County of Santa Cruz

Water Advisory Commission

701 Ocean Street, Room 312, Santa Cruz, CA 95060
(831) 454-2022 TDD/TTY -Call 711 www.scceh.com
EnvironmentalHealth@santacruzcounty.us

AGENDA

SANTA CRUZ COUNTY WATER ADVISORY COMMISSION

Wednesday April 2, 2025, 4pm

This meeting will be held in hybrid format. Commissioners are expected to attend in person.
In-Person: 701 Ocean Street; **Basement Community Room**
Remote via Teams: **Join the meeting now** Meeting ID: 295 797 311 866 Passcode: eq9Au3cu
Dial in by phone +1 831-454-2222 Phone conference ID: 852 359 789#

A. OPENING

1. Call to Order
2. Roll Call
3. Elections of Officers as outlined in Santa Cruz County Code 2.38.120:

> (1) Commission officers shall be elected during the commission's first meeting after the commission is established at which a majority of the members are present. Annually, thereafter, commission officers shall be elected during the first meeting in April, or if the commission does not meet in April, at the next subsequent meeting. Commission officers may serve for up to two consecutive years and shall be eligible to serve again after a one- year "sit-out" period.

B. PUBLIC COMMUNICATIONS

Opportunity for the public to comment on items under the purview of the Water Advisory Commission but not on today's agenda.

C. CONSENT AGENDA

Items on the consent agenda are considered to be routine in nature and will be acted upon in one motion. Specific items may be removed by members of the advisory body or public for separate consideration and discussion. Routine items that will be found on the consent agenda are meeting minutes, drought response updates, and Groundwater Sustainability Agency updates.

1. Approval of Meeting Minutes for February 5, 2025
2. Update from Groundwater Sustainability Agencies

3. Drought Response and DROP implementation update

D. <u>COMMISSIONERS' REPORTS</u>

Opportunity for Commissioners to provide brief updates

E. <u>STAFF REPORTS AND ANNOUNCEMENTS</u>

Opportunity for staff to provide brief updates

F. <u>NEW BUSINESS</u>

1. Small Water System Consolidation Workshop

   Agenda:

   1. Background
      a. SB 552 requirements for counties and role in consolidations
      b. DROP language and grant for locally relevant materials and guides
      c. SB 1188 and SB 552 requirements
      d. Introduce presentations and Q&A process
   2. County's Consolidation Feasibility GIS Analysis
      a. Physical
      b. TMF (drive time)
   3. LAFCO roles/steps for physical connection
      a. ESA for emergency intertie
      b. Annexation of a small system into a big system
   4. Guidebook development and Survey
      a. Survey results
      b. Discussion:
         1) What assistance is needed/where should we focus our work?
         2) What should we be communicating to the State?

   Attachments:

   1. Connection Feasibility Assessment Report and Attachments

G. <u>UNFINISHED BUSINESS and UPDATES</u>

None

H. <u>CORRESPONDENCE</u>

None

I. <u>BOARD OF SUPERVISORS ACTION ON ITEMS AFFECTING WATER:</u>

February 11, 2024

Adopt "An Ordinance Amending Chapter 7.70 of the Santa Cruz County Code Relating to Wells and Borings" (Approved in concept January 28, 2025) (Clerk of the Board)

Accept and file the Santa Cruz County Water Resources Management Status Report for 2024 (Health Services Agency)

J. ITEMS OF INTEREST

- "Water supply pipeline to be relocated under Graham Hill Road" — Press Banner
- "Major water project aims for decades of sustainability in Soquel, Aptos, Capitola" — Santa Cruz Local
- "Scotts Valley, Santa Cruz water projects aim for better reliability" – Santa Cruz Local
- "Newell Creek Pipeline project to be discussed at community meeting" — Santa Cruz Sentinel

K. AGENDA ITEMS FOR FUTURE MEETINGS

- Intercommission Working Group

L. ADJOURNMENT

County of Santa Cruz
Water Advisory Commission

701 Ocean Street, Room 312, Santa Cruz, CA 95060
(831) 454-2022 TDD/TTY -Call 711 www.scceh.com
EnvironmentalHealth@santacruzcounty.us

Minutes

SANTA CRUZ COUNTY WATER ADVISORY COMMISSION

Wednesday February 5, 2025, 4pm

This meeting will be held in hybrid format. Commissioners are expected to attend in person. In-Person: 701 Ocean Street; **Fifth Floor Redwood Room** Remote via Teams

A. <u>OPENING</u>

1. Call to Order 4:01
2. Roll Call

Commissioner	Attendance
Frank Cheap (1)	Present
Ray Pereyra (2)	Present
Linda A. Wilson (3)	Present
Brian Lockwood (4)	Present
Bryan Largay (5)	Present
Paul G. Lego, Chair – Rep. of Private or Mutual Water Companies)	Present
Nate Gillespie – Rep. of Public Water Purveyors	Present

B. <u>PUBLIC COMMUNICATIONS</u>

Steinbruner: Meeting today at LAFCO regarding Big Basin Water Company. Article in Santa Cruz Local about Rountree facility.

C. <u>CONSENT AGENDA</u>

Items on the consent agenda are considered to be routine in nature and will be acted upon in one motion. Specific items may be removed by members of the advisory body or public for separate consideration and discussion. Routine items that will be found on the consent agenda are meeting minutes, drought response updates, and Groundwater Sustainability Agency updates.

1. Approval of Meeting Minutes for December 4, 2024
2. Update from Groundwater Sustainability Agencies
3. Drought Response and DROP implementation update

No comments or discussion. Motion to approve consent agenda by Gillespie, seconded by Wilson. Unanimous approval, Cheap abstains from minutes.

D. COMMISSIONERS' REPORTS

Pereyra: Glad to see information on PFAS presentation on the agenda. County of Santa Clara has sued a number of large producers of PFAS. Article in the Sentinel. He said that the sites they saw in Santa Clara have higher levels of PFAS in where we had hits in this County.

Gillespie: intertie between Scotts Valley Water District and Santa Cruz Water Department has begun. There was a public meeting last night for interested parties. Capable of 1 million gallons per day.

Lockwood: on Jan 25th Brian presented at the annual meeting of the planning and conservation league at UC Davis and talked about the Recharge Net Metering. Attended a meeting about Local Hazard Mitigation Planning by OR3. PV Water was a recipient of a $2 million watershed resilience planning grant. First large scale meeting is March 10th at the Aromas grange. Lots of modeling of climate related impacts to the watershed.

Largay: SLVWD has their local hazard Mitigation Grant available for public review. Still working with Moonshot Missions to help guide the consolidation between Brackenbrae and Forrest Springs.

Lego: His water company is also working with Moonshot. Whole background of the water company is being compiled. Now working on 3 separate initiatives with them.

E. STAFF REPORTS AND ANNOUNCEMENTS

None

F. NEW BUSINESS

1. Meet Dr. Emily Donham, new Supervising Water Quality Specialist. Emily will discuss her background, as well the monitoring the Water Quality Team has done in response to the Moss Landing fire.

