# Natural and Nature-based Features for Roadway Crossings: A Tribal Case Study from a Fire & Flood Impacted Watershed

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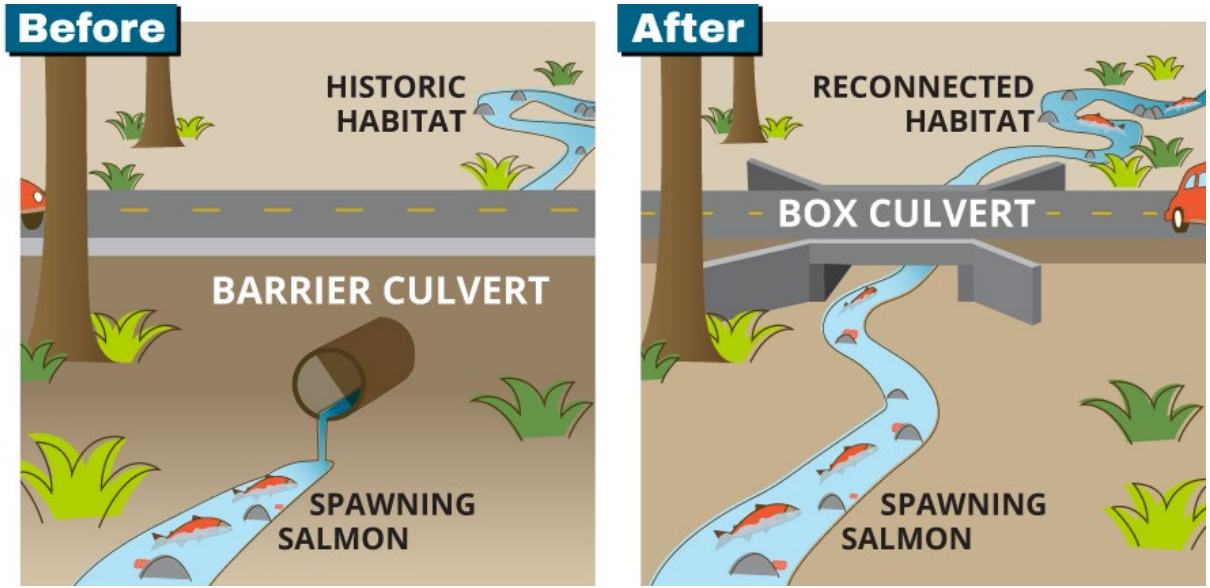
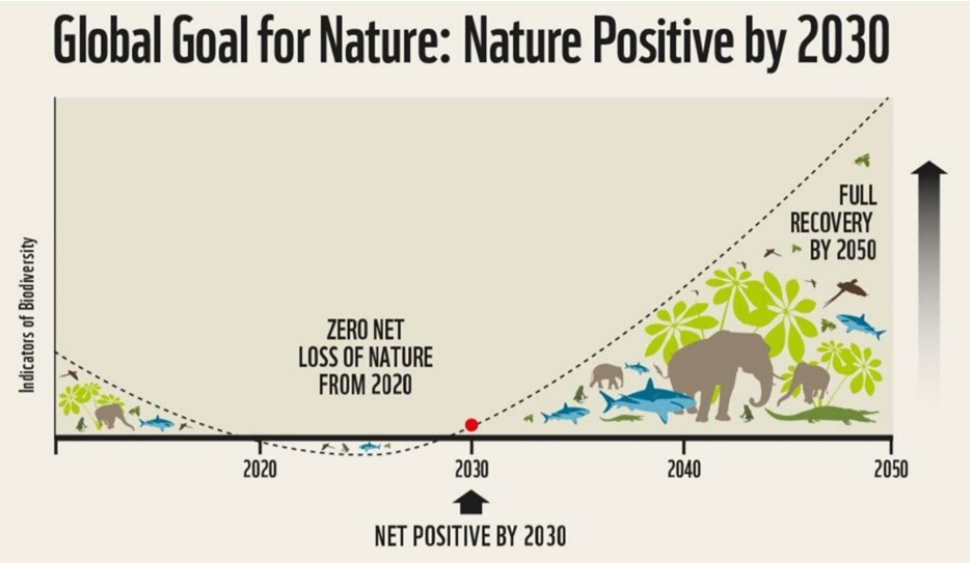
# Why roadway crossings?

- Roadway crossings often limit habitat connectivity and are prone to flooding. Culverts are particularly vulnerable.



# Why natural and nature-based features?

- Leverage natural processes and materials
- Develop resilience
- Cost-effective
- Limit foreign material inputs
- Habitat creation and structural diversity
- Nature positive



# A naturalistic approach

- A ‘stream first’ approach to roadway design and flood mitigation
- Recognize natural process occurring and tie in to them
- Infrastructure designed to work with the stream system
- Add permanency and resilience to road improvements
- Prioritize natural materials wherever possible (in-kind contribution)
- Work to be Nature Positive

Acknowledgements:

- EPA LID/Outstanding Green Infrastructure Award
- ACEC Engineering Award - Environmental
- Best practices acknowledgements

