Portuguese Bend Landslide Mitigation Project
City Council Meeting
December 17, 2019

BACKGROUND

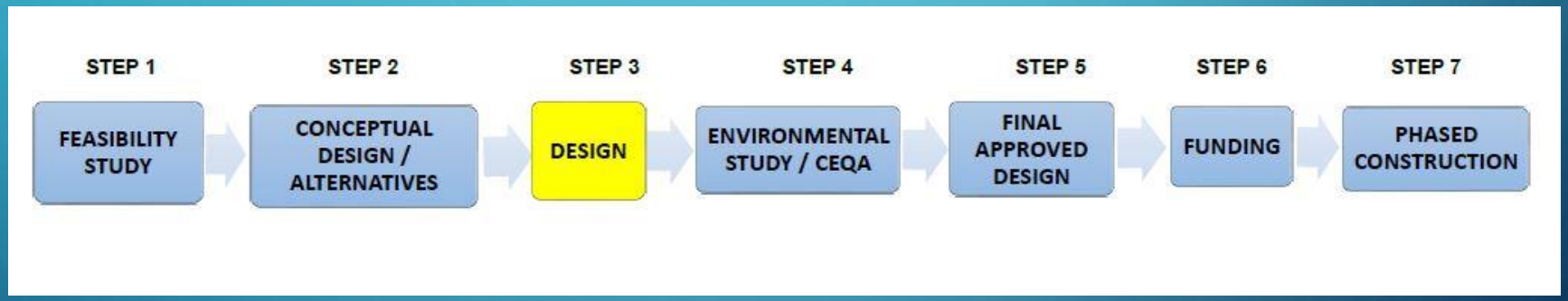
- June 1, 2017: Public workshop No.1- Identifying goals for the FS
- June 20, 2017: Public workshop No.2 - Surface & Subsurface water runoff as it related to FS
- June 29, 2017: Public workshop No. 3 – Surf Zone Erosion
- July 6, 2017: Public workshop No.4 – Ground Water as it related to FS
- October 2, 2017: NCCP workshop – Draft Feasibility Study
- January 16, 2018: A draft copy of the Feasibility Study was presented to the City Council.
- August 7, 2018: The City Council received and filed the Feasibility Study.
- December 18, 2018: The City Council approved the award of professional services agreement with Daniel B. Stephens & Associates, Inc.
    - Scope: Hydrology study and engineering design for drainage and dewatering (Hydraugers).
- Two outreach meetings were held on May 29, 2019 and October 7, 2019.
- Hydrology study and design efforts were coordinated with PVPLC, IMAC Landflow Subcommittee, and the City Council Subcommittee and incorporated the feedback from residents who attended the outreach meetings, and the design efforts are complete

SUMMARY OF DESIGN COMPONENTS

- Repair of existing fractures, to be done as Phase 1
- Surface drainage improvements, to be done as Phase 2
- Below grade hydraugers, to be done as Phase 3

NEXT STEPS:

- Proceed with preparation of the Environmental Documents
- Final Approved Design
- Identify funding opportunities
- Phased construction



Note: Staff is NOT requesting the City Council to approve the project for construction at this time.

PRESENTATION BY THE CONSULTING FIRM REGARDING:

- Water balance and hydrology
- Engineering design

City Council Meeting

Portuguese Bend Landslide Complex

Water Balance and Hydrology

City of Rancho Palos Verdes, California

Daniel B. Stephens & Associates, Inc.

December 17, 2019

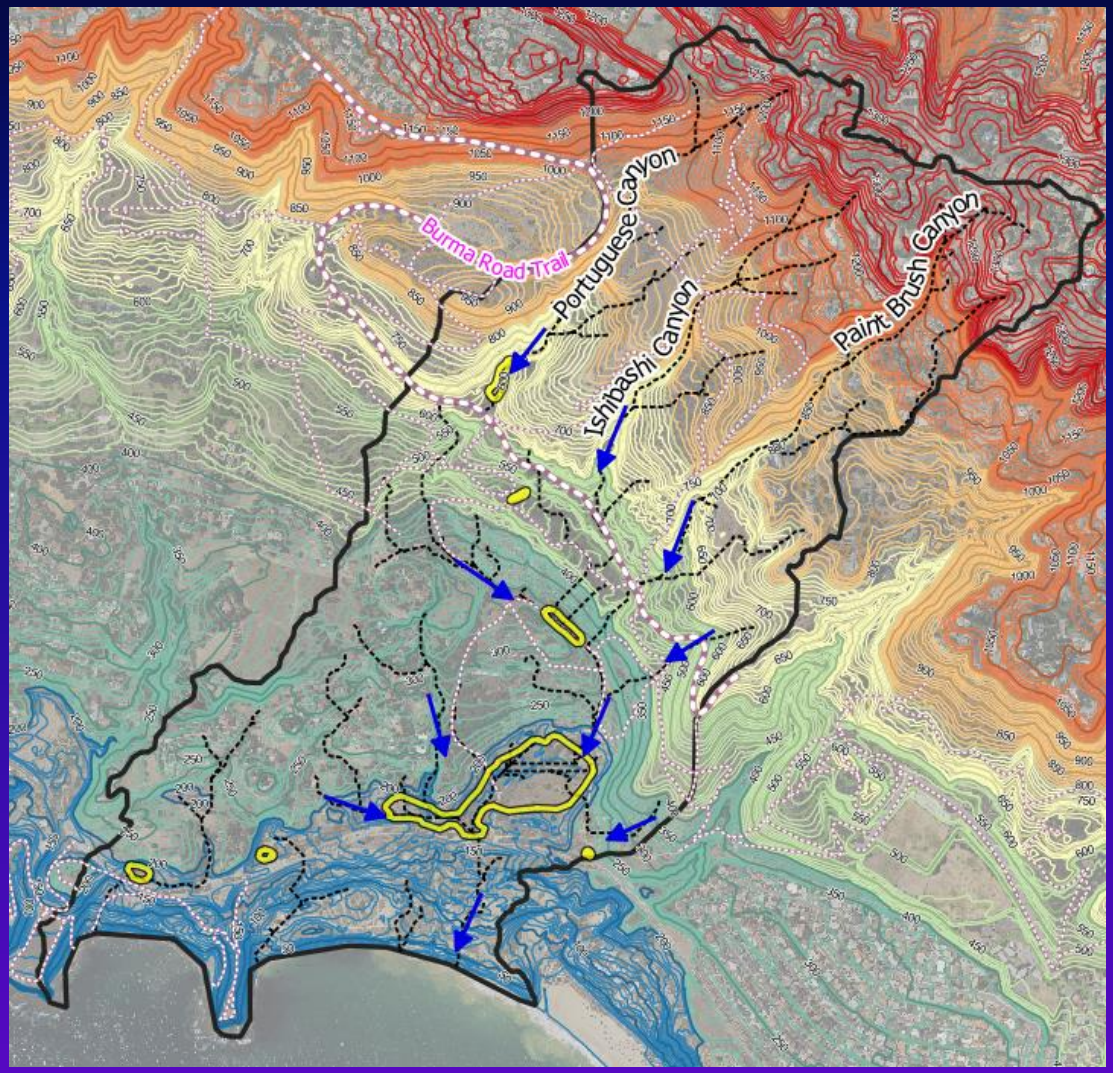
Hydrologic Analysis Objectives
Understand and Quantify Watershed

- Characterize
  - -precipitation
  - -irrigation
  - -stormwater flowpaths

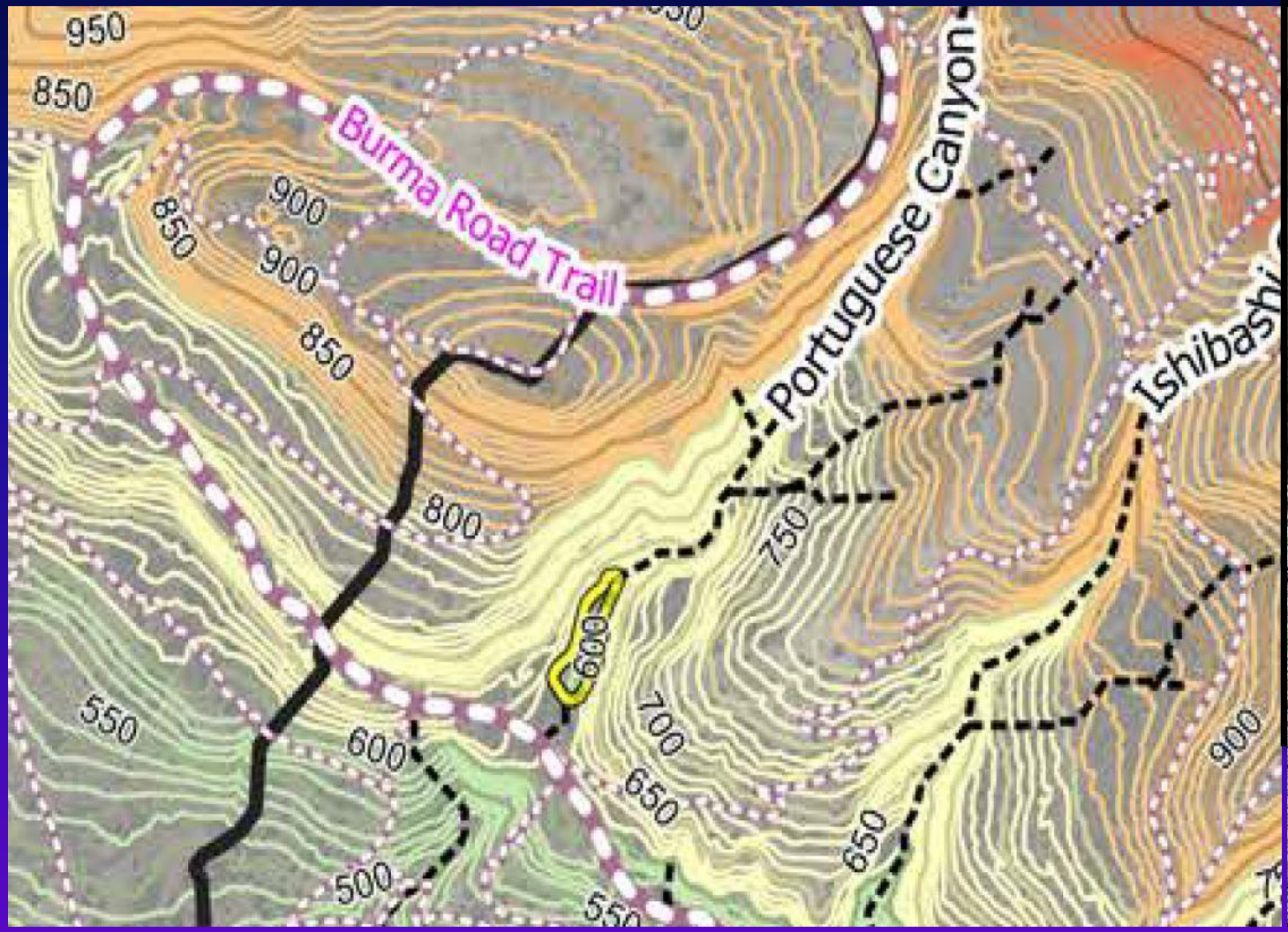
- Map Stormwater Flowpaths
- Map Stormwater Recharge
- Calculate Groundwater Recharge
- Calculate Groundwater Balance (input and output)

