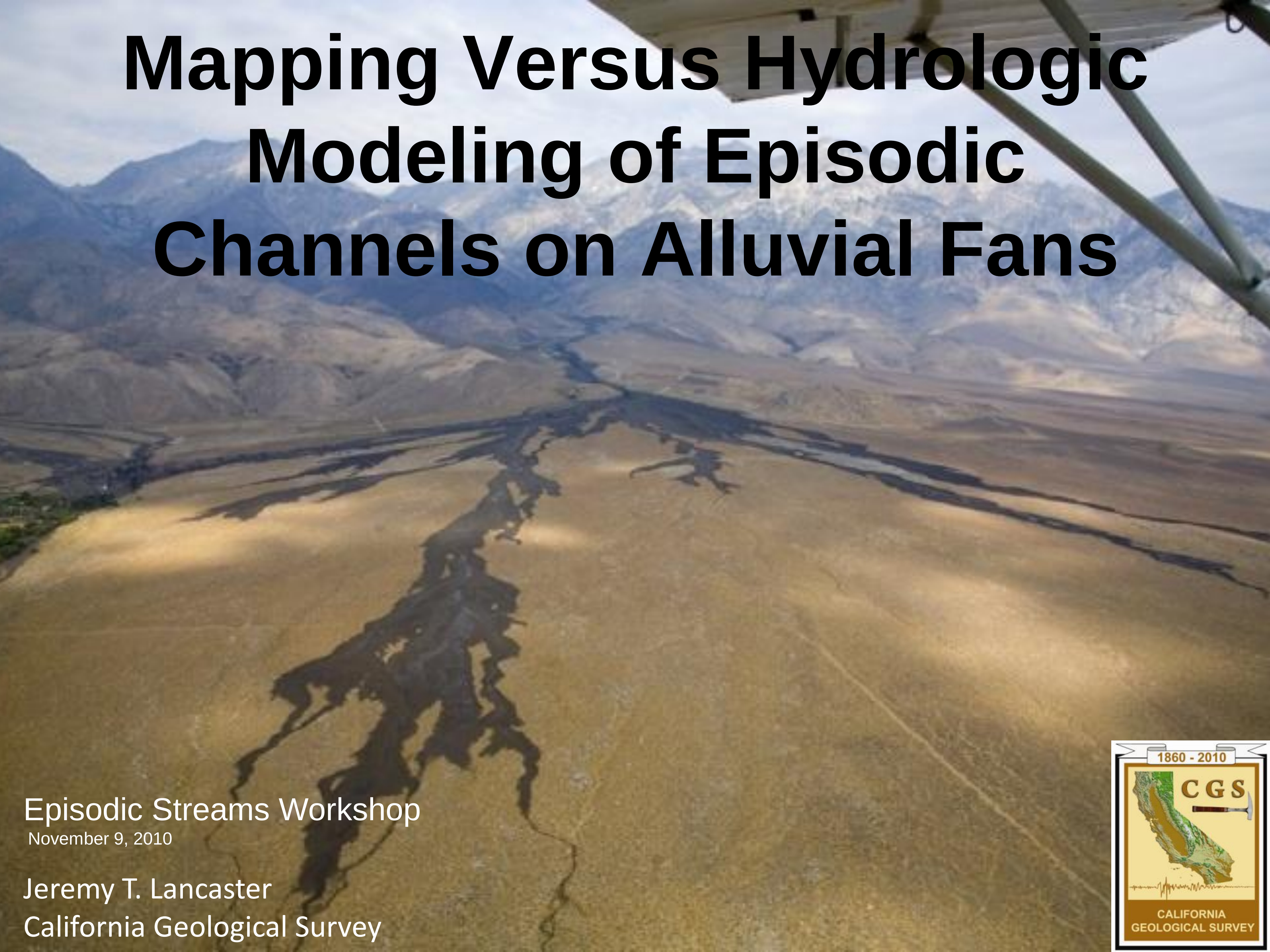
Mapping Versus Hydrologic Modeling of Episodic Channels on Alluvial Fans



Episodic Streams Workshop

November 9, 2010

Jeremy T. Lancaster

California Geological Survey

1860 - 2010

CGS

CALIFORNIA GEOLOGICAL SURVEY

Overview

- Flooding on Alluvial Fans
- Geomorphology and Alluvial Fan Flooding
- Reconnaissance Level Considerations
- Geologic Assessment and Mapping
- Hydrologic Modeling
- Mapping Versus Modeling

Characteristics Alluvial Fan Flooding

Flashy
Non-Riverine
High Velocity Flow: 15-30 FPS
Debris Deposition 15-20 feet
Unstable Flow paths
Avulsion
Rapid Aggradation
Debris flows
Impact Forces
Large Particle Sizes

Alluvial Fan Flooding

Image and Video Provided by
Coachella Valley Water District

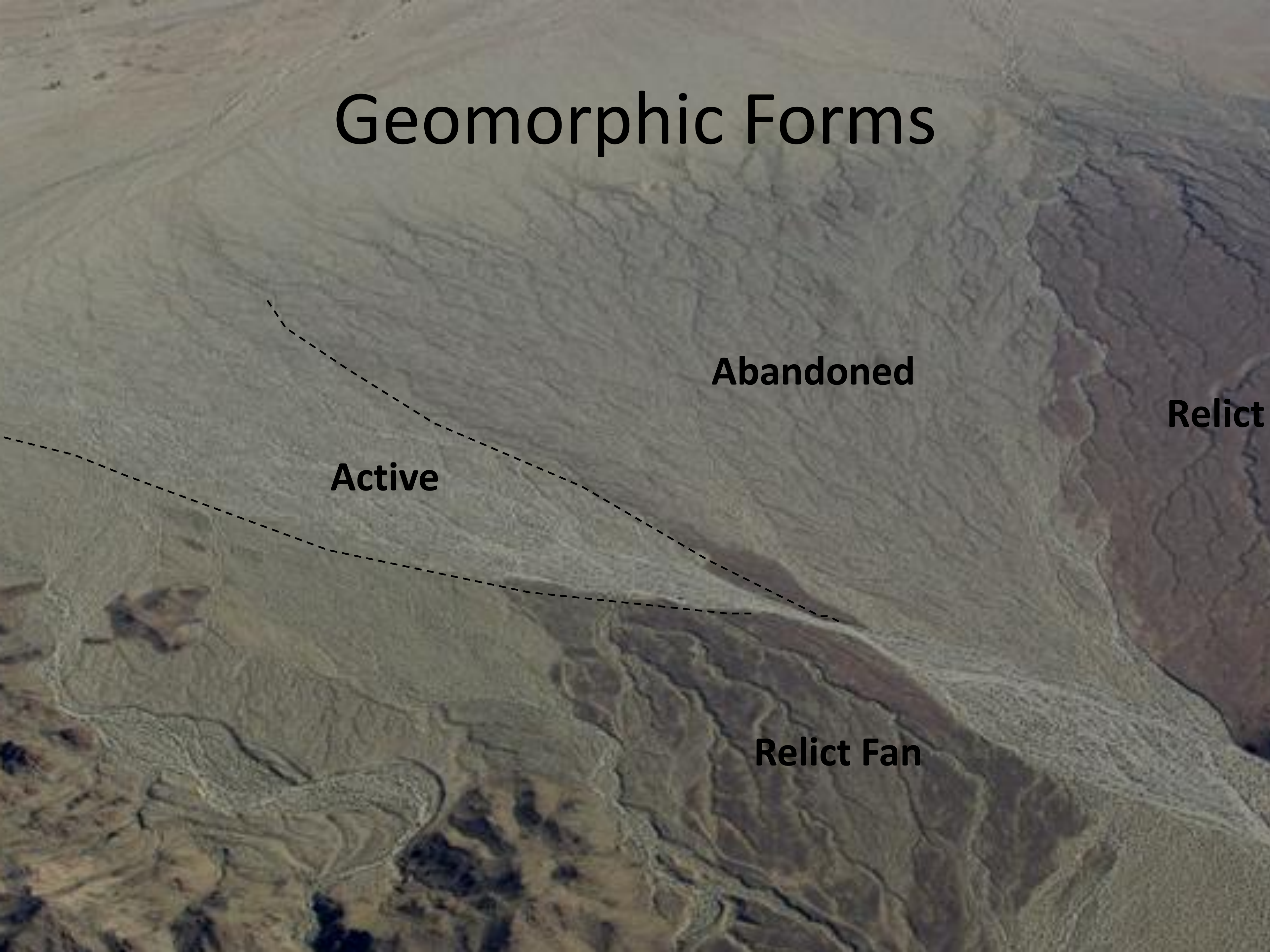

Tri-Palm Estates
Via Las Palmas Dr
Location From
where Video was shot
Provided by Coachella Valley Water District

NRC 1996: 3-Stage Analysis Approach

Stage 1	Recognize and Characterize Alluvial Fan Landform
Stage 2	Define Active and Inactive Areas of Erosion and Deposition
Stage 3	Delineate the 100-Year Flood Within the Defined active Areas

