Integrating Natural Form and Process

with Drainage Reclamation in Montana

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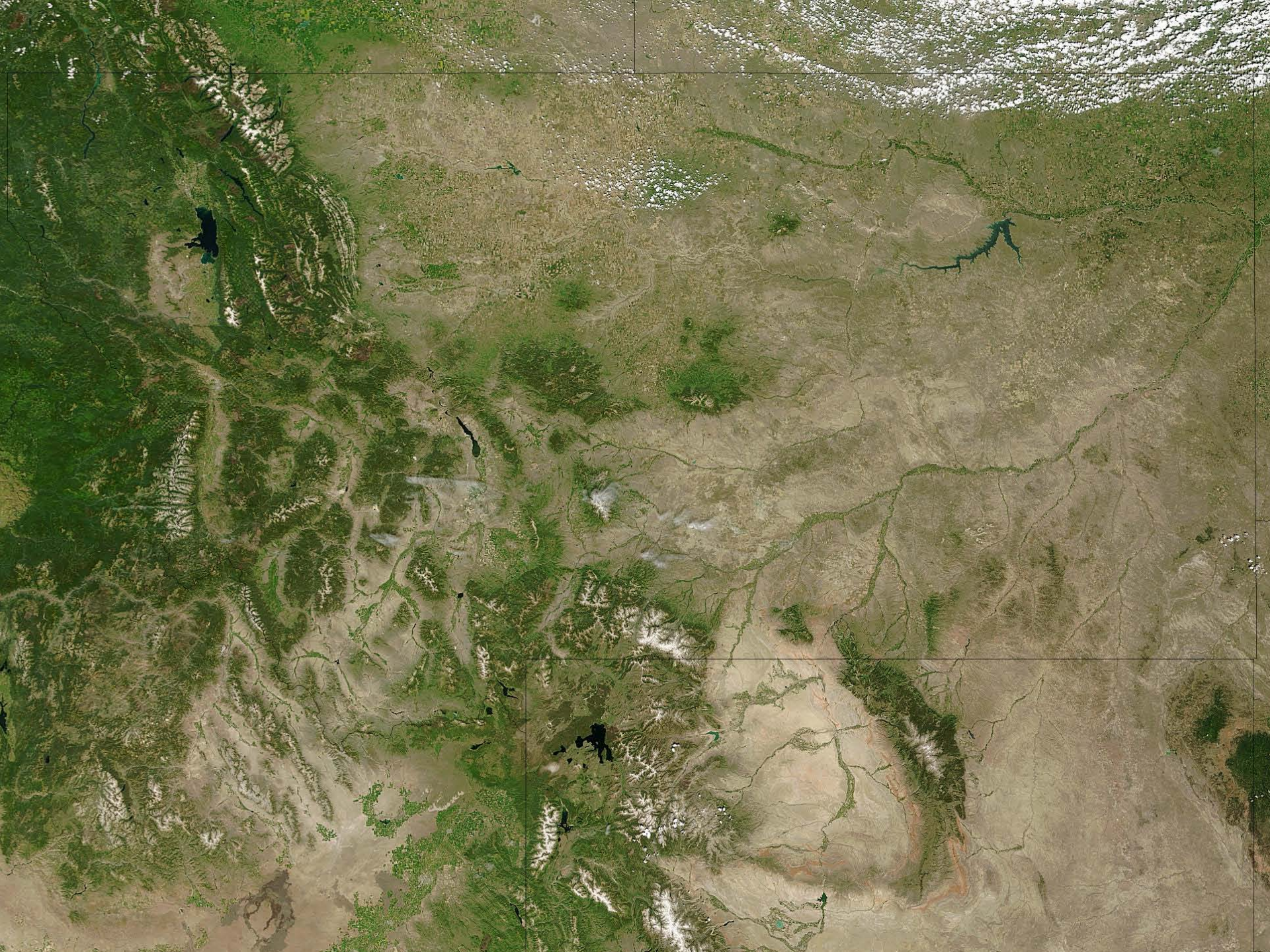
Geomorphic Reclamation and Natural Stream Design at Coal Mines
OSM National Technical Forum

April 28-30, 2009 Bristol, Virginia



Drainage Basin Reclamation - Requirements

Approximate Original Contour (AOC)

- closely resembles the general surface configuration of the land prior to disturbance
- blends into and complements the drainage pattern of the surrounding terrain

Approximate Premine Drainage Basin Topography & Geomorphology

- Drainage Basin Area, Dimensions, Shape
- Drainage Density, Profiles
- Topography – Slope Profiles, Aspect, Relief
- Valley Bottom & Floodplain Morphology, Channel Shape

Approximate Premine Hydrologic & Ecologic Processes & Land Use

- Runoff Characteristics, Infiltration, Ponding
- Soil, Vegetation & Wildlife Habitat

Drainage Reclamation Plan – Application Requirements

Description of postmining drainage basin reclamation that ensures protection of the hydrologic balance, achievement of postmining land use performance standards, and prevention of material damage to the hydrologic balance in adjacent areas, including:

- comparison of premining and postmining drainage basin size, drainage density, and drainage profiles to identify characteristics not apparent on premining and postmining topographic maps;

- explanation of how, within drainage basins the plan will:
  - meet Drainage Basin Reclamation performance standards (ARM 17.24.634); and
  - protect the hydrologic balance where postmining topography differs from AOC

Drainage channel designs appropriate to prevent material damage to the hydrologic balance in the adjacent area, and to meet drainage reclamation performance standards, including:

- detailed drainage designs, including fluvial and geomorphic characteristics - for channels that contain critical hydrologic, ecologic or land use functions, and

- typical designs and discussions of general fluvial and geomorphic habit, pattern, and other relevant functional characteristics - for all other channels.