Topographic Analysis

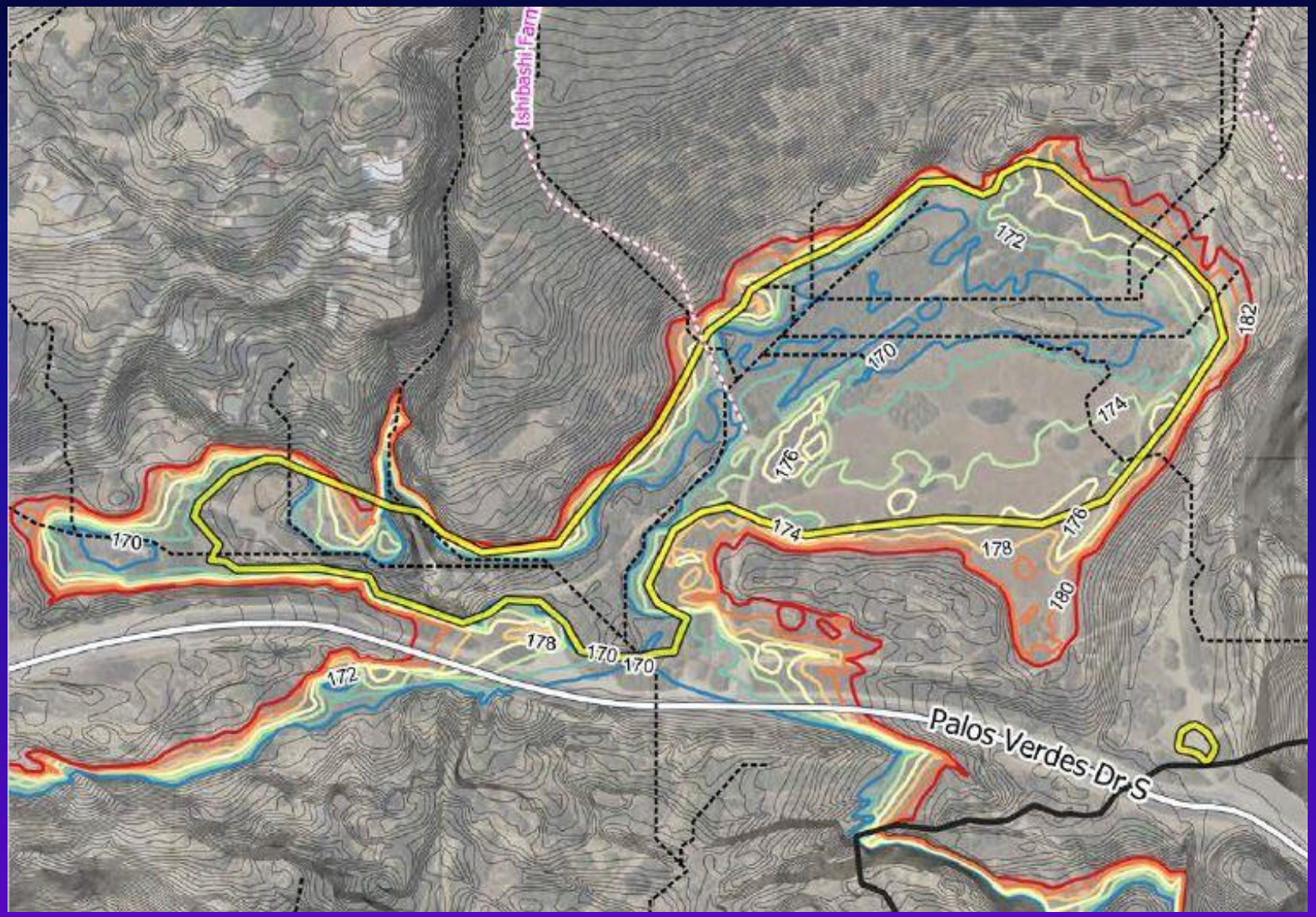
- Delineate watershed boundary, drainage network, and impounded areas
- Primary flow paths
- Topographic lows.



