Groundwater at the Rocky Flats, Colorado, Site

Rocky Flats Stewardship Council

U.S. DEPARTMENT OF ENERGY | Legacy Management

Agenda

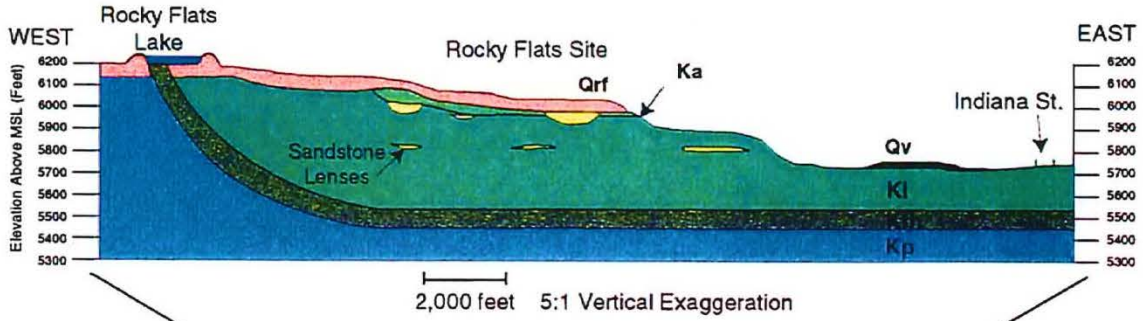
- Characteristics and hydrogeology of Rocky Flats
  - Geology
  - Water cycle
  - Data sources
  - Rocky Flats examples

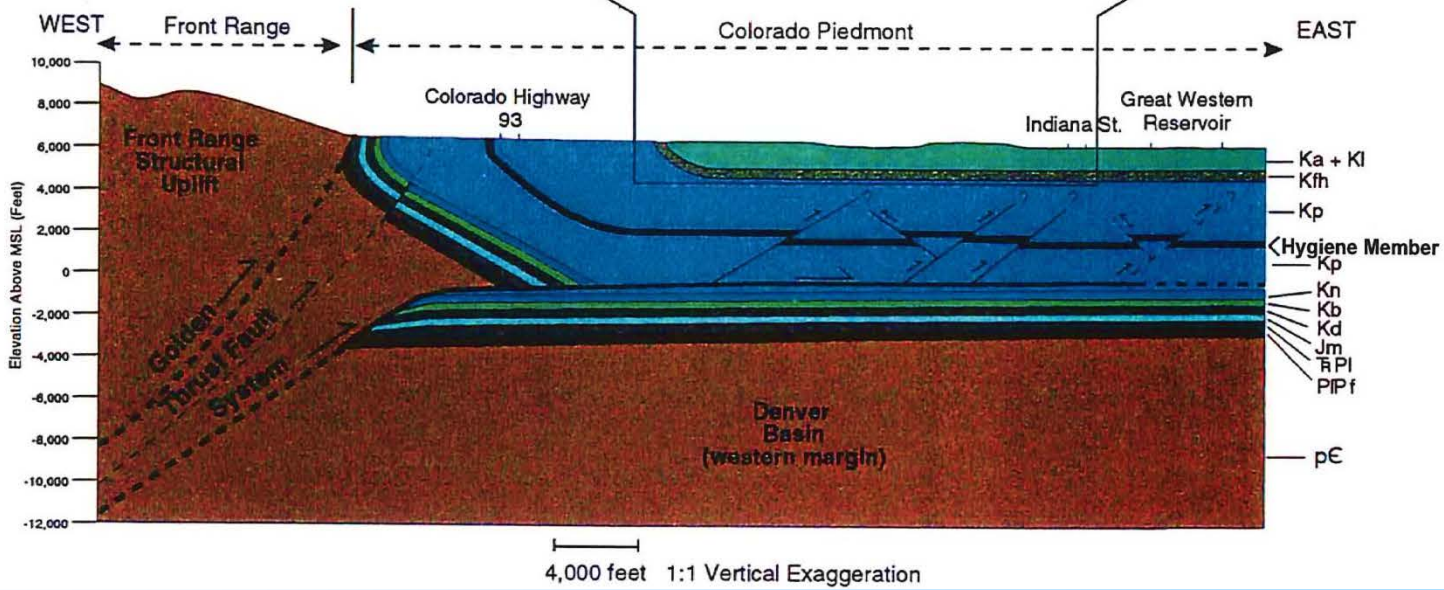
Rocky Flats Geology

Geologic Units

- Qv — Verdos Alluvium
- Qrf — Rocky Flats Alluvium
- Ka — Arapahoe Formation
- Kl — Laramie Formation
- Kfh — Fox Hills Sandstone
- Kp — Pierre Shale/Hygiene Member
- Kn — Niobrara Formation
- Kb — Benton Shale
- Kd — Dakota Group
- Jm — Morrison Formation
- TR Pl — Lykins Formation
- PIPf — Lyons & Fountain Formations
- p€ — Undivided Igneous & Metamorphic Units

Structural interpretation from EG&G, 1993a.