Drainage Basin Reclamation – Performance Standards

Drainage basins, valleys, channels and floodplains must be constructed to:

- approximate original contour
- an appropriate geomorphic habit or characteristic pattern
- an overall concave longitudinal channel profile
- dimensions and characteristics blending with undisturbed drainages above & below
- provide for long-term relative stability of the landscape
- safely pass runoff from a 100-year, 6-hour preciptiation event
- remain in dynamic equilibrium with the drainage basin system
- establish a diversity of habitats consistent with the postmining land use, and restore, enhance or maintain natural riparian vegetation

Drainage Basin Design & Evaluation - Resources

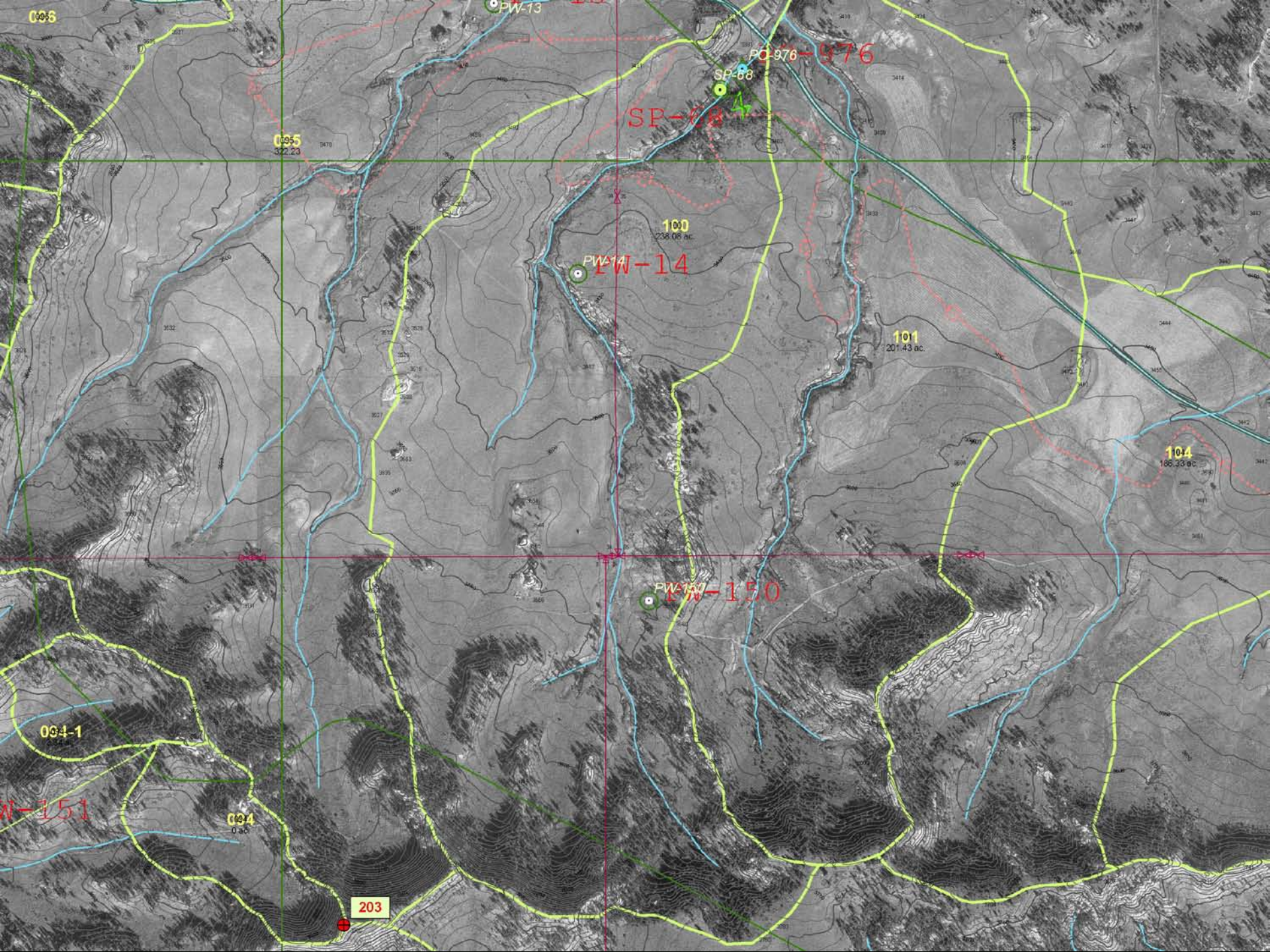
Maps, Data, other Resources (*Premine and Postmine*)

- Mine Area / Drainage Basin Maps, Aerial Photographs
  (Topography, Drainage Basins, Channel Networks)

- Drainage Channel & Valley Bottom Maps & Surveys
  (Longitudinal Profiles & Cross Sections, Plan View)

