# DIGITAL MAPPING TECHNIQUES 2016

The following was presented at DMT'16
(May 22-25, 2016 - Florida Geological Survey,
Tallahassee, FL)

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2016)

http://ngmdb.usgs.gov/info/dmt/

**California Landslide Inventory Database**

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Landslide-inventory maps are the most basic type of landslide hazard maps; they portray the location of past landslides and are an indicator of landslide susceptibility. Generally landslide inventories represent a geomorphic interpretation of an area and identification of landforms that may have formed by landsliding. Inventory maps do not necessarily distinguish the age of landslide movements, but given a trigger, some of the mapped slides—or more frequently, portions of them—may become active. The California Geological Survey (CGS) is digitizing existing maps of landslides and has prepared a statewide landslide database that is now available online. The database shows many of the landslides mapped by CGS and others over the past 50 years for the state of California. Individual landslide records reflect the standards of the project for which the landslide was mapped. Many maps show landslide source areas (scarps) separately from landslide deposits while others combine scarps and deposits into a single feature. The information recorded about each landslide has increased over time, so more information is available for more recently mapped landslides. Updates to the database are continuing, both to include more existing maps and to add or update landslides as they occur. The landslide inventory, in combination with the map of susceptibility to deep-seated landslides (CGS Map Sheet 58) can give local planners, infrastructure owners, and the public a perspective on where landslides are most likely to be triggered by winter storms or earthquakes in California.

Significant speaker notes are included in the PDF version of the presentation as an annotation layer.

# California Landslide Inventory Database

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Digital Mapping Techniques 2016
Tallahassee, FL
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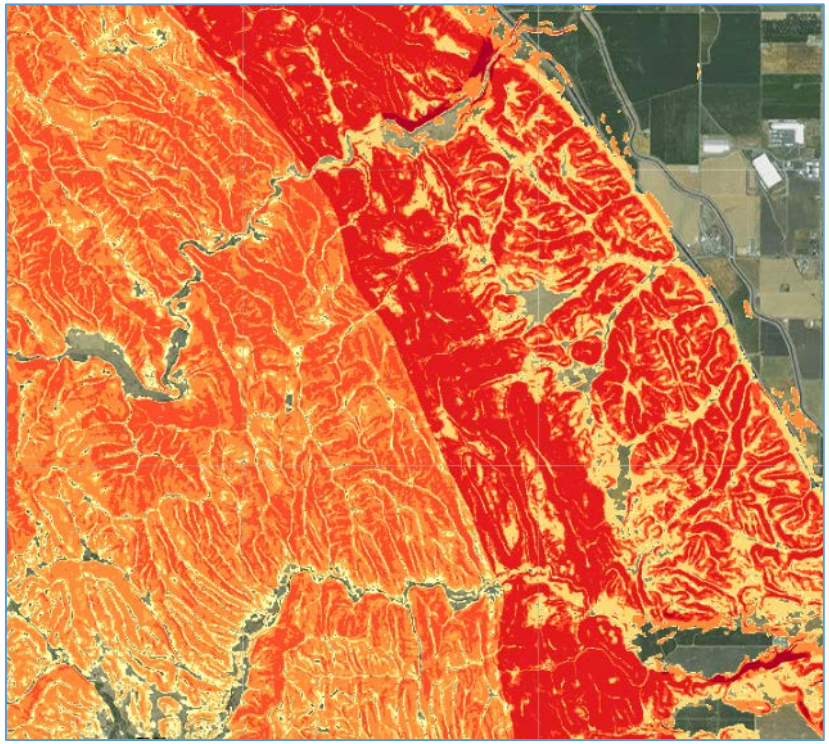
# Outline

- Types of Landslide Maps
- A Brief History of Landslide Mapping at CGS
- Landslide Inventory Database Schema
- Implemented in a Versioned Geodatabase
- Data Conversion
  - Digitization
  - Extract, Transform, and Load
- Display and Symbology
- Web Application and Data Access

# Types of Landslide Maps

- Landslide Inventory Maps
- Landslide Hazard Maps
  - Landslide Susceptibility Maps
  - Landslide Potential Maps
- Landslide Risk Maps
- Landslide Zone Maps