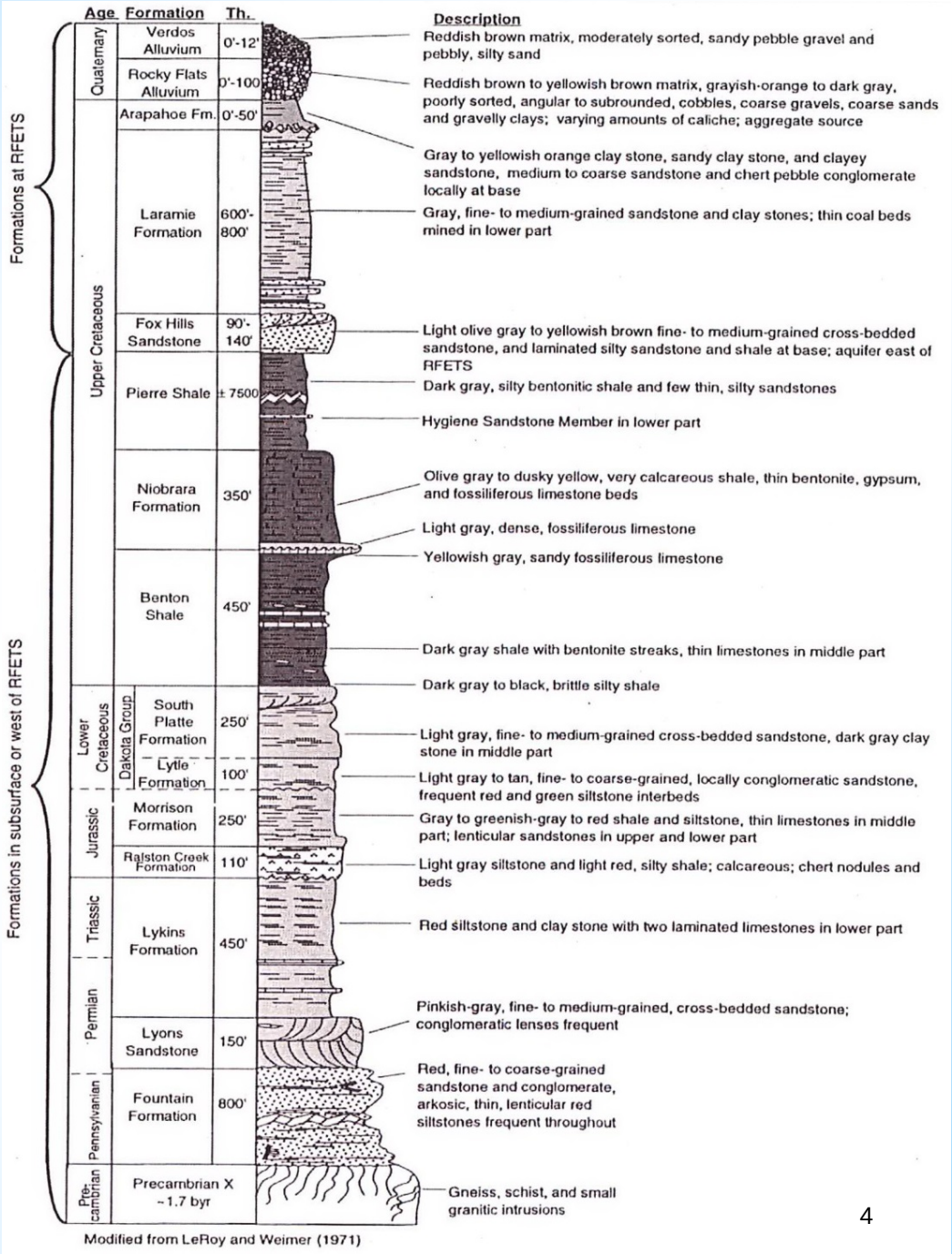




From: Groundwater IM/IRA, 2005

Rocky Flats Geology

Generalized stratigraphic section for the Rocky Flats area



From: Groundwater IM/IRA, 2005

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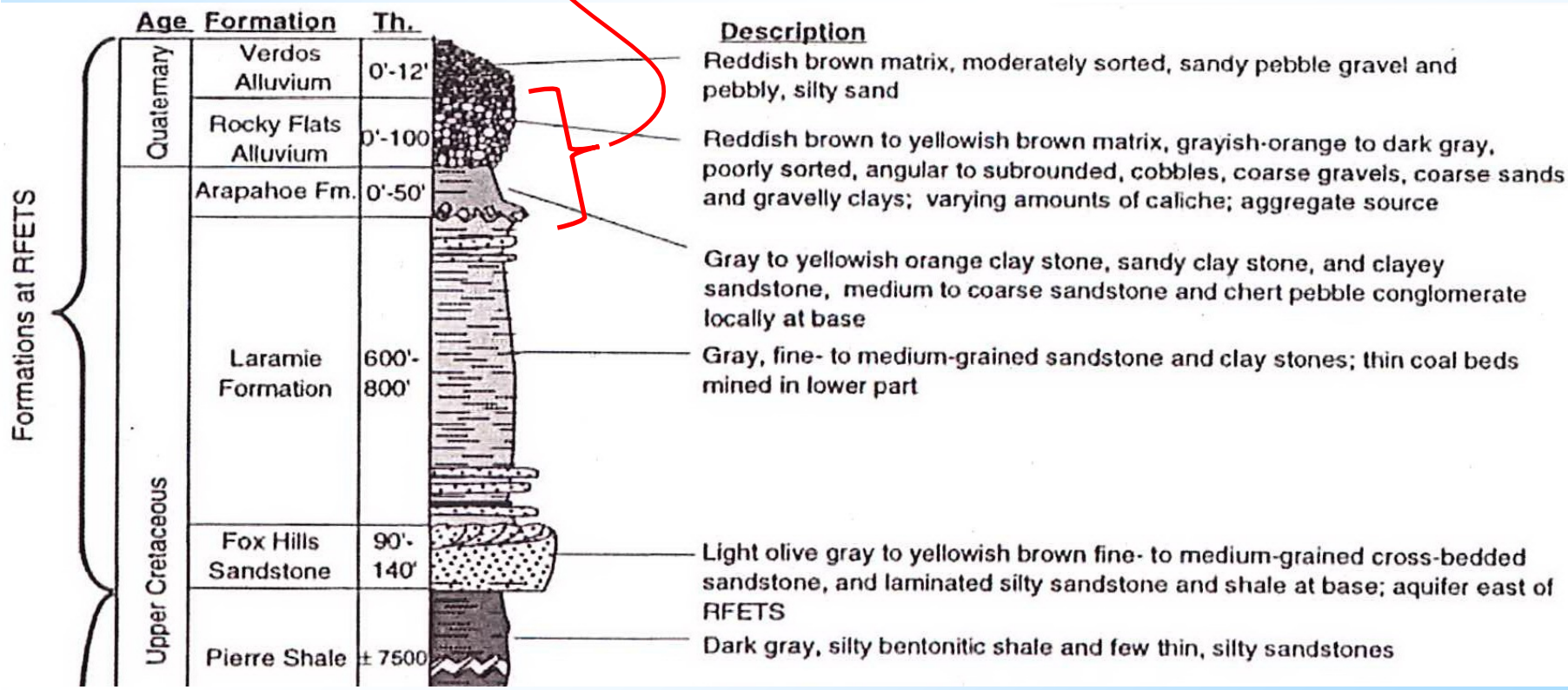
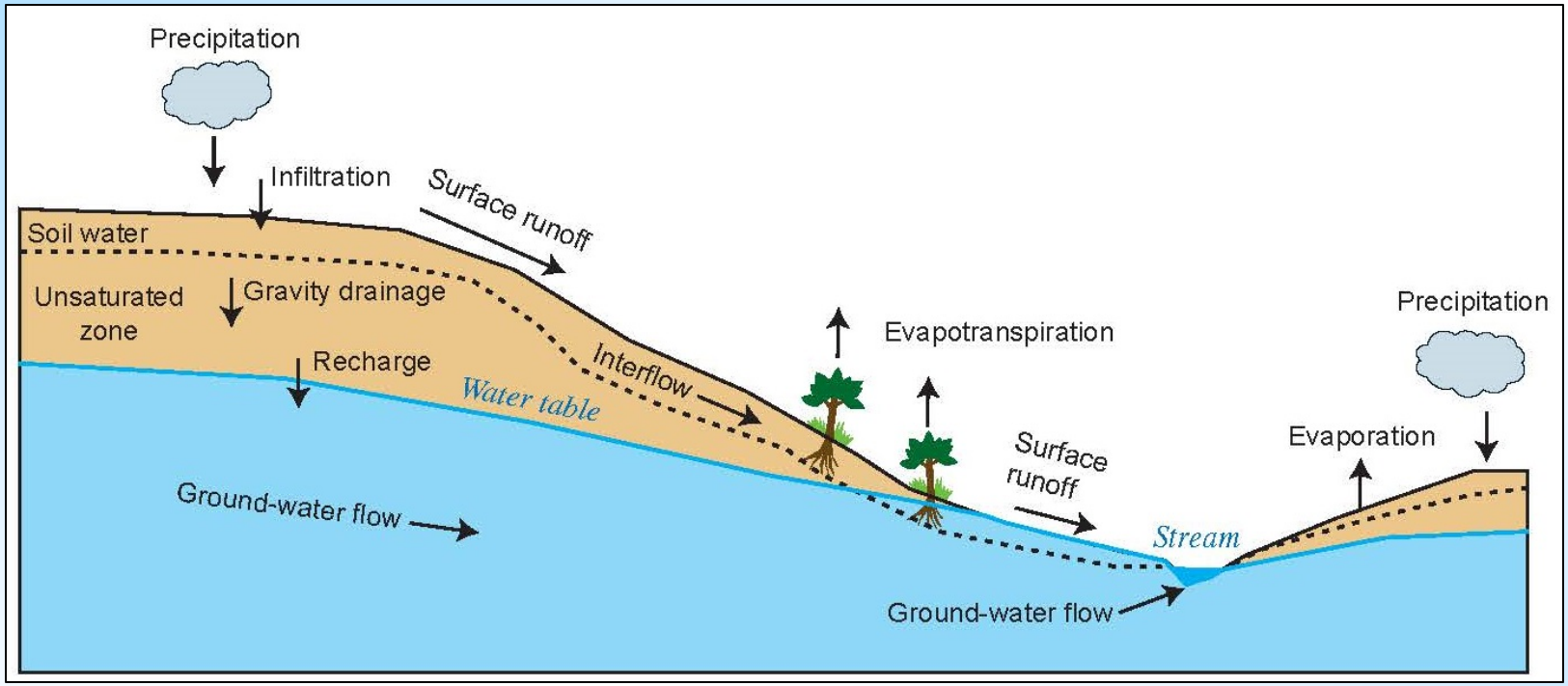
Rocky Flats Geology

Most Important:
Rocky Flats Alluvium (and other surficial materials, such as artificial fill and colluvium) and the Arapahoe and Laramie Formations