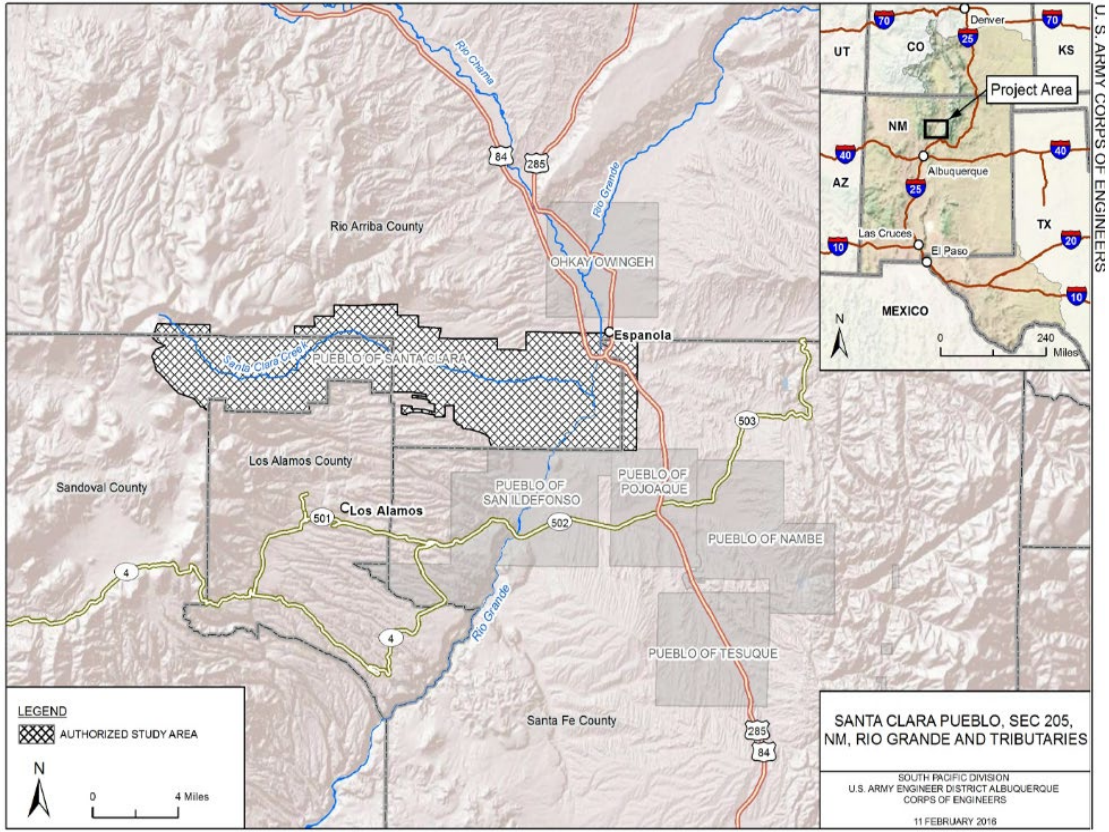
# Case study: Santa Clara Pueblo, NM

U.S. Federally recognized Native American Tribe

1,500 Tribal members

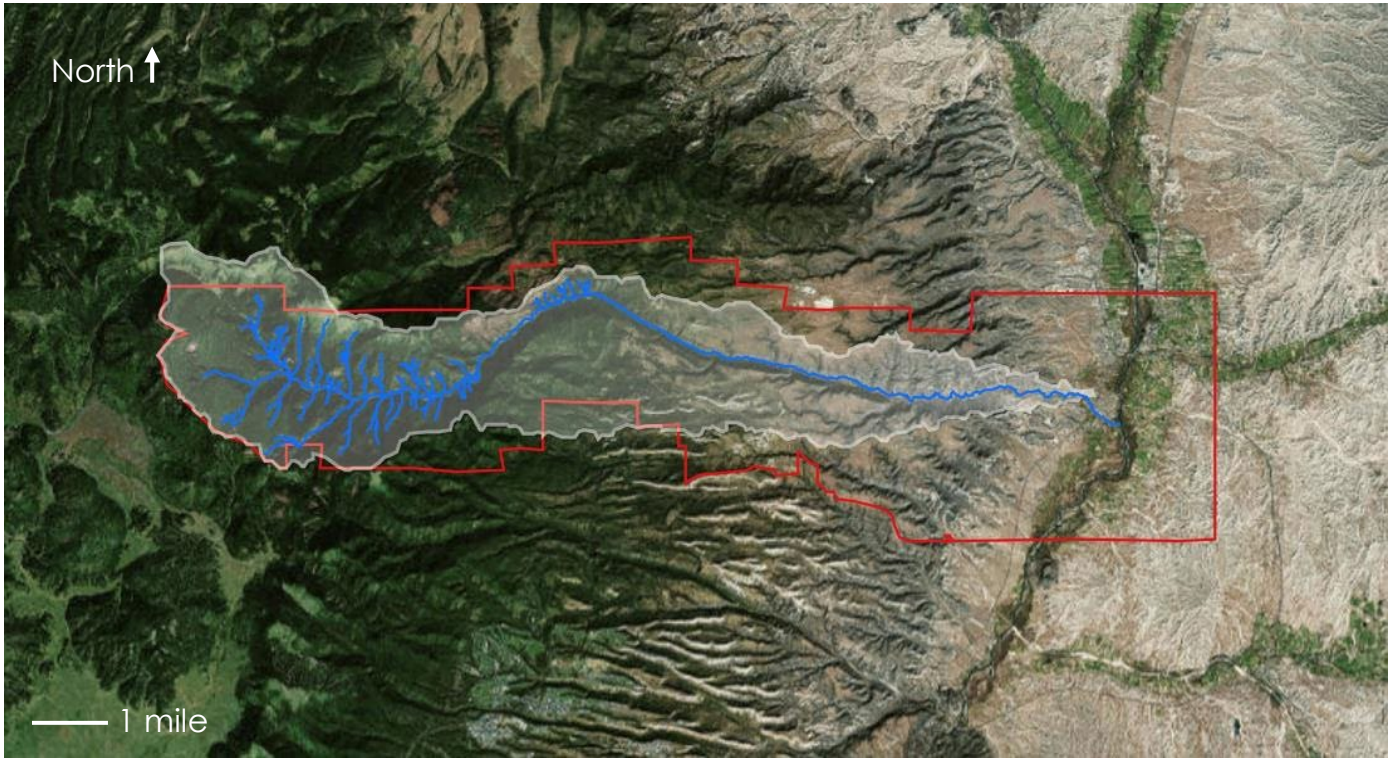
Area: 90 Square miles

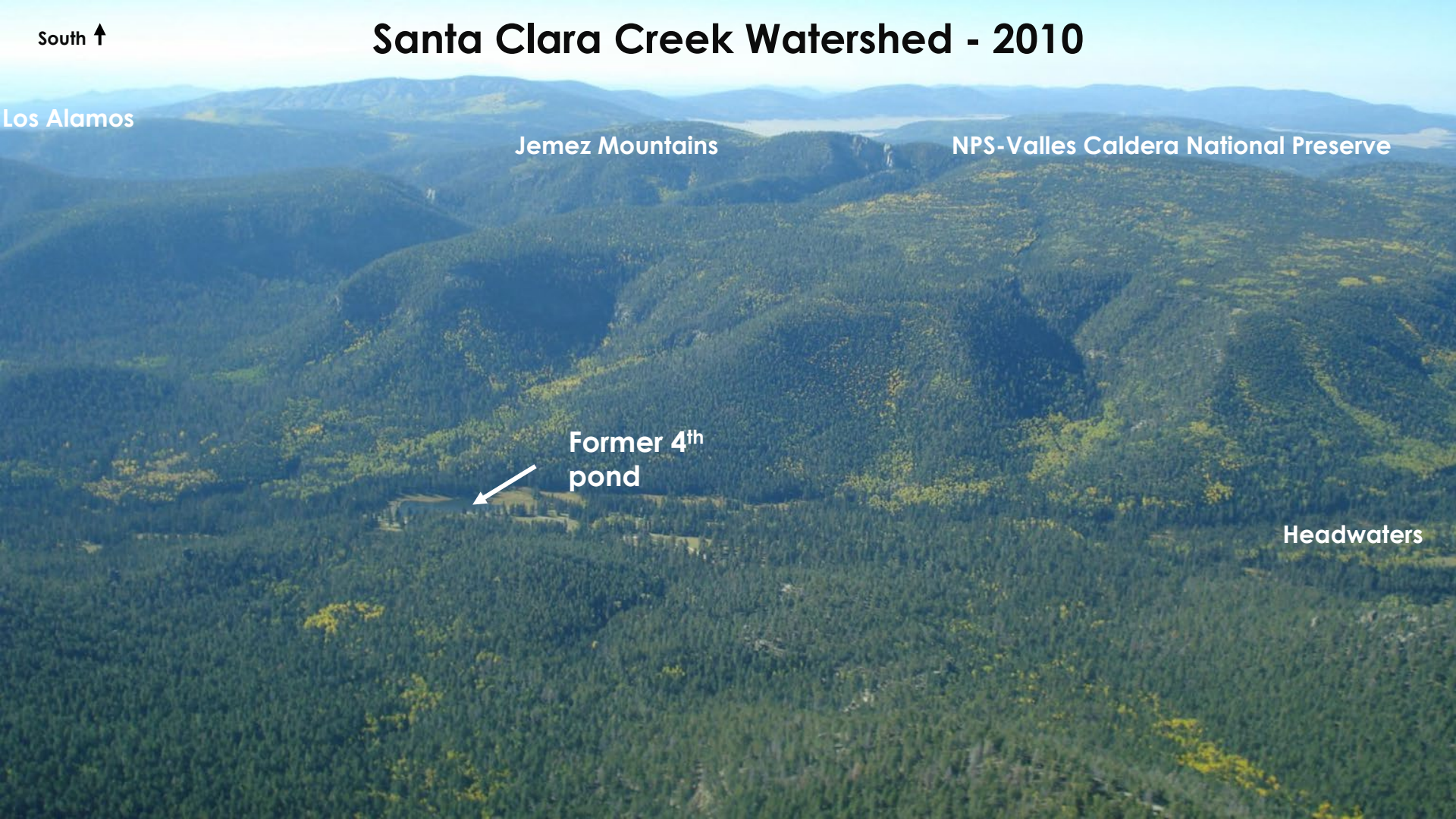
Pueblo communities situated on ancestral homelands