The Water Quality Team has taken two rounds of water samples and one round of sediment around the lakes. The sediment was collected before the rains. One water sample was last week and one was right at the tail end of the rains.

Steinbruner: can equipment to monitor metals be included as a requirement of future permits?

G. <u>UNFINISHED BUSINESS and UPDATES</u>

1. <u>PFAS treatment project at Buena Vista Migrant Center</u>
   Presentation by Nathan Salazar on the project plan and public meeting held for the Buena Vista Migrant Center well, which has elevated PFAS.
   Materials: Staff report
   Presentation

   Pereyra: Has several questions that he will take offline. Asked about the notifications, the residents are currently getting the notifications.

   Largay: Feels that the urban services line is a problem for receiving water from Watsonville. Worried about quasi-experimental treatment systems rather than having the water line from City of Watsonville extended. Would require measures by the County supervisors.
   Nathan was not sure if that is part of the feasibility study though he hopes that it would make sense.
   Lockwood: seeing Chromium VI, not all the cities wells would meet those requirements.
   Lego: do these wells also exceed the Chromium VI levels?
   Nathan: the systems have exceedances of that as well, the new systems should remove both.
   Lego: Is the waste produced, the beads, hazardous waste?
   Nathan: I believe they would be.
   Lego: do you know if they are participating in the lawsuit?
   Nathan: not sure, but did send the information to them.
   Gillespie: There is another deadline on April 12th.
   Steinbruner: What is next? What can the public expect to see and when?
   Nathan: housing authority chose to fund the treatment system. The next steps are the feasibility study for Rountree, County will have a site visit at the BVMC treatment system.

2. Local Agency Management Plan implementation update
   John Ricker presented an update on the County's progress implementing the 2022 Local Agency Management Plan for Onsite Wastewater Treatment Systems.

3. Well Ordinance Update Process
   Deferred

H. CORRESPONDENCE

No Discussion

I. BOARD OF SUPERVISORS ACTION ON ITEMS AFFECTING WATER:

No Discussion

J. ITEMS OF INTEREST

No Discussion

K. AGENDA ITEMS FOR FUTURE MEETINGS

- Intercommission Working Group
- Small Water System consolidation forum

L. ADJOURNMENT 6:05

County of Santa Cruz

Water Advisory Commission

701 Ocean Street, Room 312, Santa Cruz, CA 95060
(831) 454-2022 TDD/TTY -Call 711 www.scceh.com
EnvironmentalHealth@santacruzcounty.us

Subject: April 2, 2025 Water Advisory Commission Consent Agenda

Title: Groundwater Sustainability Agency Updates

Background

There are three groundwater basins in the County subject to the Sustainable Groundwater Management Act. The following updates come from the Groundwater Sustainability Agencies tasked with managing and monitoring those basins.

Pajaro Valley Water Management Agency

- Funding
  - Department of Conservation (DoC) Multibenefit Land Repurposing Grant, $8.89 million: Staff and consultants continue to meet monthly with DoC staff and the Statewide Support Entity (SSE); staff continue to work with Regional Block Grant partners to finalize the final sub-grantee agreements; the agreement the Board approved on February 19, 2025 with Zanjero for Multibenefit Land Repurposing Plan development support services is fully executed; staff received approval from DoC for $2.375 million to reimburse PV Water for College Lake Project expenses.
  - DWR Watershed Resilience Pilot Grant, $2 million: Work on the watershed delineation and watershed network development continues; staff and consultants held the first Watershed Network meeting on March 10, 2025 and approximately 75 people attended, including PV Water directors and DWR staff; staff submitted Invoice No. 3 in the amount of $213,920.44 on February 28, 2025.
- College Lake Integrated Resources Management Project
  - Construction:
    - Water Treatment Plant & Intake Facility
      - Work continues on the Intake Facility and Water Treatment Plant; commissioning meetings are ongoing.
    - Supplemental Well No. 4 (SW4)

            - The contractor has constructed the well; well development is ongoing.
        - Treated Water Pipeline
            - Meetings to discuss contract change orders primarily due to impacts of the Differing Site Condition at Salsipuedes Creek are ongoing, as are meetings related to flushing the pipeline.
            - Due to a cultural resource discovery, Caltrans is requiring PV Water to excavate a portion of the roadway to search for additional artifacts; this work tentatively scheduled to begin on March 18, 2025, and then continue March 24-28, 2025.
    - Environmental: Biological, Cultural, and Native American resource monitoring is taking place as needed, and worker environmental training continues as needed.
    - Adaptive Management Plan: Hydrologic monitoring, waterfowl monitoring, and steelhead surveys will occur this year as in prior years; staff is reviewing reports summarizing 2024 monitoring results.
    - Outreach Activities: Staff continue to post information about the project online. Please check https://www.pvwater.org/construction regularly for construction related updates.
- Watsonville Slough System Managed Aquifer Recharge & Recovery Projects
    - Permitting: Work on preparing permit applications continues, in addition, staff and consultants have updated the Struve Slough Water Availability Analysis and have requested to meet with Water Board Staff this month.
    - Environmental: The addendum to the Environmental Impact Report is on the March 19, 2025, Board agenda.
    - Outreach: Communications are ongoing; staff and the support team continue to meet with property owners
- Sustainable Groundwater Management Act Well Monitoring Network Expansion
    - Permitting: Staff have held preliminary discussions with the permitting agencies of Santa Cruz and Monterey Counties to identify the necessary requirements. Well permits and encroachment permits will be required

    - by both counties, and a coastal development permit may be required for proposed wells in the coastal zone of Santa Cruz County.
  - Property Rights: Staff intends to obtain consultant support to procure the necessary easements and agreements for proposed wells that will be located on privately owned land.
  - Environmental: Staff have engaged Environmental Service Associates (ESA) to consult on California Environmental Quality Act (CEQA) and environmental compliance. Staff have directed ESA to conduct a cultural resources database search to determine if the sites qualify for an exemption from CEQA.
- Pajaro River Ecological Floodplain Inundation Potential (EcoFIP) Project
  - Over the past couple of years, DWR has been funding the Pajaro River EcoFIP project as part of its Flood-Managed Aquifer Recharge (Flood-MAR) program. As described on DWR's website (https://water.ca.gov/Programs/All-Programs/Flood-MAR), "Flood-MAR" is an integrated and voluntary resource management strategy that uses flood water resulting from, or in anticipation of, rainfall or snow melt for managed aquifer recharge (MAR) on agricultural lands and working landscapes, including but not limited to refuges, floodplains, and flood bypasses. Flood-MAR can be implemented at multiple scales, from individual landowners diverting flood water with existing infrastructure, to using extensive detention/recharge areas and modernizing flood management infrastructure/operations. Within the Flood-MAR Program, DWR has been conducting "Multiple Benefit Floodplain Restoration" studies. DWR has been working with partners to develop a systematic approach to identify floodplain restoration and expansion opportunities that provide high-quality salmonid habitat and enhance naturally occurring floodplain recharge. The Ecological Floodplain Inundation Potential (EcoFIP) toolkit facilitates the identification, analysis, and prioritization of multiple floodplain restoration opportunities at the reach or project scale. The pilot study tools help visualize and compare conceptual restoration designs for potential habitat and recharge benefits and quantify potential benefits and implementation costs. For the Pajaro River study, partners included the Pajaro Regional Flood Management Agency, U. C. Santa Cruz, PV Water, Jacobs Engineering, and cbec eco engineering. DWR has

recently published the Pajaro River StoryMap, which summarizes this work, on its Flood-MAR website (https://water.ca.gov/Programs/All-Programs/Flood-MAR) and is available directly via the following link: https://storymaps.arcgis.com/stories/87678ee830c243998244f1a67daf6d51