Relationship Between Geomorphology & Alluvial Fan Flooding

Geomorphic Forms



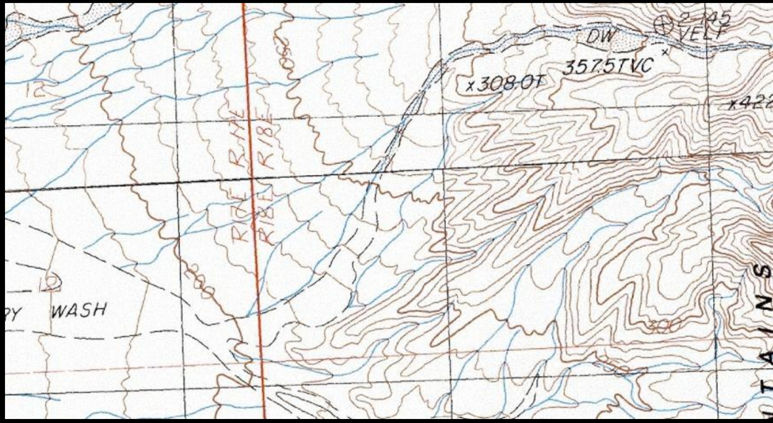
Surface Color
Desert varnish & Desert Pavements

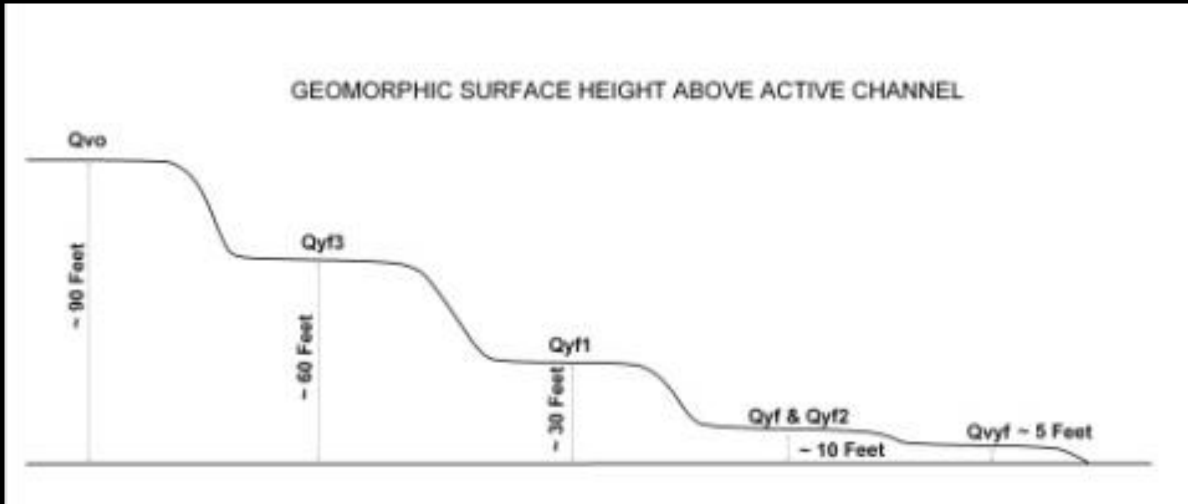
Drainage Character
Dendritic (tributary) drainage patterns
vs. Distributary drainage patterns

Connected to upland drainage basin?

Topographic Pattern
Bar-and-channel morphology = Young
Ridge and ravine morphology = Old

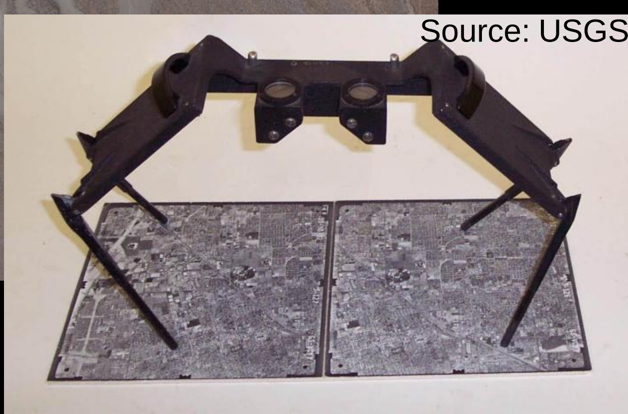
Transverse and Longitudinal Profiles





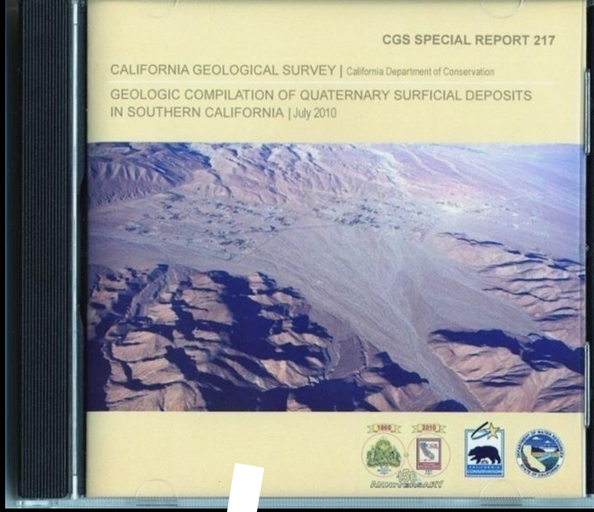
Reconnaissance Level Considerations

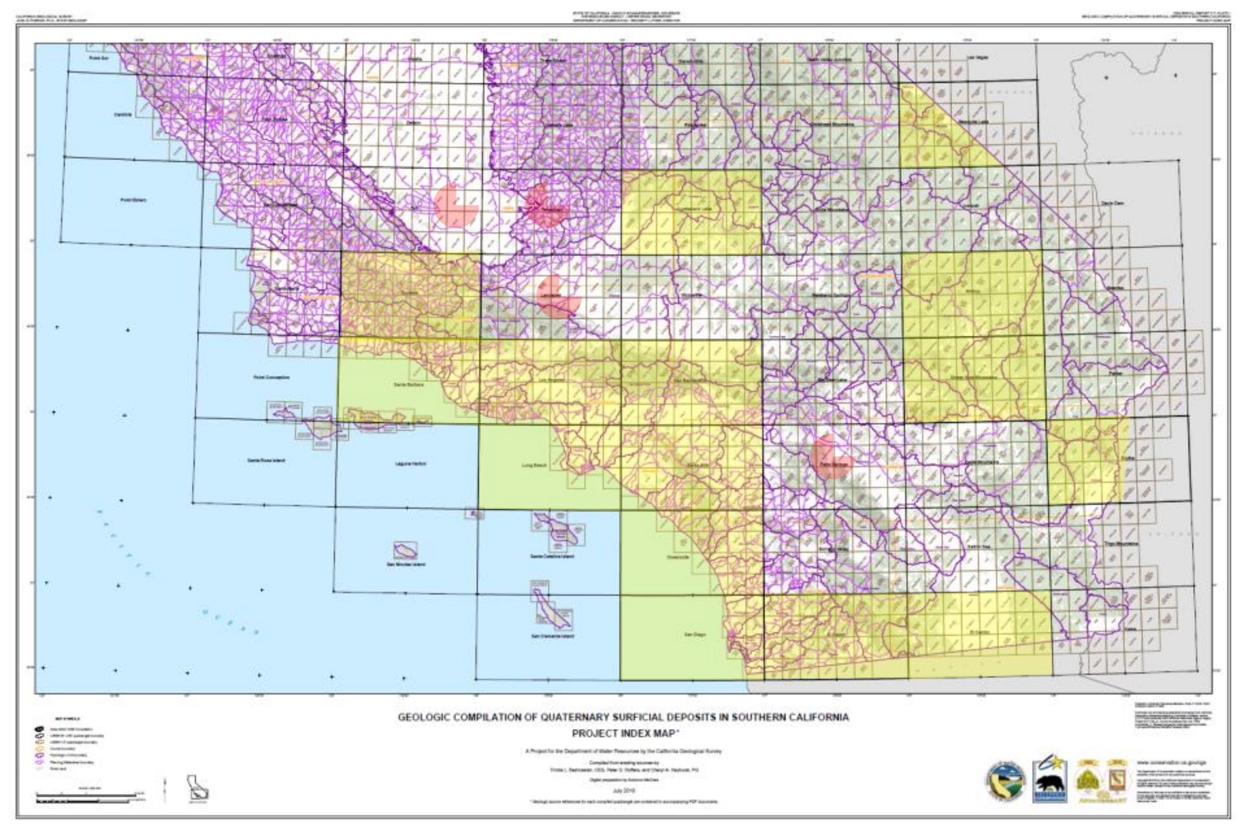
Oak Creek Fan, Inyo County, CA; Stereo Pair Images From CalTrans, 2008



Source: USGS

- Tectonic activity
- Drainage Basin Lithology
- Basin Topography/Morphology:
  Slope, Relief Ratio, and Ruggedness
- Vegetation Density and Type
- Fire History
- Climate
- Flood History
- Surficial Geology