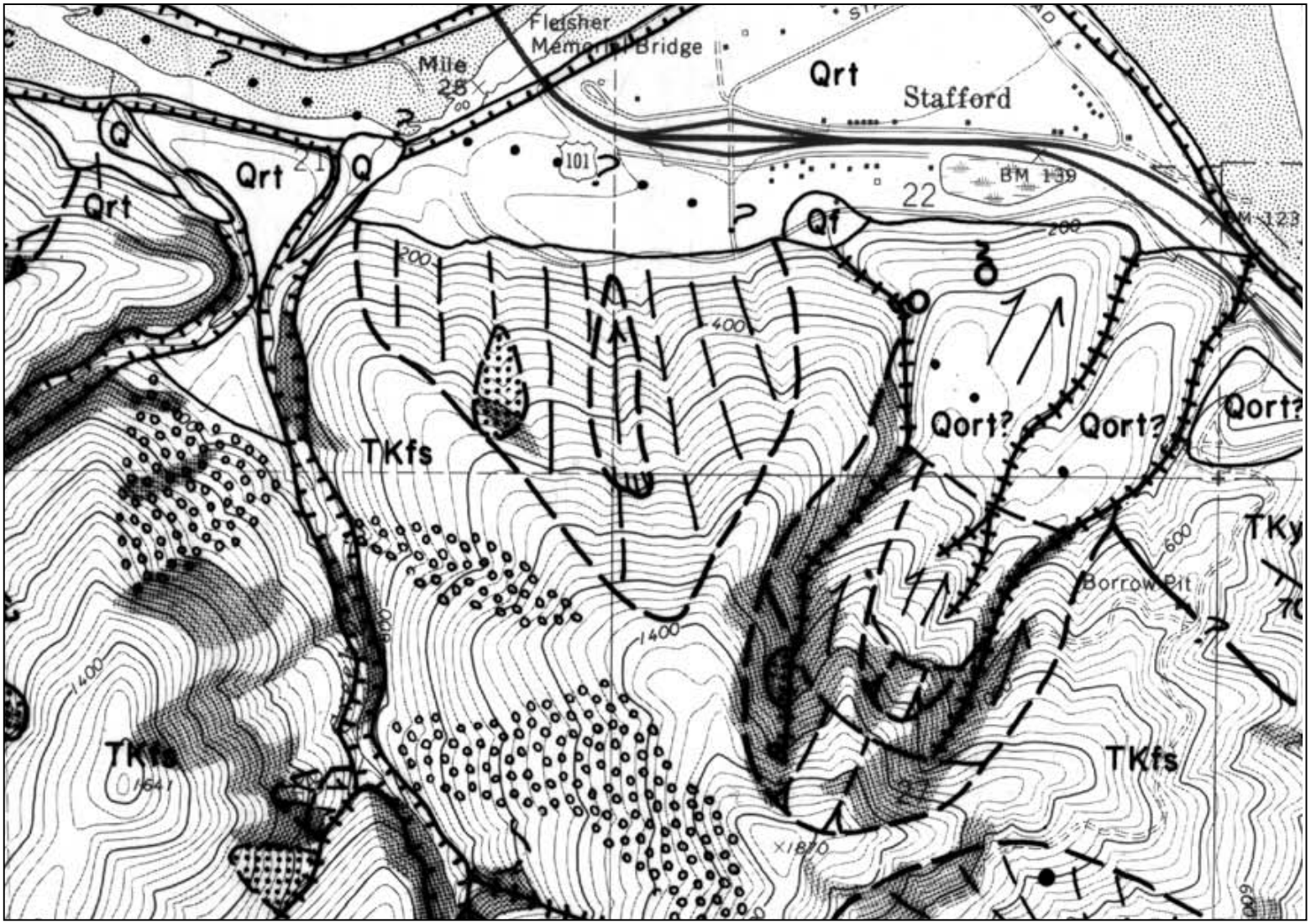
# CGS and Landslide Mapping

- 1971- state requires safety and seismic safety elements in local general plans – CGS works with local government to develop hazard maps, including landslide maps.
- 1973- state requires consideration of landslide hazards in forestry (logging) – CGS works with other state agencies to map landslides in forested areas
- 1982- Storms trigger debris flows in Bay Area. State establishes Landslide Hazard Identification Program.
- 1989- Loma Prieta earthquake triggers landslides in Santa Cruz Mountains. State enacts Seismic Hazard Zoning act.

# Landslide Mapping Programs at CGS

- Forest & Watershed Geology: Forestry related landslide mapping for timber harvest review, water quality and fish habitat protection.
- Seismic Hazards Zonation: Identifies existing landslides and delineates landslide zones requiring investigation prior to development.
- Geologic Mapping: Prepares landslide inventory maps to support the California Department of Transportation (Caltrans) and other state and local agencies.

# Historic Landslide Inventory Maps



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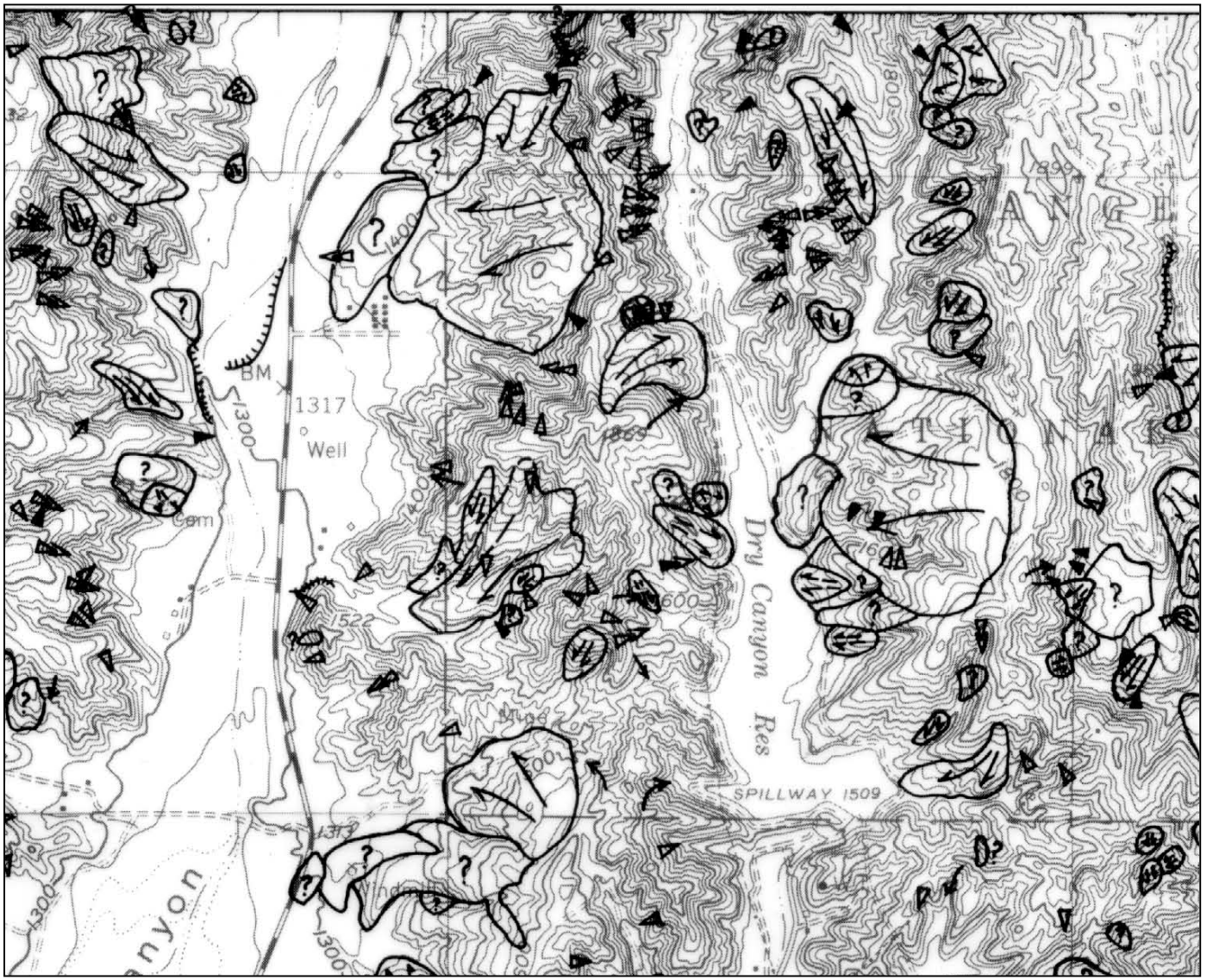