- Photographs of valley & drainage features

- Other Maps & Related Data
  (Soil, Vegetation, Wildlife, Land Use)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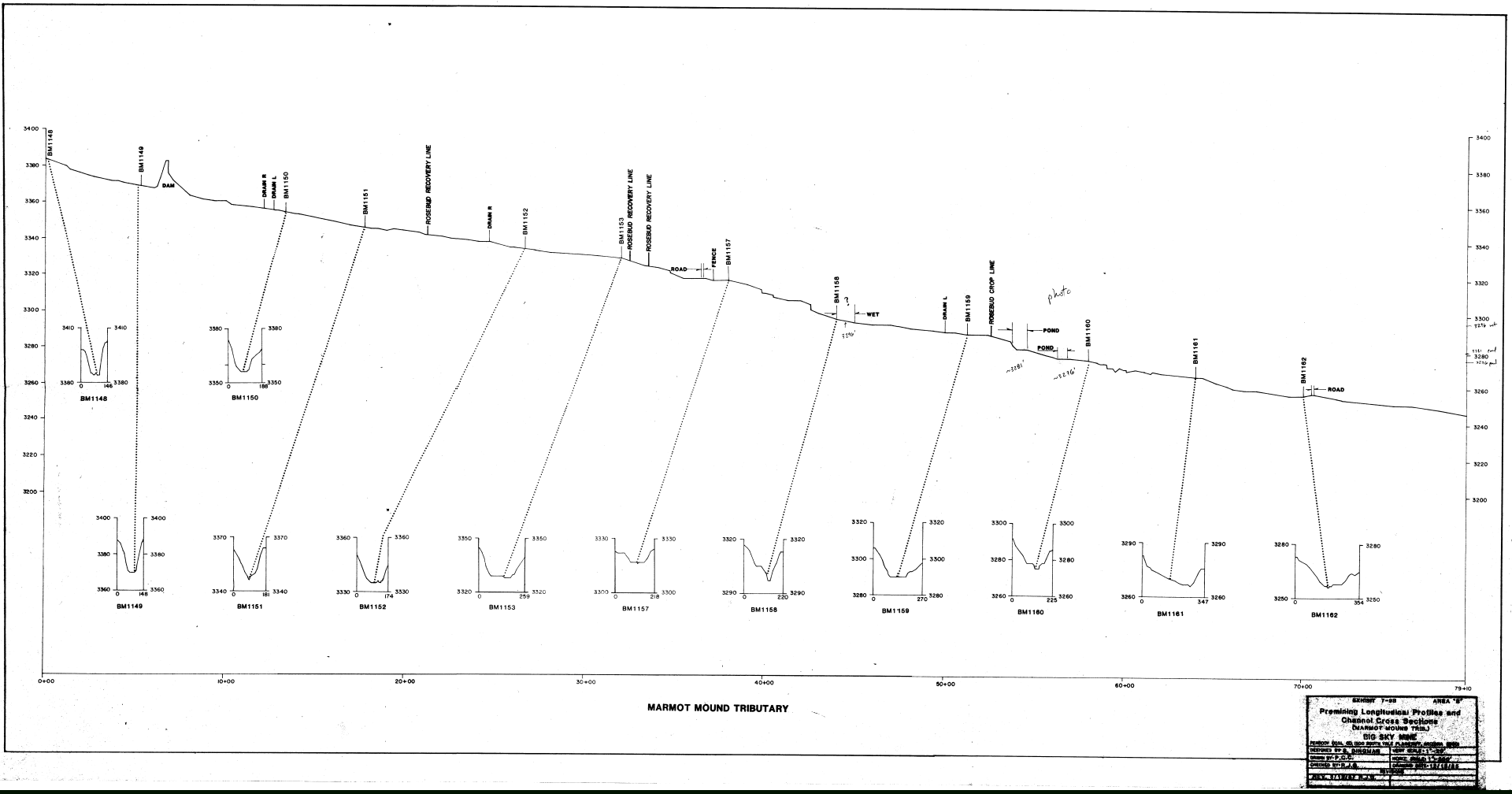
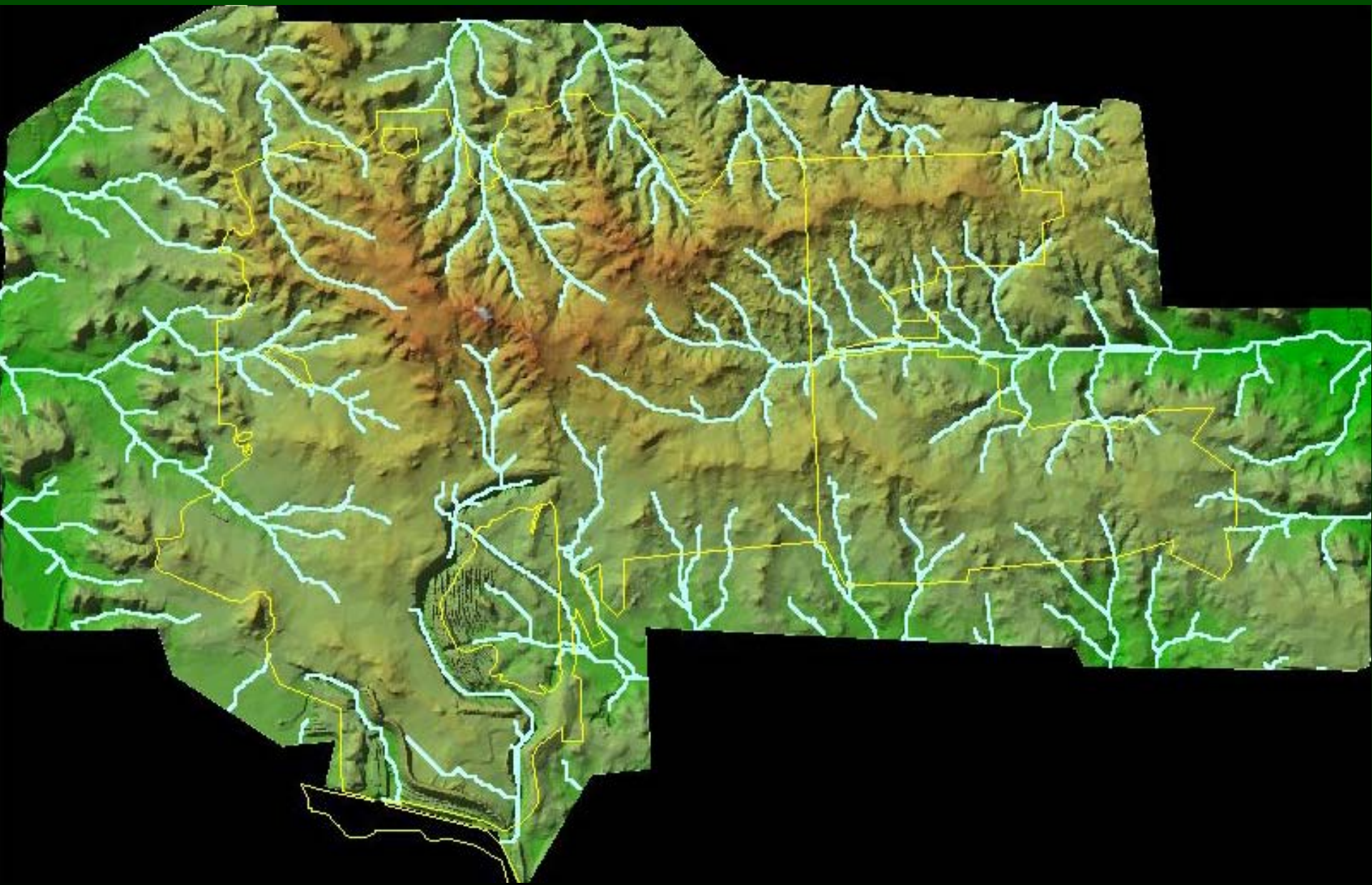
Premine Drainage Surveys – Profiles & Cross Sections