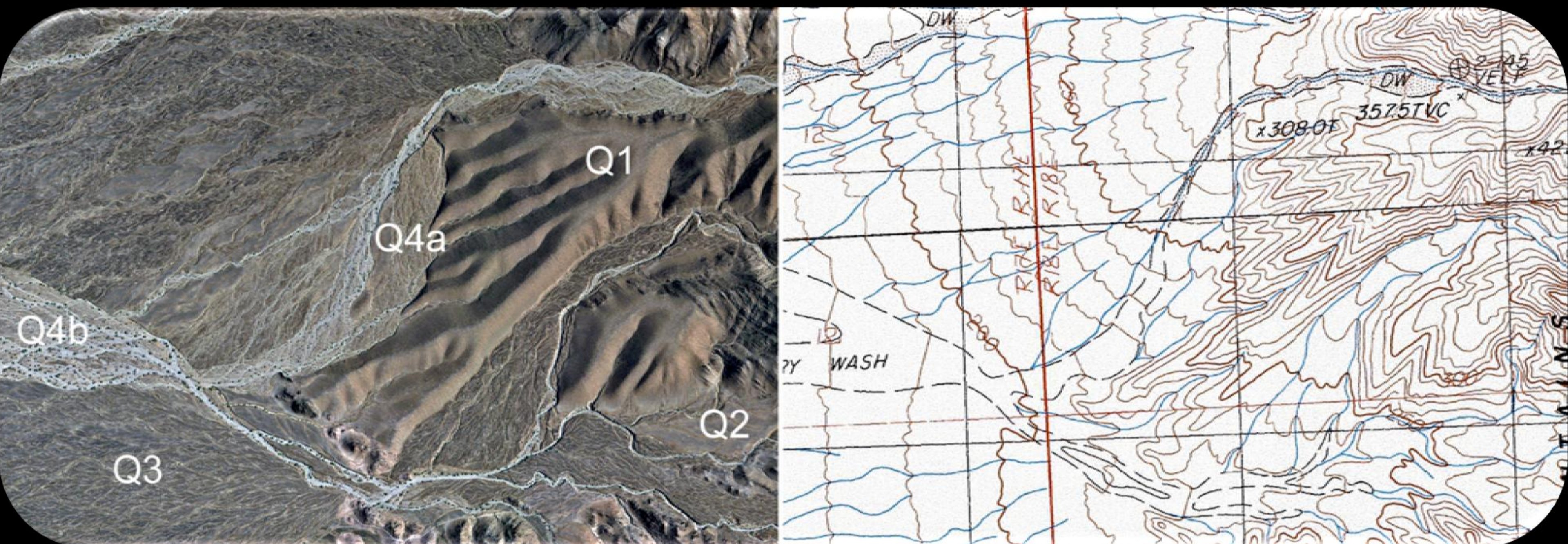


Data Sources

Data Type	**Possible Sources of Data**
Topographic Maps	USGS
Surficial Geologic Maps	California Geological Survey, USGS
Fault Evaluation Reports	California Geological Survey
Fault Rupture Investigations	Agency responsible for Building Code Enforcement
Soils Maps	NRCS
Aerial Imagery	County Flood Control, Universities, USGS
Historical documents	Newspapers, town records, personal accounts
Rainfall Data	Local agencies, State Agencies, NWS, etc.
Hydrologic Data	Local Agencies, State Agencies, USGS, etc.

Table Modified From: AFTF, 2010

Geologic Assessment
(Preliminary Studies)



Geomorphic Mapping

1. Identify Fan
2. Tectonic Regime
3. Erosion Characteristics
4. Mode of Deposition
5. Perform Geomorphic Mapping
    - Drainage Character
    - Topographic Pattern
    - Transverse and Longitudinal Profiles
    - Soil Survey Information
6. Augment With Field Work