Santa Cruz Mid-County Groundwater Agency

- The Agency Board met on March 20, 2025, at the Capitola Branch Library. At the meeting, the Board:
    - Received a presentation on the Water Year (WY) 2024 Groundwater Sustainability Plan (GSP) Annual Report and authorized submittal to the Department of Water Resources. The report indicates that the basin experienced undesirable results with respect to seawater intrusion, reduction of storage, and surface water depletion in WY 2024 as defined in its GSP.
    - Received a draft Agency budget for Fiscal Year 2026.
    - Approved the qualifications-based selection of Montgomery & Associates to continue to provide planning and technical services to the Agency.
    - Authorized the extension of an agreement with the County of Santa Cruz for administrative and planning services from the Regional Water Management Foundation, and data management system hosting and maintenance from Kisters for Fiscal Years 2026 and 2027.
    - Received an update from SCI Consulting Group related to public outreach with private domestic groundwater users as part of an assessment of funding options for expenses associated with complying with the Sustainable Groundwater Management Act. The Board provided direction to better define the process and need for a fee as well as identify other funding options before continuing engagement with private groundwater users. The Board requested additional information on what is known about water use and recharge at its next meeting.
- The next regular meeting of the Agency is on June 12, 2025, at 6:00 pm.

Santa Margarita Groundwater Agency

- The Agency Board met on February 27, 2025, at Scotts Valley Water District. At the meeting, the Board:
    - Received a presentation on the Water Year (WY) 2024 Groundwater Sustainability Plan (GSP) Annual Report and authorized submittal to the Department of Water Resources. The report indicates that the basin did not experience undesirable results in WY 2024 as defined in its GSP.
    - Received a draft Agency budget for Fiscal Year 2026.
    - Authorized the extension of an agreement with the County of Santa Cruz for administrative and planning services from the Regional Water Management Foundation, and data management system hosting and maintenance from Kisters for Fiscal Years 2026 and 2027.
- The next regular meeting of the Agency is on May 22, 2025, at 6:00 pm.

By: Sierra Ryan, Water Resources Program Manager with information from Rob Swartz and Brian Lockwood

County of Santa Cruz

Water Advisory Commission

701 Ocean Street, Room 312, Santa Cruz, CA 95060
(831) 454-2022 TDD/TTY -Call 711 www.scceh.com
EnvironmentalHealth@santacruzcounty.us

Subject: April 2, 2025, Water Advisory Commission Consent Agenda

Title: Drought Response & Outreach Plan (DROP) Update

Background

On September 23, 2021, Senate Bill (SB) 552 was signed into law. SB 552 requires that "a county shall establish a standing county drought and water shortage task force to facilitate drought and water shortage preparedness for state small water systems and domestic wells within the county's jurisdiction". The Water Advisory Commission voted to adopt the responsibility for implementing SB 552 and receives regular updates on the progress of implementation.

Updates:

- There are currently 160 applicants for the Regional Waterboards free well testing program.
- A total of 70 wells have been tested.
- 18 wells exceeded a drinking water standard for 1 or more of the following: E. coli, Nitrate, Arsenic, Hexavalent Chromium, and 1,2,3 TCP.
- 3 tested wells had 1 or more households enroll in county services. Service updates since the February meeting are:
    - 4 households, which are all served by the same well, will be receiving bottled water. It was determined that well water parameters did not meet the specifications for a POU treatment system
    - 1 household received a point of use treatment system to reduce Hexavalent Chromium levels. Test results are pending to determine if water is now meeting drinking water requirements.
- Sierra Ryan continues to represent interests of local government at the State Drought Response Interagency Partnership (DRIP) Collaborative.

By: Sean Abbey
Water Quality Specialist III

County of Santa Cruz

HEALTH SERVICES AGENCY

ENVIRONMENTAL HEALTH DIVISION

Water Resources Program

701 Ocean Street room 312, Santa Cruz, CA, 95060

Phone:(831) 454-7519 Fax:(831) 454-4770

Santa Cruz County Small Water Systems Connection Feasibility Analysis

Background and Justification

Small public water systems face significant challenges in maintaining reliable and safe drinking water due to regulatory requirements, financial constraints, infrastructure limitations, geophysical constraints, and water quality and quantity limitations. SB 552 introduces new mandates aimed at increasing the resilience of small public water systems as well as Nontransient-Noncommunity systems. These requirements include backup power by 2024, multiple water sources by 2027, metering of all service connections by 2032, and meeting fire flow capacity standards by 2032. While these measures improve long-term reliability, they also impose substantial financial and operational burdens on already resource-limited systems.

As a response to SB 552, the County of Santa Cruz developed the Drought Response Outreach Plan (DROP) which includes a Small Water Systems Support Plan (Plan) as part of its efforts to support small water systems in navigating these new requirements. While the DROP was only mandated to consider State Small Water Systems, which serve fewer than 15 connections, the County chose to consider the small public water systems under 200 connections as well. This Plan is intended to help by providing emergency support and also assistance with taking proactive steps to build resiliency and avoid emergency situations. The DROP highlights that small systems must meet many of the same regulatory obligations as large systems but lack the number of connections to spread costs effectively. The Plan identifies voluntary consolidation as a key strategy to improve resiliency and reduce compliance burdens. Consolidation allows smaller systems to merge with larger, more stable providers, benefiting from shared infrastructure, operational efficiencies, and improved water supply reliability.

The County's role in consolidation is facilitative rather than regulatory. While the State Water Resources Control Board (SWRCB) has authority to mandate consolidations in some cases of severe and persistent water quality violations, the preferred approach is voluntary consolidation, supported by decision-making tools and financial assistance. The DROP outlines the need for a decision-support tool to assess consolidation feasibility, providing small water systems with data-driven insights into the costs and benefits of potential connections.

This Connection Feasibility Analysis serves as a critical step in that process, evaluating the physical and managerial feasibility of consolidations across the County. By analyzing infrastructure requirements, cost factors related to constraints, and operational considerations, this study helps identify viable consolidation opportunities that align with SB 552's resilience objectives. The findings will contribute to the County's ongoing efforts to support small systems, improve regional water reliability, and develop sustainable solutions for long-term drought resilience.