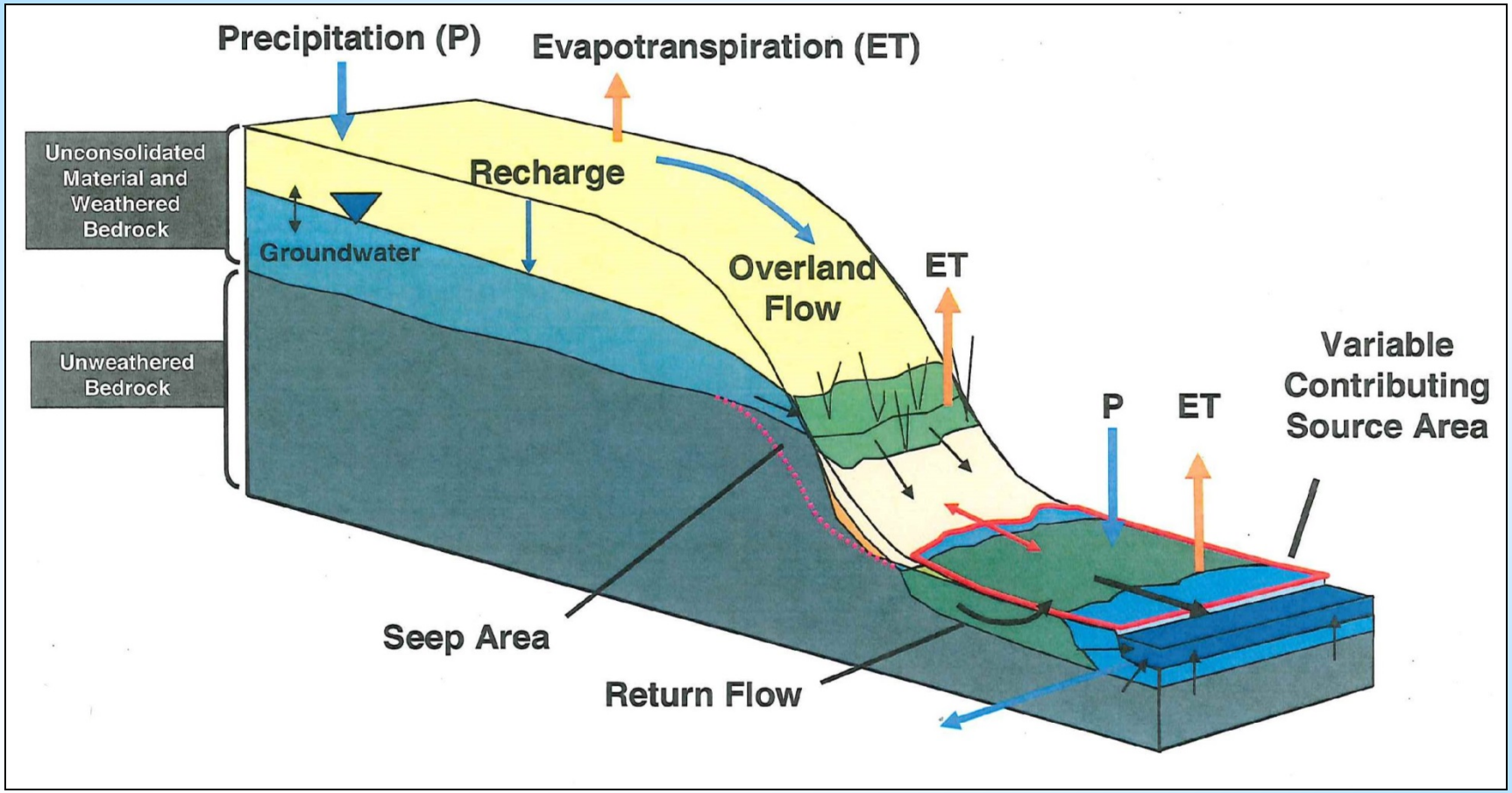
From: Groundwater IM/IRA, 2005

Typical, Generalized Water Cycle



From USGS: GSFLOW model documentation, 2008

Water Cycle at Rocky Flats



Modified after: Groundwater IM/IRA, 2005

Water Cycle at Rocky Flats (continued)

Water Cycle at Rocky Flats (continued)

Rocky Flats Water and Hydrogeology

- Semiarid climate
  - Only 12 to 15 inches of precipitation are received annually
  - All but 1 to 2 inches of precipitation are lost each year due to evapotranspiration (ET)
- Primary sources of groundwater
  - Recharge from precipitation
  - Baseflow from west of the site
- Very limited amounts of groundwater are available

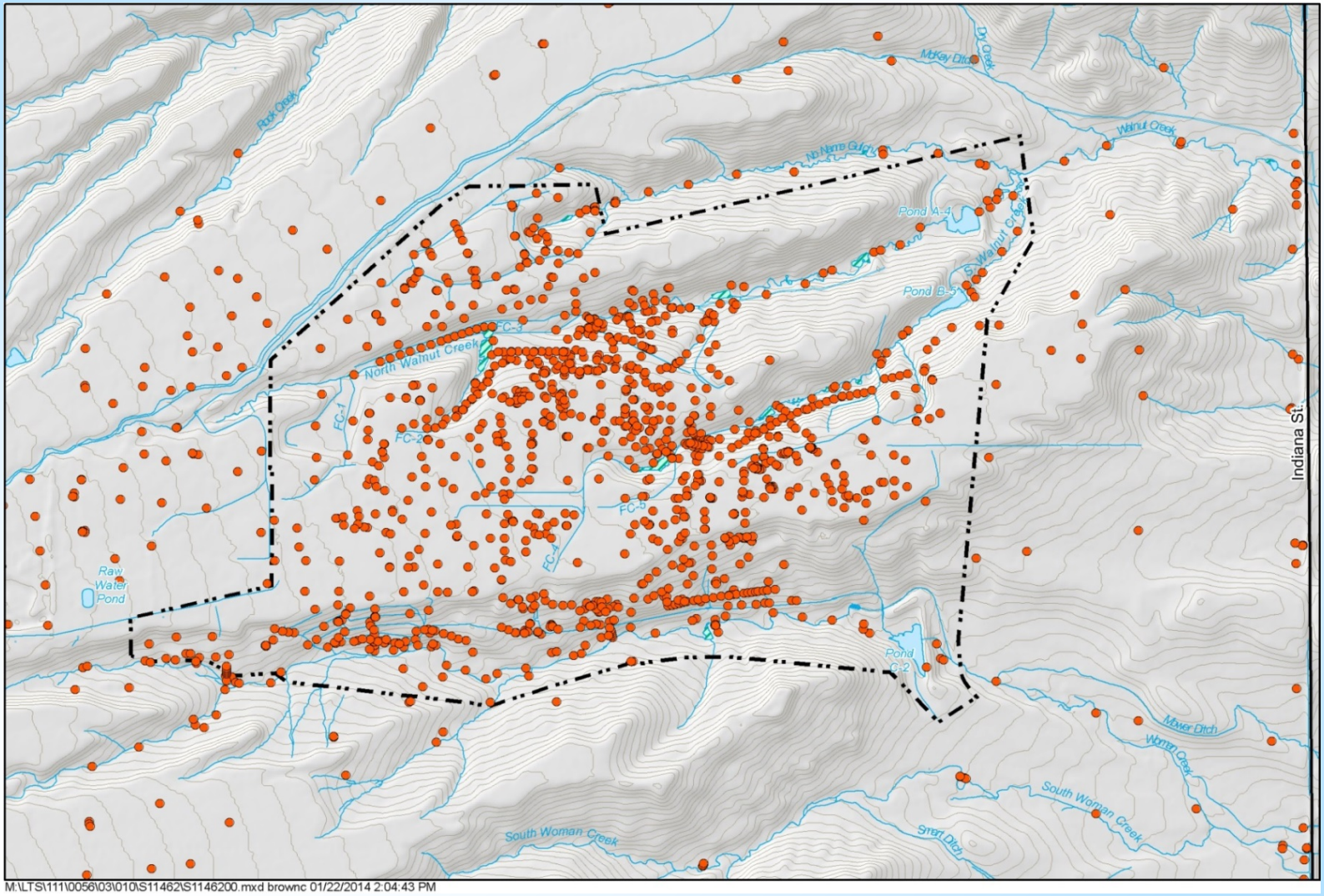
Rocky Flats Water and Hydrogeology (continued)

- Hydrogeology
  - Two fundamental units
    - Upper Hydrostratigraphic Unit (UHSU) – surficial materials, weathered bedrock
    - Lower hydrostratigraphic unit (LHSU) – deeper, unweathered bedrock
  - Groundwater in some areas of UHSU is affected by past operations
  - Data show LHSU is hydraulically isolated from UHSU
  - Bedrock surface largely resembles ground surface
    - Groundwater flows downhill along bedrock contact
    - Generally west to east
  - UHSU groundwater discharges to surface water within the Central Operable Unit
- **This is why we monitor the groundwater – to watch for threats to surface water**

Monitoring Wells

- Source of data
  - Over 1,400 wells and hundreds of boreholes have been installed since the 1950s
    - Unnecessary wells abandoned according to Colorado State Engineer requirements
  - Most monitoring wells are located on site
  - Data collected
    - Geologic
      - Characteristics of the subsurface materials
      - Depths of important features, like bedrock contact
    - Hydrogeologic
      - Water level
      - Aquifer characteristics
    - Chemical
      - Field parameters (pH, temperature, etc.)
      - Contaminants and other chemistry