Refining Geomorphic Map

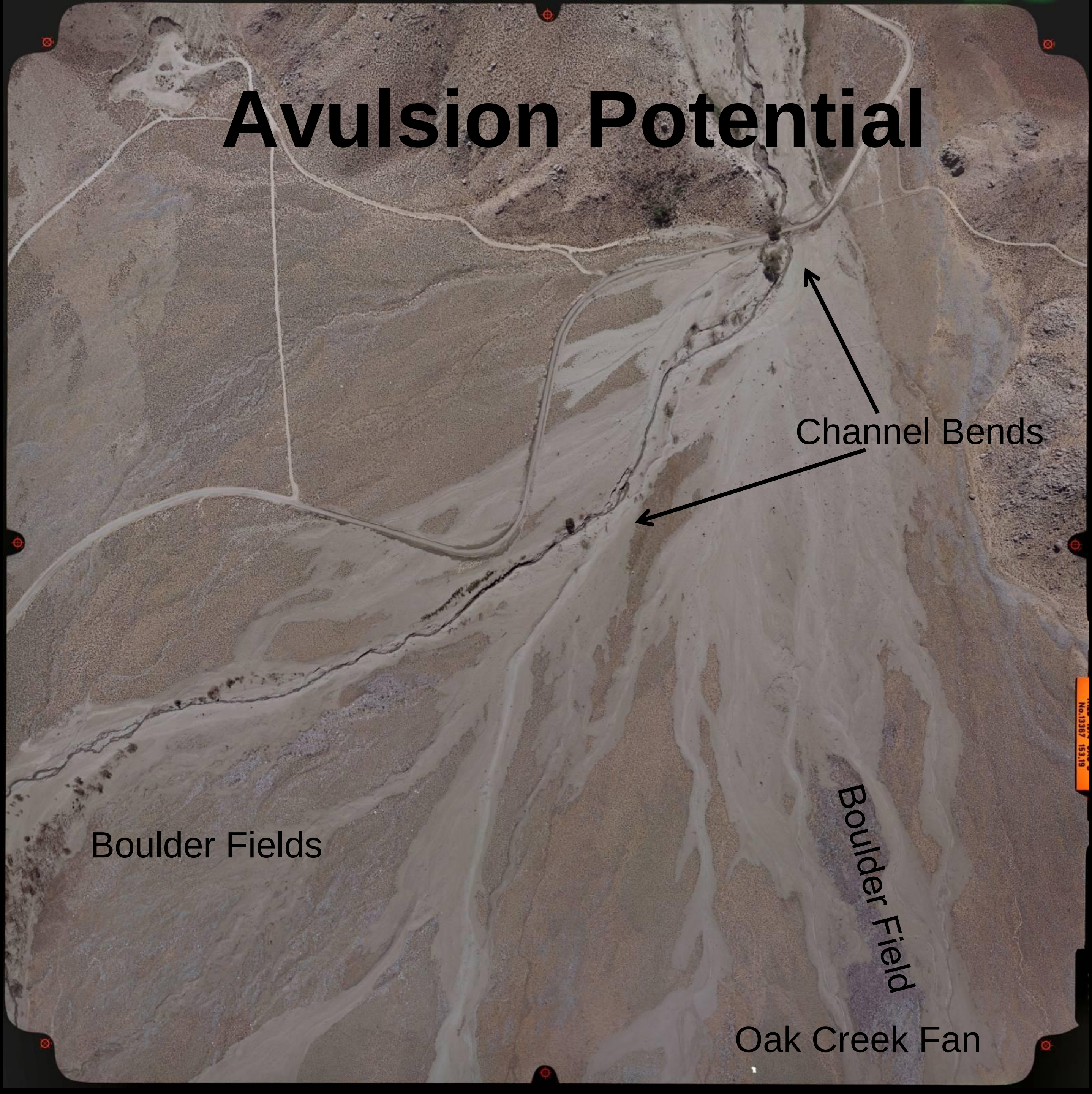
<u>Lithologic Data</u>

Grain size, bedding thicknesses, sorting, mineralogy, clast provenance

<u>Age Indicators</u>

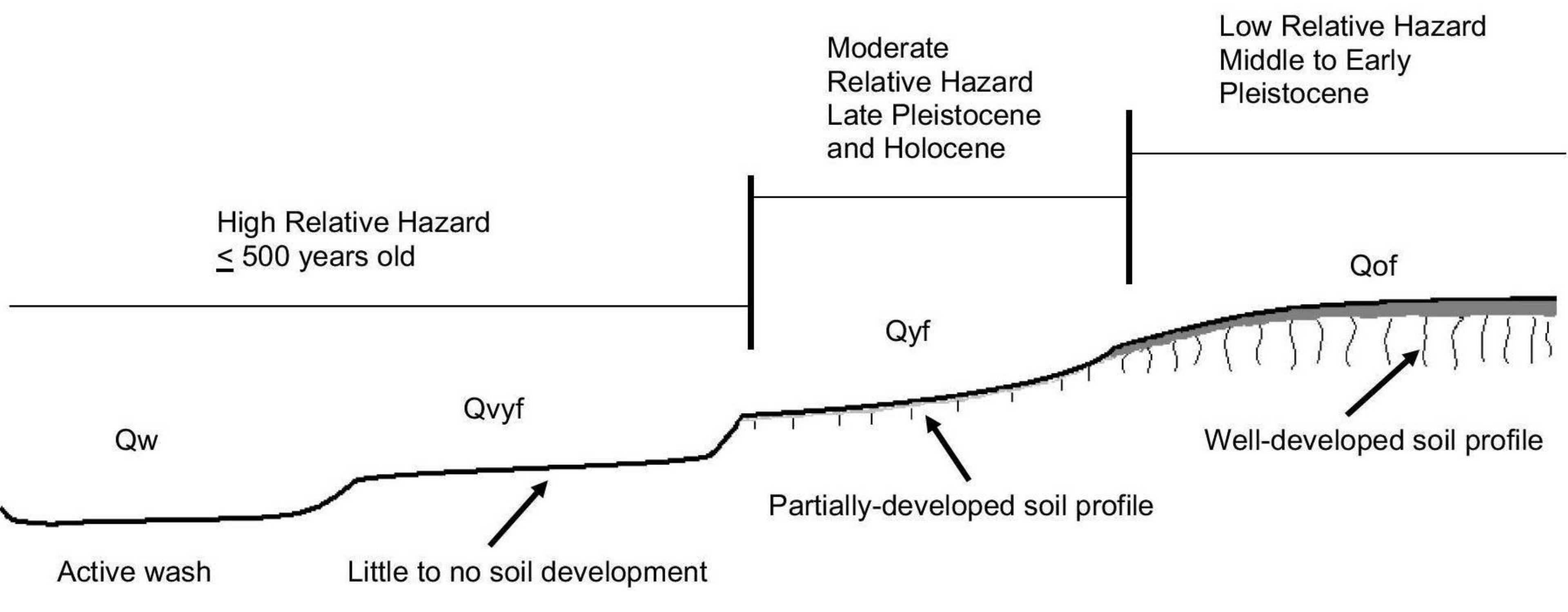
- *B horizon development*
- *Rubification*
    - *Munsell - Hue and Chroma*
- *Carbonate Stage*
- *Fines Carbonate Morphology*
- *Gravel Carbonate Morphology*
- *Desert Pavement*
- *Parent material influences*
- *Cobble Weathering Stage*
- *Weathering Rind Thickness*
- *Desert Varnish*

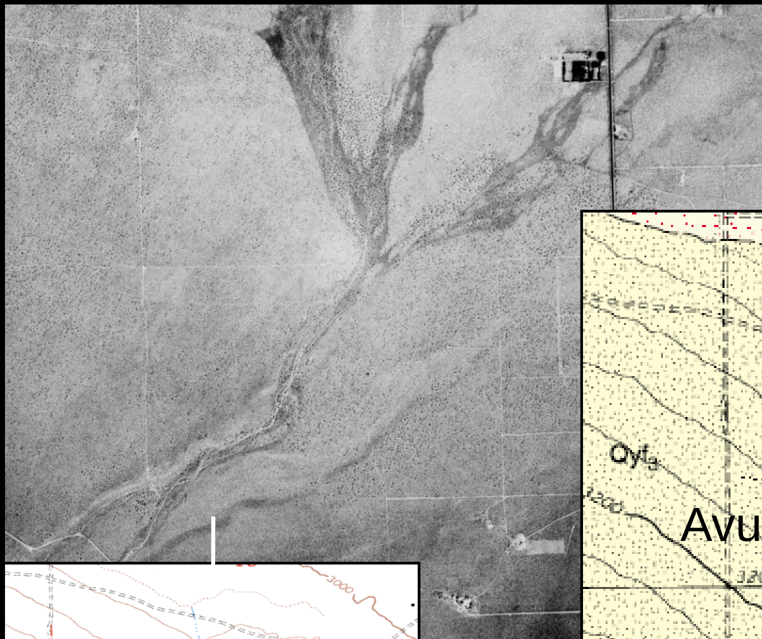
Avulsion Potential

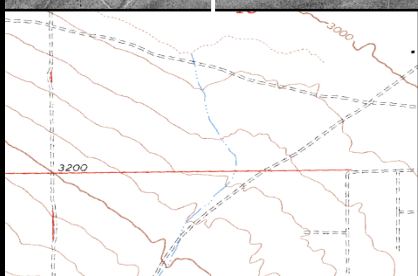


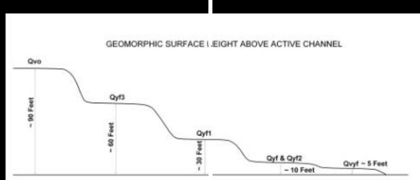
Relative Hazard Ranking

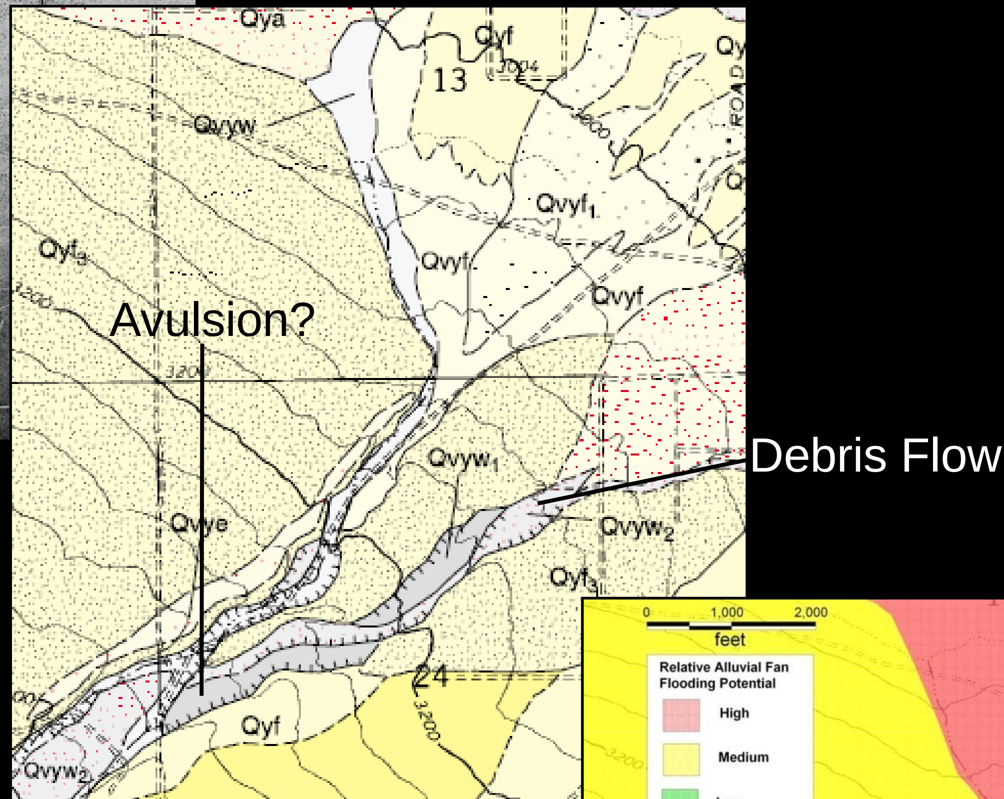
- Relatively High
- Relatively Moderate
- Relatively Low
- Uncertain
- Non Fan Geologic Unit
- Debris Flow Hazard Area