Objectives and Scope

The purpose of this Connection Feasibility Analysis is to evaluate potential opportunities for connecting smaller water systems to larger, more resilient water systems in Santa Cruz County. The analysis primarily focuses on small systems that are viable candidates for consolidation with larger systems that already have extensive pipeline networks and support larger communities.

Systems included in an analysis fall into the following categories:

- **Individual Water Systems (1 to 4 connections):** These systems are regulated by the County Code (Chapter 7.73) and more information can be found here; Individual Water Systems
- **State Small Water Systems (5 to 14 connections):** These systems are regulated by the Drinking Water Regulatory program under both County Code (Chapter 7.71) and State laws and regulations. These systems are typically small in scale but may have the potential to benefit from consolidation with larger systems to increase resilience and reduce operational challenges.
- **Small Public Water Systems (15 to 199 connections):** Classified as Public Water Systems and regulated by both County Code (Chapter 7.71) and Federal and State law. Public Water systems incorporated into this analysis include two groups:
    - **Community Systems:** Serve full-time residences (homes)
    - **Non-transient, Non-community Systems:** Serve the same group of people over a long period of time (for schools only).

- **Large Water Systems (200+ Connections):** The following large water systems were considered as potential sources of reliable water in this analysis:
  - San Lorenzo Valley Water District
  - City of Watsonville
  - City of Santa Cruz
  - Scotts Valley Water District
  - Soquel Creek Water District
  - Central Water District

Considerations:

- The managerial analysis does not include State Small Water Systems, as managerial consolidation offers limited efficiency improvements—regulatory requirements are minimal and remain largely unchanged even after consolidation.
- Individual Water Systems (1 to 4 connections) were excluded from both the managerial and physical analysis due to their limited capacity and lack of resources for expansion or connection to larger systems. However, a separate proximity analysis was conducted for Individual Water Systems (see Sections 1.4, 3.4, and 5.0).
- Transient Non-Community Systems, such as campgrounds serving a variable group of people, were excluded.
- Physical interconnections between small water systems were not considered due to:
  - The low likelihood that a small system would have the capacity to supply another system without major infrastructure upgrades.
  - The uncertainty of water reliability, particularly during drought conditions, making smaller systems less dependable as a source for others.

This analysis focuses on two primary types of consolidation:

1. **Physical** – Merging water system infrastructure, such as distribution pipelines.
2. **Managerial (TMF)** – Involve the integration of administrative and operational functions between systems, which includes sharing billing, equipment, and staff or operators to streamline operations and reduce costs

The analysis follows a multifaceted approach:

- **Geographic and Infrastructure Constraints** – Geographic factors such as system locations, proximity to existing reliable water line infrastructure and established water service areas, and distances along road networks (physical connections) were analyzed. Additionally, travel times between systems (for managerial connections) and path conditions were considered to identify potential connection routes and assess operational overlaps.

- **Cost Estimation and Financial Factors** – A cost model was developed to estimate infrastructure and associated construction related costs with physical connections. This model incorporates variables such as slope, elevation changes, and groundwater conditions, and other geotechnical factors, providing an overview of the financial implications, particularly related to pipeline installation for consolidation.
- **Decision Framework**- Findings are presented through visual tools, including bar charts, maps, and matrices, to illustrate potential consolidation candidates and cost ranges. These tools help assess feasibility by providing comparative cost estimates, geographic relationships between systems, and key decision factors such as distance, infrastructure constraints, and operational considerations. This framework supports an at-a-glance evaluation of viable consolidation opportunities.

Data Sources

This The Connection Feasibility Analysis relies on a combination of geographic, geophysical, regulatory, and infrastructure datasets to assess potential consolidation opportunities. Key sources include:

- **Regulatory and Administrative Data** – Information from regulatory agencies, including water system classifications, water service area boundaries, sphere of influence boundaries (LAFCO), number of connections, operational status, and APN data.
- **Infrastructure Data** – Pipeline networks of large water systems and small water system locations sourced from local water agencies and the County's Local Primacy Agency respectively. Additionally, the road network within Santa Cruz County was used to evaluate potential connection pathways and estimate travel times between systems.
- **Hydrologic and Geotechnical Data** – Elevation data, groundwater conditions, landslide distributions, expansive soils, liquefaction susceptibility, and active fault traces were analyzed to assess terrain-related constraints and potential construction challenges.
- **LiDAR Data (2020):** High-resolution (2-foot) LiDAR (Light Detection and Ranging) data collected in 2020 to generate slope rasters and extract elevation data. LiDAR is a modern remote sensing technique that uses airborne laser measurements to

generate highly detailed topographic data. This technology allows for the creation of bare-earth models by filtering out vegetation, providing an accurate depiction of the underlying terrain for hydraulic analysis.

- **Cost Estimation Data** – Pipeline installation cost estimates were derived from a California State Water Resources Control Board white paper report: *Draft White Paper Discussion on Proposed Drinking Water Cost Assessment Model Assumptions on Physical Consolidation (July 14, 2023).*

Tools

The Connection Feasibility Analysis was conducted using a combination of Geographic Information Systems (GIS) software and programming tools to process spatial data, perform geospatial analyses, and develop cost estimation models.

- **ArcGIS Pro** – Used for mapping, spatial analysis, and geoprocessing tasks such as proximity analysis, network analysis for travel time estimates, and spatial data visualization.
- **Python** – Used for data processing, automation, plotting, and geospatial analysis. Specific libraries include:
  - **arcpy**- Used for interacting with GIS data, such as accessing and modifying geospatital data and feature classes.
  - **pandas**- Used for data manipulation and analysis.
  - **matplotlib**- Used for creating plots and charts.
  - **numpy**- Used for numerical operations and arrays.
  - **os**- Used for interacting with the operating system.
  - **textwrap, locale, and seaborn-** Used for formatting and other visualization operations.

Methodology

The Connection Feasibility Analysis follows a systematic approach to evaluate potential consolidation opportunities for small water systems in Santa Cruz County. The methodology generally consists of three primary components: (1) spatial and infrastructure analysis, (2) cost estimation, and (3) decision framework development.

1. Spatial and Infrastructure Analysis
This step identifies potential consolidation opportunities by assessing the geographic distribution of small water systems, their proximity to larger systems, and the feasibility of physical and managerial connections. Key spatial analyses include:

1.1 Service Area and Infrastructure Mapping – Using GIS datasets from local water agencies and regulatory bodies, the pipeline networks (source) and small system locations (sinks) were mapped. This process involved the following steps:

1.1.1 Identifying Small Water System Locations (Sinks)

1. Import the existing County GIS layers containing Small Public Water Systems and State Small Water Systems.
2. Create a feature layer from an existing county-maintained data table containing latitude and longitude coordinates for a subset of system wells. These well locations serve as the sink points where potential pipelines would connect.
3. Perform a *Spatial Join* between the GIS feature layers and the county data table, using the water system number as the common field to link datasets.
4. Perform a number of *Calculate Field* operations to select only systems classified as "Community" (serving full-time residences) or "Non-Transient Non-Community (NTNC-School)" (e.g., schools). Export this subset into a new dataset, as these are the primary small systems considered for consolidation.
5. For systems lacking defined well locations:
    - Use the *Feature to Point Tool* on the polygon feature class associated with those water systems.
    - Select the "Inside" option to generate a centroid point within each polygon, representing an assumed well location.
    - Apply the *Add Locations* tool to integrate these newly generated points into the primary sink dataset.