Impoundment at Burma Rd and Portuguese Canyon

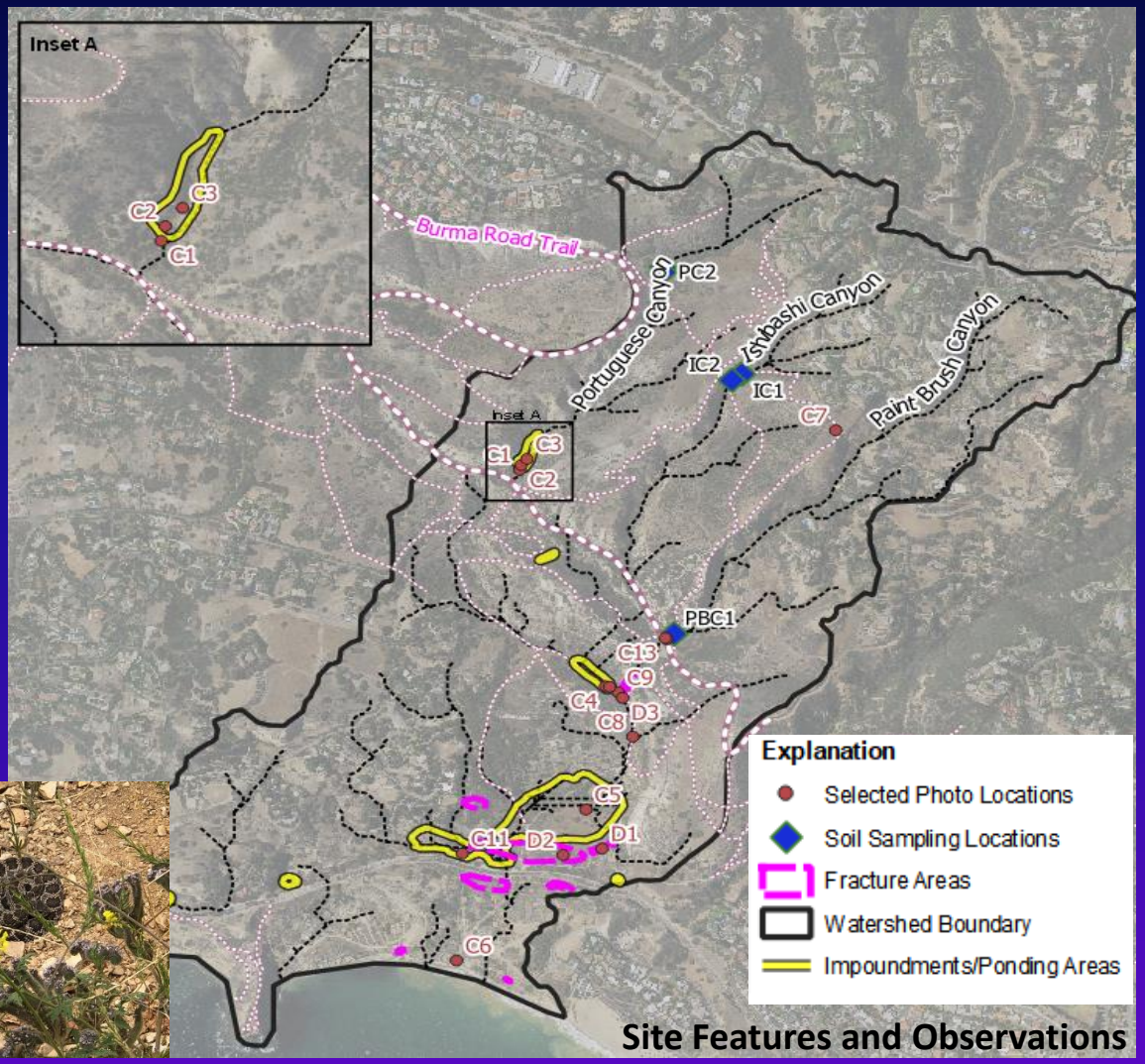


Impoundment at PVDS



Watershed Sitewalks

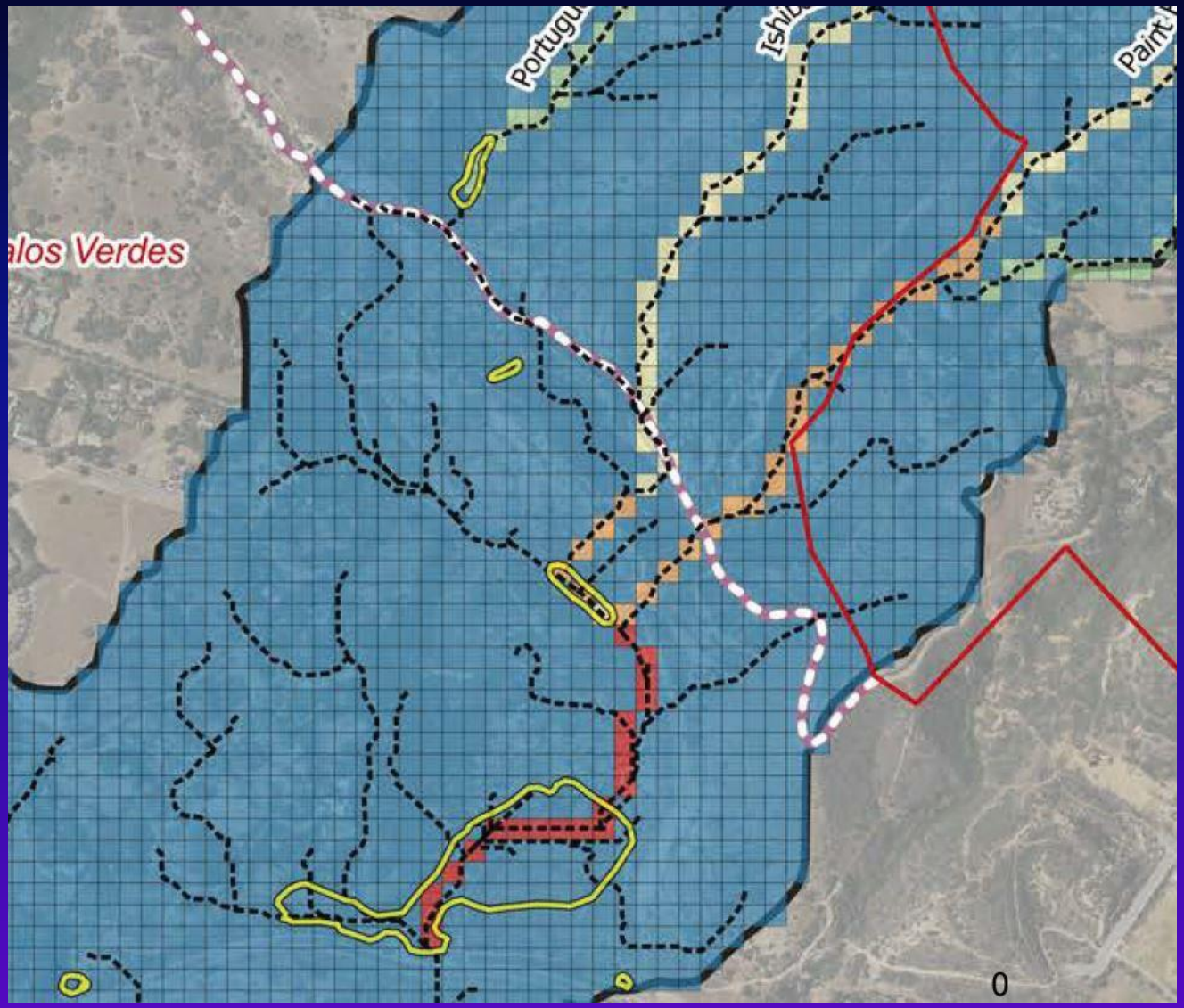
- April - May 2019
- Upper canyon soil samples
- Irrigation practices
- Dewatering wells
- Surface water flowpaths
- Watershed characteristics



Site Features and Observations

Aerial Survey for Fractures

5/14/19



Watershed Model
Surface Water Runoff

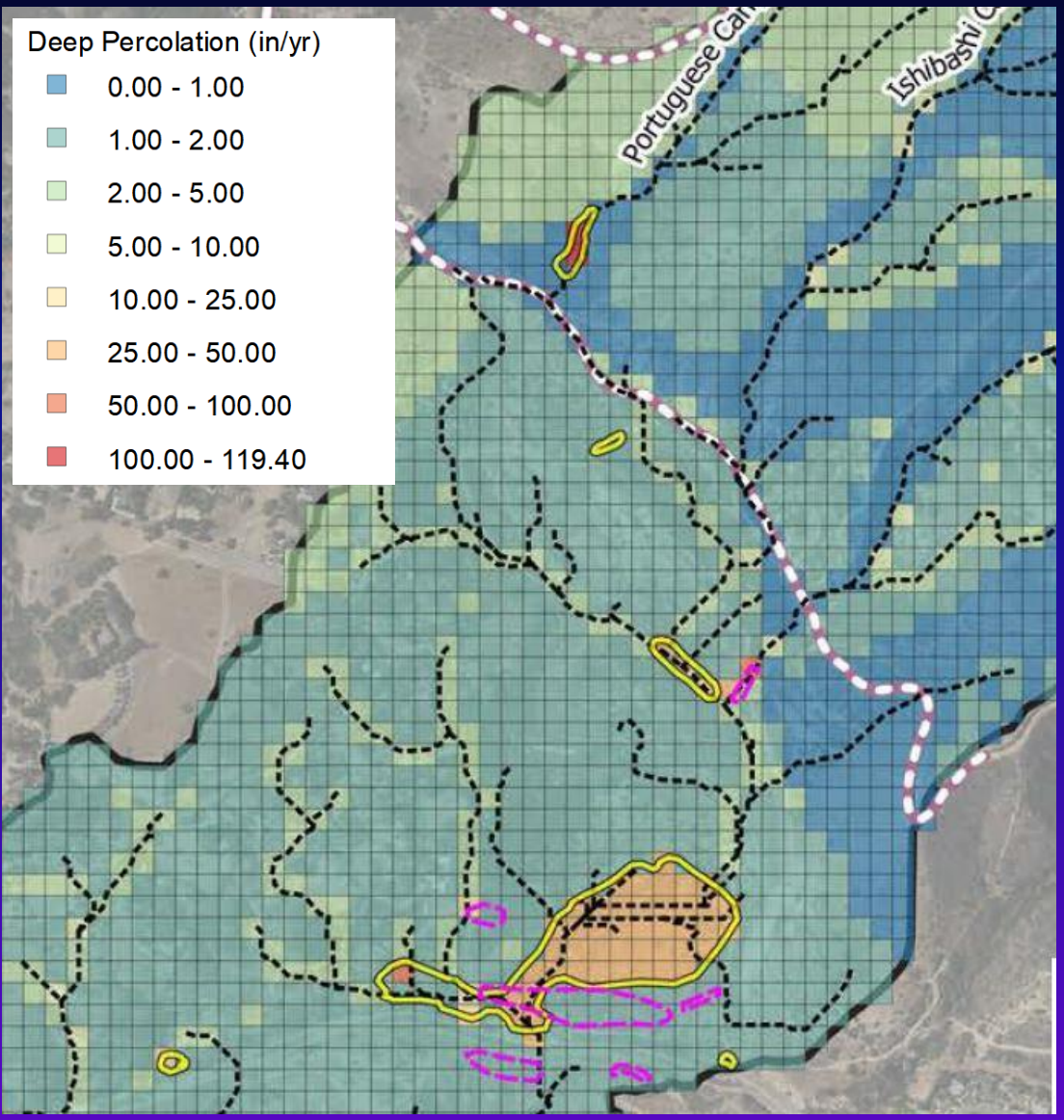
Approx 20 ac-ft/yr

in high-flow areas

(average values)

Runoff (ac-ft/yr)