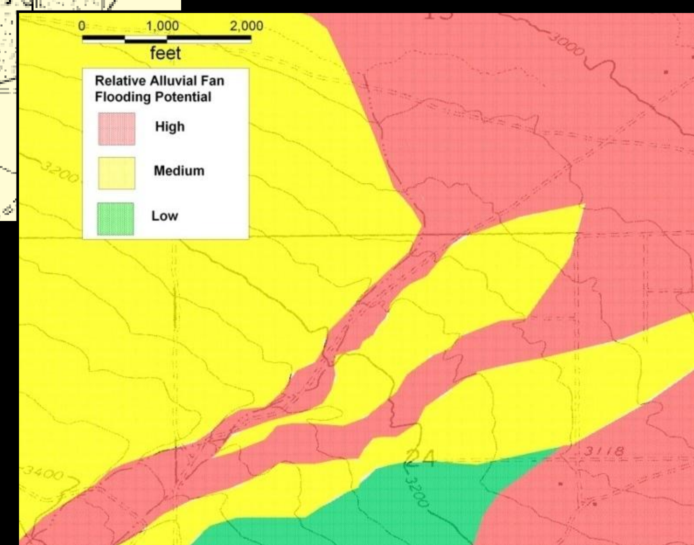


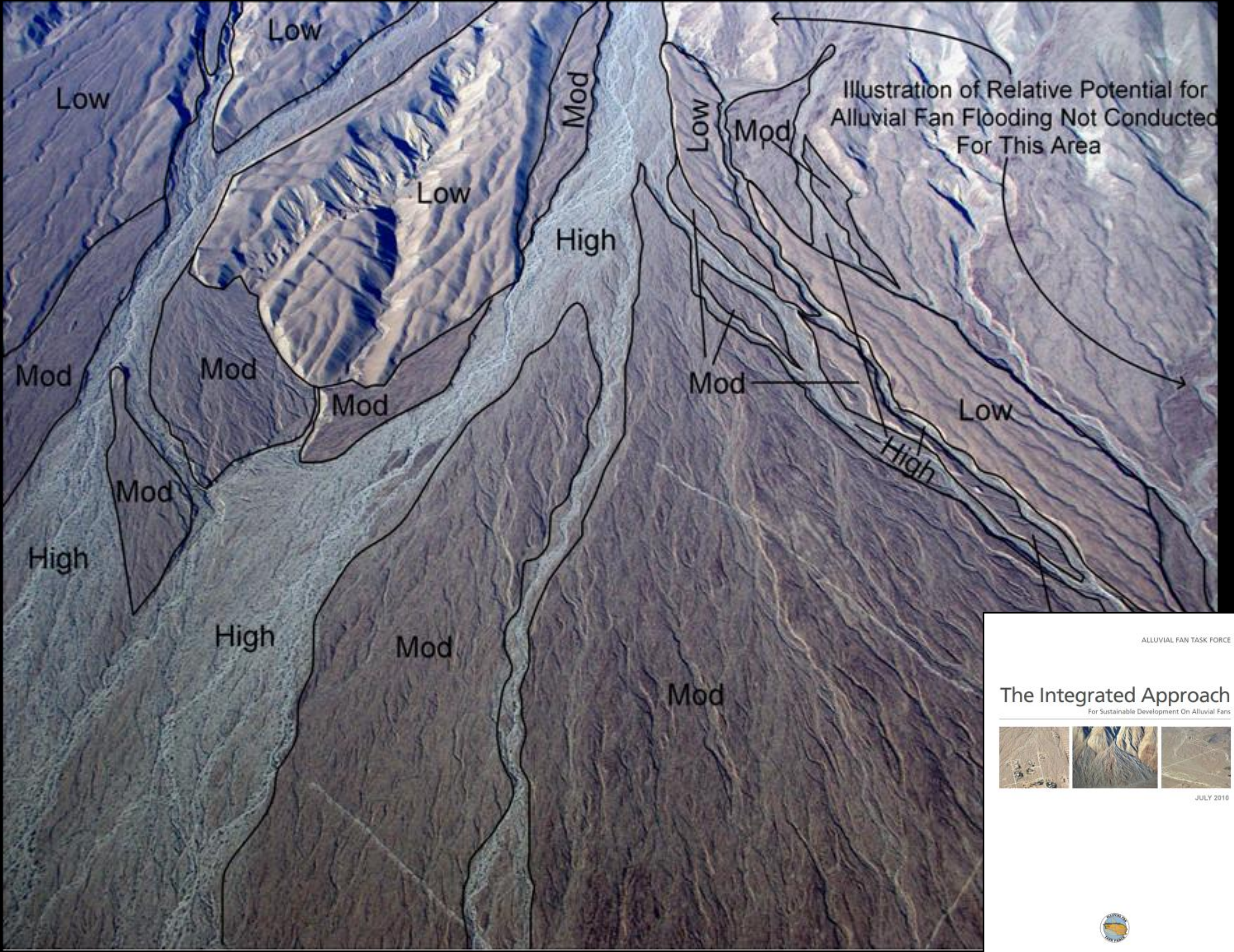





GEOMORPHIC SURFACE HEIGHT ABOVE ACTIVE CHANNEL
Qvo
Qyf3
Qyf1
Qyf & Qyf2
Qvyf ~ 5 Feet
~ 90 Feet
~ 60 Feet
~ 30 Feet
~ 10 Feet


Qya
Qyf
13
Qvyw
Qvyf1
Qyf3
Qvyf
Avulsion?
Qvyw1
Debris Flow
Qvye
Qvyw2
Qyf3
24
Qyf
Qvyw2


0 1,000 2,000
feet
Relative Alluvial Fan Flooding Potential
High
Medium
Low


Low
Low
Low
Mod
Low
Mod
Illustration of Relative Potential for Alluvial Fan Flooding Not Conducted For This Area
High
Mod
Mod
Mod
Mod
Low
High
Mod
High
High
Mod
Mod
ALLUVIAL FAN TASK FORCE
The Integrated Approach
For Sustainable Development On Alluvial Fans
JULY 2010

Hydrologic Modeling

Stage 1 Recognize and Characterize Alluvial Fan Landform

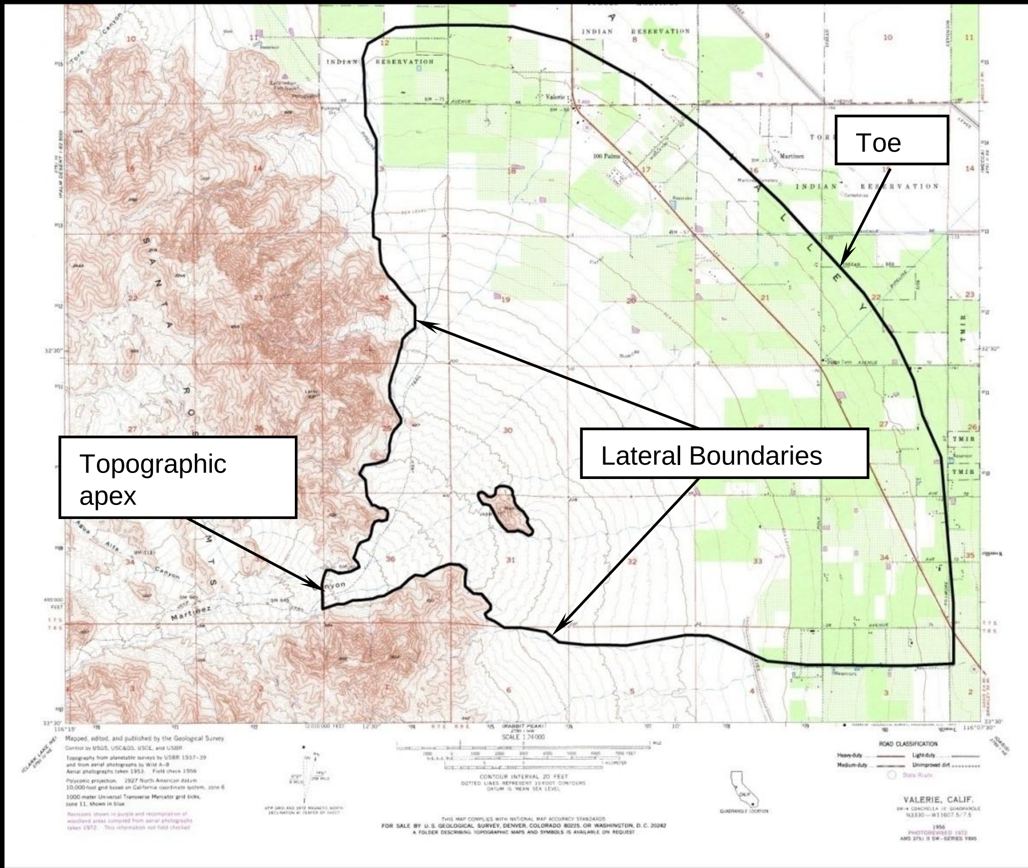
Stage 2 Define Active and Inactive Areas of Erosion and Deposition

Stage 3 Delineate the Design Flood Within the Defined Active Areas

Geomorphic Mapping

- Review Reconnaissance Data
- Review Geologic Assessment Data/Maps
- Delineate Fan
- Identify:
  - Active
  - Abandoned
  - Relict

- Avulsion Locations



Modeling Considerations

- Identify Hydrographic Apex
- Develop Peak Discharge
- Model Peak Discharge on Fan Surfaces
- Calibrate/Compare Modeling With Historic Data
- Incorporate Avulsive Processes

Hydrographic Apex Discharge

- Selected Hydrologic Input Tools
  - NOAA Atlas 14 (Precipitation Frequency Estimates)
  - USGS Regression Models
  - County Regression Models

- Selected Apex Discharge Modeling Tools
  - ➢ HEC-1
  - ➢ HEC-HMS
  - ➢ Rational Method (Basins <1mi^2)
  - ➢ Modified Rational
  - ➢ Unit Hydrograph
  - ✓ Flood Control District Hydrology Manuals

Sediment & Debris Loading

- Water Flood Dominated
  - Sediment Transport Function
- Debris & Sediment Dominated
  - Bulking Factors
- Fire/Flood Sequence
  - Los Angeles (USACE) Debris Method (2000)
  - USGS

Modeling Below Hydrographic-Apex

Consider:

- Uplift > Erosion
  - Flow Paths Migrate Across Landform
  - Modeling Should Include Foreseeable Flow Paths
- Uplift < Erosion
  - Redistribution of Flow May Occur Through Avulsion
  - Modeling Should Include Flow Paths Due to Avulsion
- Debris Flows

Modeling Below Hydrographic-Apex (Cont.)