1.1.2 Identifying Large Water System Infrastructure (Sources)

1. Obtain pipeline infrastructure datasets from large water systems in Santa Cruz County.
2. Extract water mains from these datasets, making minor refinements where necessary.
3. Manually place source points along key areas of the pipe network:
    - Position points at pipeline endpoints that extend closest to a particular small water system.
    - Review the road network in relation to target small systems to determine likely connection paths.
    - If likely closest source is unclear, place multiple potential source points along all possible routes to ensure the Closest Facility Analysis identifies the most efficient pathway.

1.1.3 Alternative Approach for Source Point Placement

- If cost and GIS processing credit usage are not constraints, an alternative automated method can be used:
    - Utilize the *Generate Points Along Lines* tool, setting an appropriate interval distance.
    - Combine these generated points with existing pipeline endpoints, which are typically the most likely potential tie-in locations.

1.2 Road Network and Distance Analysis for Physical Consolidation

Once the sink locations (small water systems) and source points (large system pipelines) were established, the county road network was analyzed to estimate the shortest feasible pipeline installation pathways. To perform this analysis, the *Closest Facility* tool within the *Network Analysis* framework was used. The setup included:

- Facilities: Potential source points along the pipeline distribution network (Section 1.1.2).
- Incidents: Presumed tie-in location (assumed to be the same as well location) for each small water system (Section 1.1.1).
- Travel Network: The analysis was constrained to an ESRI-defined road network, ensuring that pipeline pathways followed existing roads, as new pipeline infrastructure is typically installed along roadways.

The following parameters were applied:

- Maximum Travel Distance: Set at 50 km to prevent restrictions and ensure all feasible connections were considered.
- Number of Facilities to Find: Limited to 1, ensuring each small water system was assigned to the nearest large system pipeline.
- Road Restrictions: Highway 17 was designated as a line barrier due to the low feasibility of construction along or across this major roadway.

The output geometry represents the most direct and feasible pipeline installation pathways based on the road network constraints.

1.3 Road Network and Travel Time Analysis for Managerial Consolidation

The Managerial Connection Analysis aimed to evaluate the feasibility of consolidating management functions, such as administration, billing, and operational oversight, among Public Water Systems (PWS). This analysis was conducted using the *Closest Facility* tool within the *Network Analysis* framework, which identifies the nearest feasible managerial connections based on the drive travel time.

Analysis Setup:

- **Facilities & Incidents:** The same dataset, comprising PWS (74 total), was utilized for both facilities and incidents within the analysis. Each system was considered a potential facility or incident.
- **Travel Network:** The analysis was constrained to an ESRI-defined road network, similar to the physical connection analysis.
- **Maximum Travel Time:** A 60-minute cutoff was applied to identify feasible managerial connections within a reasonable timeframe.
- **Number of Facilities to Find:** The analysis was set to find a minimum of 9 potential facilities for each system.

The output geometry represents the most travel efficient managerial connections candidates based on the travel time.

1.4 Individual Water System Consolidation

This analysis evaluates the feasibility of transitioning a household from well water to a connection with a nearby large water system.

1.4.1 Determining Feasible Distance Limitations

The maximum feasible connection distance was determined using a formula derived from the State Water Board's *Draft White Paper Discussion on Proposed Drinking Water Cost Assessment Model Assumptions on Physical Consolidation* (July 14, 2023):

$$\text{Cost} = \text{Regionally Adjusted Pipeline Cost} + \text{Regionally Adjusted Service Line Cost} \\ + \text{Connection fees} + 10\% \text{ (Planning \& Construction)} + 3\% \text{(Inflation)}$$

The total costs for at-risk domestic wells were adjusted for inflation (~6% over two years) and planning/construction costs (10%), applying these adjustments multiplicatively to reflect proportional increases. A benchmark cost of $50,000—representing the approximate cost of drilling a new domestic well in Santa Cruz County—was used to provide a realistic basis for justifying new connections, even for parcels with reliable, high-quality groundwater. Geotechnical and other site constraints were not included in this estimate.

The formula was then rearranged to solve for the maximum feasible pipeline length:

$$\text{Pipeline Length} = \frac{\frac{\text{Total Cost}}{1.06 \times 1.10} - \text{Service Line Cost} - \text{Connection Fee}}{\text{Pipeline Cost per Foot}}$$

By inputting $50,000 as the total cost and using the recommended values for service line costs ($6,200), pipeline costs ($220 per foot), and connection fees ($4,230) from the report, the equivalent connection distance to a large water system was calculated as approximately 150 feet.

1.4.2. Identifying Parcels within Reasonable Distance

To identify parcels located within 150 feet of a primary water main, the following datasets were used:

- **Parcels served by domestic wells** (Santa Cruz County GIS database)
- **Water mains of large water systems** (consistent with the physical consolidation analysis for small water systems)

A 150-foot *buffer* was applied to the water mains to define potential connection areas. A *pairwise intersect* was then performed, incorporating both the buffer and the domestic well parcel layer to identify overlapping parcels.

Since the domestic well parcel dataset is outdated, the initial results were refined by manually identifying and removing parcels known to served by city or district water providers.

Once the dataset was cleaned, a *spatial join* was conducted between the refined dataset and the original parcel layer, using a common identifier to link records. Finally, parcels within the 150-foot buffer were *extracted*, enabling clear visualization of parcels with potential connection opportunities.

2. Estimating Constraints Along Output Pipeline Paths

This section assesses key constraints affecting pipeline feasibility and develops pipeline installation cost estimates for the potential consolidation projects. Many of the following estimates are based on percentage increases relative to the baseline pipeline cost of $220 per linear foot. The recommended cost reference is derived from the State Water Board's Draft White Paper Discussion on Proposed Drinking Water Cost Assessment Model Assumptions on Physical Consolidation (July 14, 2023).

2.1 Terrain Related Constraints

Geospatial datasets were incorporated to evaluate construction limitations and risks along potential pipeline routes:

2.1.1 Slope Analysis

To assess the impact of terrain on pipeline feasibility and cost, slope analysis was conducted using high-resolution 2020 LiDAR-derived elevation data. The analysis involved calculating slope values, extracting slope statistics along pipeline routes, and incorporating terrain-based cost adjustments. The key steps included:

1. Slope Calculation – A slope raster was generated from the 2020 DEM using the *Slope* tool in ArcGIS Pro, generating grid values in degrees.
2. Extracting Slope Values Along Pipeline Routes – The *Zonal Statistics as Table* tool was used to extract slope conditions along each pipeline segment.
    - The input was set to the extracted potential pipleline pathways from 1.2.
    - The slope raster was used as the value input.
    - The tool calculated the mean slope for each pipeline segment.
3. Joining Slope Data to Primary Route Dataset – The output table from the Zonal Statistics as Table tool was joined to the primary route dataset containing pipeline route attributes.
    - The *Join* was performed using a common identifier field linking pipeline segments to their corresponding slope statistics.
    - A *Calculate Field* operation was executed to transfer the mean slope values from the zonal statistics table to the dataset.
4. Slope Factor for Cost Adjustment – A cost adjustment factor was applied based on the mean slope values:
    - Determining Maximum Slope – To normalize cost adjustments, the maximum slope across all pipeline segments was identified using a scripted search function that iterated through all slope values. This maximum slope served as a reference for scaling cost adjustments.