Historic Monitoring Wells



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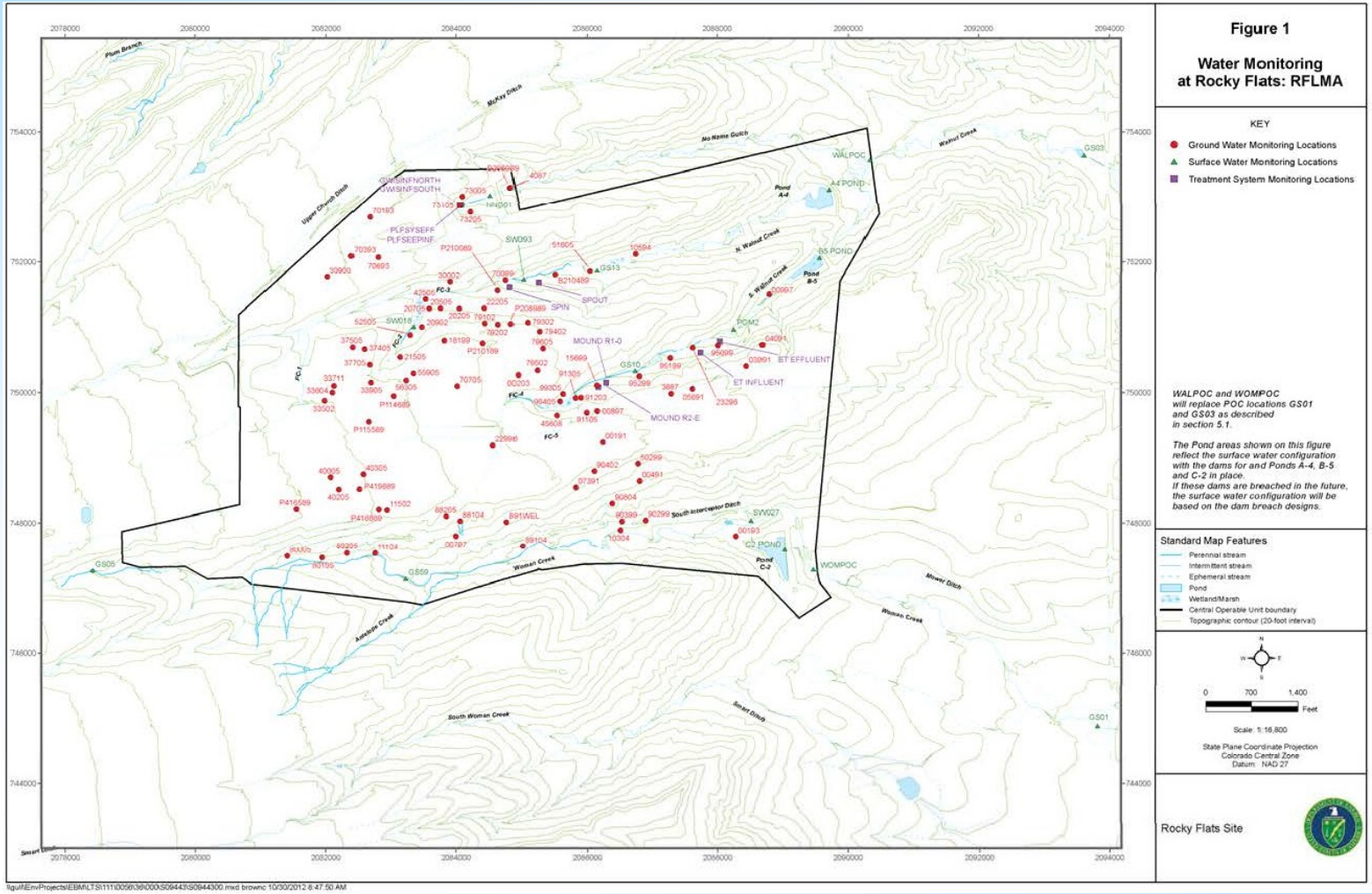
Post-Closure *Rocky Flats Legacy Management Agreement* (RFLMA) Monitoring



From RFLMA, 2012 (prior to revision currently underway)

Groundwater Elevation and Flow

- Plot and contour map of elevations
- Estimate flow directions and velocities

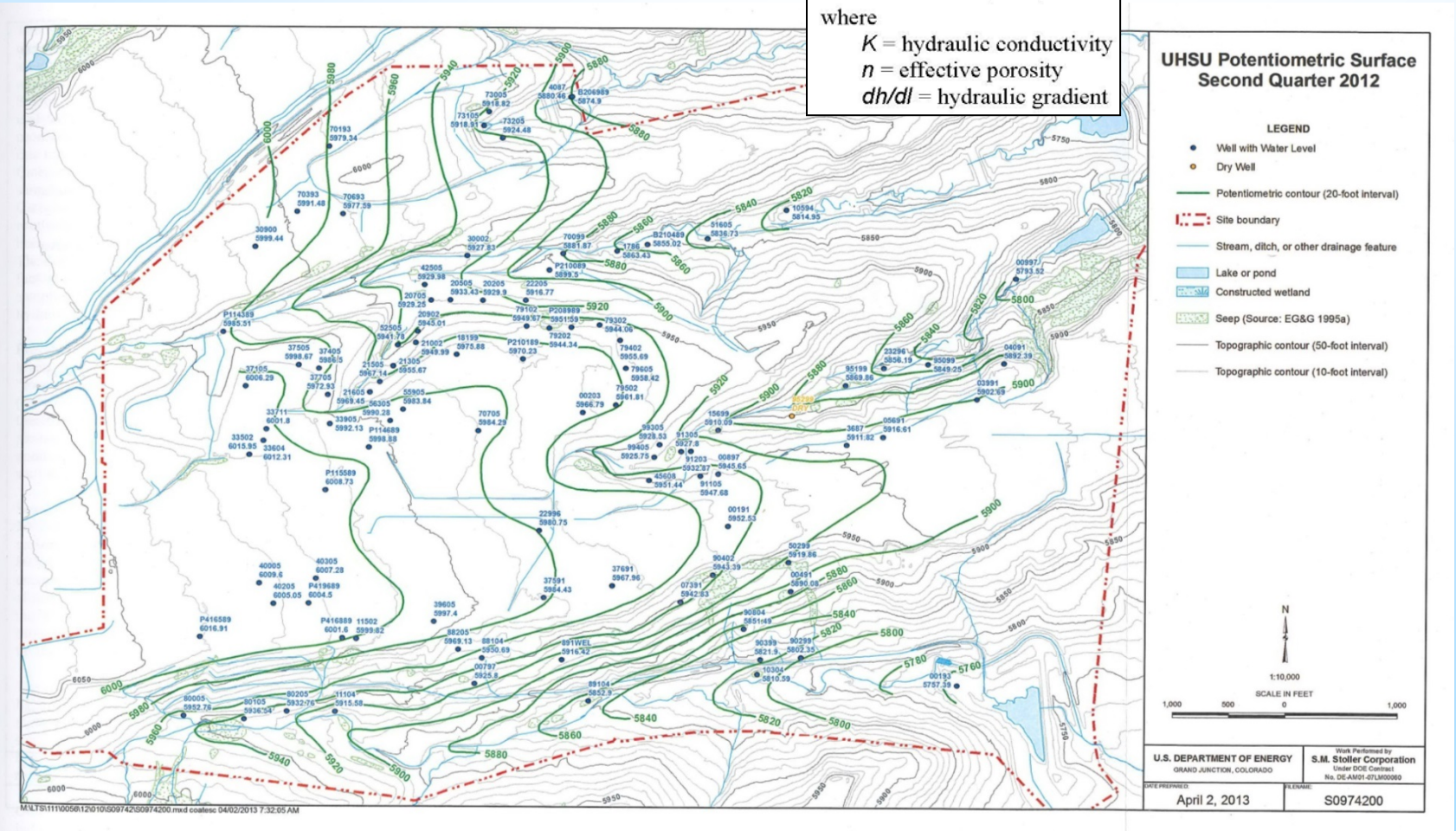
velocity $v = \left(K/n\right)\left(dh/dl\right)$