# Santa Clara Watershed

- 31,480 acres
- 5,400'– 10,900'
- Climatically variable
- 23-mile headwater stream
- 28-mile rural access road
- Four fishing ponds



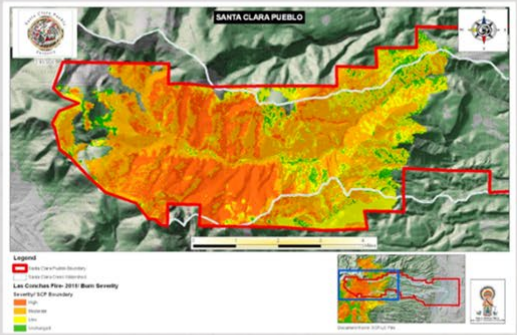

South
Santa Clara Creek Watershed - 2010
Los Alamos
Jemez Mountains
NPS-Valles Caldera National Preserve
Former 4th pond
Headwaters

# Fire History

Since 1998, three devastating wildfires have impacted Santa Clara Pueblo

**More Frequent and Severe Fires**

Over the past 20-years, three large wildfires have impacted more than 90% of Santa Clara forests. During the 2011 Las Conchas Fire, at the time the largest in New Mexico state history, 90% of tribal forest burned with roughly 50% of the Santa Clara Creek watershed burned by high intensity fire.



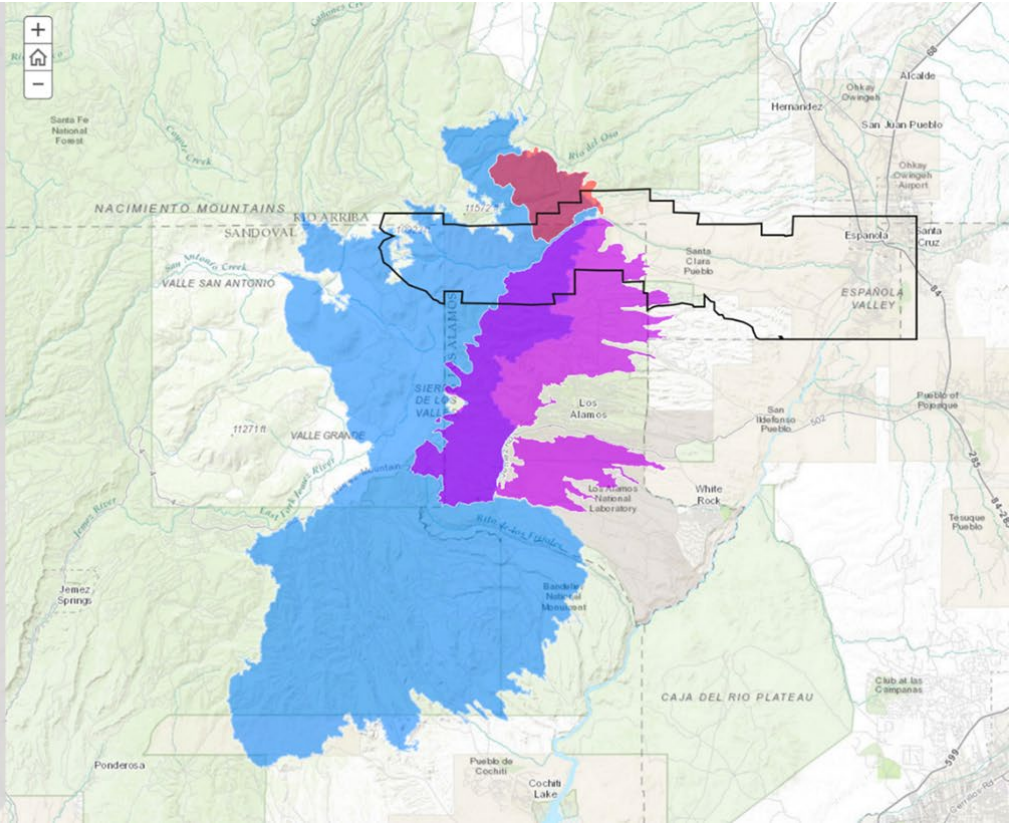

Burn severity map of Santa Clara lands impacted by the 2011 Las Conchas Fire.

Santa Clara Pueblo Boundary

Oso_Fire_1998

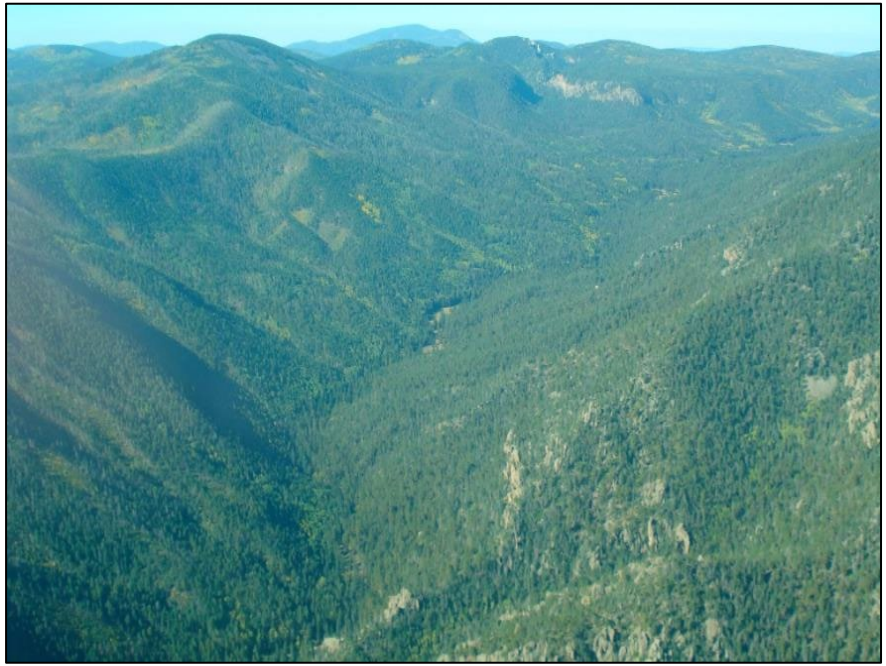
Cerro_Grande_2000

Las_Conchas_Fire_2011



# Las Conchas Fire - 2011

Pre-burn (2010)