- A slope adjustment factor was applied to account for increased construction challenges in steeper areas. This factor was scaled between 1.0 (i.e. no impact for gentle slopes) and 1.15 (for the steepest terrain), to apply cost adjustments proportionally to terrain difficulty. The formula for computing the slope factor was:

$$SlopeFactor = 1.0 + \left(\frac{Slope(i) - 1.0}{MaxSlope - 1.0}\right) \times (1.15 - 1.0)$$

The purpose of this equation is to ensure that the cost remains largely unchanged for paths with gentle slopes, while for steeper slopes, the cost is proportionally increased by up to 15% relative to the maximum slope.

Incorporating Slope-Adjusted Costs – The slope factor was monetized relative to the base cost:

$$SlopeCost = (PipelineLength \times BaseCost \times SlopeFactor) - (PipelineLength \times BaseCost)$$

2.3 Pressure-Related Costs

Pressure related costs were determined by evaluating the elevation difference between the source and sink locations. For systems with an elevation difference of less than 50 feet (or ideally negative, gravity-fed), the existing pressure is assumed to be sufficient, and no additional cost is incurred. However, when the elevation difference exceeds 50 feet, the water pressure is assumed to drop and requires increased cost such as the installation of booster pumps to maintain flow.

2.3.1 Extracting Elevation at the Source and Sink

Elevation values were extracted at the source and sink locations using the DEM dataset and the *Extract Values to Points* tool in GIS.

- The elevation difference between the source and sink was *calculated* in GIS to determine if it exceeded 50 feet.

2.3.2 Elevation Cost Adjustment

The elevation difference is evaluated in a script, and if it exceeds 50 feet, a cost adjustment is applied.

- A 0.05% increase in cost relative to the base cost is added for each unit of pipeline length if it exceeds 50 feet.

2.4 Landslide-Related Costs

If a pipeline crosses a landslide, it can increase installation costs due to factors such as increased excavation depths, enhanced shoring requirements, higher backfill compaction requirements, the need for more robust piping materials, a higher frequency of trench plugs, and other construction-related mitigation costs. To assess landslide-related cost impacts, pipeline segments were analyzed for intersections with mapped landslide zones using geospatial data.

2.4.1 Identifying Landslide-Affected Pipeline Segments:

Landslide susceptibility was determined by evaluating whether modeled pipeline paths crossed mapped landslide areas based on the 1975 Cooper-Clark and Associates landslide inventory. The *Pairwise Intersect* tool in ArcGIS Pro was used to extract pipeline segments that overlapped these mapped landslides.

2.4.2 Cost Adjustment for Landslide Crossings:

For pipeline segments intersecting a mapped landslide, a cost adjustment factor was applied to account for additional engineering and material requirements. A 25% cost increase was assigned to these impacted length segments in a scripted calculation, roughly reflecting the increased engineering and material costs required for pipeline stabilization and risk mitigation.

2.5 Expansive Soils-Related Costs

If a pipeline crosses an area with expansive soils, installation costs can increase due to factors such as higher susceptibility to soil movement, increased structural reinforcement requirements, offhaul and import material cost for backfill, enhanced backfill compaction standards, and the need for more flexible or specially engineered piping materials. To assess cost impacts associated with expansive soils, pipeline segments were analyzed for intersections with mapped expansive soil zones using geospatial data.

2.5.1 Identifying Expansive Soil-Affected Pipeline Segments:

Expansive soil susceptibility was determined by evaluating whether modeled pipeline paths crossed mapped expansive soil areas based on a GIS layer maintained by the County of Santa Cruz GIS team (follow up w/ matt for source). The *Pairwise Intersect* tool in ArcGIS Pro was used to extract pipeline segments that overlapped these mapped expansive soil areas.

2.5.2 Cost Adjustment for Expansive Soil Crossings:

For pipeline segments intersecting a mapped expansive soil zone, a cost adjustment factor was applied to account for additional engineering and material requirements. A 15% cost increase was assigned to these impacted length segments in a scripted calculation, roughly reflecting the additional construction measures needed to mitigate soil expansion and contraction risks.

2.6 Liquefaction-Related Costs

If a pipeline crosses an area susceptible to liquefaction, installation costs can increase due to factors such as enhanced shoring requirements (typically loose sands), higher backfill compaction standards, the need for more flexible or specially engineered piping materials, and additional stabilization measures. To assess cost impacts associated with liquefaction, pipeline segments were analyzed for intersections with mapped liquefaction zones using geospatial data.

2.6.1 Identifying Liquefaction-Affected Pipeline Segments

Liquefaction susceptibility was determined by evaluating whether modeled pipeline paths crossed mapped liquefaction areas based on a GIS layer maintained by the County of Santa Cruz GIS team (follow up w/ matt for source). The *Pairwise Intersect* tool in ArcGIS Pro was used to extract pipeline segments that overlapped these mapped liquefaction areas.

2.6.2 Cost Adjustment for Liquefaction Crossings

For pipeline segments intersecting a mapped liquefaction zone, a cost adjustment factor was applied to account for additional engineering and material requirements. A 30% cost increase was assigned to these impacted length segments in a scripted calculation, roughly reflecting the increased construction measures needed to mitigate soil liquefaction risks during seismic events.

2.7 High Groundwater-Related Costs

If a pipeline crosses an area with high groundwater, installation costs can increase due to factors such as increased dewatering requirements, enhanced shoring, additional trench stabilization, higher backfill compaction standards, and the need for corrosion-resistant piping materials. To assess cost impacts associated with high groundwater, pipeline segments were analyzed for intersections with mapped high groundwater areas using geospatial data.

2.7.1 Identifying High Groundwater-Affected Pipeline Segments:

High groundwater susceptibility was determined by evaluating whether modeled pipeline paths crossed mapped high groundwater areas based on a GIS layer maintained by the County of Santa Cruz GIS team (follow up w/ matt for source). The *Pairwise Intersect* tool in ArcGIS Pro was used to extract pipeline segments that overlapped these mapped high groundwater areas.

2.7.2 Cost Adjustment for High Groundwater Crossings:

For pipeline segments intersecting a mapped high groundwater zone, a cost adjustment factor was applied to account for additional engineering and material requirements. A 20% cost increase was assigned to these impacted length segments in a scripted calculation, roughly reflecting the increased construction measures needed to manage high groundwater and maintain trench stability.