Selected Modeling Tools:

- HEC-RAS
- FLO-2D

Should Consider:

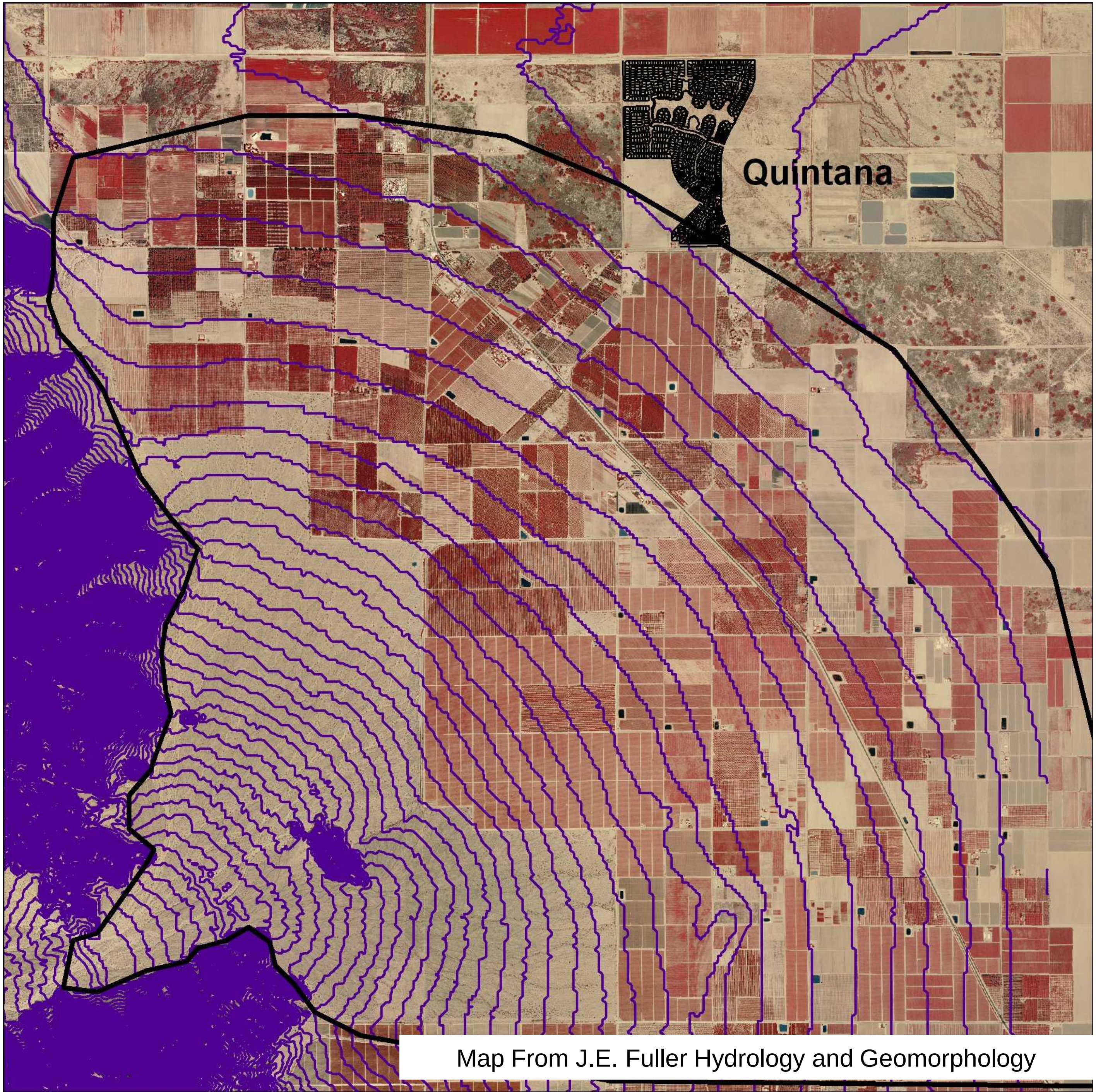
Geomorphology as the Basis of Modeling

Channel Stability

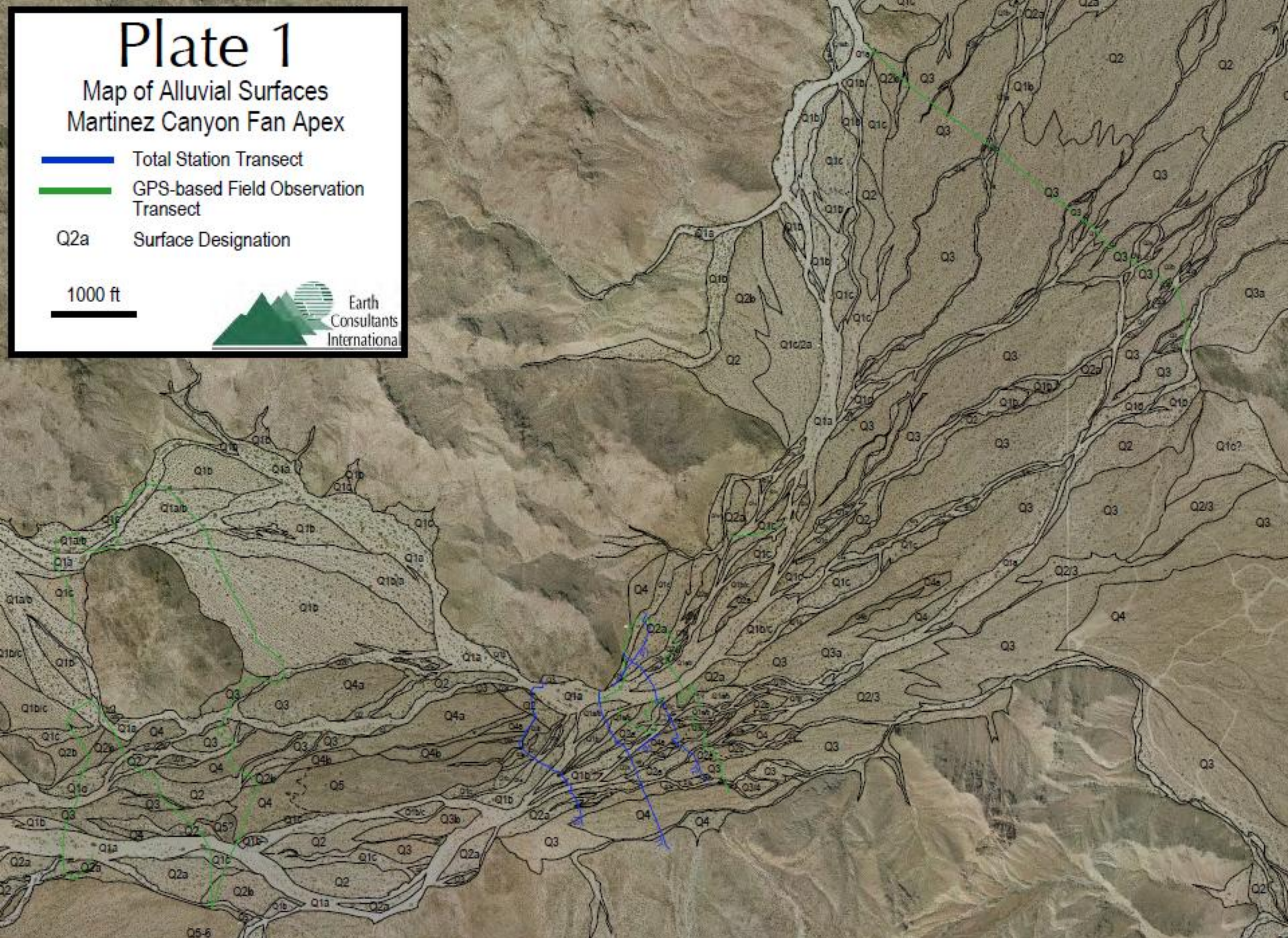
Historic Flooding Information

Debris Flows