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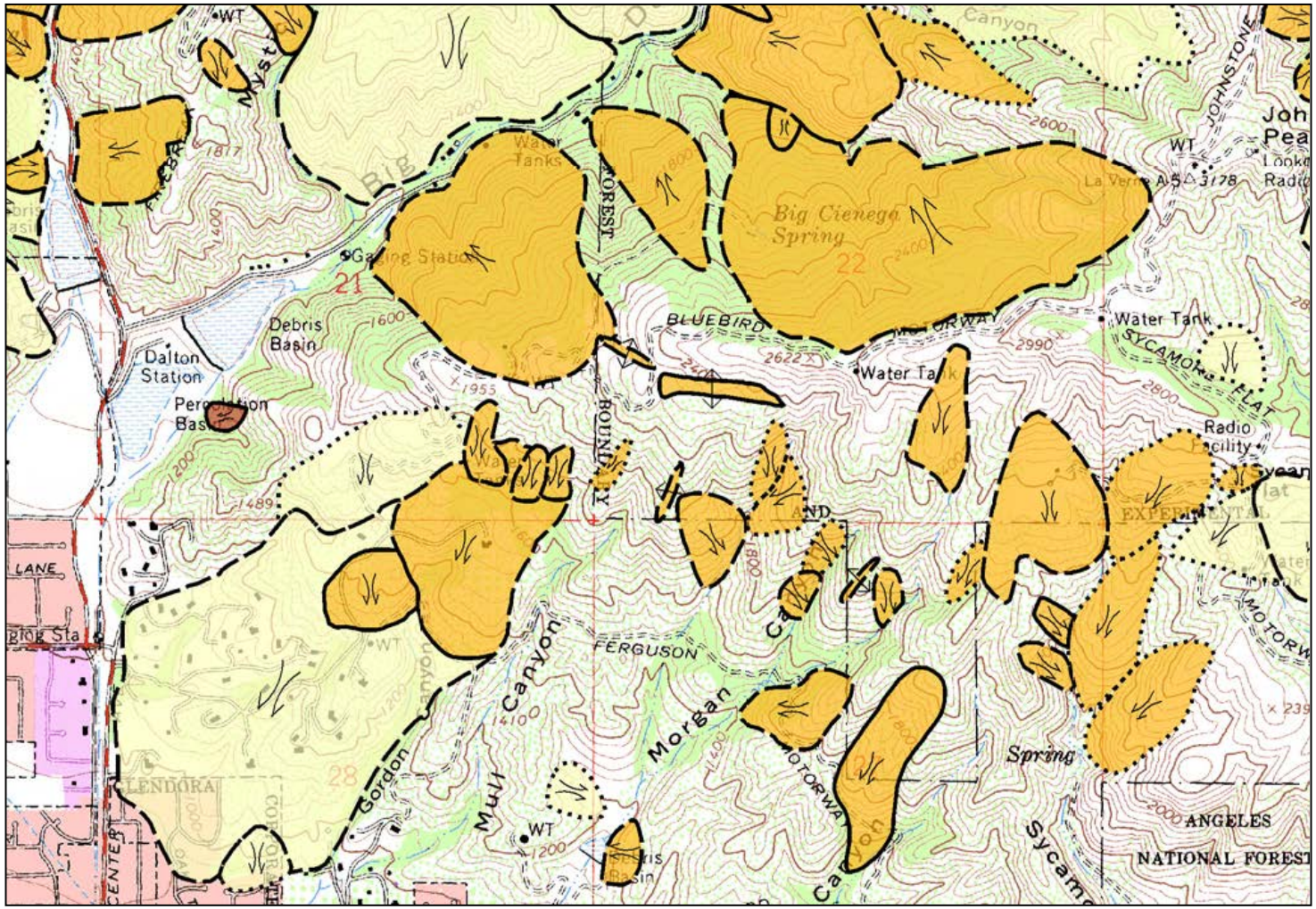
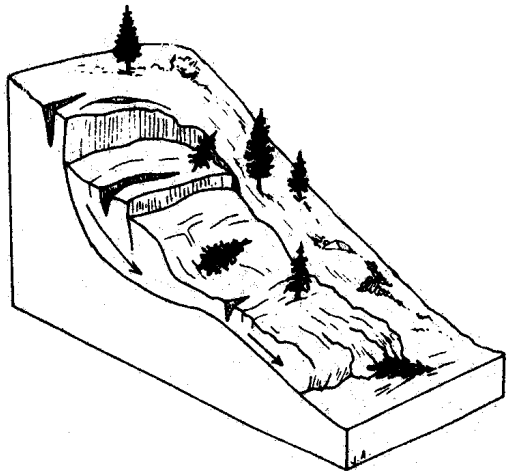