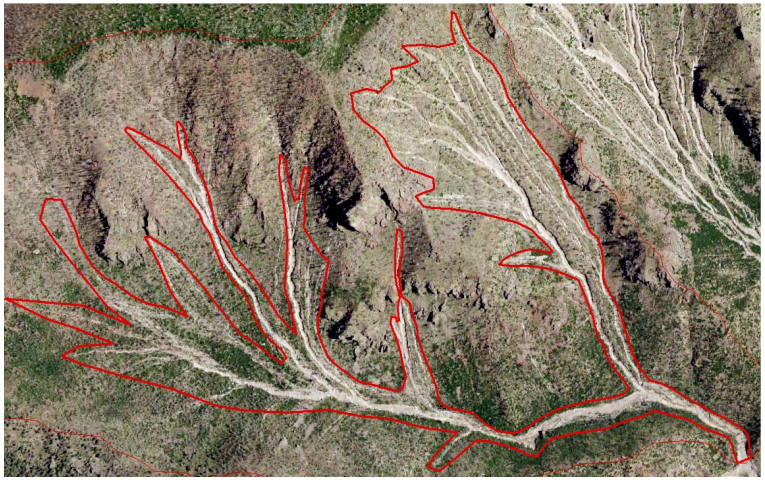


Post-burn (2013)

Stand replacing crown fire consumed over half of watershed

# Flood Impacts

- Severe damage to roads, campgrounds and infrastructure
- Prevented tribal access 20 of last 25 years.
- Excess of $200M in infrastructure losses