- 0.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 23.5

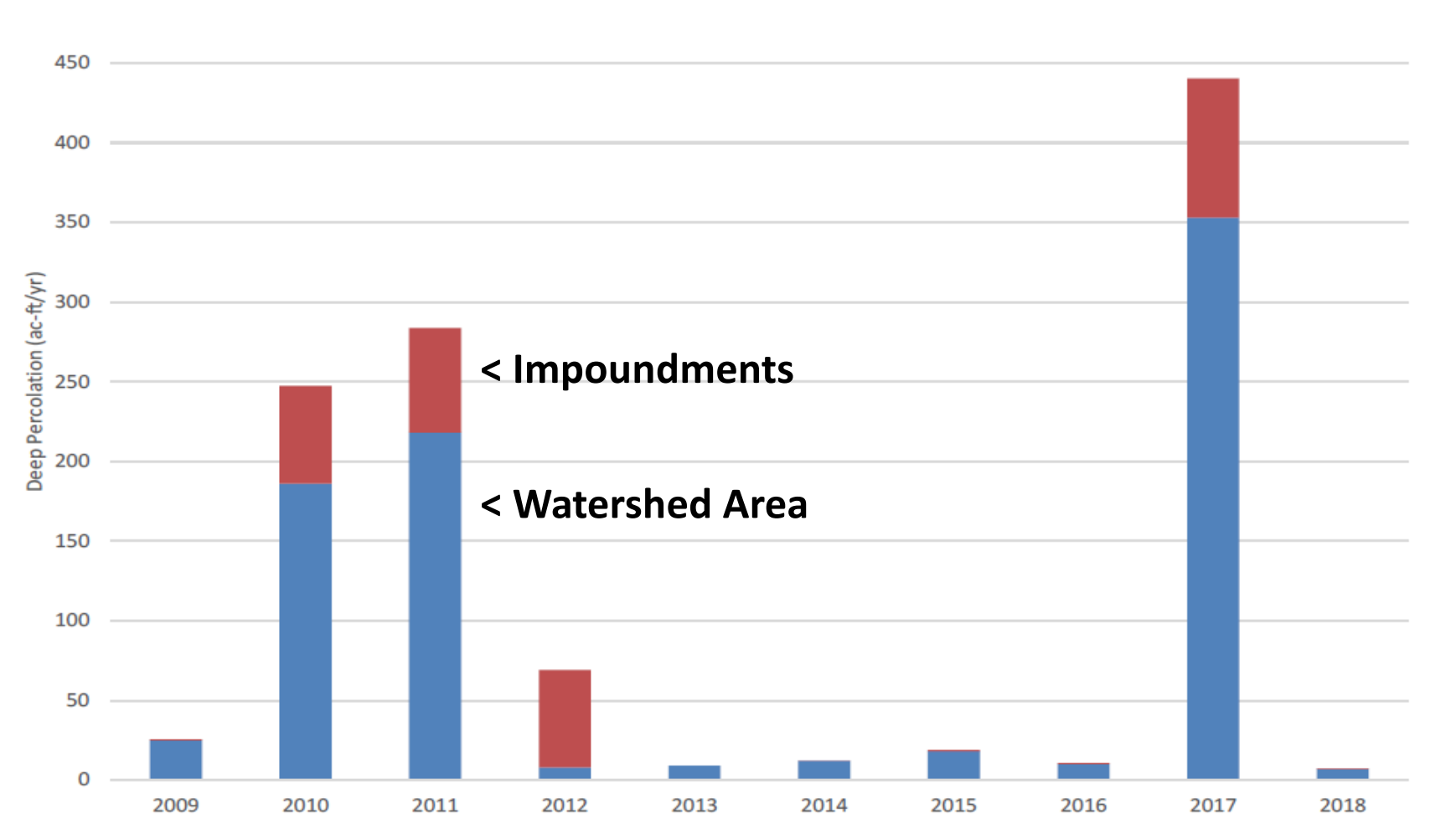


Watershed Model Groundwater Recharge

- 85 ac-ft/yr in model (average)
- +28 ac-ft/yr at impoundments
- 1.4 - 2.9 inches per year percolation
- Approx 100 inches per year in some areas
- Highest in drainage channels and at impoundments

Watershed Model - Groundwater Recharge 2009 - 2018

Acre-feet per year



Groundwater Balance

	Range (ac-ft/yr)	
Inflow		
Precipitation recharge	73–153	
Irrigation recharge	0–7	
Septic systems	5–9	
Flow from Altamira Complex	15-58	
Total	94-226	
Outflow		
Pumping for dewatering	3.5–24	
Subsurface flow to Ocean	90-202	
Total	94-226	

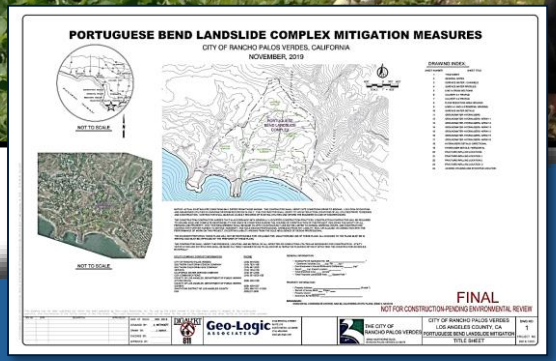
Summary

- Stormwater and Recharge mapped
- High stormwater runoff in lower Paint Brush Canyon along Peppertree Trail
- Groundwater Recharge
  - <30 ac-ft/yr in drier years
  - >200 ac-ft/yr in the wettest years
- Groundwater Recharge highest in lower drainage channels, at impoundments, and in fractures
- Most groundwater recharge from deep percolation of precipitation

City Council Meeting
Engineering Design

Proposed Mitigation Measures
Portuguese Bend Landslide Complex
Rancho Palos Verdes, California

December 17, 2019



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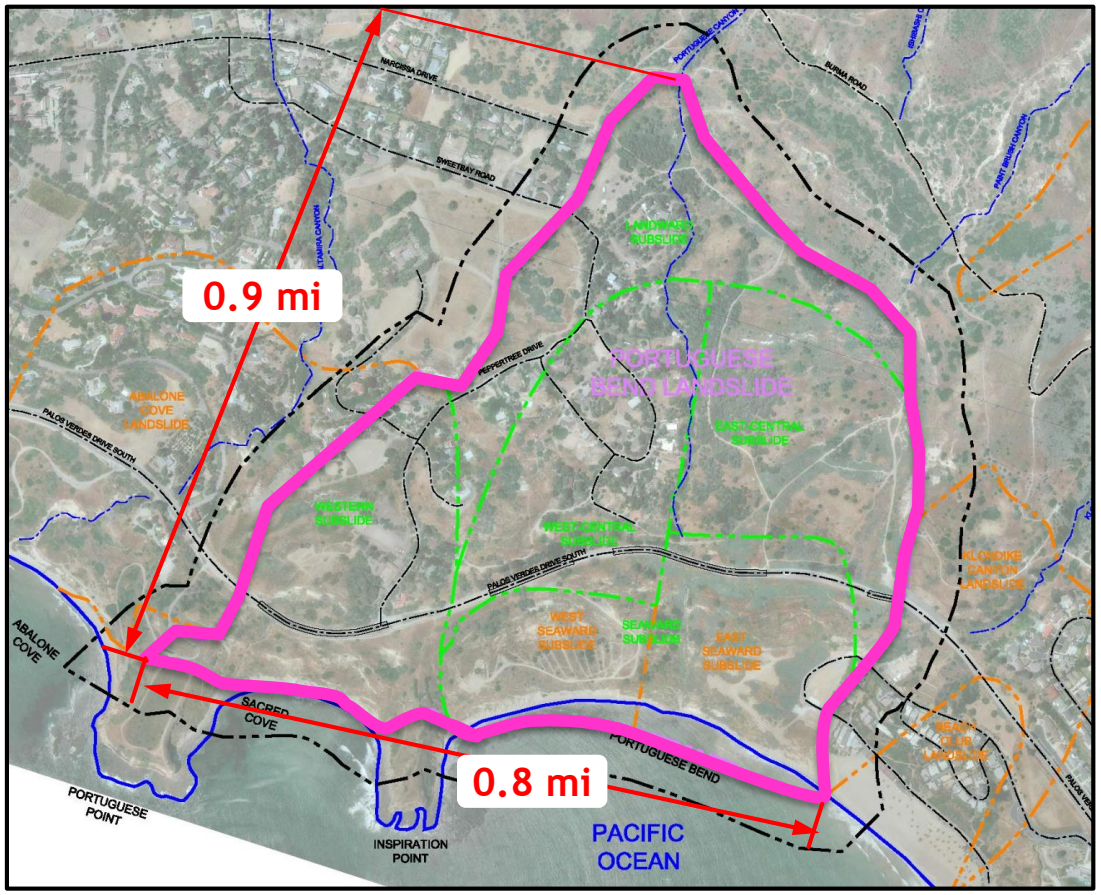
Site Location

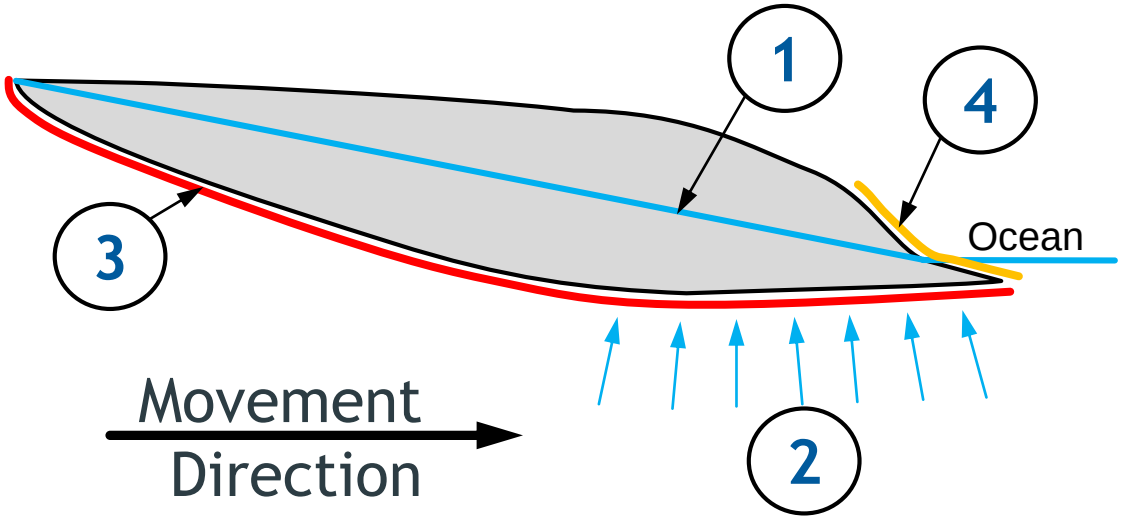


Portuguese Bend Landslide Complex (magenta outline)

<u>PBLC Key figures</u>:

- **240 acres**
- **38 million** cubic yards
- Moving up to **11 ft** per year
- **$640k+** annual maintenance (PVDS roadway)
- **$500k+** annual maintenance (sewer forcemain)