# Towards A Geodatabase Standard (for CGS)

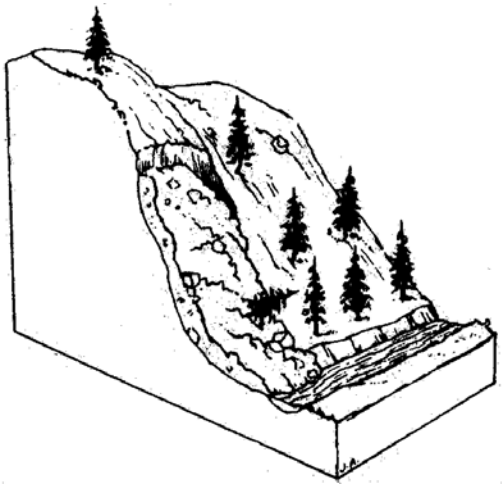
- From the beginning CGS's mapping included more than the presence of a slide.
- Most maps include the slide's type, an indication of the author's confidence that it is a slide, and many show relative activity.
- In the early 1990's the data being tracked became more structured.
  - Type of Landslide
  - Activity: Recency of movement
  - Interpretation Confidence
  - Author/Interpreter
  - Depth
  - Geologic Unit & Lithology
  - + others
- But, different mapping programs in CGS continued to use slightly different database structures.