where

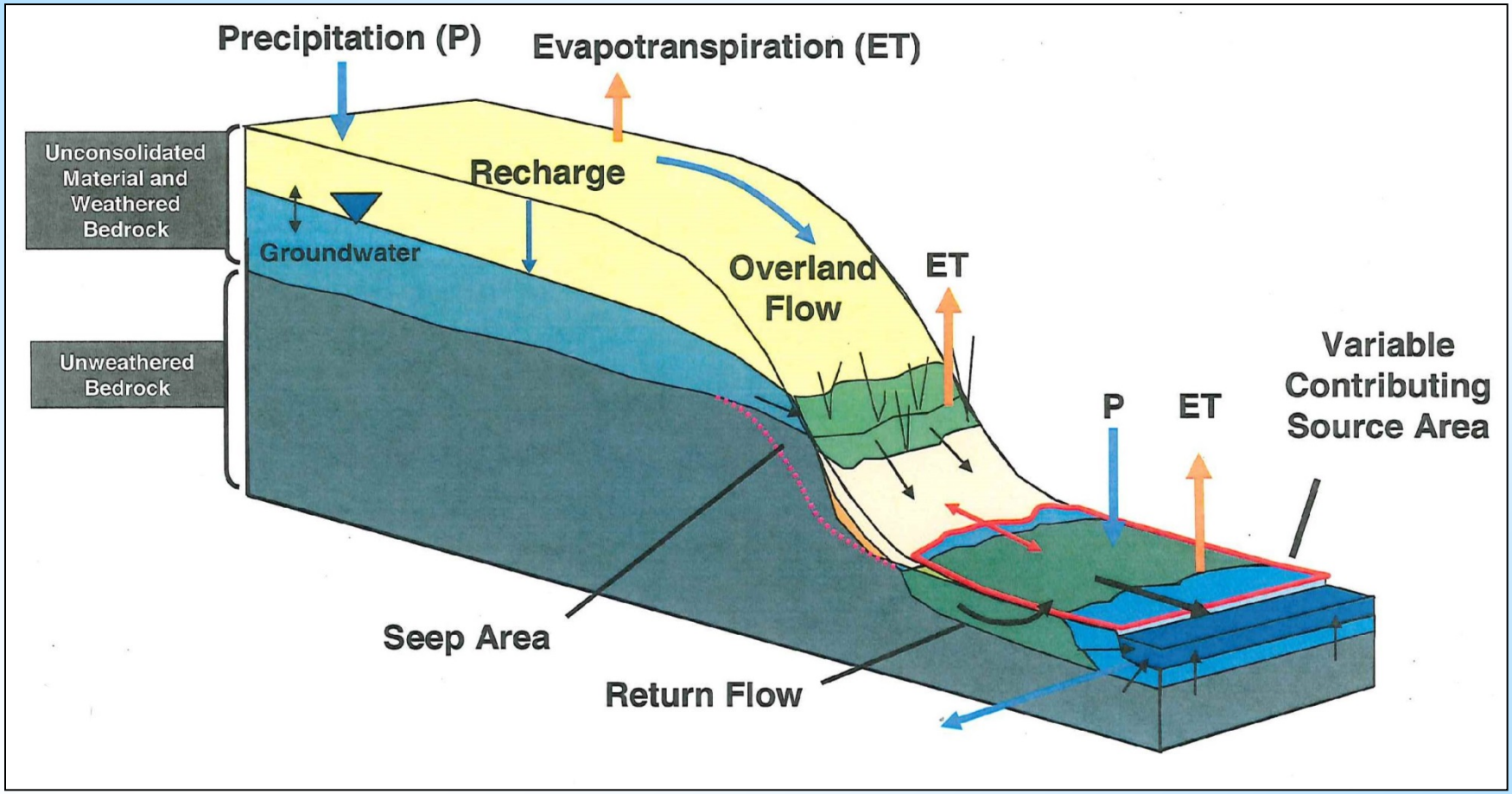
K = hydraulic conductivity

n = effective porosity

dh/dl = hydraulic gradient



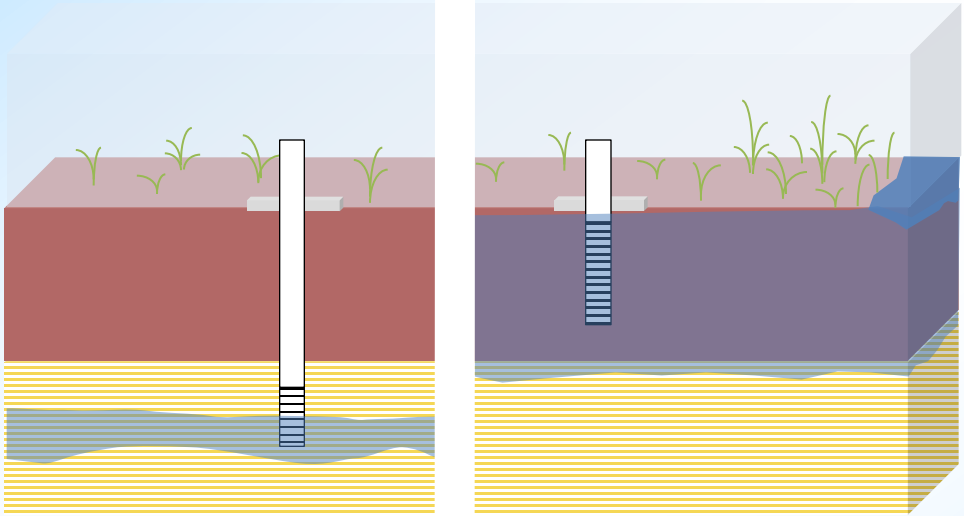
The Water Cycle at Rocky Flats

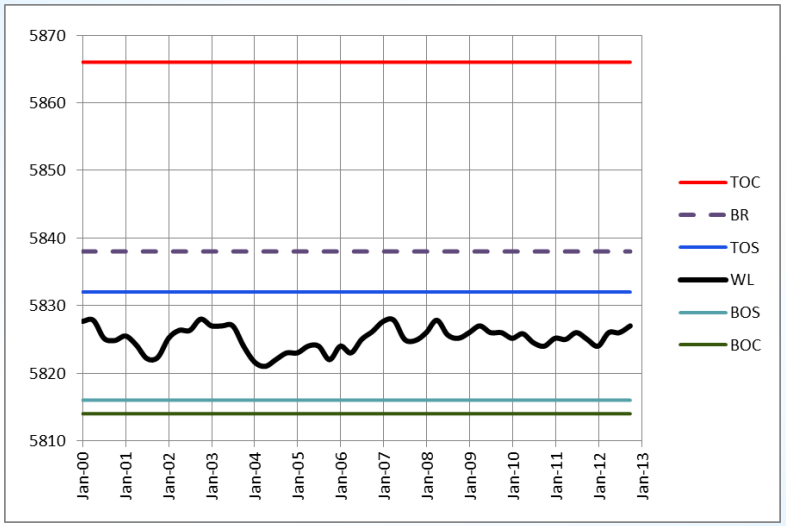


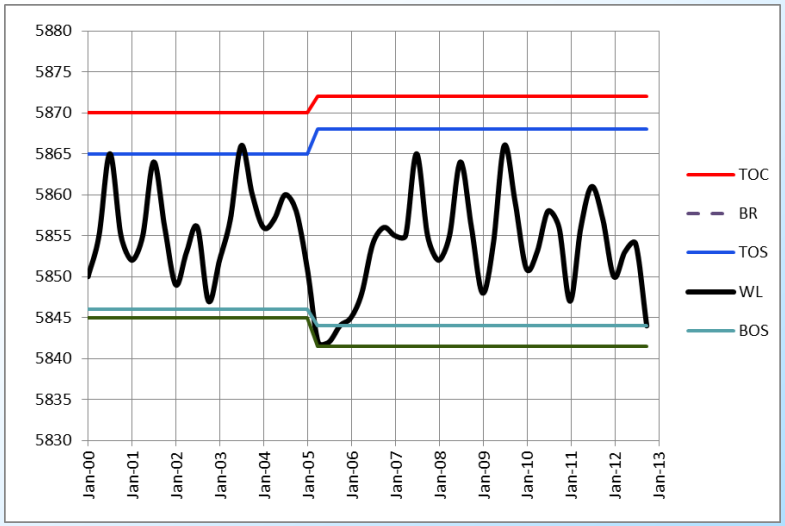
Modified after: Groundwater IM/IRA, 2005

Water Levels

Hydrographs for **hypothetical** wells screening weathered bedrock and alluvium

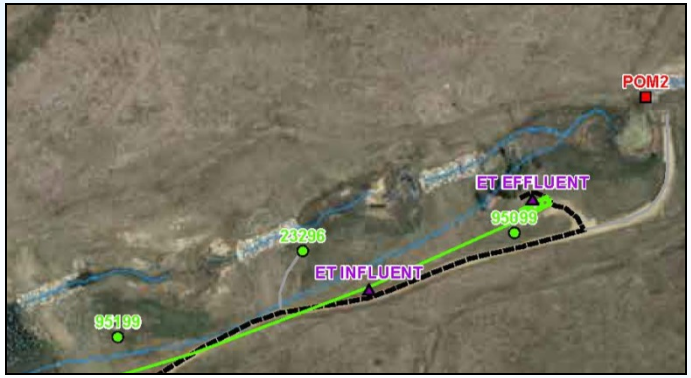




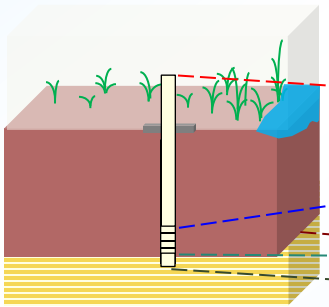


TOC = top of well casing; **BR** = bedrock contact; **TOS** = top of screen; **WL** = water level;
BOS = bottom of well screen; **BOC** = bottom of well casing (also referred to as TD, total depth)