Causes of Movement

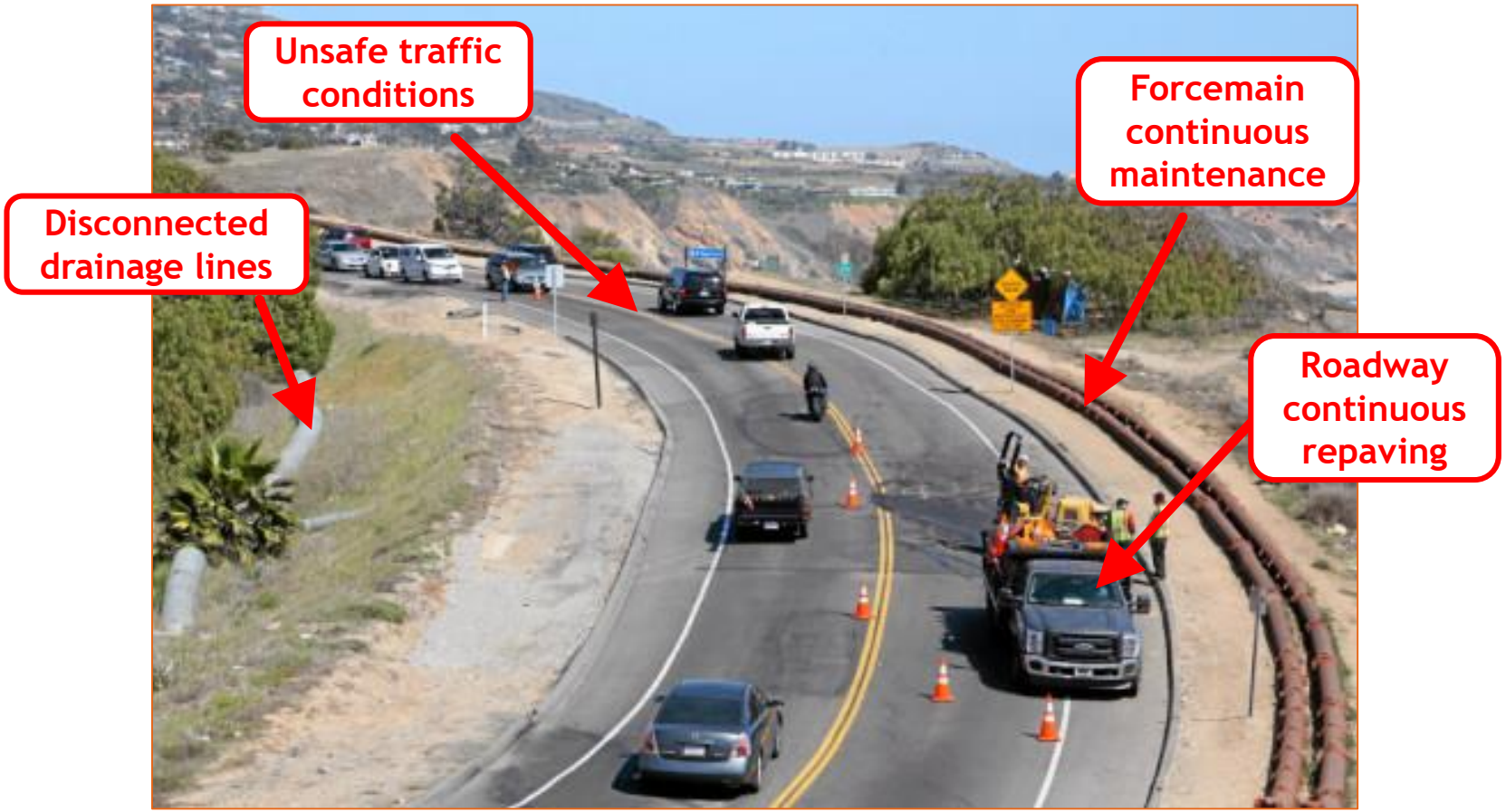


Schematic cross-section through landslide

To be addressed by proposed mitigation

1. Perched water above slip surface (upper zone)
2. Pressurized water below slip surface (lower zone)
3. Weak soil along slip surface
4. Erosion at landslide toe

Effects of Movement



Looking east along Palos Verdes Drive South

Phased Mitigation Approach

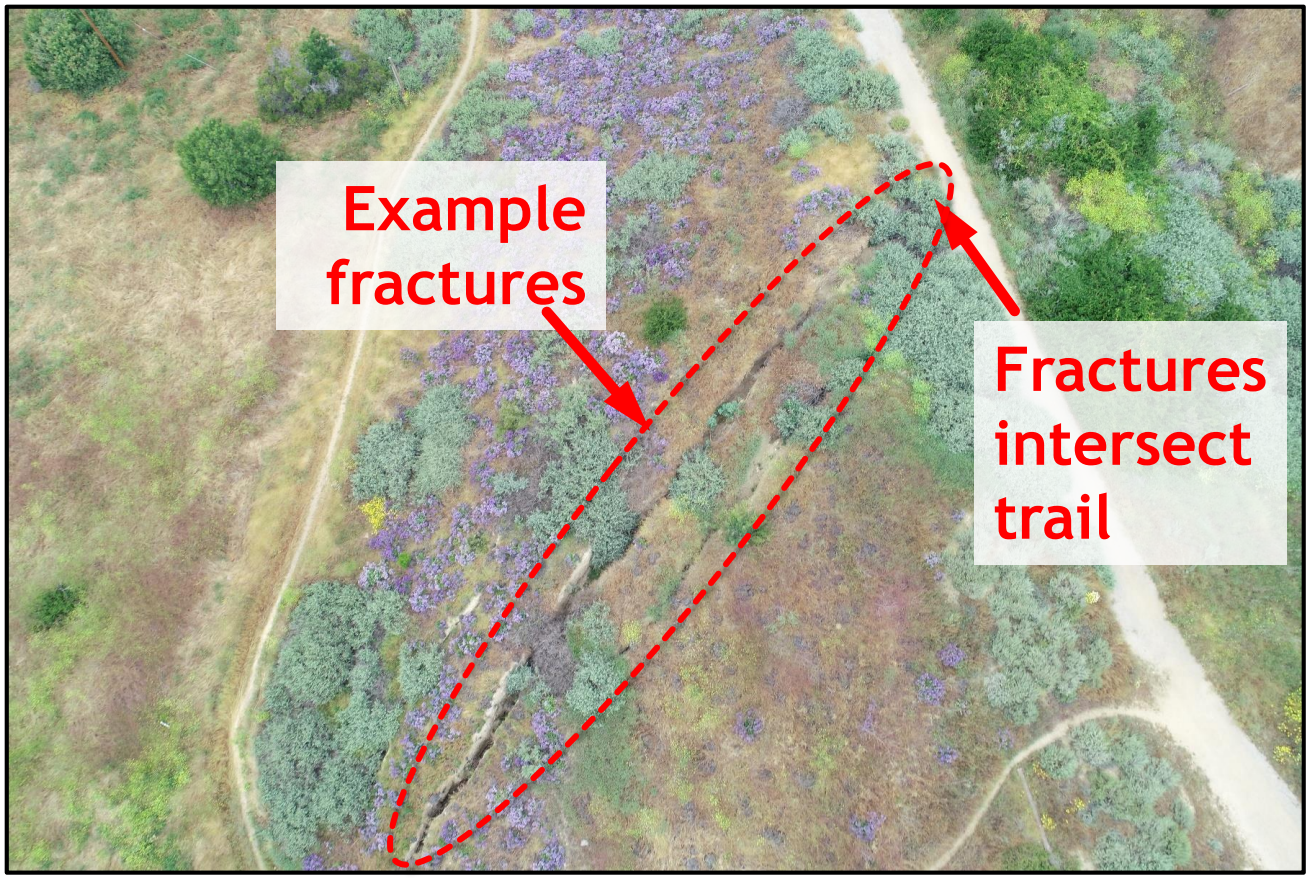
1. ***Fracture Infill***
2. ***Surface Water Improvements***

Reduce perched water recharge (upper zone)

3. ***Groundwater Pressure Relief***

Reduce existing water pressure (lower zone)

Fracture Infill - Key Issues



Drone photo, late spring 2018, east side of landslide

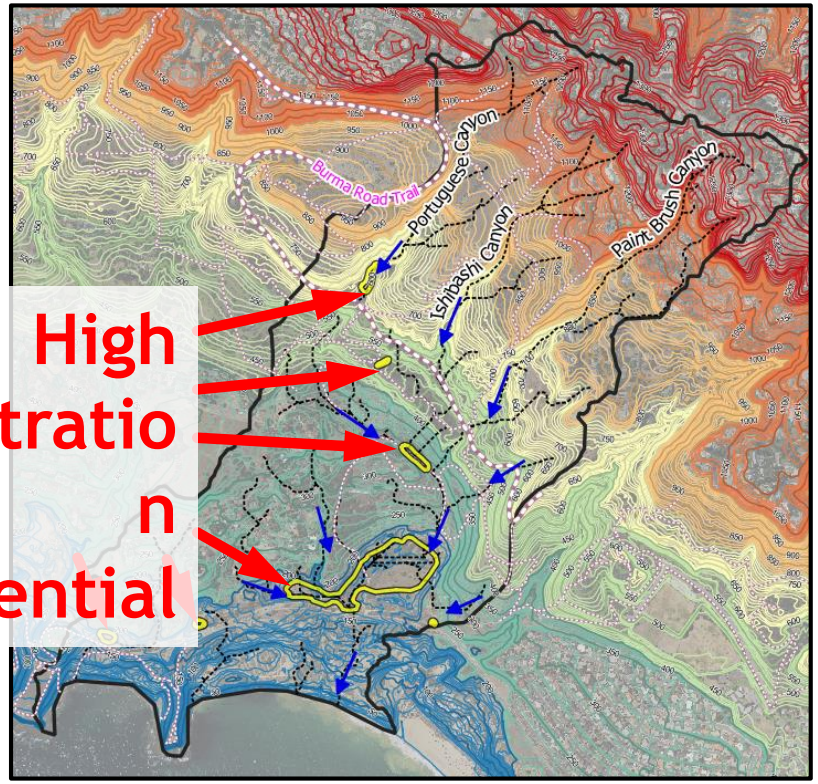
<u>Surface fracture expression:</u>

- Groundwater recharge
- Impaired emergency vehicle access
- Slip / trip / fall hazard