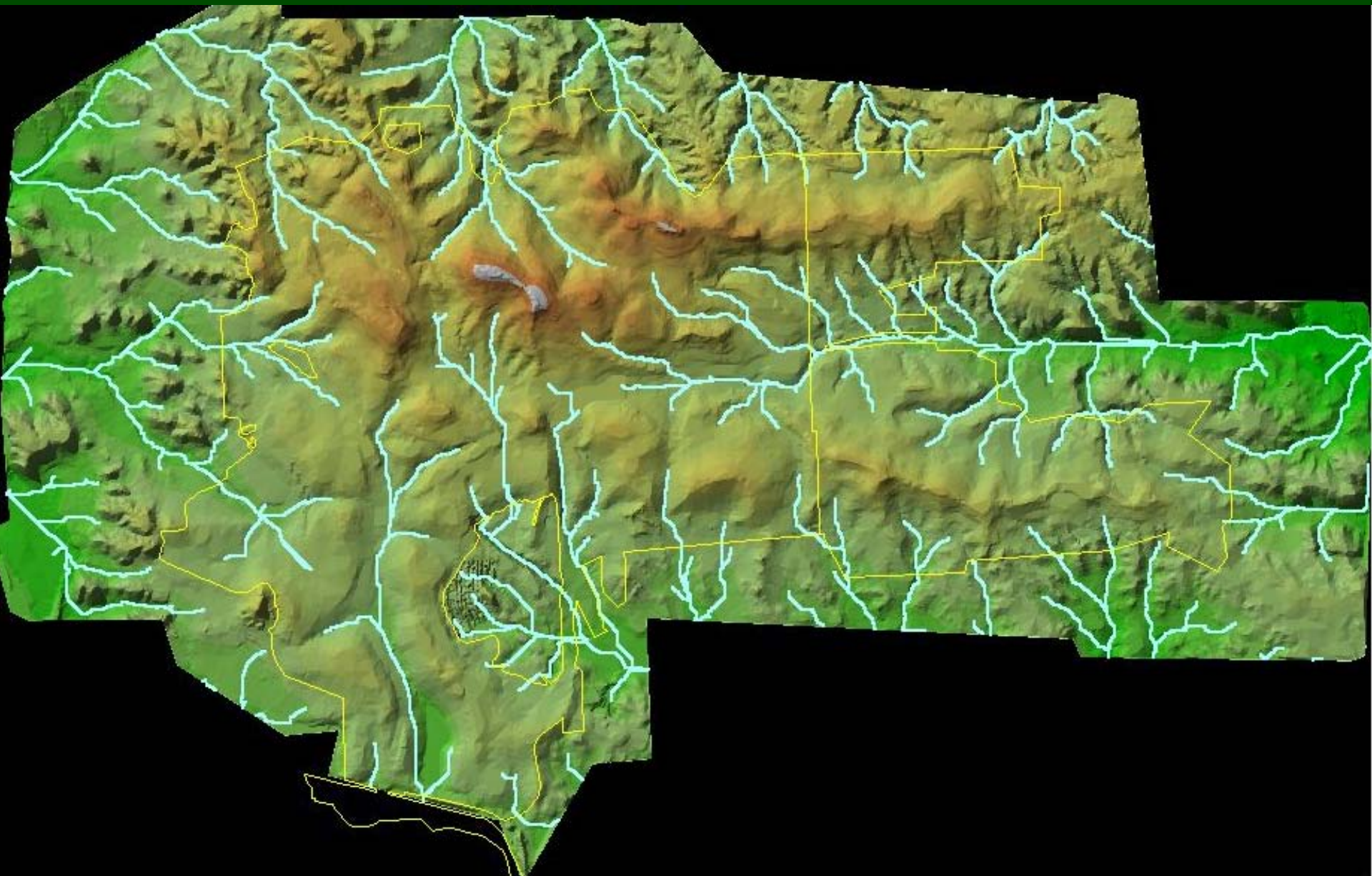
Drainage Basin Design & Reclamation - Process

- Design Plans & Review
  - Approximate PMT & Drainage Reclamation Plans in Permit
  - Final Reclamation Plan Adjustments (including field adjustments)
- Construction/Reclamation
  - Prep Work Staking/Surveying
  - Regrading & Resoiling
  - Reseeding, Tree & Shrub Planting
- Monitoring
  - As-built Survey
  - Follow-up Inspections, Surveys, Hydrologic & Other monitoring
- Maintenance ?
  - Case-by-Case Evaluations (problems, potential development, need for intervention)
  - Initial Design/Reclamation Quality, Reclamation Surveys & Monitoring critical
- Bond Release