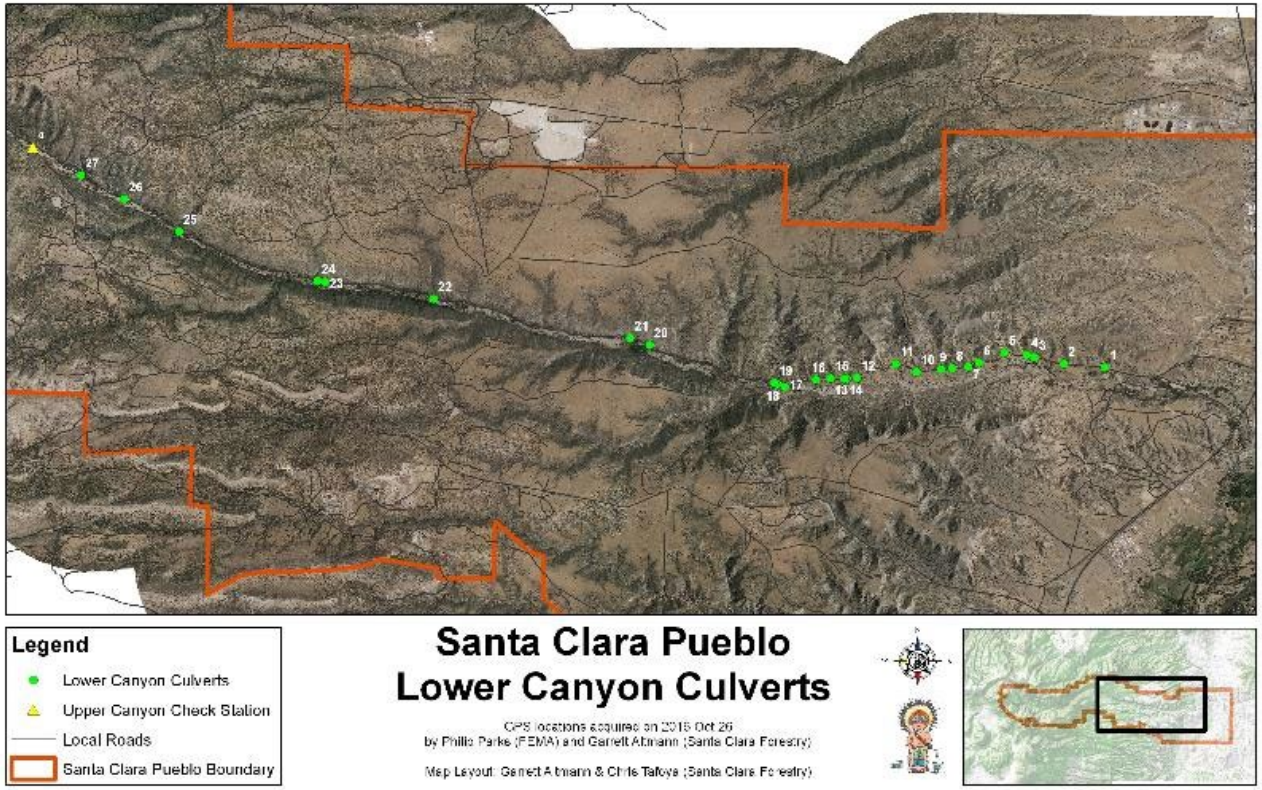


# Numerous canyon culvert crossings - 63


# Lower canyon roadway

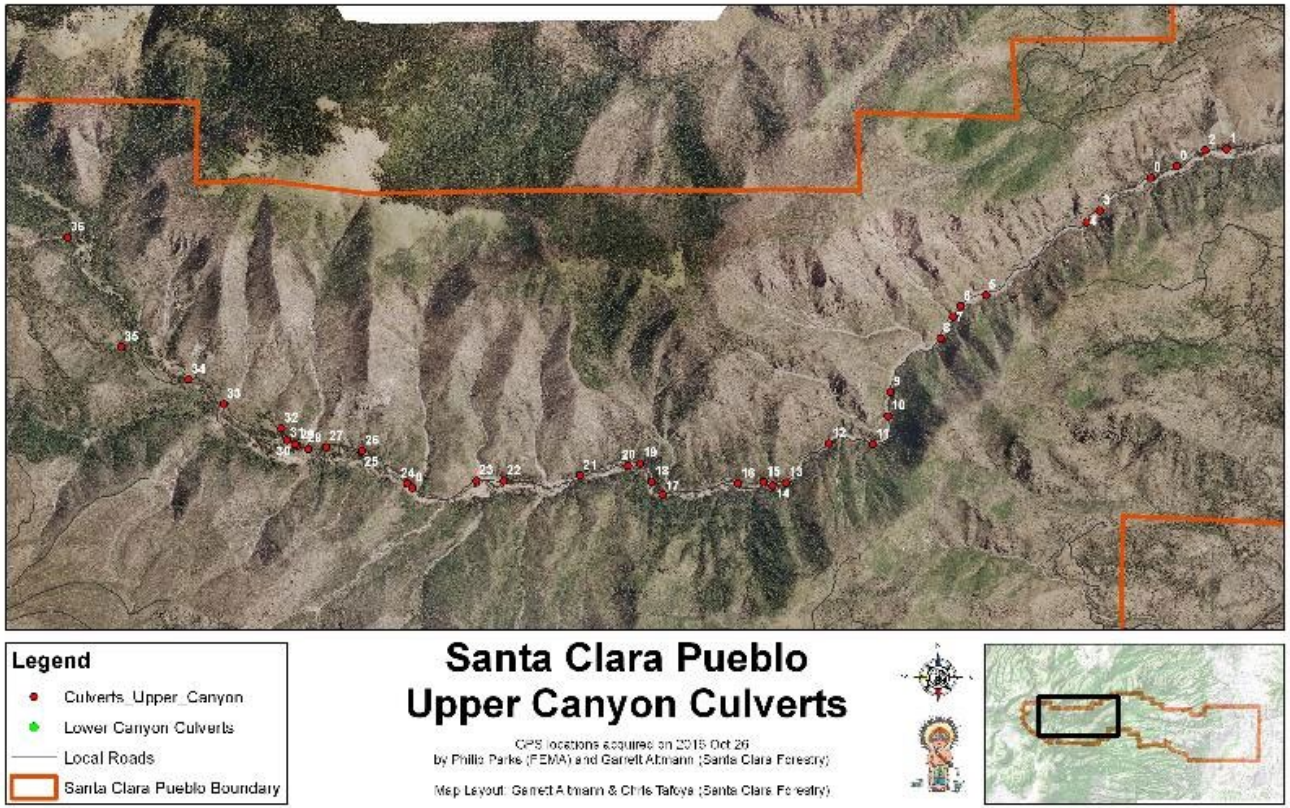
- 27 tributary culverts

Historic wooden box culvert



# Upper canyon temp road

- Historically the roadway was on the north side of creek, with 6 creek crossings
- Temp road includes 14 creek crossings, 22 tributaries



# Road crossing flood impacts

7.5” precipitation event on 6/20/24

# How can we develop resilience?

- ❑ Eliminate crossings
  - ○ Often requires roadway realignment
- ❑ Bridge span
  - ○ Maximizes conveyance but costly
- ❑ Culvert upgrades
  - ○ Grade & floodplain connectivity - natural or structural
  - ○ Natural bottom- “bottomless” (arch, box or set below grade)
  - ○ Auxiliary perched culvert as high-water spillway

# Culverts vary greatly in type, material, design, and style


# Roadway crossing impacts: NM-30 Highway

Scour from 2013 flooding

2016 box culvert extension and scour protection

# Auxiliary options

- Overtopping channels
- Inclined inlet headwalls for debris catchment
- Ramps to connect grade (natural or structural)
- Perched culverts for conveyance, and wildlife

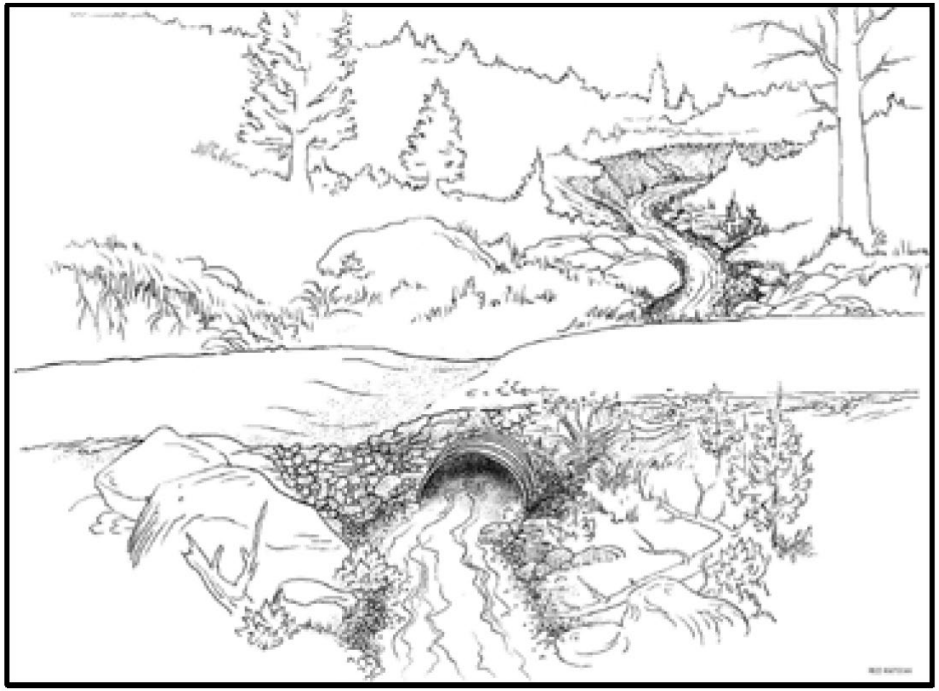
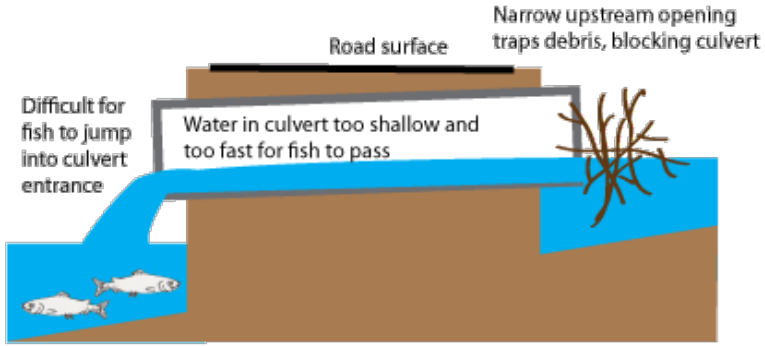
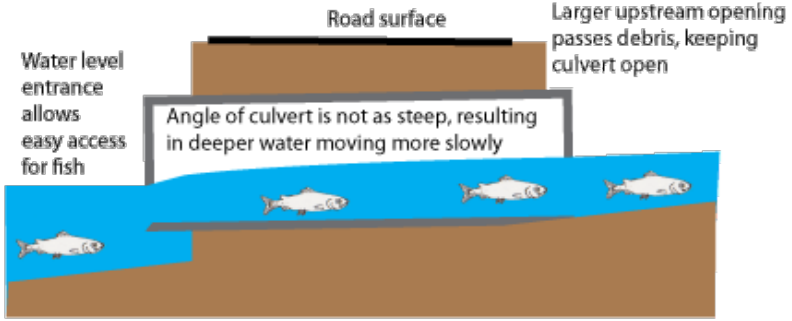


**Figure 3.2 Conceptual rendering of a cylindrical culvert with an over topping roadway spillway that can integrate scour protection.**
Source: Furniss et al. (1991)