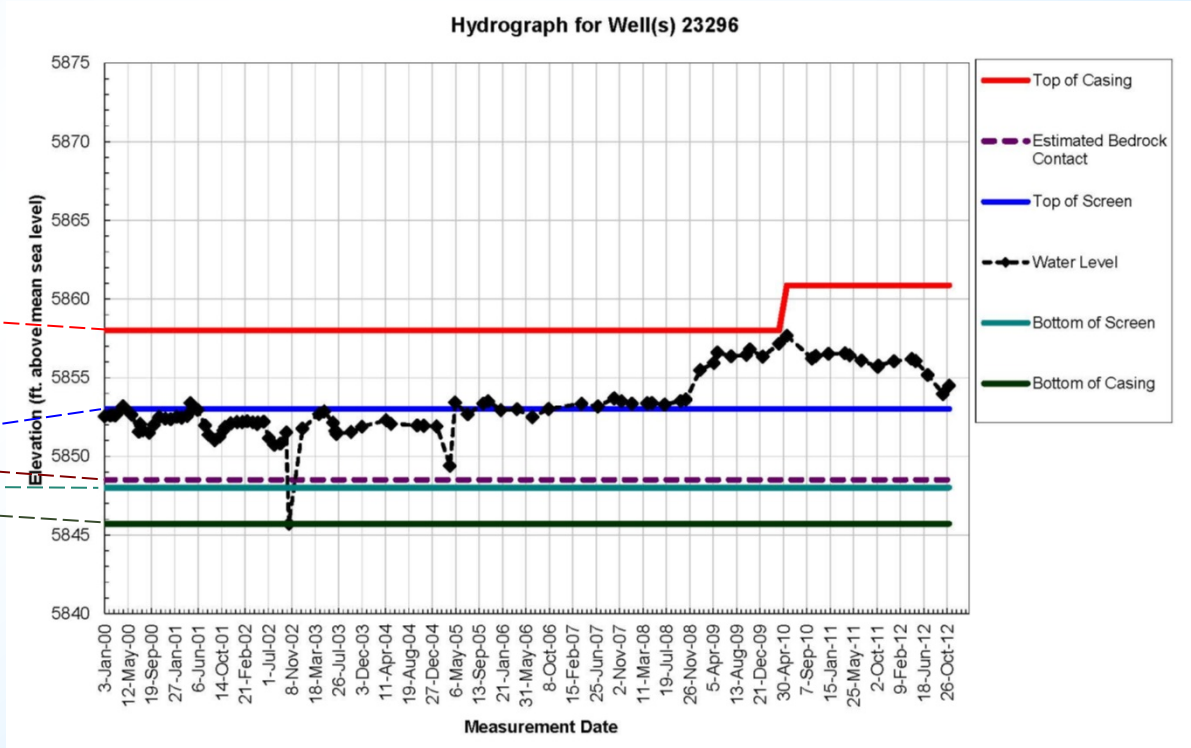
Water Level Example:
Rocky Flats Well 23296



- Sentinel well
- Adjacent to South Walnut Creek, downgradient of ETPTS intercept trench
- Shows influence of breaching dams for former Ponds B-1, B-2, B-3
- Not a strong seasonal pattern (GS10 is “always” flowing, helping to keep this area saturated)

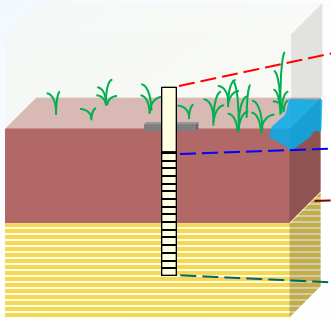


Conceptual sketch

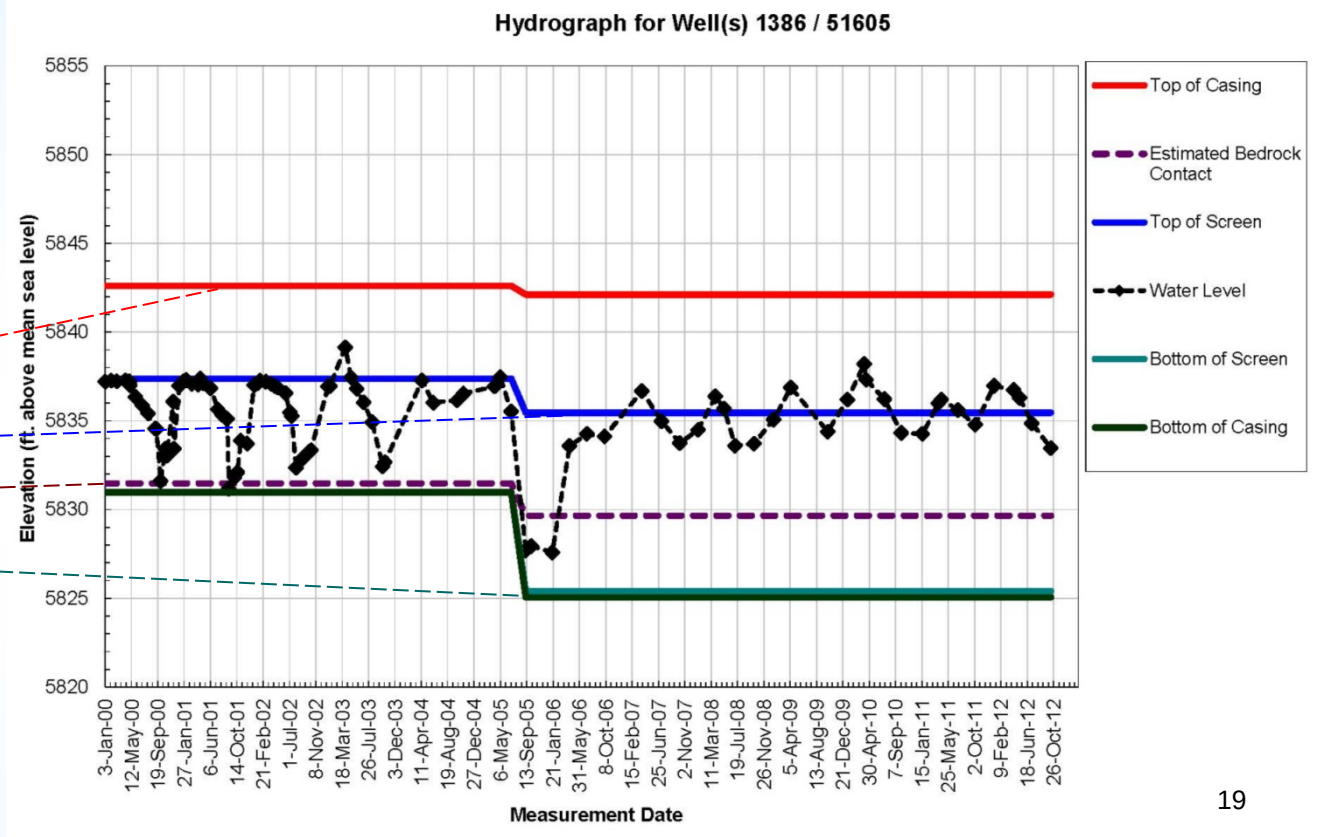


Water Level Example:
Rocky Flats Well 51605

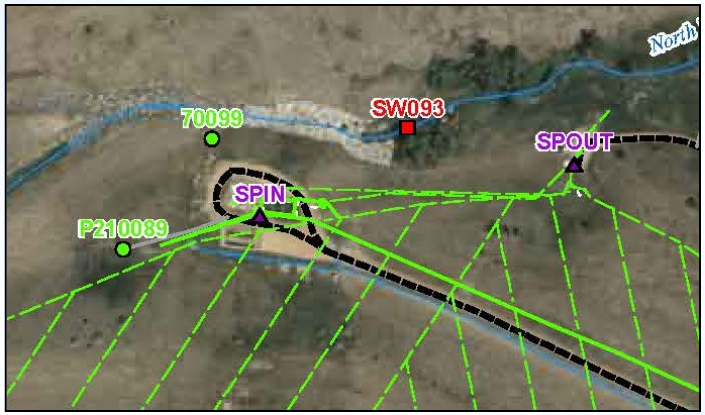
- Evaluation well
- Next to north Walnut Creek
- Seasonal pattern
- Slow recovery after well replacement