2.8 Active Fault Trace-Related Costs

If a pipeline crosses an active fault trace, installation costs can increase due to factors such as the need for specialized seismic design, enhanced joint flexibility, additional trench stabilization, and other fault rupture mitigation measures. To assess cost impacts associated with active faults, pipeline segments were analyzed for intersections with mapped active fault traces using geospatial data.

2.8.1 Identifying Active Fault-Affected Pipeline Segments:

Active fault trace susceptibility was determined by evaluating whether modeled pipeline paths crossed mapped active fault traces based on USGS fault data. The *Pairwise Intersect* tool in ArcGIS Pro was used to extract pipeline segments that overlapped these mapped fault traces.

2.8.2 Cost Adjustment for Active Fault Crossings:

For pipeline segments intersecting a mapped active fault trace, a fixed cost increase of $100,000 was applied in a scripted calculation. This rough adjustment reflects the additional construction measures needed to enhance pipeline resilience against fault displacement and seismic activity.

2.9 Path Overlap Adjustments

The cost adjustments described in 2.4-2.8 apply to pipeline pathways crossing only one constraint criterion. However, when pipeline pathways intersect multiple criteria (e.g. landslide area and high groundwater zone), costs must be adjusted to prevent overestimation due to overlapping factors. If not accounted for, overlapping conditions could lead to double counting, triple counting, or other forms of overestimation, resulting in exaggerated cost estimates. To manage these cases, the total length for each criterion is adjusted to exclude segments where it overlaps with another constraint, where those situations are handled separately. This ensures that each impacted section is only counted once while still incorporating the increased complexity of construction and mitigation efforts.

2.9.1 Length Adjustments for Overlapping Constraints

The following generic approach is used to adjust pipeline segment lengths (see 2.9.3 for detailed approach):

- **Single-Criteria Segments:** Pipeline segments intersecting only one constraint are adjusted by subtracting overlapping portions that also fall under another constraint.
- **Double Overlap Segments:** Segments affected by two overlapping constraints are extracted and scaled separately.
- **Triple Overlap Segments:** The limited cases where three constraints overlap (liquefaction, expansive soils, and high groundwater) are extracted and scaled separately.
- **Unimpacted Pipeline Length:** Segments that do not intersect any constraint are identified and calculated by subtracting all impacted segments from the total pipeline length.

  In Santa Cruz County, only one triple-overlap scenario was identified, involving liquefaction, expansive soils, and high groundwater. No instances of quadruple or higher overlaps were found in the county.

  Pipeline lengths are analyzed using the *Pairwise Intersect* tool in ArcGIS, and the adjusted lengths are then passed to a script for cost factor calculations. The following sections provide a detailed breakdown of the adjustment methodology and cost factor scaling for overlapping conditions.

2.9.2 Cost Factor Adjustments for Overlapping Conditions

The cost factors for overlap conditions are scaled rather than summed. This is because mitigation efforts often involve overlapping strategies, meaning the costs should increase but not necessarily at a rate equal to the sum of individual criteria. The general cost adjustments follow this logic (see 2.9.4 for detailed approach):

- **Unimpacted Segments:** The base cost is applied to the pipeline length that does not intersect any constraints.
- **Single-Criteria Cost:** Each constraint has its own cost factor (Appendix X) applied to the adjusted length.
- **Double Overlap Cost:** The cost factor for double overlaps is calculated as the average of the two criteria's cost factors, scaled by an additional adjustment factor (Appendix X).
- **Triple Overlap Cost:** The cost for triple overlap areas (liquefaction, expansive soils, and high groundwater) is computed as the average of the three criteria's cost factors, further scaled by a multiplier (Appendix X).

Detailed Path Overlap Adjustments

Building on the framework outlined in 2.9.1 and 2.9.2, this section provides a step-by-step breakdown of the methodology used to adjust pipeline segment lengths and prevent cost overestimation.

2.9.3 Detailed Length Adjustments for Overlapping Constraints

The pipeline overlap lengths are extracted using the *Pairwise Intersect* tool in ArcGIS and are then processed in a script to adjust the length calculations for each record.

Single-Criteria Segments: The length for each constraint is adjusted by subtracting overlapping portions where the pipeline crosses another constraint. This includes:

- Double Overlaps (e.g., landslide + liquefaction)
- Triple Overlaps (e.g. landslide + liquefaction + groundwater)

Since the *Pairwise Intersect* extraction of the pipleline path and geohazard constraint layer captures all overlap scenarios alongside single-constraint segments, and cost adjustments for these overlapping segments are handled separately, they need to be fully subtracted from each individual constraint calculation. For each record, the adjusted single-criteria lengths are computed as follows:

- Adjusted **landslide length**:

$$ls\_length\_total - (ls\_exp\_length + ls\_liq\_length + ls\_gw\_length)$$

- Adjusted **liquefaction length**:

$$liq\_length\_total - (exp\_liq\_length + gw\_liq\_length + ls\_liq\_length) + (liq\_exp\_gw\_length(if\,applicable))$$

- Adjusted **expansive soil length**:

$$exp\_length\_total - (exp\_liq\_length + exp\_gw\_length + ls\_exp\ length) + (liq\_exp\_gw\_length\ (if\ applicable))$$

- Adjusted **groundwater length**:

$$gw\_length\_total - (gw\_liq\_length + exp\_gw\_length + ls\_gwlength) + (liq\_exp\_gw\_length(if applicable))$$

Double-Criteria Segments

In addition to single-criteria segments, some pipeline segments are impacted by two or more overlapping constraint criteria, such as:

- Double Overlaps (e.g., landslide + liquefaction, expansive soil + groundwater)
- Triple Overlaps (e.g., landslide + liquefaction + groundwater)

Since the *Pairwise Intersect* extraction for double-criteria paths includes both double-overlapping and triple-overlapping segments where multiple criteria share the same path, and because cost adjustments for triple-overlap scenarios are handled separately, the triple-overlap sections must be fully subtracted from each individual double-constraint calculation. For each record, the adjusted double-criteria lengths are computed as follows:

- **Landslide & Expansive Soils:**

$$ls\_exp\_length(no further adjustment)$$

- **Landslide & Liquefaction:**

$$ls\_liq\_length(no further adjustment)$$

- **Landslide & Groundwater:**

$$ls\_gw\_length(no further adjustment)$$

- **Expansive Soils & Groundwater:**

$$exp\_gw\_length - (liq\_exp\_gw\_length(if applicable))$$

- **Expansive Soils & Liquefaction:**

$$exp\_liq\_length - (liq\_exp\_gw\_length(if applicable))$$

- **Groundwater & Liquefaction:**

$$gw\_liq\_length - (liq\_exp\_gw\_length(if applicable))$$

Triple-Criteria Segments

Since the *Pairwise Intersect* extraction for three overlapping criteria does not include scenarios with four or more overlapping constraints, the triple-overlap length is directly determined from the extracted dataset. Unlike single- and double-overlap adjustments, no additional subtractions are required, as there are no cases in the county where more than three constraints overlap.