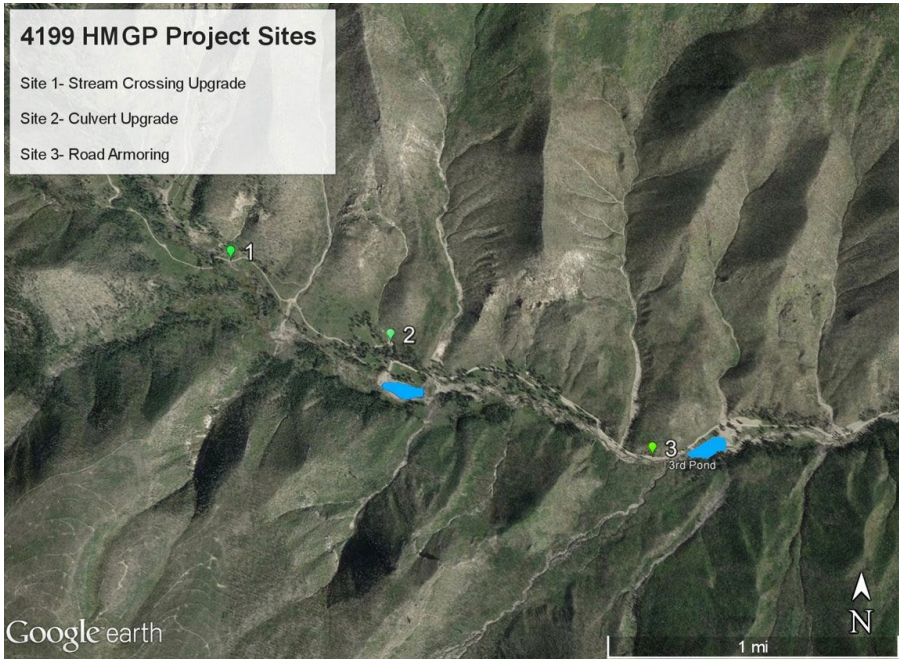
# Alternative strategies to promote fish passage




Culvert baffles https://www.ats-environmental.com/




# FEMA 4199 Hazard Mitigation




(3) Culvert Upgrades

- Site 1 – PK Crossing
- Site 2 - Culvert 32
- Site 3 - Elk Valley
- (~$500k each)

(1) Road Armoring - Site 3

- 1,100’ ($800k)

2,000’ Roadway Improvements

3,200’ of Stream Restoration

# Site 1: P’opii Khanu road crossing

Confined single culvert

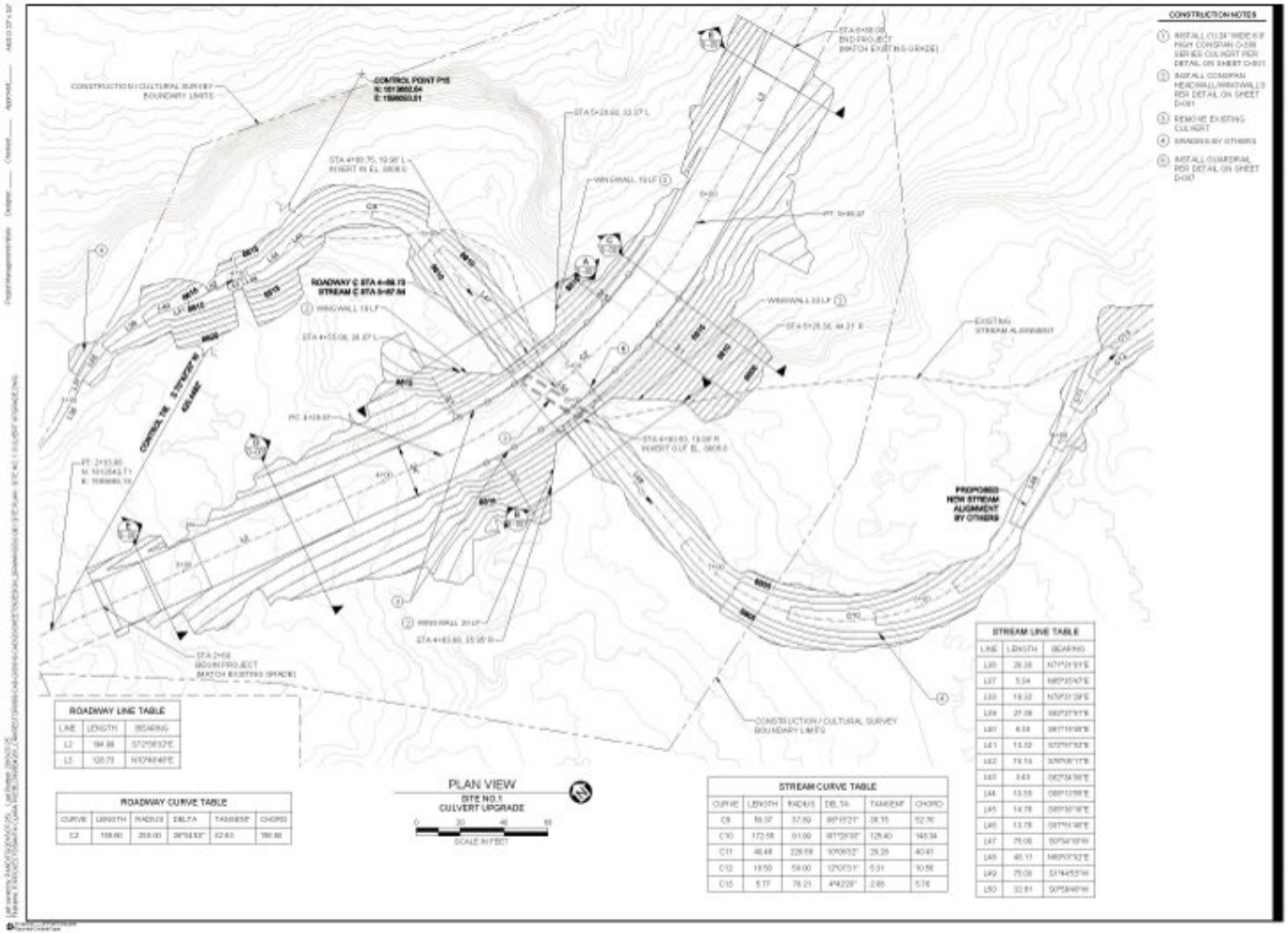
- 48” x 20’ CMP
- Prone to clogging
- Past useful life
- No inlet/outlet protection
- Limited conveyance
- Barrier to fish passage
- Adjacent wetlands & springs
- Culturally sensitive area

As a result, we opted for an arch-type culvert upgrade and extensive stream restoration for this site.