Avulsive Processes



Map From J.E. Fuller Hydrology and Geomorphology



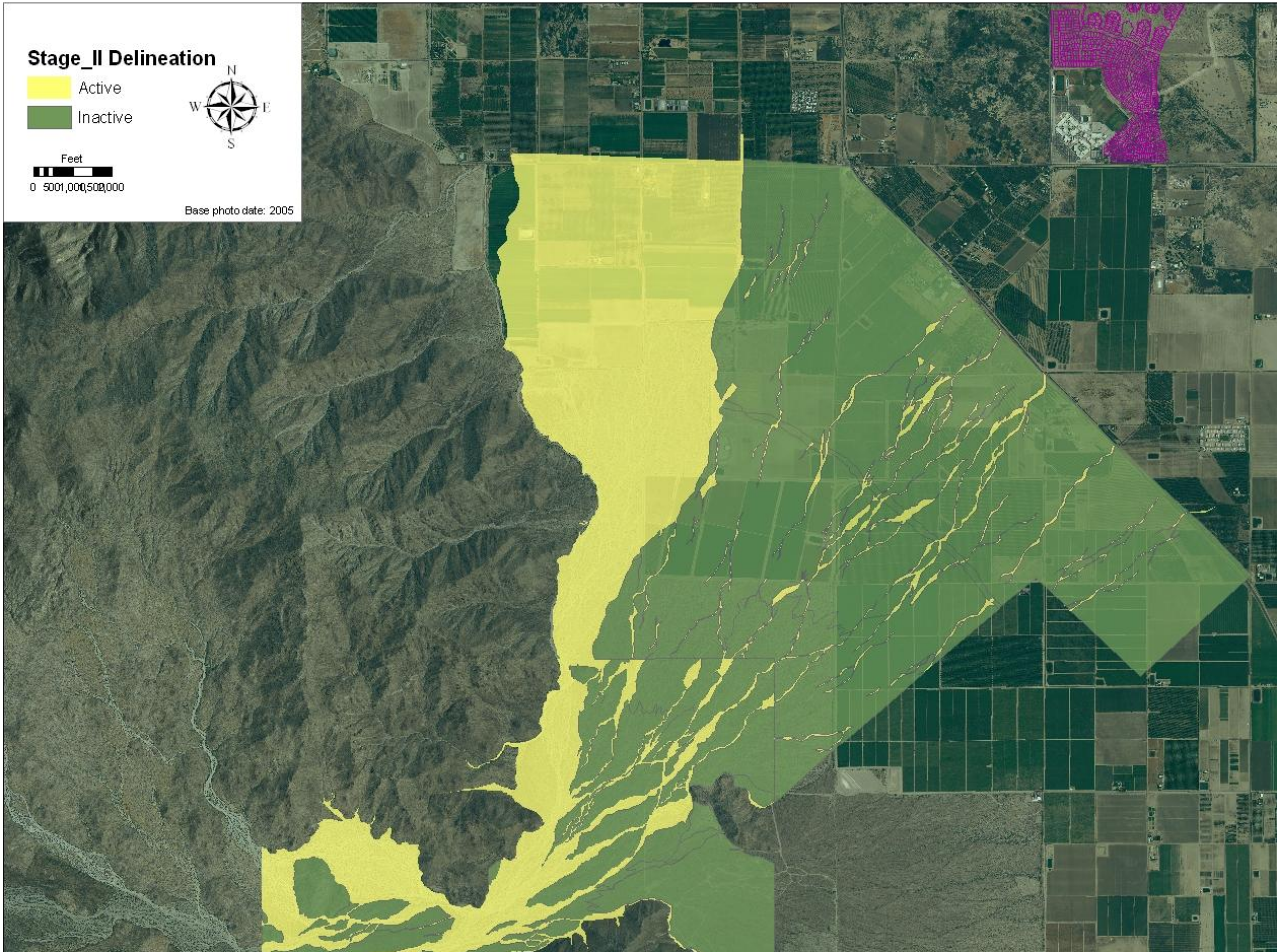
Map From Earth Consultants Internati

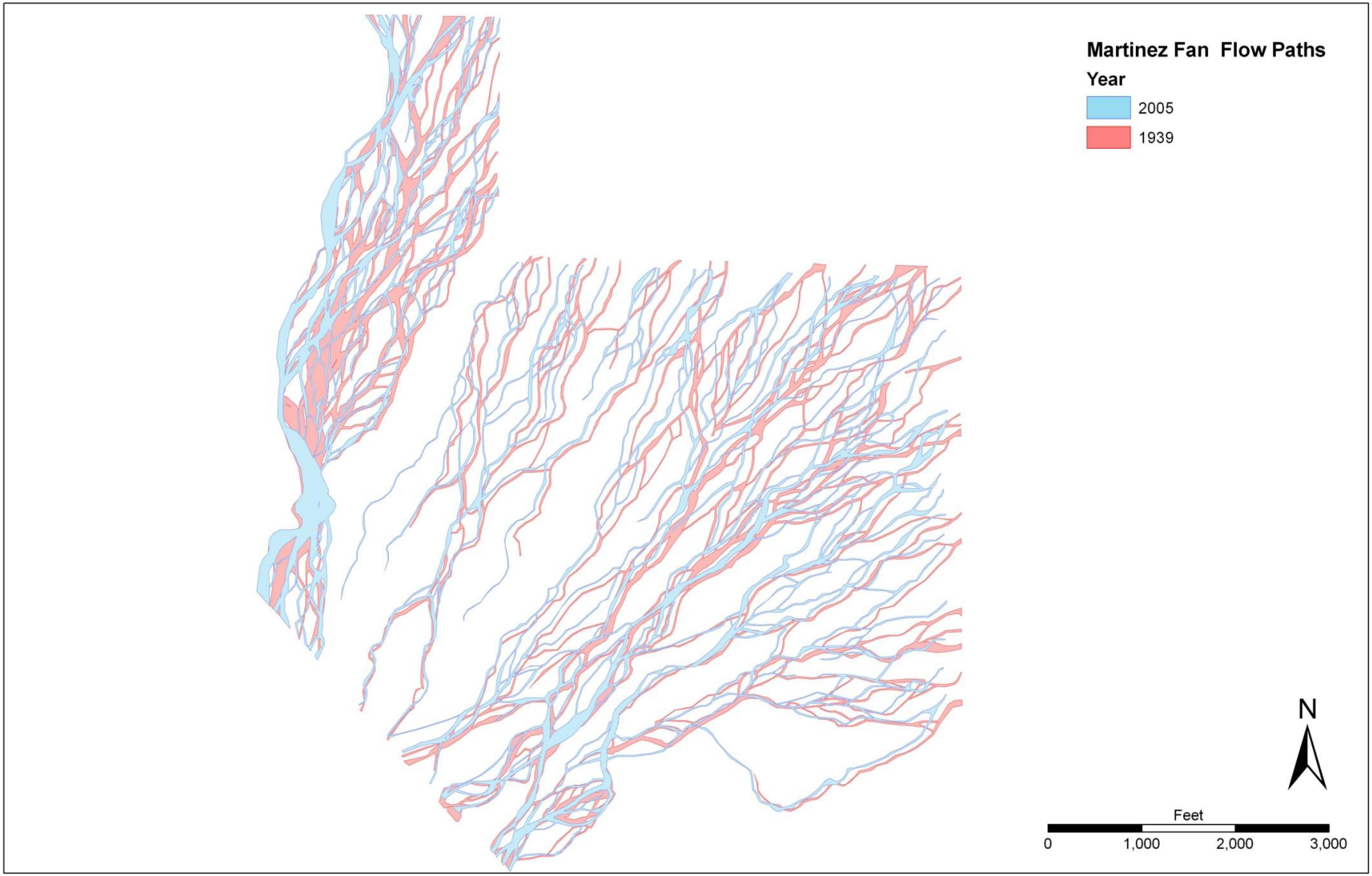
Table 1. Surface Classification - Martinez Fan