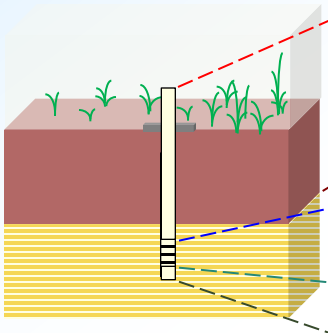
Conceptual sketch



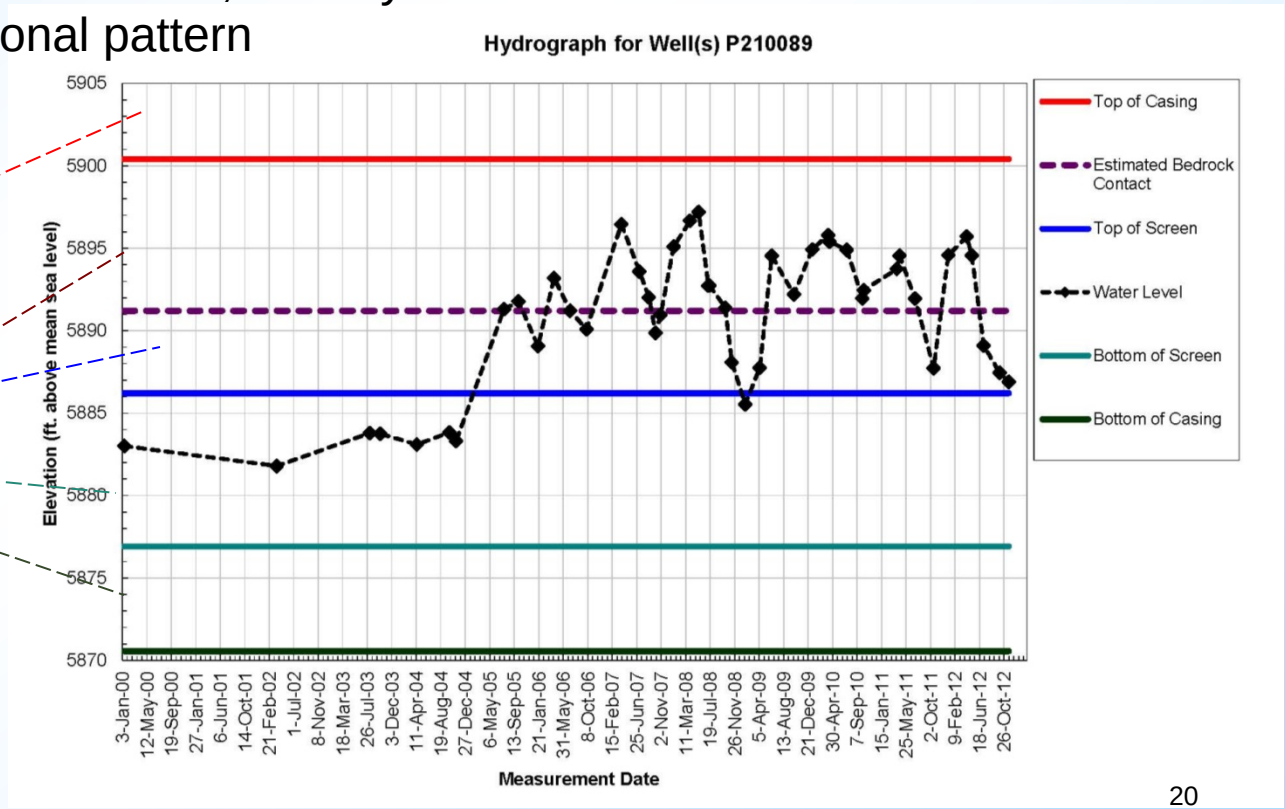
Water Level Example:
Rocky Flats Well P210089



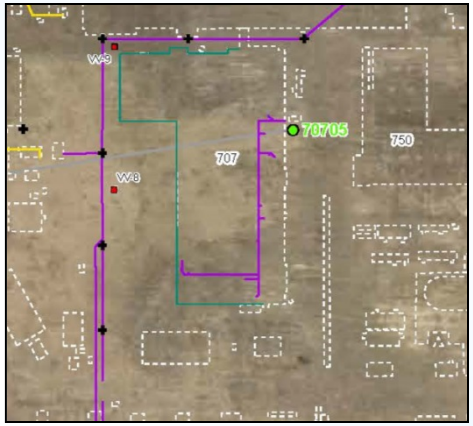
- Sentinel well
- Adjacent to solar ponds plume treatment system intercept trench
- Shows influence of closure—removal of drain and conversion to flat, marshy area—followed by seasonal pattern



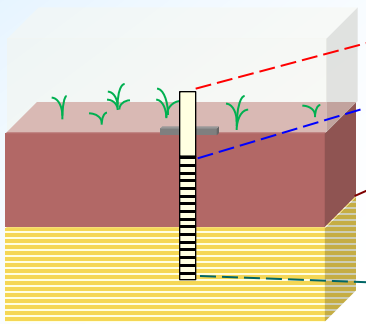
Conceptual sketch



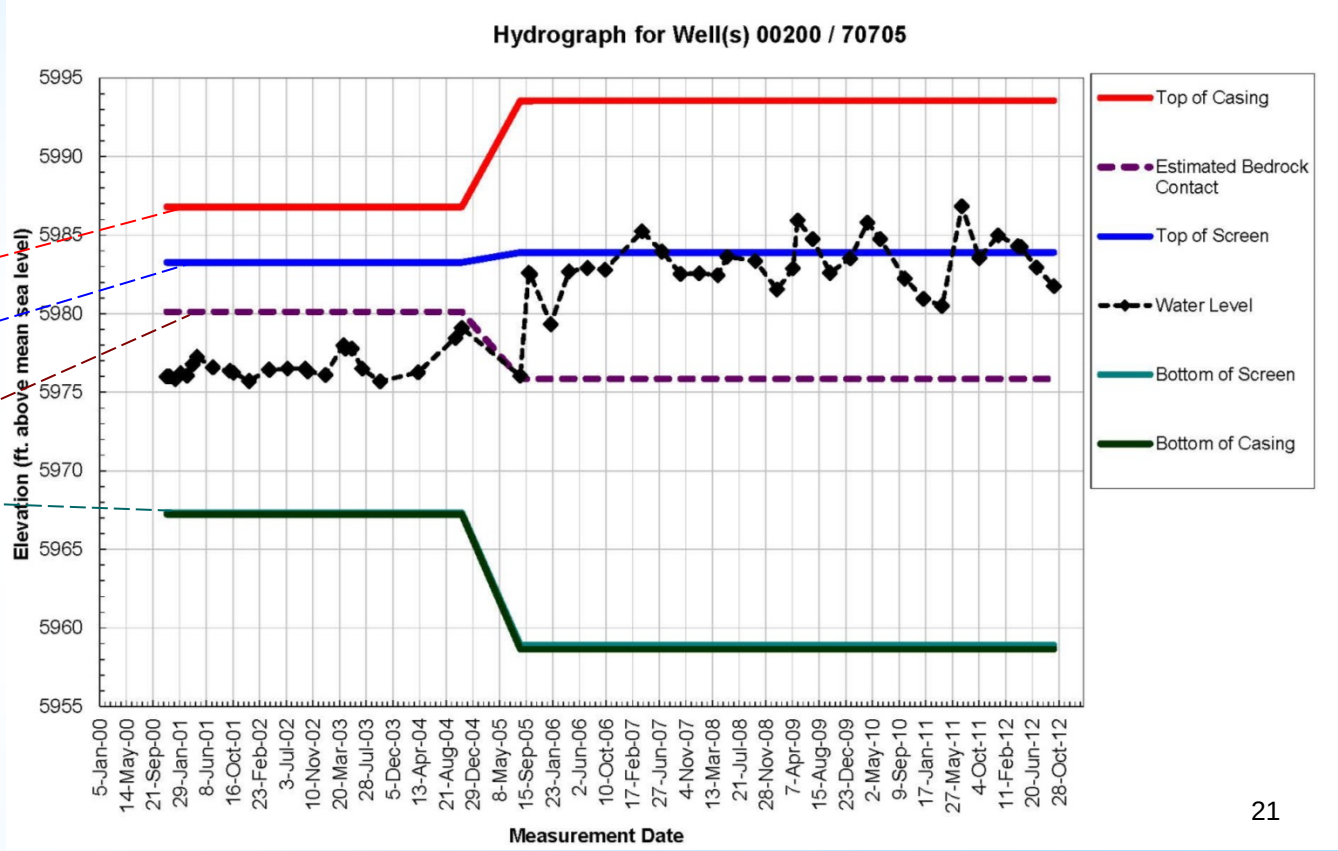
Water Level Example:
Rocky Flats Well 70705



- Evaluation well
- Adjacent to east side of former Building 707
- Shows influence of closure—removal of building, parking lots, etc.—then ET-dominated seasonal pattern