# Arch type, natural-bottom culverts





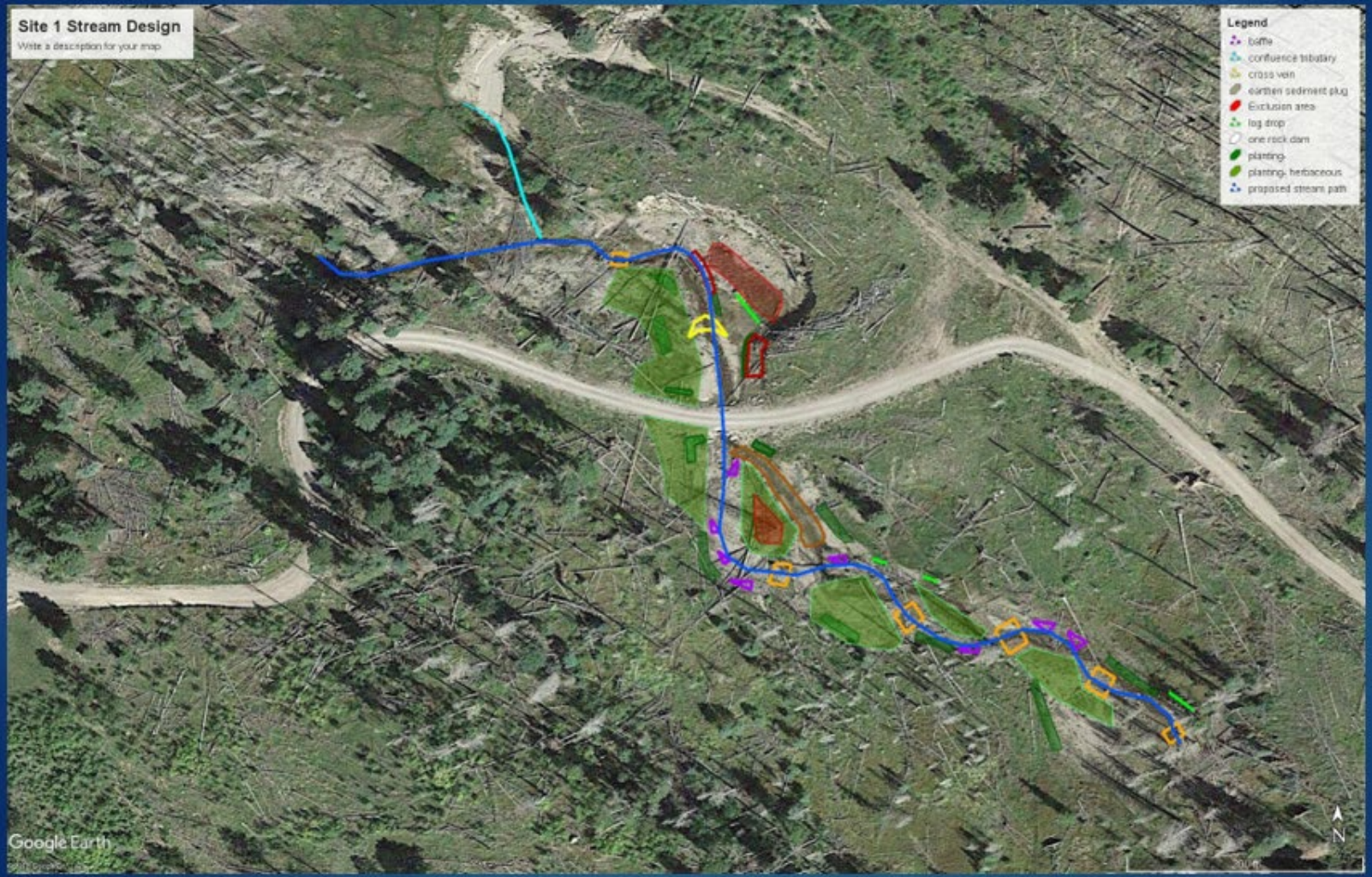




100 %
Design Plans

Site 1
Culvert
Upgrade

26' x 8.2' x
24'

log guard ra

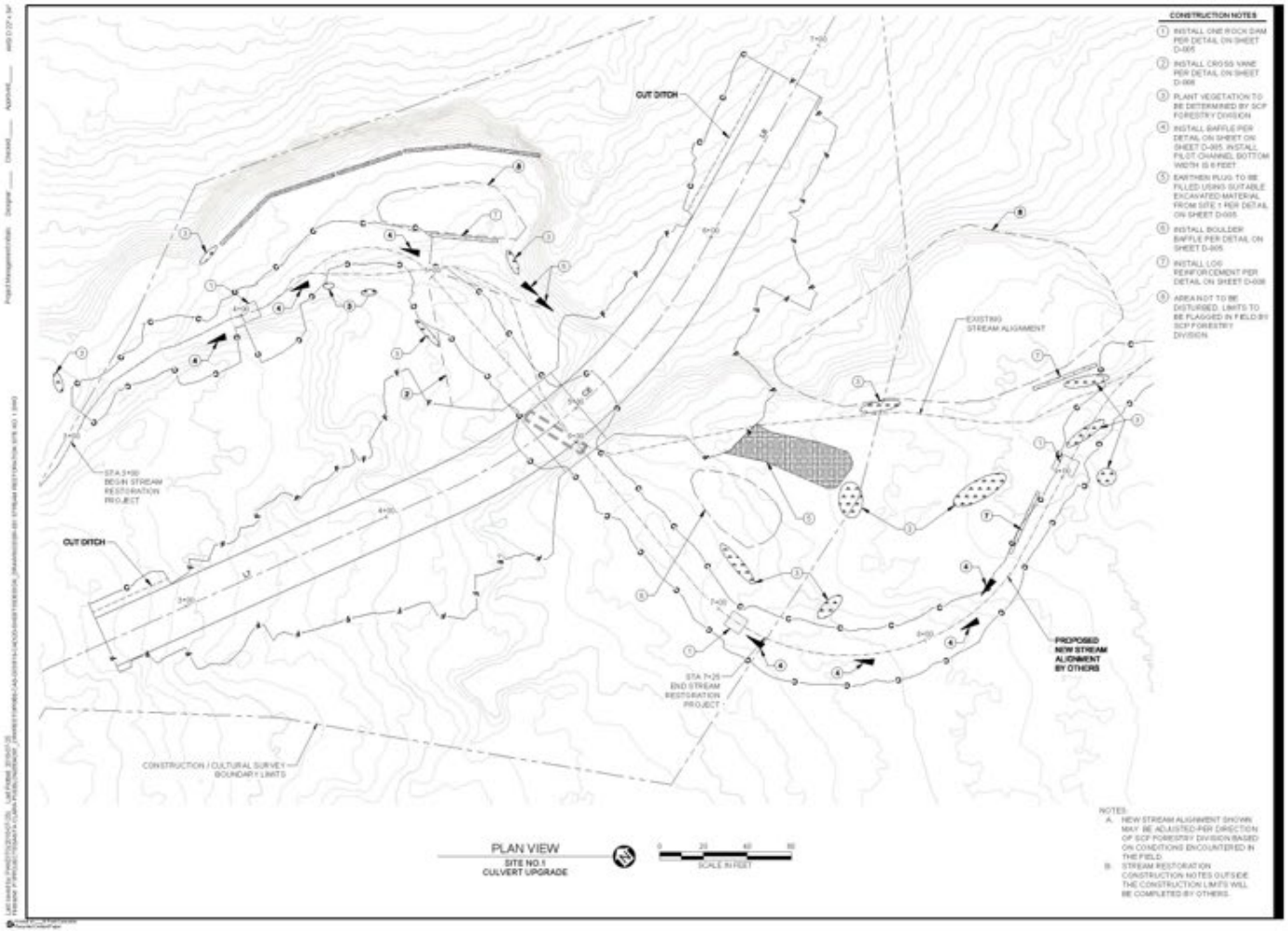



Site 1

Stream Restoration

"Soft Engineering"