Fracture Infill – Design Objectives

1. Identify candidate fracture areas
2. Evaluate fracture dimensions
3. Seal fractures using flowable slurry

Surface Water - Key Issues



High infiltration potential

Disrupted flow

Example erosion feature

Recurrent erosion

Surface Water – Design Objectives

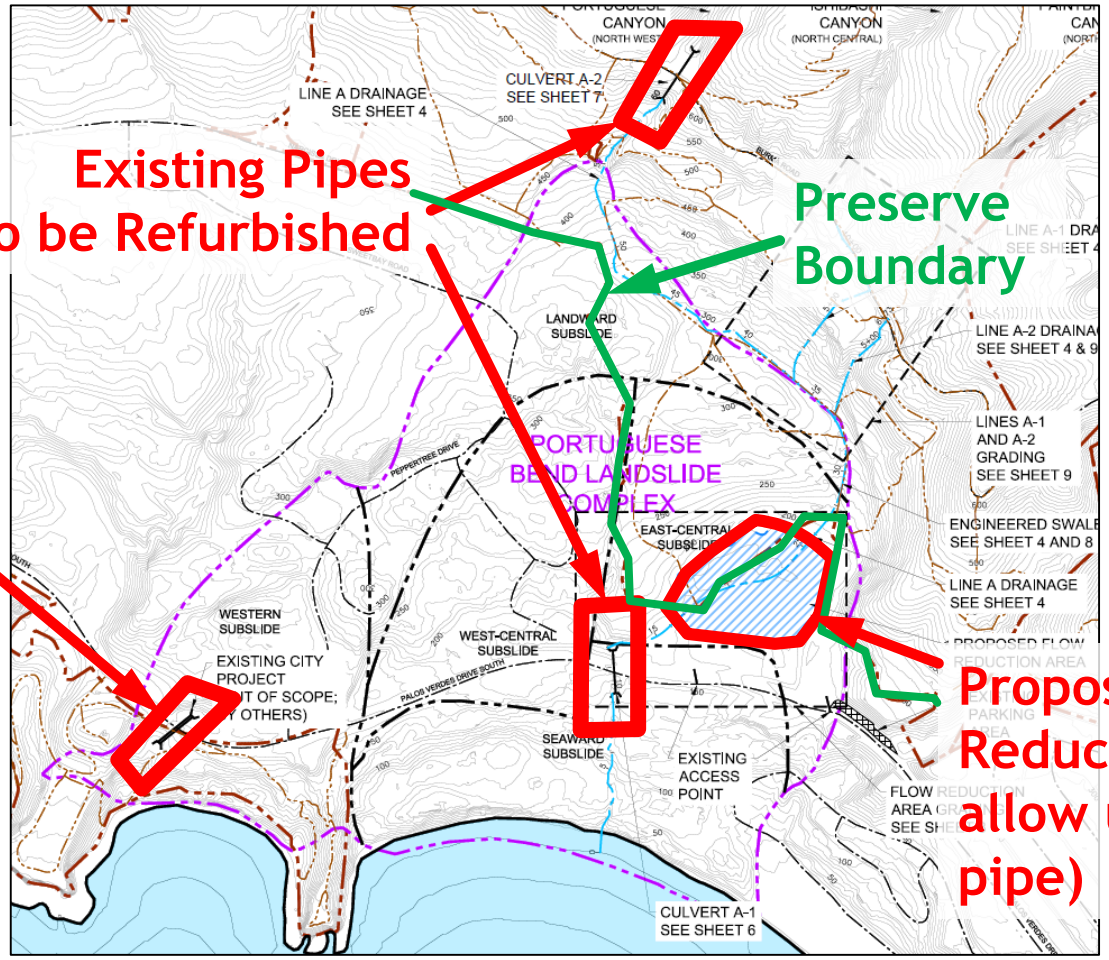
1. Minimize habitat impact

2. Minimize erosion → engineered swales

3. Minimize infiltration → impervious lining
   (flow reduction area only)

4. Minimize cost → refurbish existing facilities &
   work with existing terrain

Surface Water Improvements



Existing Pipes to be Refurbished

Preserve Boundary

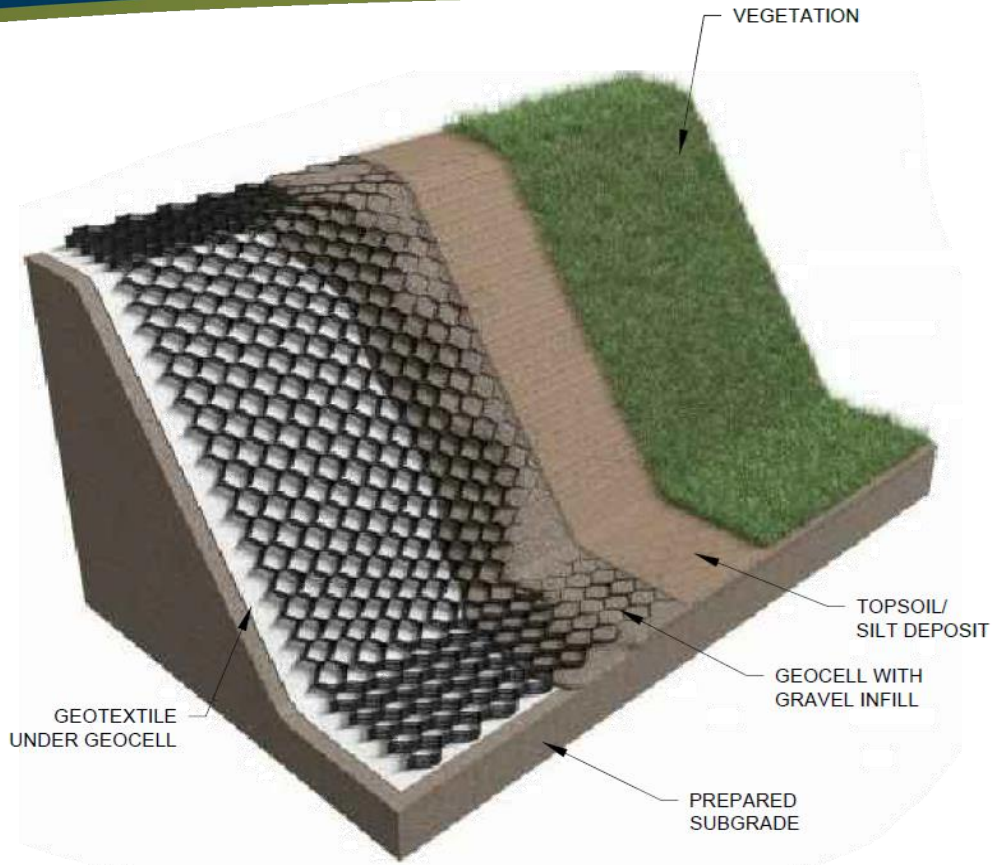
Ongoing City Project (minimal flow approx 80 cfs)

Proposed Flow Reduction Area (to allow use of existing pipe)

Swales:

- About 14-28 ft wide
- Can be Vegetated / made to look natural (meandering)
- Similar to natural flow

Surface Water – Engineered Swales

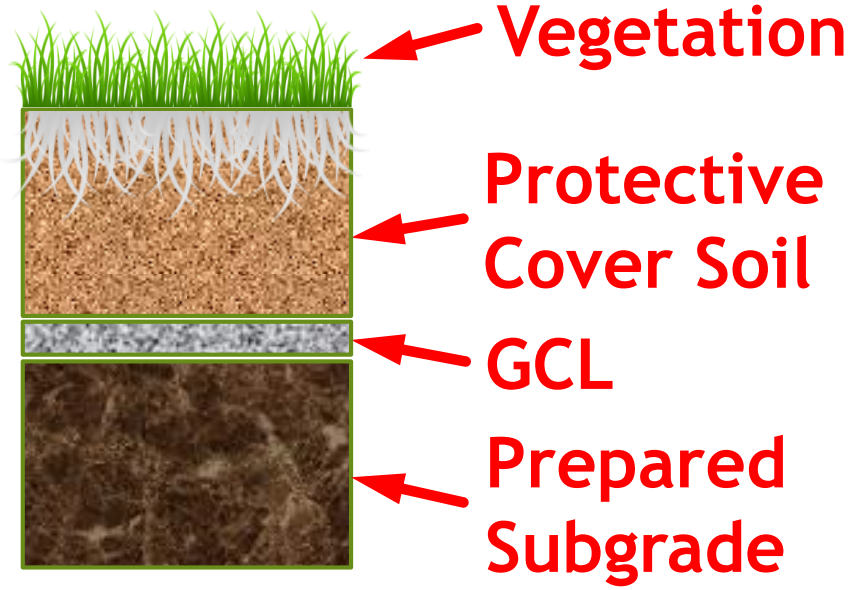


"Geocell" - high-strength plastic cells with soil / gravel infill

Geocell deployment (top)
Vegetated geocell channel (bottom)