# Types of Landslide

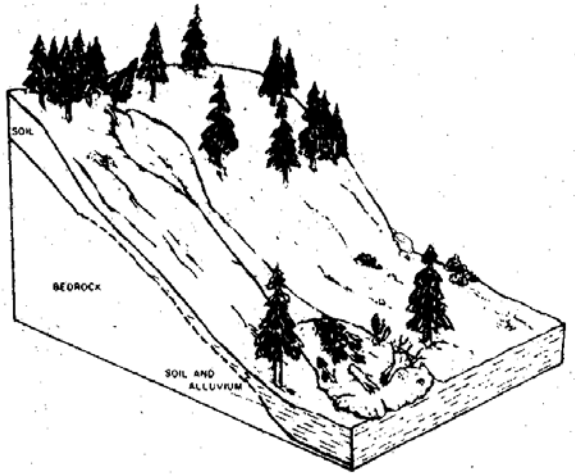


Rock slide

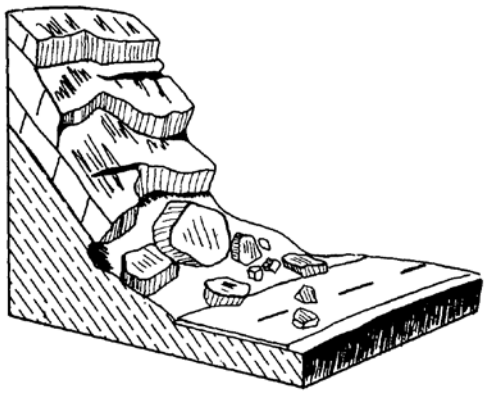
Earth flow



Debris slide

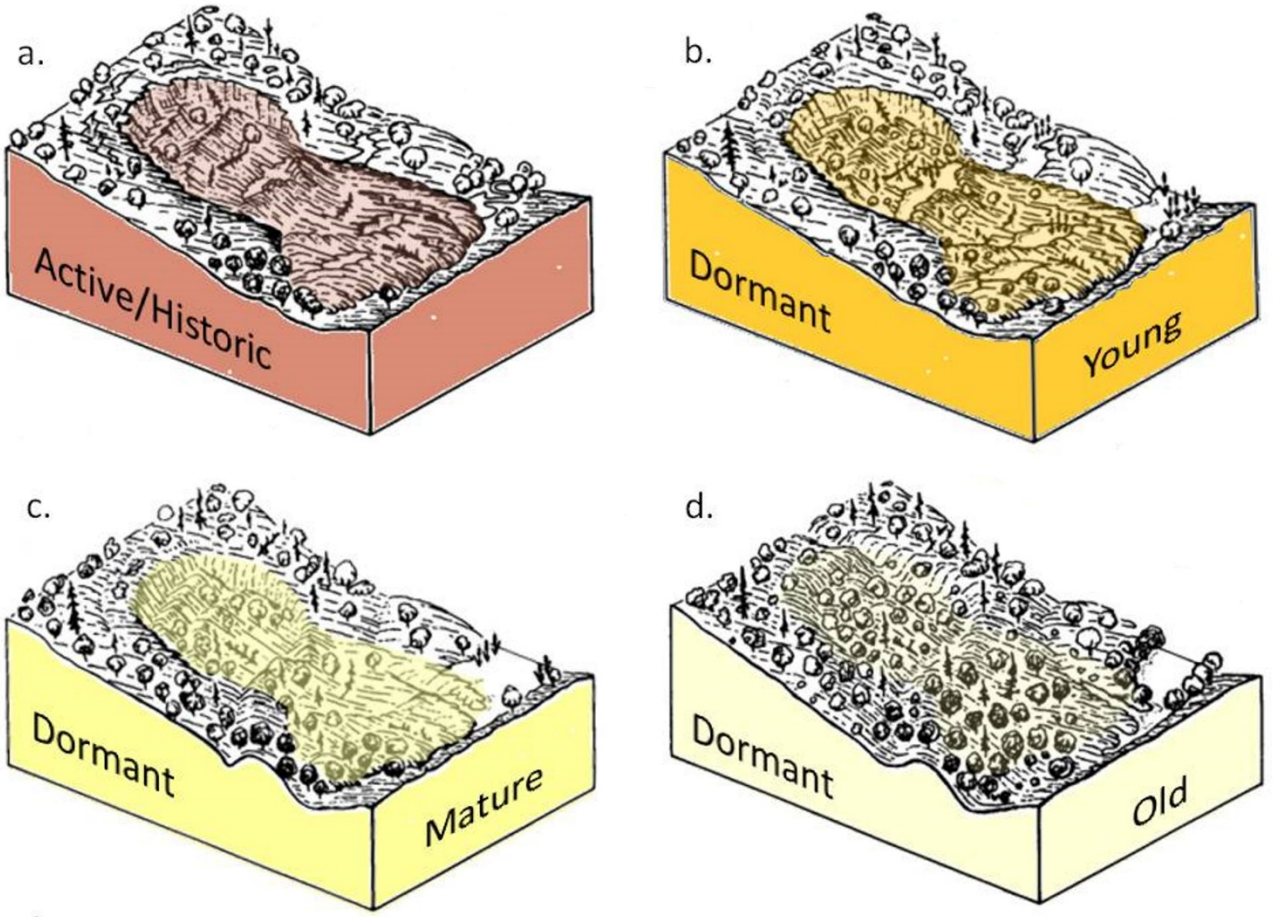



Debris flow



Rock fall

# Activity




Activity is an interpretation of the recency of movement based on how erosionally degraded the landslide appears. Ideally, we would like to know when each landslide moved. That information is rarely available.

# Evolution of a Standard (For CGS)

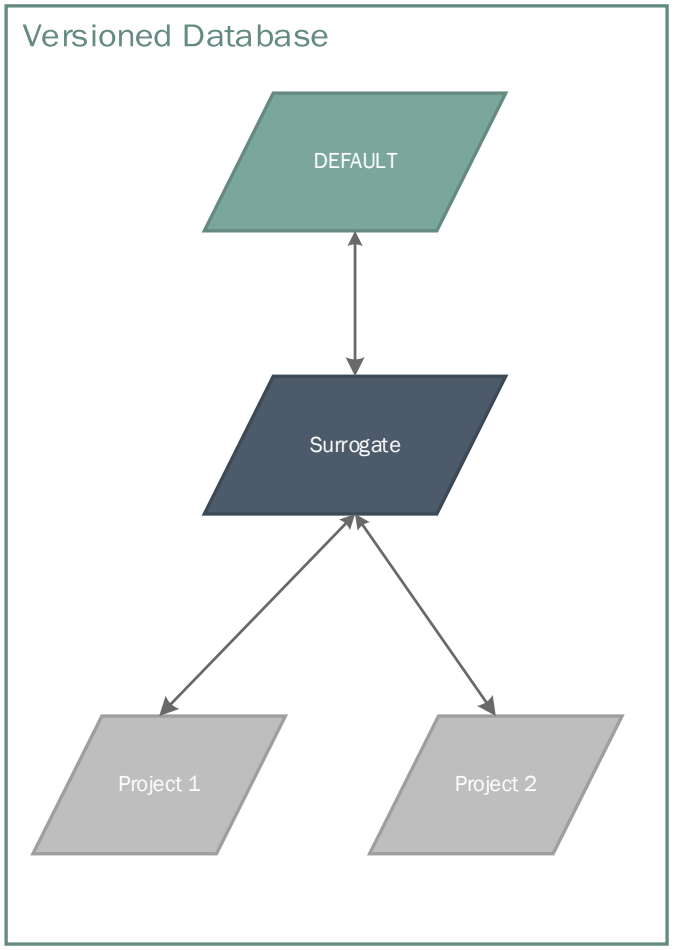
- To ingest historic data, preserving the data's provenance
- And support the creation, storage, and analysis of new data.
- Three mapping types: single-slide, source, and deposit
- Three geometry types: point, line, polygon
- With feature descriptions (type, activity, confidence,…) and metadata (author/interpreter, last edited, citable product)
- Using controlled vocabularies/domains where possible