Bioengineering Principles

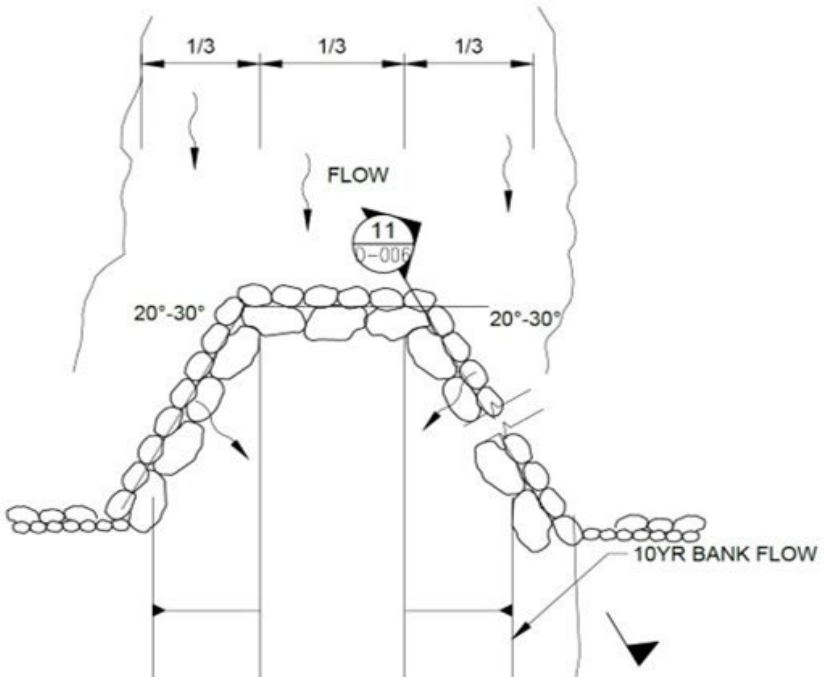



100 % Design Plans

Site 1

Natural and nature-based features

# NNBF: Cross vanes for grade control




# NNBF's for grade control

# NNBF’s for sediment management

# Hand-built NNBF's for stream restoration

## One-rock dams, baffles, run-downs

# Site 1 crossing upgrade



- Natural bottom arch culvert with stacked stone headwalls
- Removed fish barrier

# Creek restoration downstream of crossing upgrade

FEMA HMGP 2021 Flood mitigation and creek restoration project, Santa Clara Pueblo, NM

# Site 1 crossing upgrade

- Incorporated stream restoration above and below
- Goal to maximize riparian habitat availability (i.e. ecological uplift)

**Before (2018)**

**After (2021)**

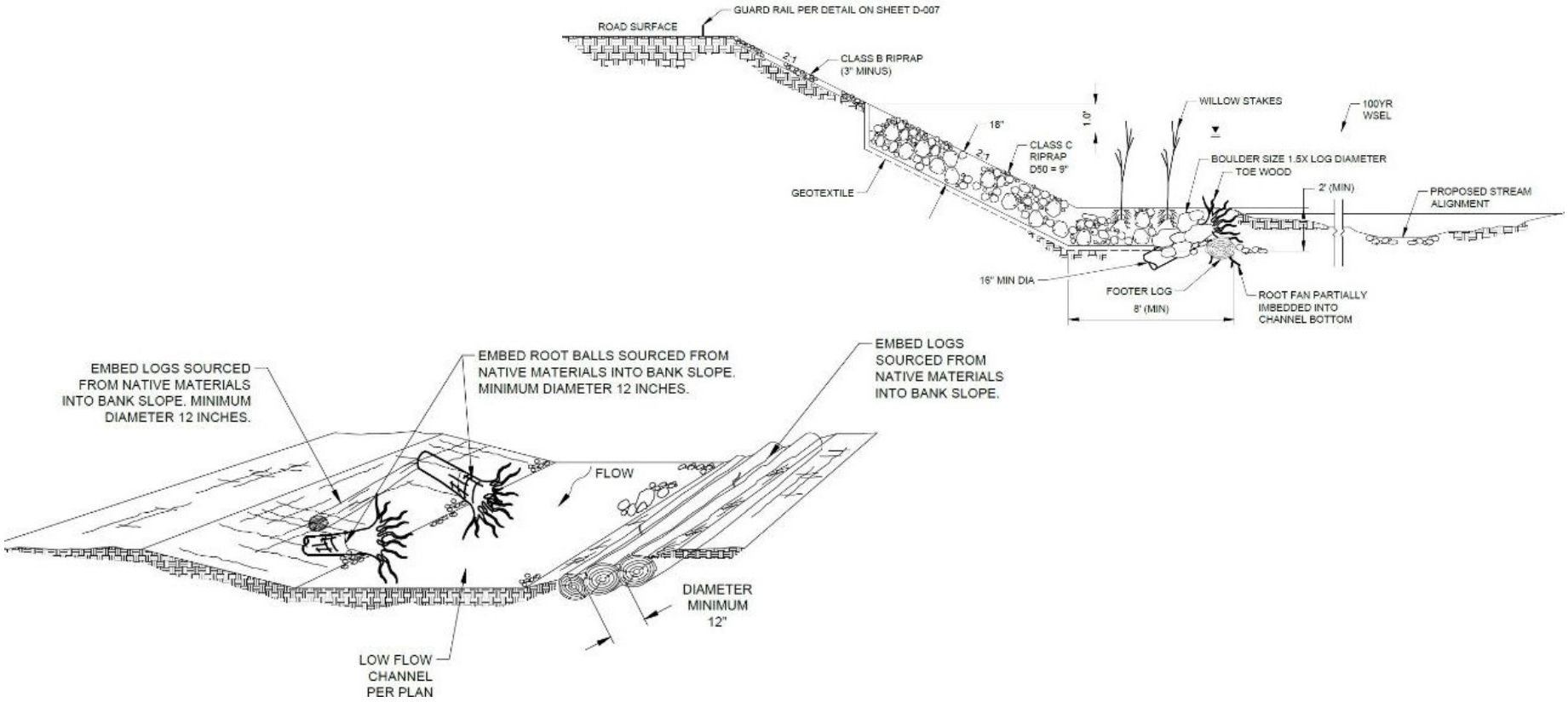
# Site 2 crossing– stacked stone

36”x 40’ CMP Culvert

6’x 3’x 58’ Bottomless Culvert

- Cylindrical culverts provide a cost-effective alternative when set below grade.

# Bank Stabilization with natural materials



# Site 3- Bank stabilization

**Before**

**After**

# Site 3- Bank stabilization

**Before**

**After**

# NNBF Best practice recommendations

- ❑ Observe and work with natural processes
- ❑ Leverage ecosystem services
- ❑ Incorporate natural materials as in-kind contributions
- ❑ Prioritize natural bottom passage
- ❑ Integrate both aquatic and terrestrial wildlife connectivity
- ❑ Bankfull channel integration and floodplain connectivity
- ❑ Offset a bankfull channel below in multiple barrel/box culverts
- ❑ Include restoration upstream and downstream of culvert
- ❑ Prioritize locally available natural materials
- ❑ Inclined headwalls for debris catchment
- ❑ Woody debris dispersal and transplanting in disturbed areas

# Conclusion

- NbS can provide a cost-effective resilient solution to roadway crossings.
- Working with nature will ensure our transportation corridors minimize negative impacts.

*"If it's good for the planet, it's ultimately good for us."*

Santiago Naranjo, Forestry Tech and Tribal Member, Santa Clara Pueblo

# Thank you

# Questions?