Surface Water – Flow Reduction Area

Geosynthetic Clay Liner (GCL) to minimize infiltration



Protective soil layer over GCL can be vegetated to minimize habitat impact

Surface Water – Flow Reduction Area

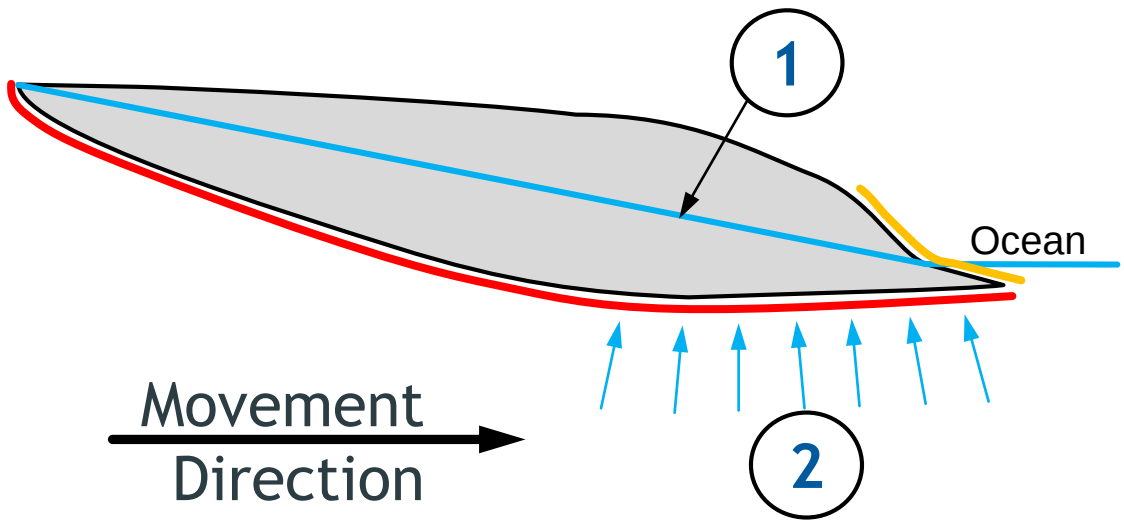
Advantages:

1. Environmentally Friendly
2. Much less erosion
3. Reduction of flow and discharged velocity
4. Improved water quality
5. Much less expensive

Alternative:

1. Adding 4 box culverts under PVDS
2. Upgrade the pipe downstream of PVDS
3. Very expensive; Agency review intensive
4. Very disruptive environmental & road impact

Groundwater - Key Issues



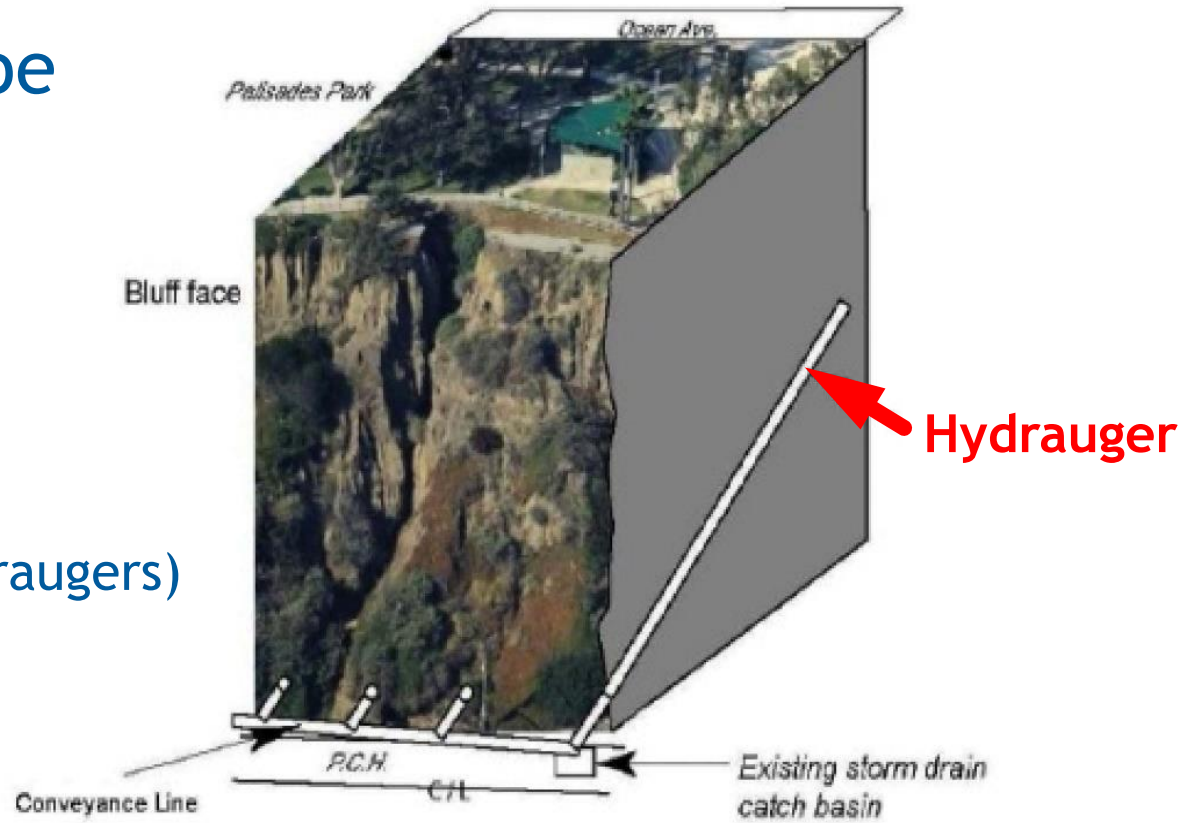
Schematic cross-section through landslide

1. Perched water – buoyancy effect
2. Confined water – uplift effect

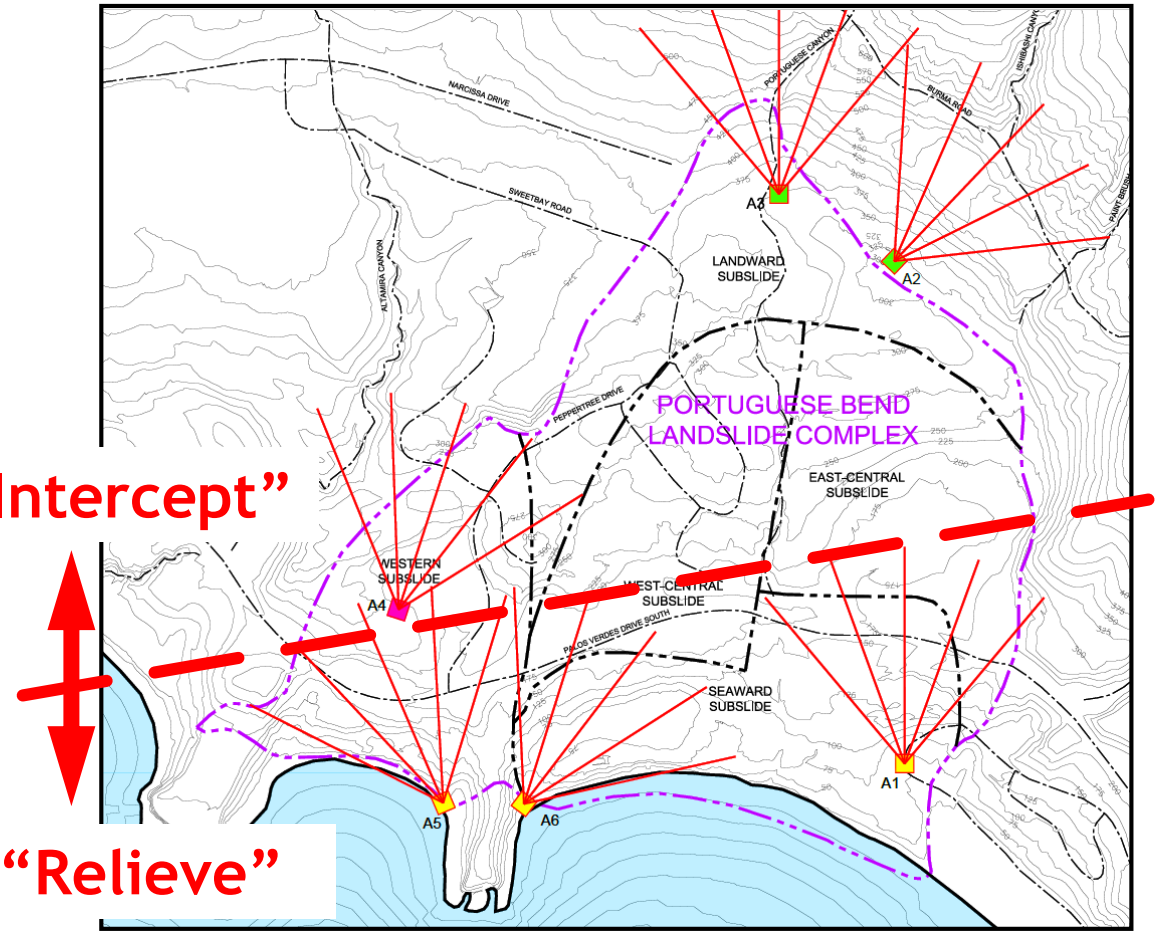
Both effects reduce sliding resistance

Groundwater – Design Objectives

1. "Relieve" artesian condition down-slope
2. "Intercept" recharge up-slope
3. Numerous successful applications in CA
   - -Big Rock Mesa, Malibu (34 hydraugers)
   - -Paseo Del Mar (San Pedro)



Groundwater – Horizontal Drains



"Intercept"

"Relieve"

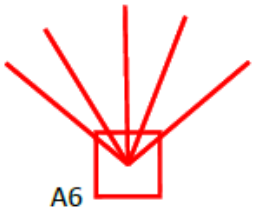
- Six possible drain array locations
- Five drains proposed per array

PROPOSED HYDRAUGER ARRAY LOCATION. BOX REPRESENTS WORK LOCATION, RED LINE REPRESENT DIRECTION AND LENGTH OF HYDRAUGERS. FILL COLOR DENOTES TYPE OF PROPOSED HYDRAUGER.