Premine Topography & Drainages



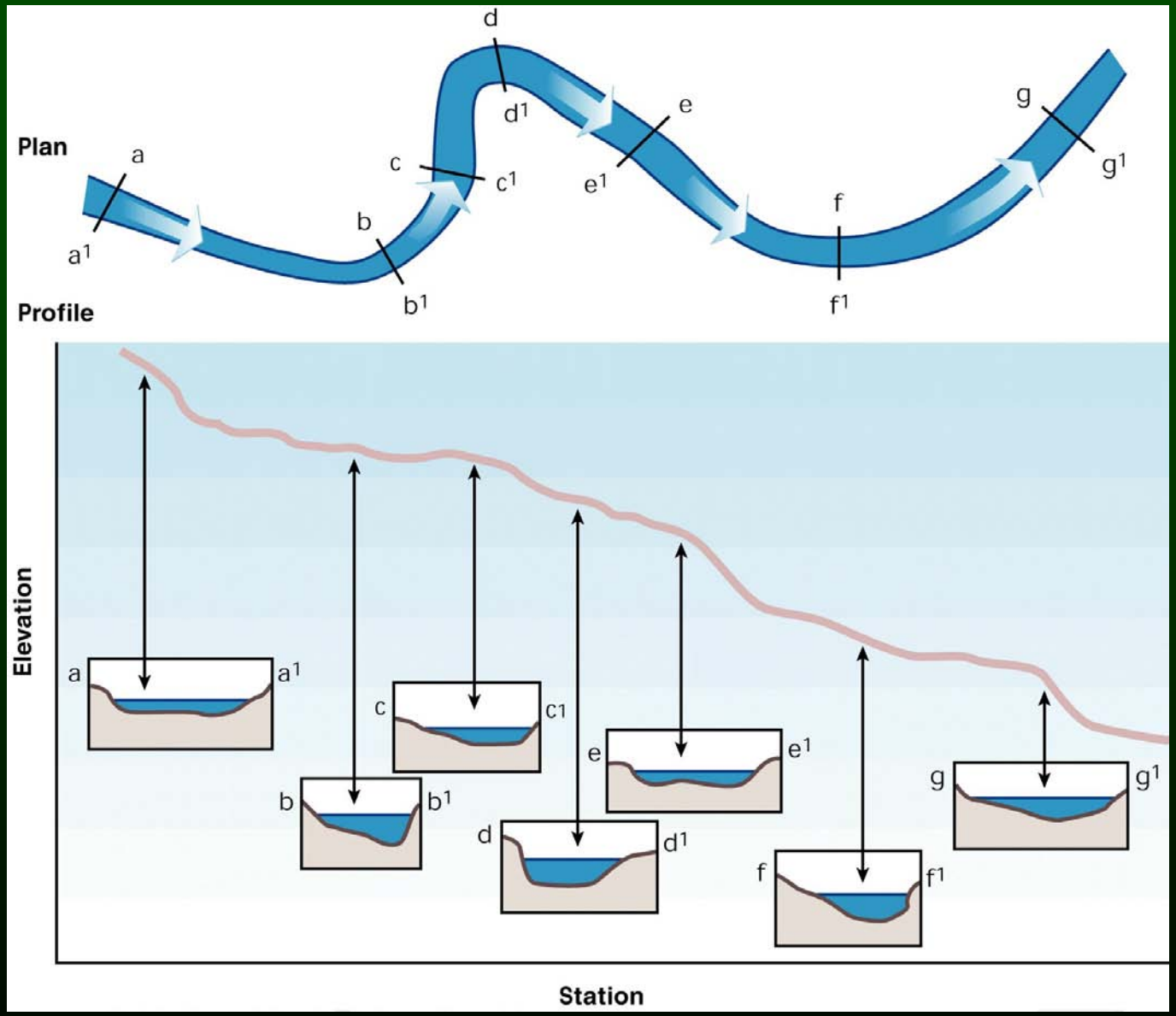
Postmine Topography & Drainages



Basic Channel Morphology

- **Longitudinal profile**
  - Valley Slope, Channel Slope , Sinuosity
  - Average, Concave Longitudinal Profile
- **Cross section**
  - Width, Depth, W/D Ratio, Entrenchment
  - Bed & Bank Materials, Roughness, Flow Velocity
- **Plan view**
  - Channel & Floodplain Patterns, Dimensions
  - Meander Wavelength, Belt width

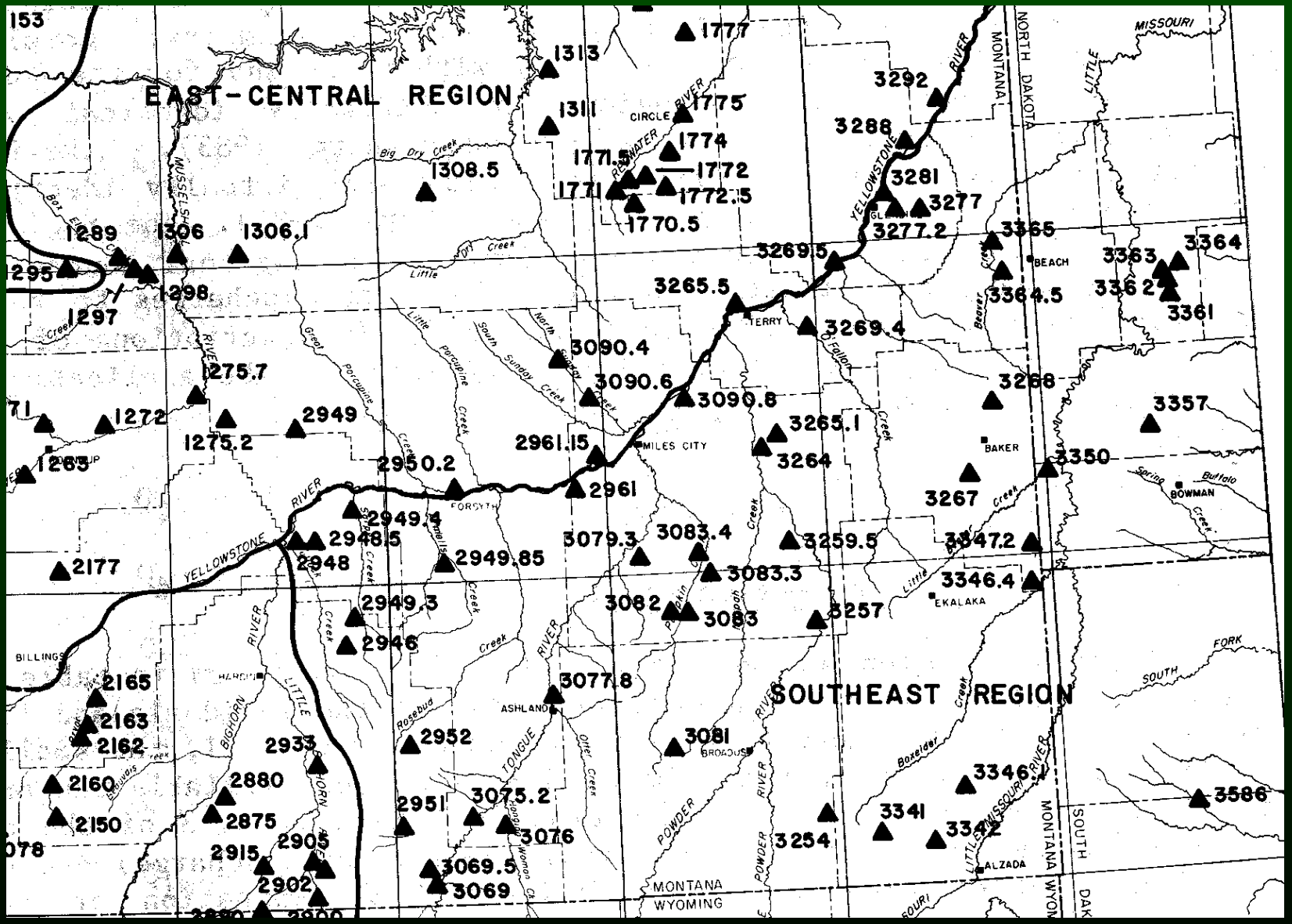
Channels - Plan View, Long Profile & Cross Sections