| | |
|---|---|
| ACTIVITY | Landslide activity. Acceptable values are h (historically active, dormant historic), d (unspecified dormant), dy (dormant young), dm (dormant mature), do (dormant old/relict) |
| INIT_TYPE | Initial movement type. Combine material type (r-rock, s-soil, e-earth, d-debris) with movement type (s-slide, f-flow, t-topple, p-spread, l-fall) or multiple movement types (composite-cl). |
| SUBS_TYPE | Type, subsequent movement. |
| MVMT_MODE | Landslide movement mode. |
| CONFIDENCE | Confidence of interpretation; definite (d), probable (p), questionable (q). |
| THICKNESS | Maximum thickness estimate; s-shallow (0-10ft), m-moderate(11-50ft),d-deep(>50ft), ?-unknown. |
| DIR_MVMT | Azimuth direction estimate. Valid values are 1 to 360; North is 360, zero is not used. |
| BASE_MAP | Digital source used for compilation, i.e. the base used to locate identified landslides and digitize their boundaries. |
| MAP_YEAR | Year CGS interpreted/compiled landslide. |
| LS_DATA_ SOURCE_ TYPE | Type of source used to identify geomorphic features indicative of past landsliding; map, publication, report, air |
| PRIM_GEOL_ UNIT_MAP_ SYMB | Geologic unit abbreviation for map symbol identification. Geologic formation abbreviation for the formation most affected (area-wise) by the landslide. |
| PRIM_GEOL_ UNIT_NAME | Full name for the primary geologic formation. |
| SEC_GEOL_ UNIT_MAP_ SYMB | Geologic formation abbreviation for the second-most affected formation. If more than two formations involved add others in remarks. |
| SEC_GEOL_ UNIT_NAME | Full name for the secondary geologic formation. |
| GEOL_DATA_ SOURCE | Geologic map used for rock unit and lithology; publication series & number for CGS or USGS products, e.g. USGS OFRXX or CGS SRXX, etc. Authors and dates for other references. Null if no geologic data (4 previous fields) |
| STRIKE_AZ | If available, the overall geologic strike direction, as an azimuth (USGS strike direction convention; valid values 0-360, North is 360, zero for flat beds) |
| DIP | If available, the overall geologic dip value estimate. Valid values 0 - 90. |
| ATTITUDE_ TYPE | Type of attitude measurement; |
| ATT_DATA_ SOURCE | Geologic map used for attitudes; publication series & number for CGS or USGS products, e.g. USGS OFRXX or CGS SRXX, etc. Authors and dates for other references. Null if no attitude data (3 previous fields). |
| DATA_CLASS | Readiness of data for public release. |
| CITABLE_ PRODUCT | Publication series and number for CGS; authors and dates for other references. May contain hyperlink. |
| MVMT_DATE_YR | The year of the latest movement. For landslides that are moving continuously, the year used is the last date it moved. |
| MVMT_DATE_MON | The month of the latest movement. For landslides that are moving continuously, the month used is the last date it moved. Valid values 01-12. |
| MVMT_DATE_DAY | The day of the latest movement. For landslides that are moving continuously, the day used is the last date it moved. Valid values 01-31 |
| TRIGGERING_EVENT | Comments on event that triggered the most recent phase of movement. |
| SUPERSEDED | Flag to indicate if this feature has been retired. Valid values are null or Y. Attribute value updates are not considered substantial enough to retire a feature. If there is a substantial change required for a landslide deposit boundary (> 50% of the perimeter needs to be modified) then the original feature is copied to create a new feature with a new ls_id and the new polygon is edited to reflect current mapping. The original feature is then flagged as superseded ("Y" in this field). |

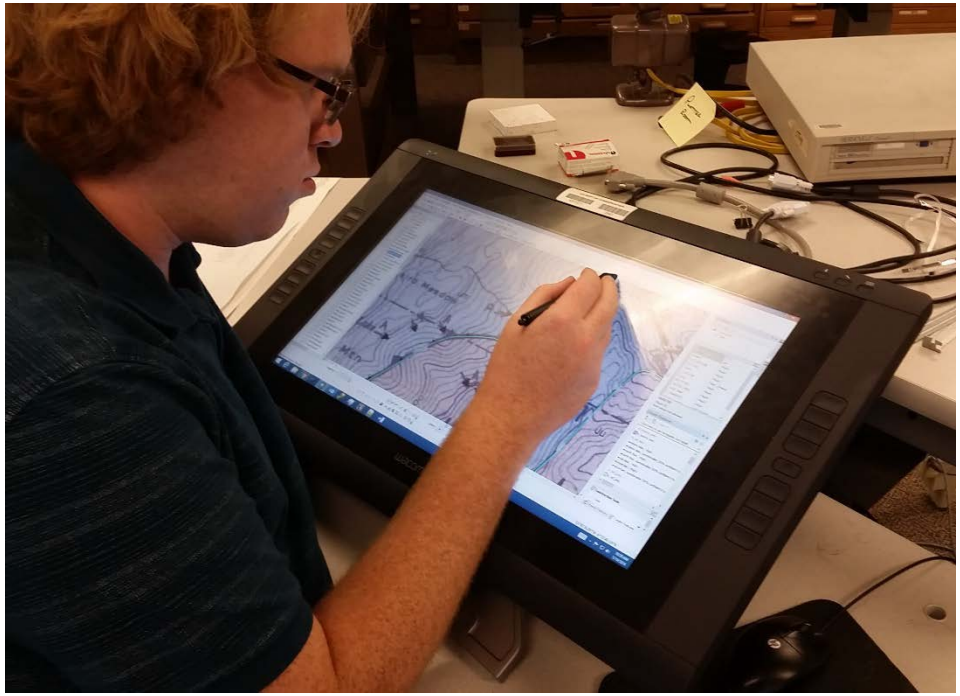
CGS
CALIFORNIA GEOLOGICAL SURVEY

# Versioned Database

- Project/Individual Workspaces (Versions)
- Using familiar editing tools
- In the same database
- With access to others' work as needed
- And support for peer review and integration