TYPE OF HYDRAUGER

- DIRECTIONAL / GRAVITY FLOW
- DIRECTIONAL / PUMP ASSISTED FLOW
- HORIZONTAL / GRAVITY FLOW

Groundwater – Horizontal Drains



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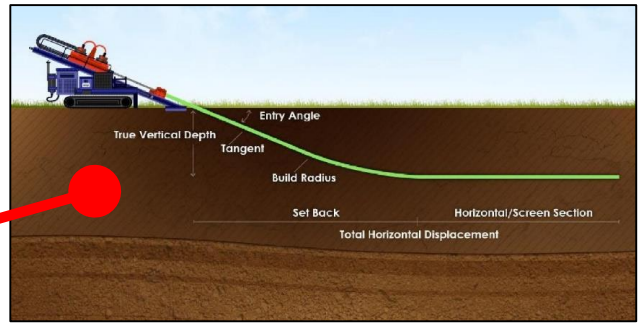
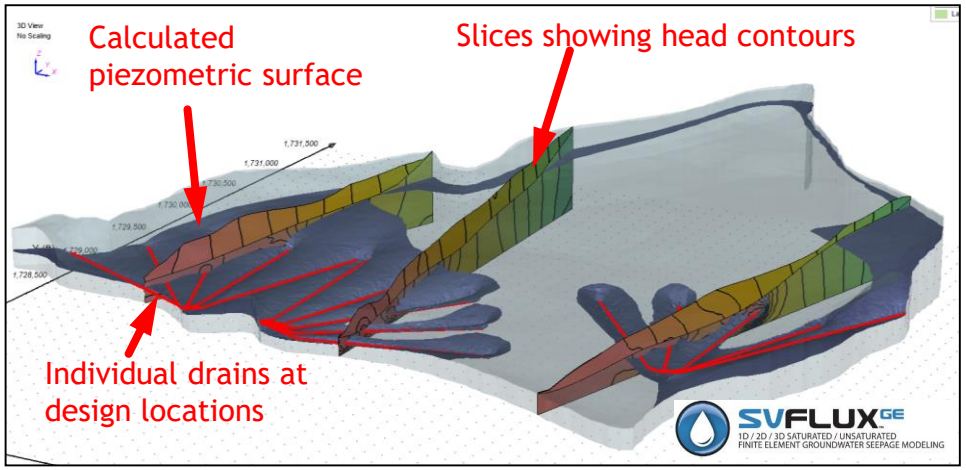
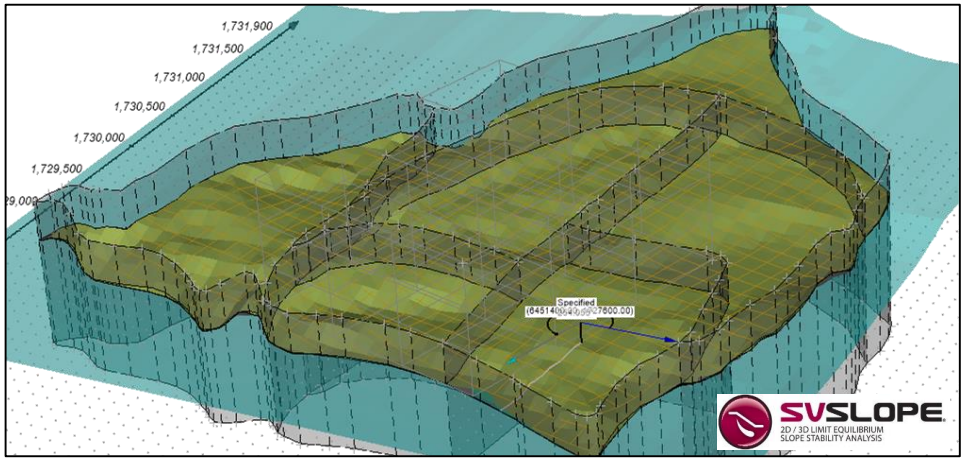


- Curved well alignment
- Specialty equipment

- Straight well alignment
- “Conventional” equipment
- Cost savings

3D Slope Stability & Seepage Modeling

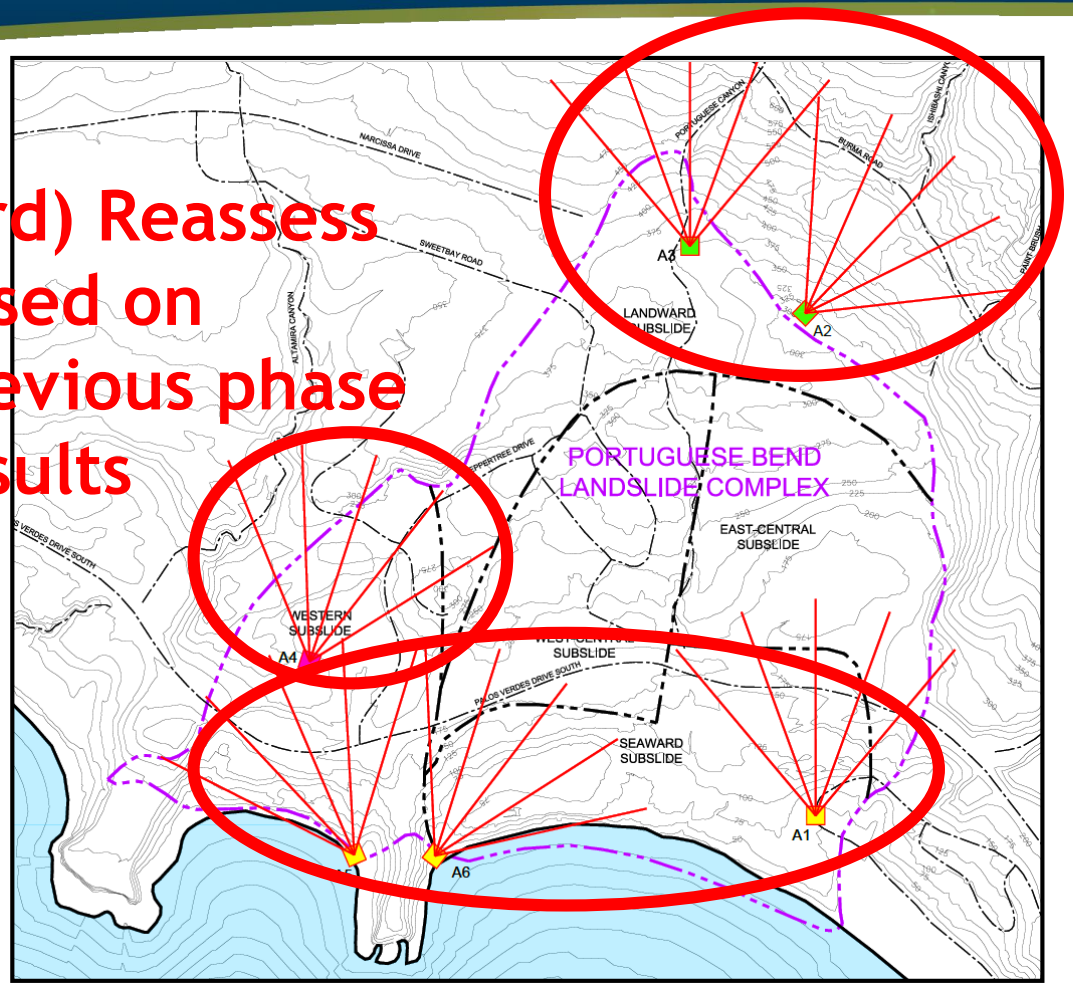




- Computer modeling to evaluate drains' effect on stability
- Step 1 – seepage model using Finite Element Method (top)
- Step 2 – slope stability model using 3D Limit Equilibrium (bottom)

Groundwater – Horizontal Drains Sequencing

(3rd) Reassess based on previous phase results



(1st) Relatively cheap & easy installation, but less effective

(2nd) More difficult installation, but more effective

Metrics for Successful Project

Short-term

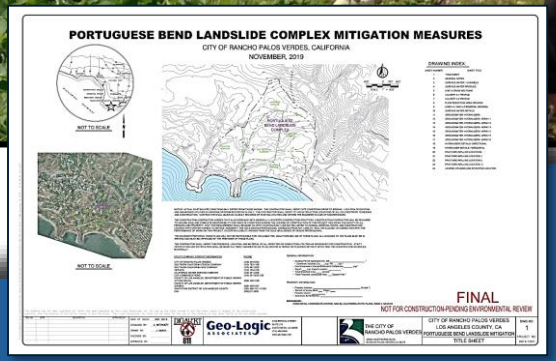
1. Installed drains (hydraugers) produce water
2. Reduced water pressure observed at instrumented locations

Medium-to long-term

1. Slowed movement at GPS monitoring points
2. City observes reduced maintenance costs

Thank You!

Discussion & Questions



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