Federal Interagency Stream Restoration Working Group (1998)

http://www.usda.gov/stream_restoration

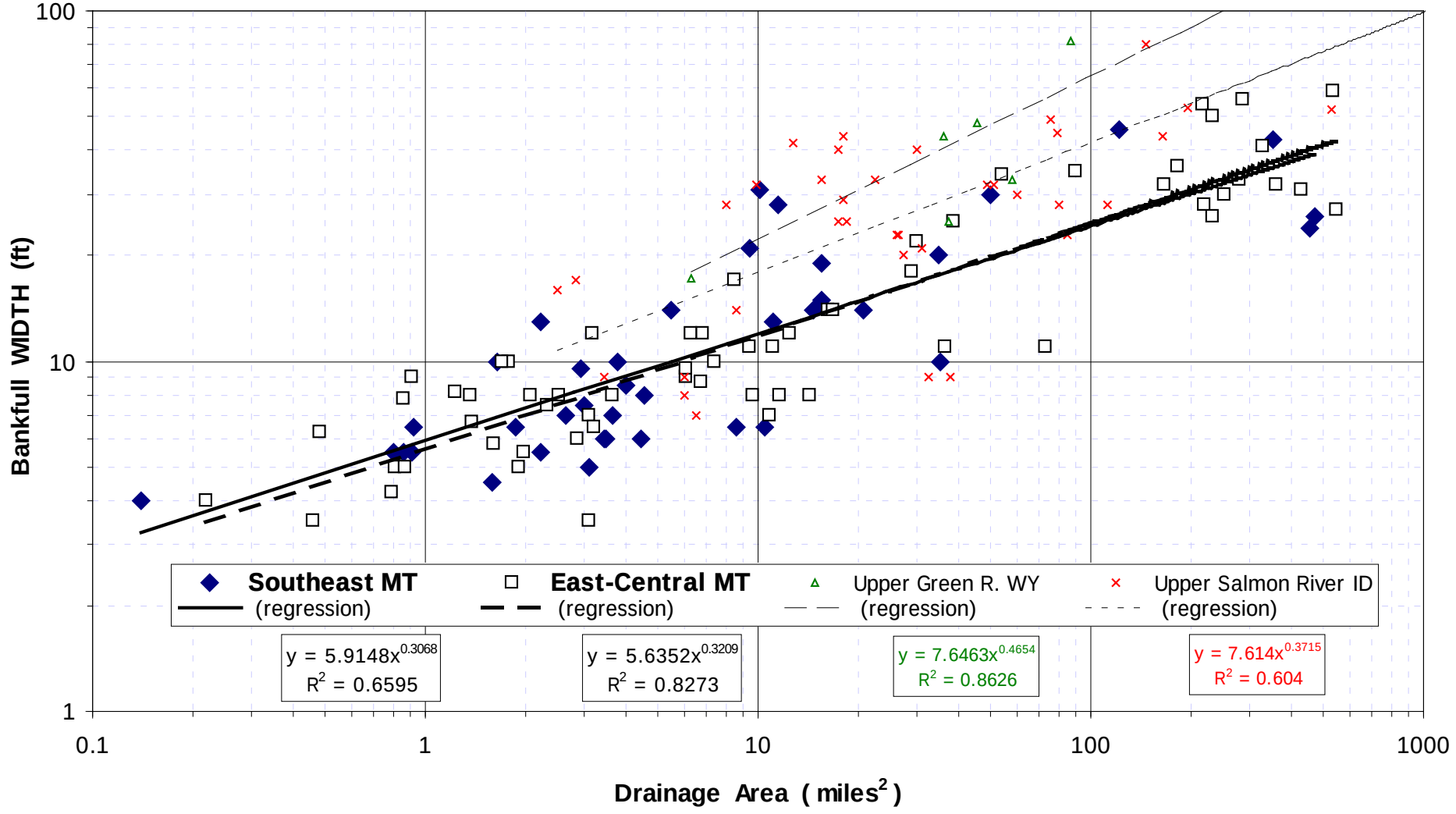
Regional Relationships - USGS Peakflow Gaging Stations
(Southeast Montana)