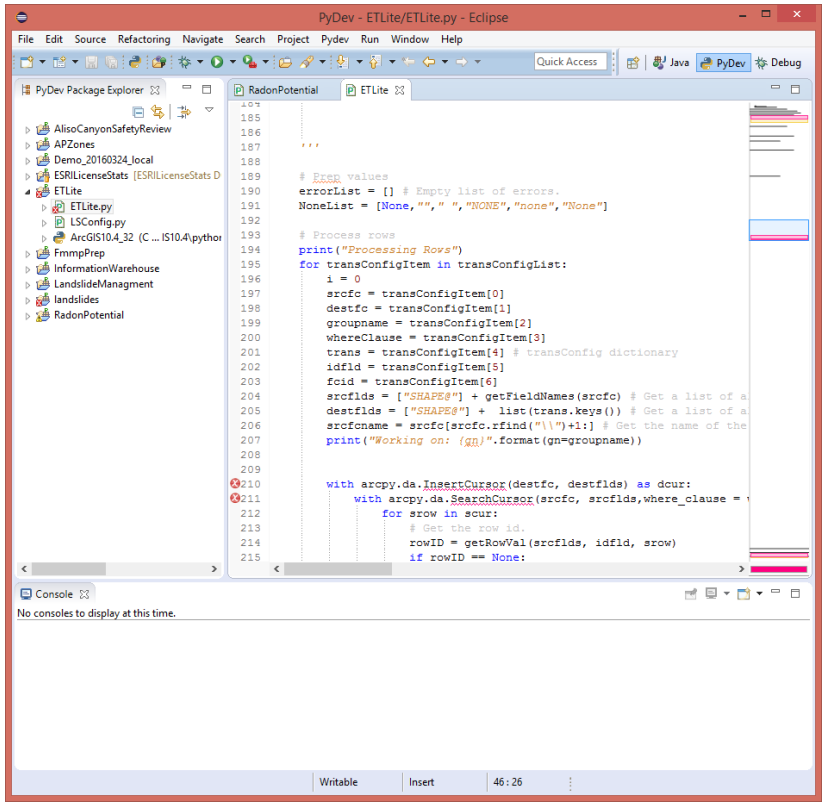
# Data Conversion and Loading



- Scan and digitize older maps to GIS
- Extract, Transform, and Load (ETL)
  - Using a lightweight Python/Arcpy based ETL module
- Review, Reconcile, & Post

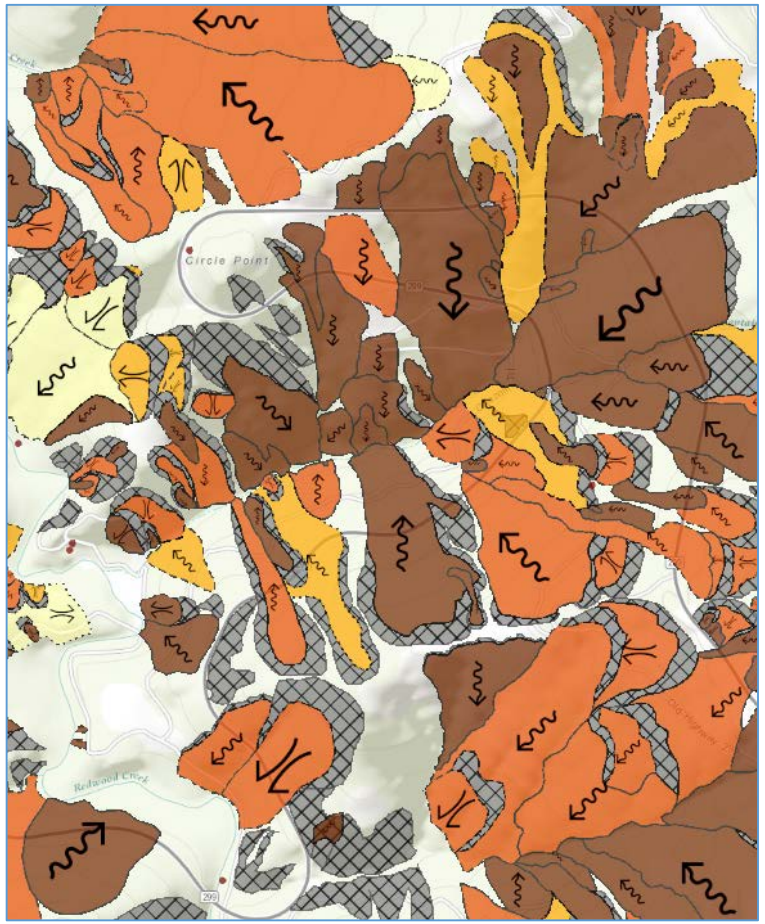
# ETLite (a light-weight data translator)

- Python 2.7 (using the default ArcGIS Python installation)
- Capabilities:
  - Copy (w domain validation)
  - Rename (w domain validation)
  - String replacement
  - Fixed Values
  - Value conversion
  - Substring extraction
  - Set Null
- Error Reporting

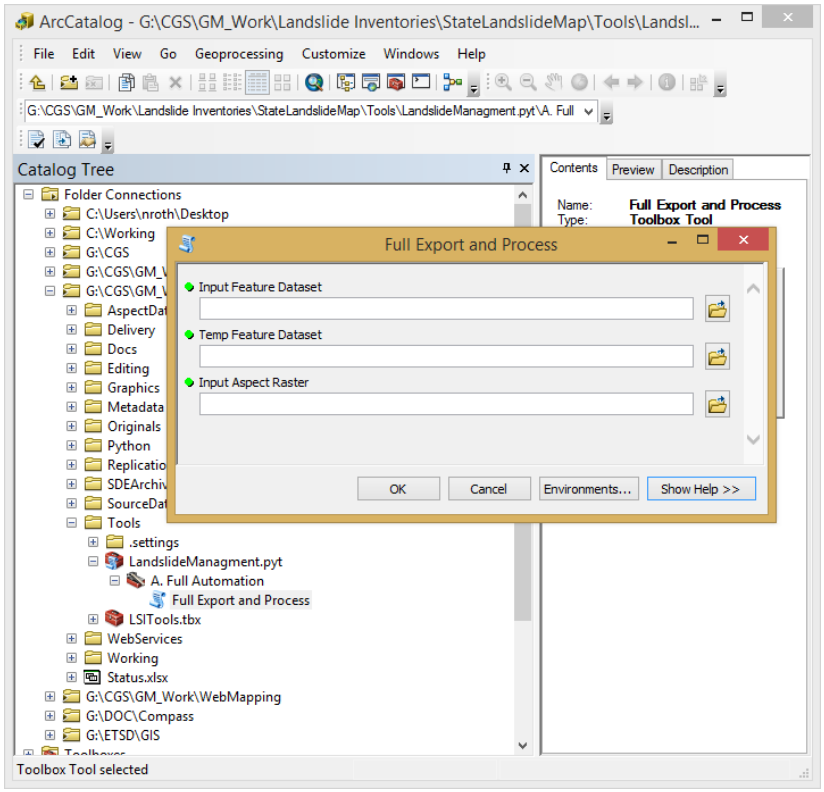


# Symbology

- Based on CGS's past symbol sets and standards of practice
- Display Classes
  - DC1: All attributes for symbology present, CGS sourced or reviewed data.
  - DC2: Some attributes present, CGS sourced or reviewed, may need further review.
  - DC3: Non-CGS sourced or less reliable source material
- Scale dependent rendering is critical for web services.
- The symbology is not perfect.



