Historical channel change on the Upper Gila River, Arizona and New Mexico in response to anthropogenic modifications and extreme floods
Upper Gila River Fluvial Geomorphology Study

Catalysts for study
  – Extreme floods during the 1970’s-1990’s
  – Erosion of agricultural land, critical infrastructure
  – Flooding of emergency routes and communities

Objectives
  – To provide an understanding of the physical processes operating in the Upper Gila River corridor
  – To explain recent (1935-2000) geomorphic change on the Upper Gila River in Safford and Duncan valleys
Upper Gila River Fluvial Geomorphology Study

- Background Information
- Field Data Collection Plan
- Hydrologic Analysis
- **Catalog of Historical Changes**
- Geomorphic Analysis
- Stable Channel Analysis
- Stream Corridor Assessment
- Final Report

Geomorphic Map of the Upper Gila River, Arizona
Partnerships

Arizona Water Protection Fund
  – GRANT NO. 98-054WPF

Graham County
  – COST SHARE AGREEMENT 00-GI 32-0054

Bureau of Land Management

Gila Watershed Partnership

Landowners
  – Property access, accounts of river history, flooding, property history
Practically Speaking…

• Erosion/sedimentation of agricultural land
• Limited emergency access across river (flooding across bridge approaches)
• Damage to infrastructure
  – Bridges: overtopping/erosion of abutments, undercutting
  – Levees: overtopping, breaching, lateral erosion
  – Diversion dams: flanking, sedimentation and scour, siltation of irrigation ditches
  – Bank protection: lateral erosion
Geomorphological Analysis

- Geomorphic mapping
  - Landform delineation (i.e., river channel, stream terraces...)
  - Human features (levees, dams...)

- Soil descriptions
  - USDA soils mapping and descriptions
  - Site descriptions of bank exposures

- Laboratory analysis
  - Macrobotanical identification
  - $^{14}$C dating of charcoal fragments
Soils (Poulson and Young, 1938)

- **Gila alluvium (G, Rv)**
  - Weakly developed soils
  - Stratified alluvium
  - Recently occupied by the river channel

- **Pima alluvium (P)**
  - Weakly to moderately developed soils
  - Floodplain alluvium

- **Upland soils (A, C, I)**
  - Alluvial fans
  - Older stream terraces
  - Bedrock
**Historical channel change**

**Channel width measurements**

- by photo year (**recent flow** and **flood flow** width, 1935-2000)
- by location in channel (variability)
- changes before and after extreme floods


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Patterns of historical changes in channel width

Large floods: increase in width
- lateral erosion to accommodate flood flows

Few large floods: decrease in width
- floodplain rebuilding
- vegetation encroachment
- levee construction
Variability in channel width

- highlights wide and narrow sections in the river corridor
- Identifies sections of greatest historical channel change
Right angle bends in alluvial reaches with no apparent geologic control.

Scalloped meander scrolls along margins of diversion structures.

Dog ear erosion scars located lateral to channelized sections.
Channel change processes

- Channel widening and narrowing in response to hydrologic regime
- Channel avulsion
- Meander cutoffs
- Overbank channel splays

Factors in channel change

- Levee construction/failure
- Land leveling
- Propagation of erosion
- Channel straightening
- Diversion dam orientation
- Vegetation
- Alluvial fans
Areas of greatest change: Safford Valley
• Thatcher Bridge to Smithville diversion
  – Flow redirection following levee breach in channelized section upstream of Smithville Div.
  – Flow redirection by diversion dam and levees
  – Erosion of alluvium upstream of bridge
• Watson and Butler Washes
  – propagation of lateral erosion following levee breach up stream of Butler Wash
• San Jose Diversion
  – Channel widening
  – Flow redirection downstream of diversion structure
  – Propagation of lateral erosion
• Fort Thomas Bridge
  – Levee breach
  – Isolation of floodwaters by vegetation, prevented water from reentering channel downstream
Duncan Valley

- Willow Creek
- Cottonwood Wash
- Kaywood Wash
- Waters Wash
- Whitefield Wash
- Duncan Bridge
- Railroad Wash
- AZ-NM border
Railroad wash area
• Railroad Wash area
  – Levee breach, flow redirection, creating scalloped features
  – Continued erosion behind levee
  – Erosion followed previous channel paths
Gila River near Duncan, AZ

Effects of the 1993 and 1995 floods:

Red: erosion of floodplain around outside bends
Green: deposition behind levees
Pink: damage/destruction of flood control structures
• Influence of alluvial fans
  – Restricts channel width, expansion zones u/s and d/s of fan feature
  – Control on location of channel
  – Alternating channel position in areas of multiple tributaries
Summary and Conclusions

- Channel narrowing during periods of few large floods
- Channel widening during periods of multiple large floods
- Gila River channel width readily adjusts to accommodate the largest floods
- In some cases, human modifications have profound effects on channel geometry
- Geomorphic response to human modifications
  - Lateral erosion associated with levees, dikes and bridges
  - Redirection of flow over diversion dams into opposite banks
  - Propagation of erosion downstream from levee breaches
Previous studies


  Channel widening during periods of large floods and floodplain building during periods of few floods


  stable channel zones correspond to places were control is located (i.e., bedrock or man-made structures). Unstable channel zones were located in sections dominated by deep alluvial fill, in areas with heavy human impacts, and in areas of dense phreatophyte growth


  the morphological response to high flow events depends on sequences of events and critical combinations of conditions
Recommendations

• Levees
  – Setback to average historical channel width
  – Setback to width of Gila alluvium
  – Levee/revetment maintenance in areas with critical infrastructure

• Diversion dams
  – lengthening, reorientation and/or redesign
  – Continued maintenance—sediment removal, direct low flow

• Bridges
  – Lengthen bridge span to width of flood channel

• Monitoring plan to document effects of activities
Thank you!