Earth Consultants International

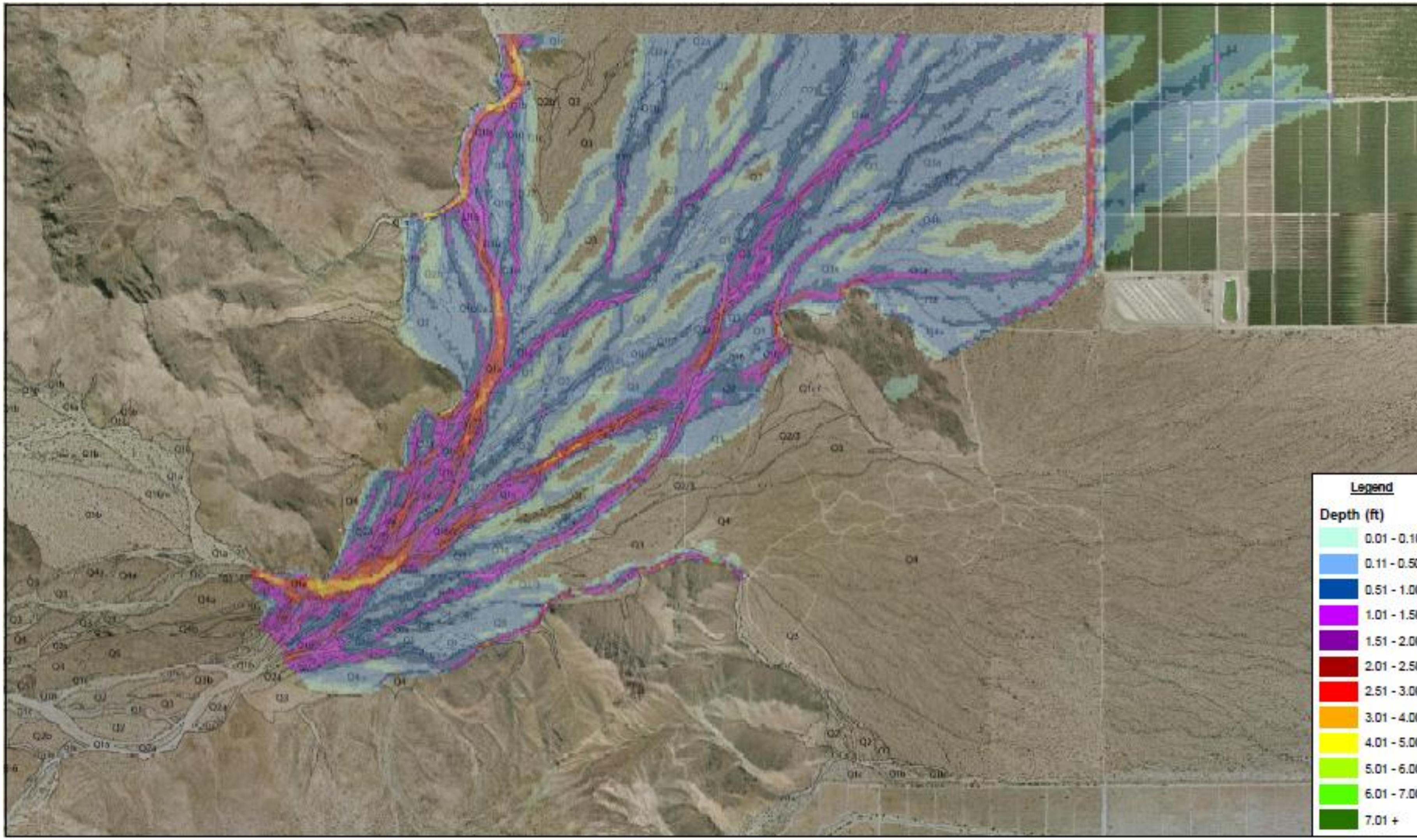
Surface	Inferred Age (ka)	Roughness/ Pitting	Patina	Rubification	Carbonate	Other Characteristics	Examples
Q1	Q1a, Q1b < 0.3 Q1c 0.3 - 0.5 for deposition, with flooding < 0.3	Smooth to slight increase in roughness of limestone clasts	Non-existent to slight color	Non-existent to slight color covering 0-25% of clast bottoms	Non-existent to light dusting of carbonate, weakly effervescent	- Q1a surfaces show no development of patina, rubification or roughness. - Q1b surfaces show very slight development of patina, rubification and roughness on some clasts. - Q1c surfaces show slight development of patina and rubification, along with distinct increase in roughness.	
Q2	0.5-1 (best estimate) 0.3-2 (max. range)	Strong increase in roughness in limestone clasts, slight increase in roughness of granitic clasts	Thin complete coverage of slight coloring	Munsell color 10YR developed over 25-90% of clast bottoms	Continuous 1-7 cm wide carbonate rind ~ 0.5 mm thick, strongly effervescent	- Q2a surfaces are locally inundated with overbank deposits and can have the development of cryptobiotic soil. Surfaces also contain distinct flow features, including evidence of recent incision and rilling. - Q2b surfaces appear stable, lacking evidence for recent deposition or erosion from surface flow.	
Q3	2-3	Distinct 2mm-deep pitting of limestone clasts, strong increase in roughness of granitic clasts	Moderately thick coating of color	Munsell color 10YR developed over 25-90% of clast bottoms, with distinctly developed small patches of 7.5YR	Continuous 1-7 cm wide carbonate rind ~ 1mm thick, explosively effervescent	- Swales are filling with locally derived sand from clast disaggragation, and swales exhibit pavement development. - Some removal of surface patina by flaking / disaggragation or shattering of clasts.	
Q4	3-9	Pitting of limestone clasts creates 5-10 mm relief, dis-solution of carbonate layers gives appearance of layering in clasts, some granitic clasts display substantial disaggregation	Distinctly developed varnish, glossy coating of color	Munsell color 7.5YR developed over 25-90% of clast bottoms, with small less-developed patches of 10YR	Generally too deep to observe - requires digging, which is not possible in the Wilderness areas	- Well-developed pavement. - Dissolution and disintergration of granitic and carbonate clasts.	
Q5	9-20	Pitting of limestone clasts creates relief of 5-10 mm in depth, dissolution of carbonate layers gives ap-pearance of layering in clasts. Some granite disaggregated.	Well-developed, thickly coated varnish	Munsell color 7.5YR developed over entire base of clasts	Generally too deep to observe - requires digging, which is not possible in the Wilderness areas	- Darkly varnished surfaces. - Extremely well-developed pavement. - Complete dissolution and disintergration of granitic and carbonate clasts.	

From Earth Consultants International


Stage_II Delineation
Active
Inactive
N
W
E
S
Feet
0 500 1,000 1,500 2,000
Base photo date: 2005



Map From J.E. Fuller Hydrology and Geomorphology & RBF Consulting



Map From J.E. Fuller Hydrology and Geomorphology & RBF Consulting

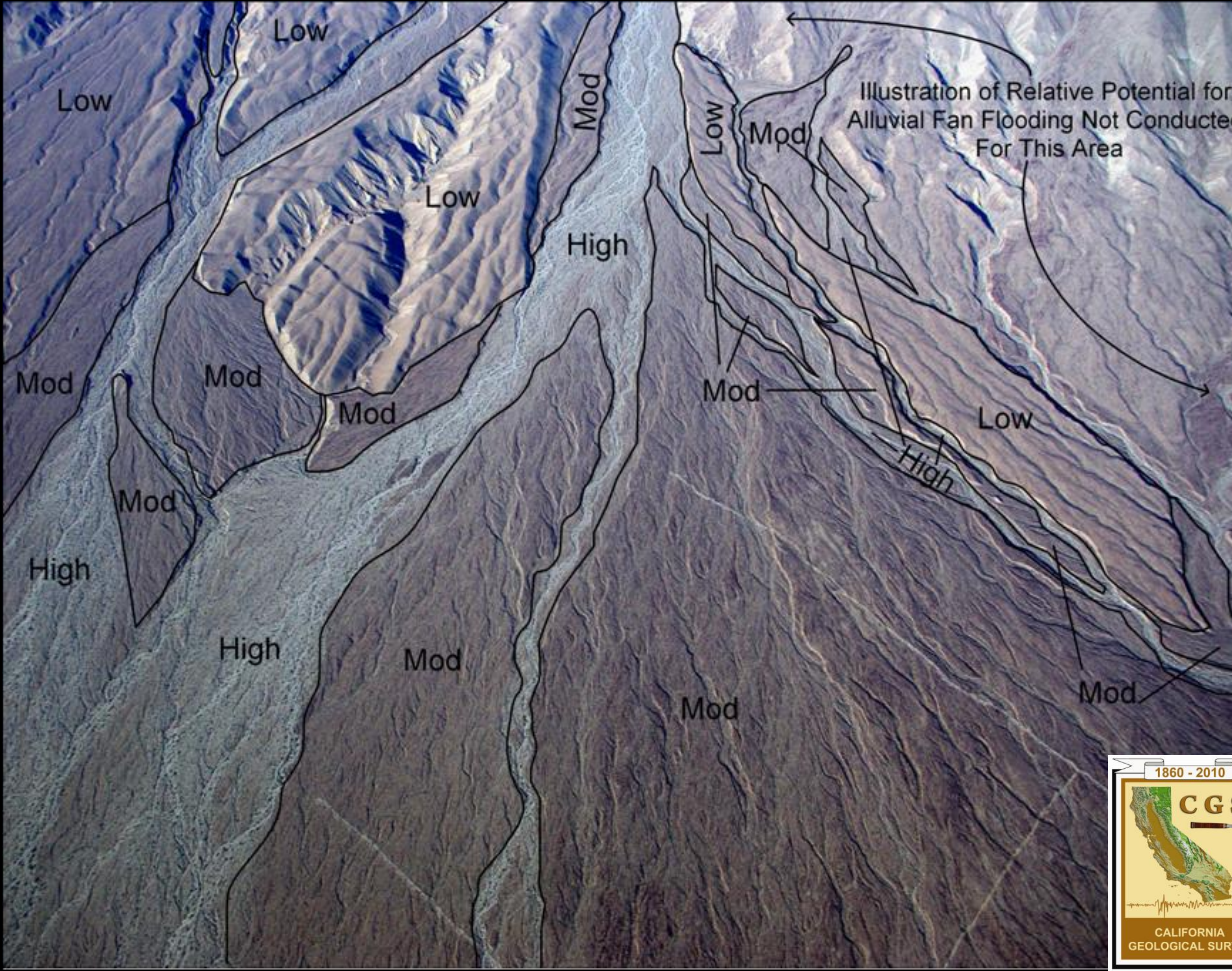
Mapping Versus Modeling

Geomorphic/Quaternary Mapping

- Approximate
- Utilizes Historic Flooding Information
- Cost Effective
- Does Not Yield Design Q

Modeling

- Yields Design Information
- Needs Preliminary Geomorphic Information to Identify:
  - Active and Inactive
- Difficult to Account for all Variables
- A Snapshot in Time
- Needs Detailed Topography



CALIFORNIA GEOLOGICAL SURVEY