# Pre-Publication Script




- Currently run from a Python Toolbox in ArcGIS
- Computes direction of movement from aspect (Majority)
- Calculates the arrow sizes as a function of the area/perimeter
- Assigns Display Class
- Creates centroid feature class for polygons
- Other minor data cleanup
- Reprojects to Web Mercator (EPSG: 3857)

# Web Services

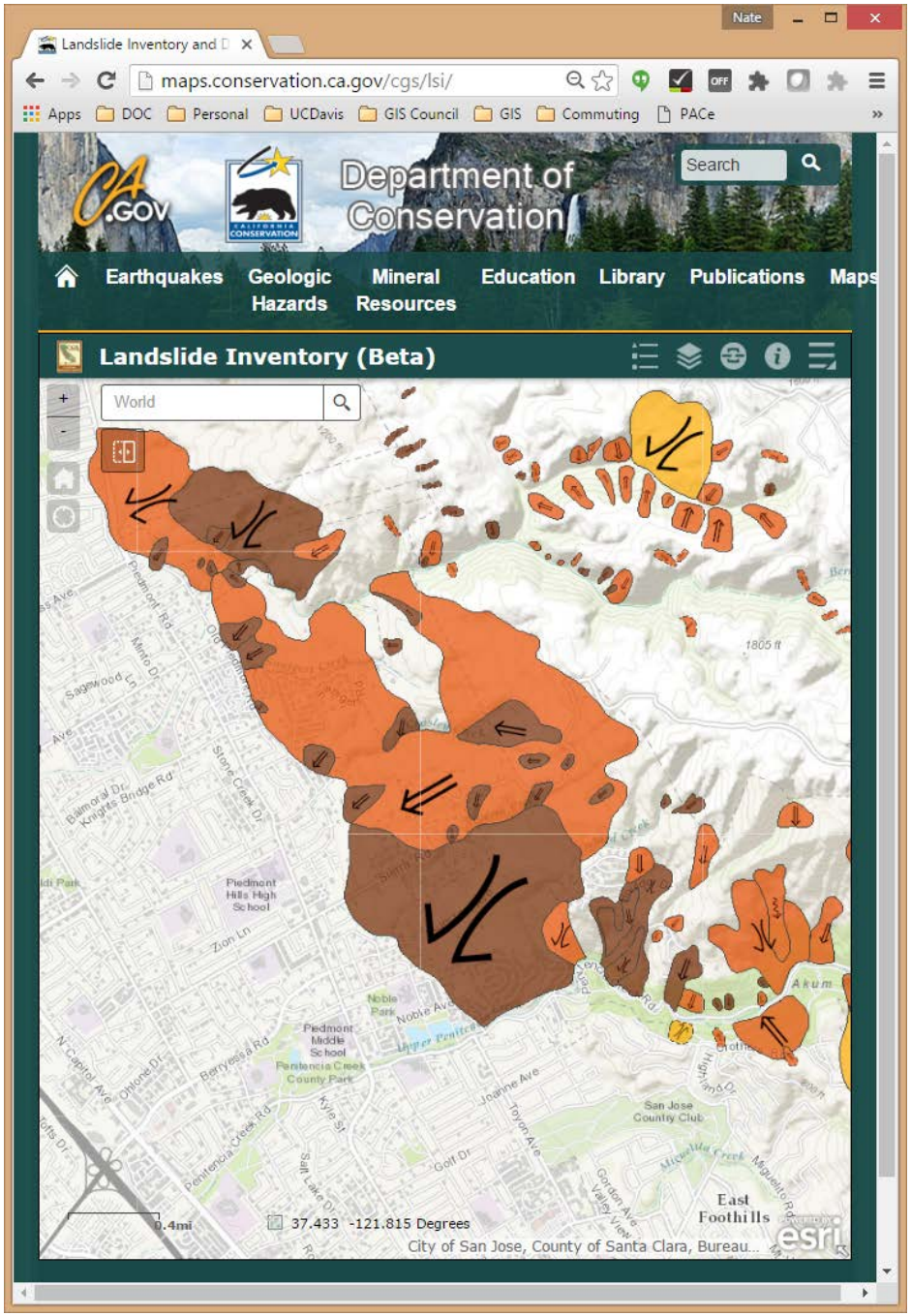

- 4 Services
  - DC1_Younger (active/historic, or dormant young)
  - DC1_Older (Dormant Mature, Old/Relict, or Age Not Specified)
  - DC2
  - DC3
- External
  - Link
  - ESRI Map Services
- Internal
  - ESRI Map Services
  - ESRI Feature Services
  - WMS
  - WFS

# Web Application

- Constructed using ESRI Web AppBuilder Developer Edition
  - With minor CSS and JS changes
  - Pages hosted at DOC
  - Map in ArcGIS Online
- Link

# Take Home Messages

- Establishing a standard that matches the practical realities is important.
- ETL tools, whether light weight like mine, or more fully featured like FME are powerful.
- Don’t overly complicate web applications.
- In multi-user environments consider using a central versioned database.





# Thank you

Contact Information:

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