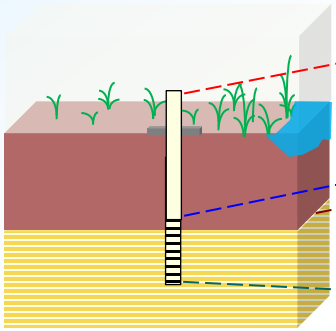


Conceptual sketch

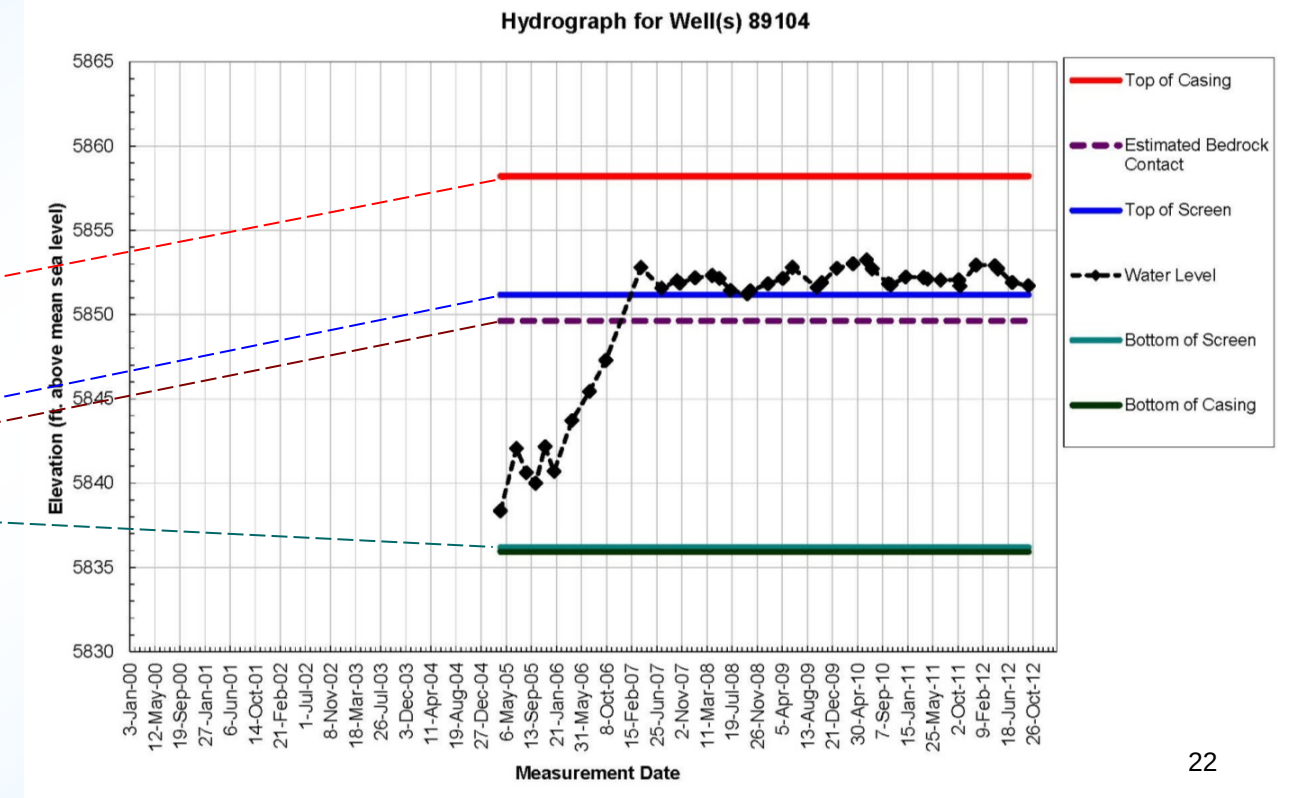


Water Level Example:
Rocky Flats Well 89104

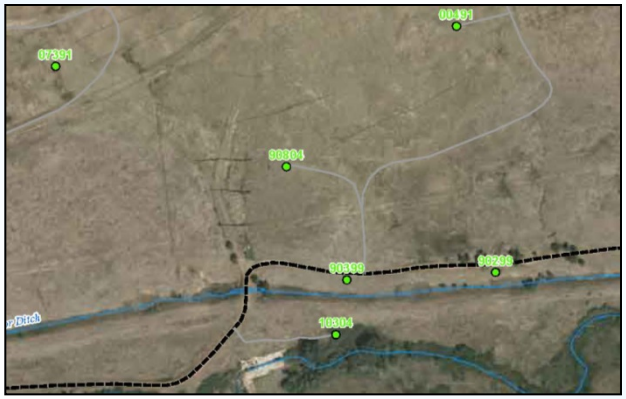
- Area of concern well
- Adjacent to Woman Creek
- Shows slow initial charge, then steady with reduced seasonal influence



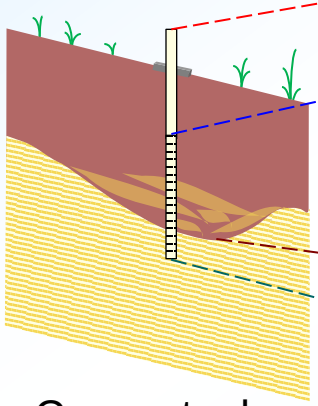
Conceptual sketch



Water Level Example:
Rocky Flats Well 90804



- Evaluation well
- On 903 hillside
- Monitors groundwater beneath slump-reworked claystone
- Steady water levels, essentially unaffected by seasonality and ET



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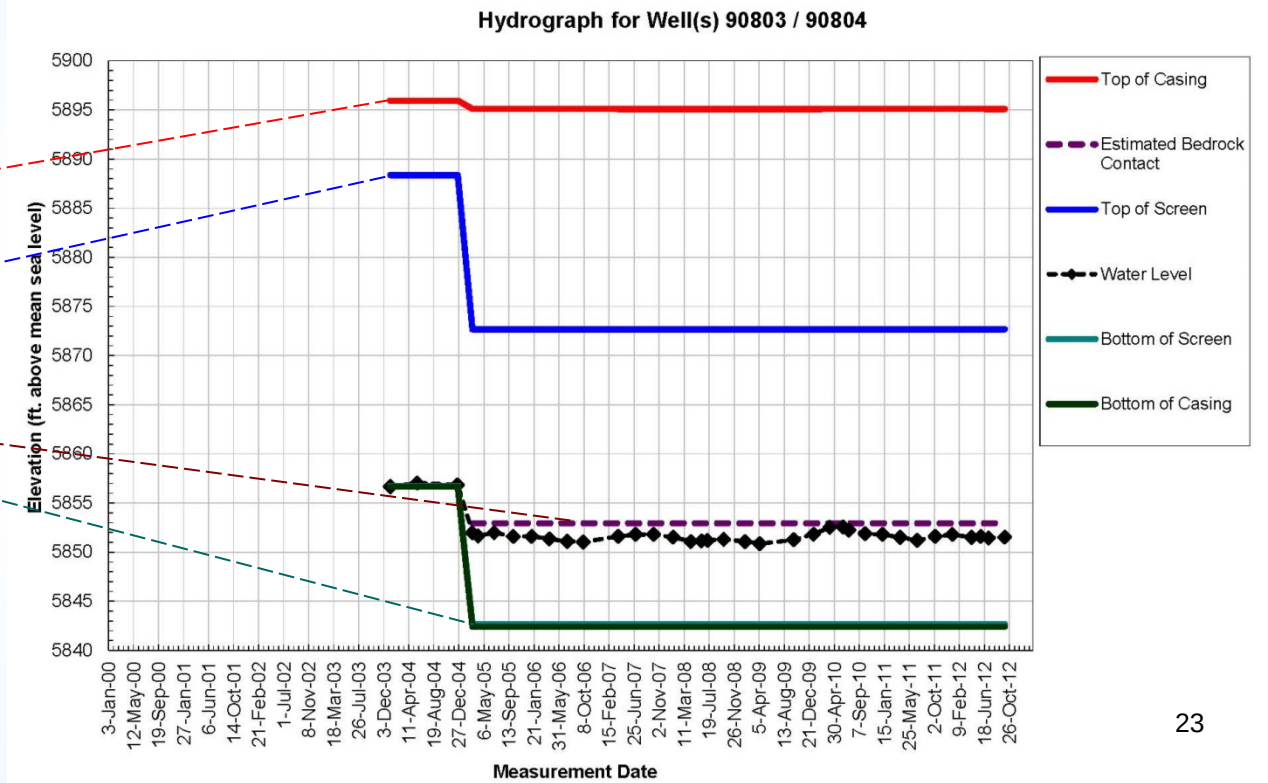

In the Future . . .

- Meeting discussion topics:
  - Groundwater contaminants
  - Monitoring network
  - Treatment

Questions?