Dataset
- USGS 30 m (1 arcsecond) DEM
- USDA STATSGO/SSURGO digital soils data
- Weather data generated by SWAT
- Subbasin and steam reach parameters generated by AVSWAT and check against other sources


grup3.avsx - AVSWAT-X for SWAT2005 - Blackland Research Center - Temple, TX - Ver. Beta 4.11 2/17/2006
File Edit View Theme Input Edit Input Simulation Tools Reports Window Help
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5,065,441.23
SWAT View
Streams
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329.322
329.322 - 460.56
460.56 - 545.532
Swat-OutputSub_default_
0 - 0.373
0.373 - 2.234
2.234 - 7.35
7.35 - 14.353
14.353 - 24.911
Weagages
Subbasins
SoilClass
OR105
OR106
OR108
OR109
OR125
OR161
OR163
OR168
OR169
OR170
OR171
OR172
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OR174
SwatLandUseClass
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Nlcd2001
Dem
Sediment Yield
(metric ton/ha/yr)