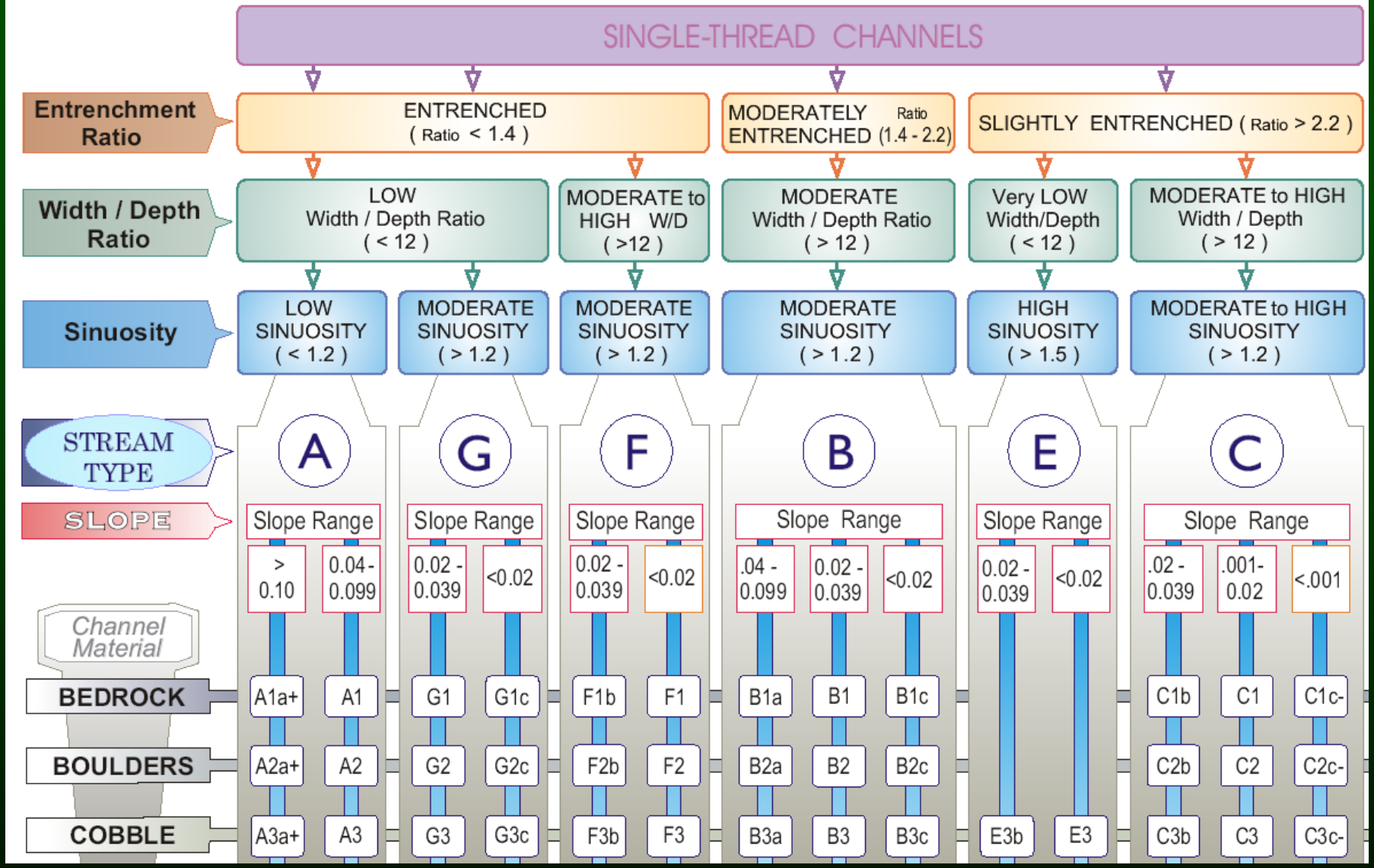
From: Parrett et al. (1987)

Regional Relationships - Channel Width vs. Drainage Area

Southeast & East-Central MT (with regional comparisons)



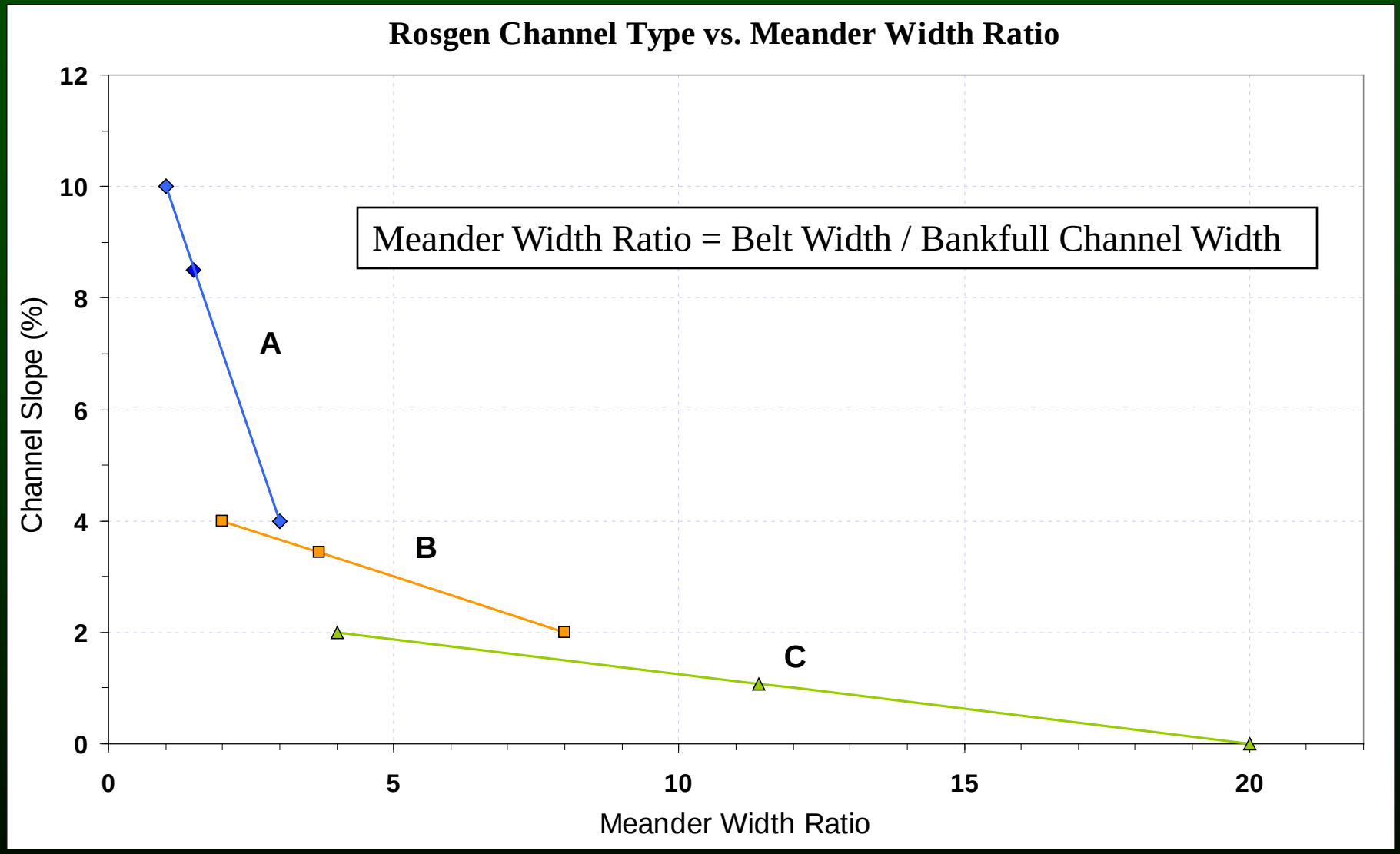
Montana data from Parrett et al. (1987) and Omang (1992), with updates from Parrett (pers. comm., 5/2001); Upper Green River, WY and Upper Salmon River, ID data from Dunne & Leopold (1978); and Emmett (1975).



KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the "*continuum of physical variables*" within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units; while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

excerpted from: Rosgen Geomorphic Channel Design by David L. Rosgen (2007). Chapter 11 In J. Bernard, J.F. Fripp & K.R. Robinson (Eds.), Part 654 Stream Restoration Design National Engineering Handbook (210-VI-NEH). Washington, D.C.: USDA Natural Resources Conservation Service (see also http://www.wildlandhydrology.com).

Approximating Floodplain Width



data from : Rosgen, D.L. 1994. A classification of natural rivers. Catena 22: pp. 169-199. see: http://www.wildlandhydrology.com

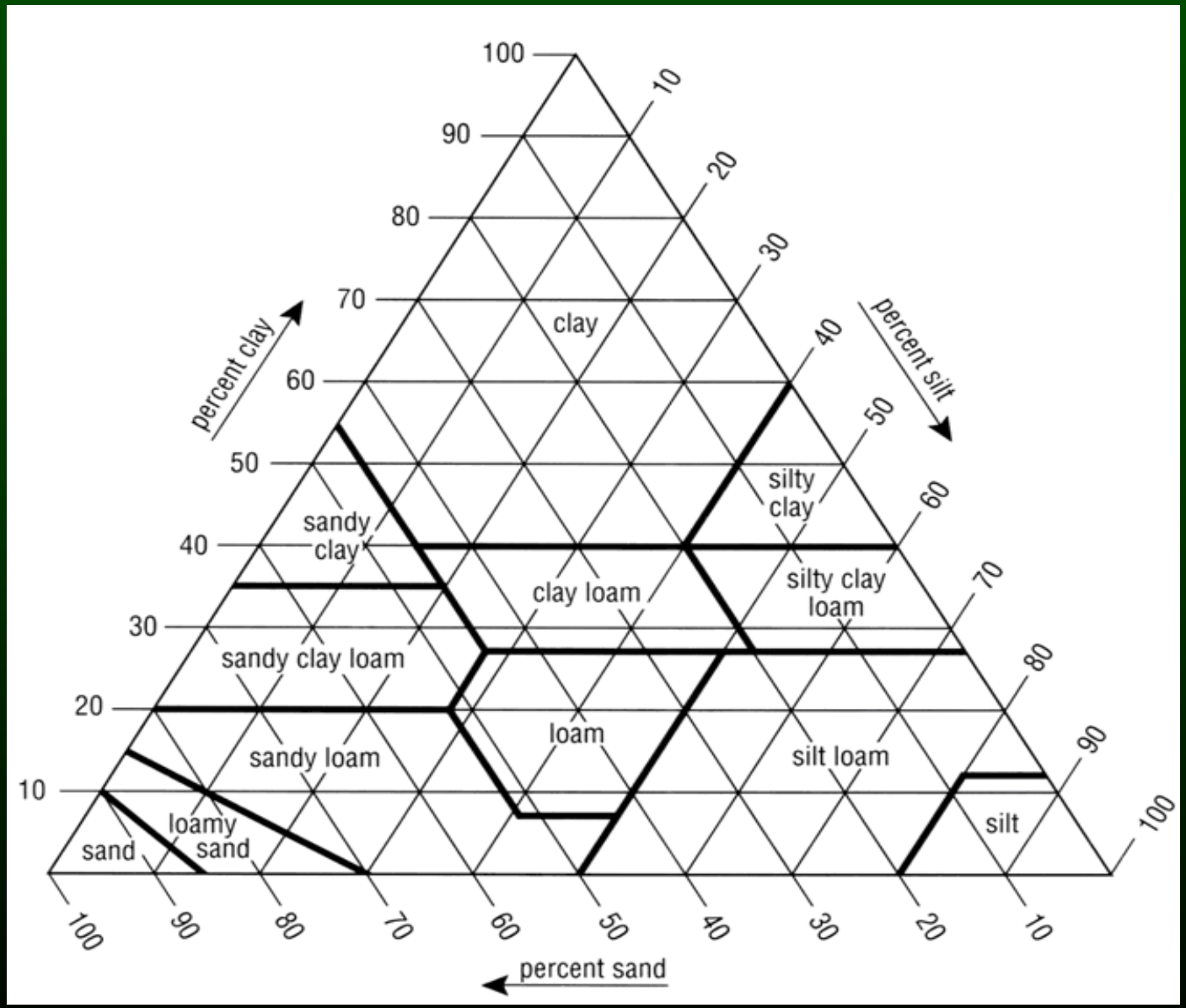
Reconnection – Upland Slopes & Tributaries

Final Regrading – Communicating with Bulldozers

Final Regrading Adjustments – Staking Tributaries

Final Regrading Adjustments – Tributaries In

Soils ?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loamy sand
sand
silt
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percent sand

2008/ 5/30

2007/05/23

Vegetation