Note: There are no triple-overlap areas in the county involving landslides.

For triple-overlap scenarios, the extracted length is derived from the intersection of:

- **Double-overlap paths** (e.g., expansive soils + groundwater)
- **Single-constraint paths** (e.g., liquefaction)

For each record, the triple-overlap length is computed as follows:

$$adjuste\_triple\_overlap\_length = liq\_exp\_gw\_length$$

Since liq_exp_gw_length represents the segment where all three constraints (liquefaction, expansive soils, and groundwater) overlap, no further modification is needed.

- **Unimpacted Pipeline Length:** The total pipeline length that does not cross any constraint is calculated by subtracting all impacted segment lengths from the total pipeline length:

$$unimpacted\_length = total\_length - \left(\sum adjusted\ single, double, and\ tripleoverlaplengths\right)$$

While more than three constraints could theoretically overlap in other locations, no cases of quadruple or higher overlaps were found in the county.

2.9.4 Detailed Cost Factor Adjustments for Overlapping Conditions

The detailed cost adjustments implemented in the script (Appendix X) follow this logic:

- **Unimpacted Segments:**

$$unimpacted\_length \times base\_cost$$

- **Single-Criterion Cost:**

$$adjusted\ length \times base\ cost \times corresponding\ factor$$

- **Double Overlap Cost:**

$$adjusted\ double\text{-}overlap\ length \times \frac{(factor_1 + factor_2)}{2} \times double\ overlap\ factor \times base\ cost$$

- **Triple Overlap Cost (only liquefaction, expansive soils, and groundwater):**

$$triple\_overlap\_length \times \frac{(liquefaction\ factor + expansive\ soils\ factor + groundwater\ factor)}{3} \times triple\_overlap\_factor \times base\ cost$$

- **The total project cost is then computed as follows:**

$$TotalCost = Non\_ImpactedCost + \sum Single\_CriterionCosts + \sum Double\_OverlapCosts + \sum Triple\_OverlapCosts$$

3.0 Visualization

The visualization of the results focuses on representing the potential cost savings and risk factors associated with water system consolidation, using bar charts, heatmaps, and maps to illustrate the findings:

3.1 Stacked Bar Chart for Cost Breakdown

The stacked bar chart (Appendix X) displays the breakdown of total costs for each record. The x-axis labels represent water systems, including their names, and the number of existing connections shown in parentheses to provide context, which is intended to help evaluate the feasibility of consolidation, as more connections may imply greater financial resources or reserves. Each bar segment represents a different cost factor, such as non-impacted costs, landslide costs, expansive costs, etc. The total height of each bar reflects the overall cost for that particular system connection. To identify potential cost-saving opportunities, an overlap area is shown within the chart, represented as a hatch pattern. This area indicates overlap from one or more water systems that share a potential pipeline path, intended to convey that if these systems pool their resources, they could save on installation costs.

3.2 Heatmap for Managerial Connection Travel Time

A heatmap (Appendix X) was used to visualize travel times between water systems for managerial connections, providing a general overview of travel time patterns and helping decision-makers assess the feasibility of merging operations. The heatmap is structured as a matrix that plots travel times between different systems using a color-coded scale:

- Green (0–10 minutes) – Close proximity, facilitating easier managerial coordination
- Orange (10–20 minutes) – Moderate travel time, involving more logistical planning
- Red (20–30 minutes) – Longer travel time, potentially complicating managerial consolidation

This visualization helps identify which systems are geographically closest to one another, offering insights into the practicality and efficiency of administrative integration across different systems.

3.3 Map for Physical Consolidation

The map (Figure 1) visualizes the feasibility of physically connecting small water systems to larger regional infrastructure, focusing on the primary driver of cost: distance to tie-in points on major water mains. Several key elements are highlighted in the map:

- Water Mains: Color-coded by system to show the regional distribution infrastructure.
- Small Water Systems: These are categorized by connection size and location relative to water service areas.

- Distance to Water Mains: Color gradients represent proximity to water mains, with darker colors indicating closer proximity and lighter colors indicating greater distances. This highlights the accessibility challenges faced by small systems that are further away from existing infrastructure.
- Overlapping Paths: Dashed purple lines identify shared routes between systems, indicating potential cost-saving opportunities if multiple systems can coordinate and consolidate resources along the same pipeline routes.

3.4 Map for Individual Water Systems Proximity Analysis

This map (Figure 2) identifies parcels currently served by domestic wells that are within 150 feet of a water service line from a large water system. Key features include:

- Parcels served by wells (yellow) – Indicating properties that rely on private well water.
- Proximity Zone (orange) – The portion of each parcel that falls within the 150-foot buffer from a water main, highlighting feasible connection areas.
- Water Mains – Color-coded by system to illustrate regional distribution infrastructure.

4.0 Small Water System Results

A total of 85 water systems were included in the physical consolidation analysis (Figure 1). One system that initially met the inclusion criteria was ultimately eliminated because its only road network path to a large water system required crossing Highway 17, a designated path barrier, rendering its connection infeasible.

Key Findings

- **Distance to Water Mains:**
    - The average distance from small water systems to the nearest water main is approximately 12,500 feet, while the median distance is around 6,500 feet.
    - Given the baseline cost of $220 per linear foot, distance represents the primary cost driver and a significant limiting factor for physical connections in the county.
- **Terrain and Slope:**
    - The average slope along potential pipeline paths is 8.9°, associated with moderately sloping topography.
- **Connections and Shared Pathways:**
    - On average, there are 31 connections per system.
    - Approximately 56 of the 85 systems share at least one common pipeline path with another system.
        - Among these, the average percent overlap is around 65%, although the overall average overlap across all systems is 43%.
        - Furthermore, 30 systems share a path with two or more systems, indicating considerable potential for resource pooling and cost-sharing.

- **Geotechnical Constraints:**
    - Only 3 systems have potential pipeline paths that cross an active fault—specifically, the San Andreas Fault—minimizing the seismic design challenges in most areas. A fault is considered active if they have moved within the last 10,000 years.
    - The liquefaction criterion was found to be the largest contributor to increased costs (aside from distance), impacting 53 systems.
    - Approximately 50% of the total potential pipeline length is impacted by at least one geotechnical constraint, underscoring the widespread nature of these challenges.
- **Pressure and Elevation Differences:**
    - The pressure differences between systems range from -181 feet (ideal, as gravity-fed systems are more cost-effective) to 2,062 feet (which significantly raises installation costs due to the need for booster pumps and additional infrastructure).
    - The median pressure difference is 88 feet, and only 14 systems have negative pressure differences, indicating that the majority of systems will require extra measures to manage water pressure deficiencies.
- **Regulatory and Administrative Considerations:**
    - Only 3 of the 86 small water systems that met the analysis criteria are located within existing water service areas, suggesting that most systems face additional regulatory and administrative challenges. 19 small water systems were identified to be within a sphere of influence boundary administered by LAFCO.
- **Cost Estimates:**
    - The average estimated physical pipeline cost is approximately $3,400,000, with a median cost of around $1,750,000.
    - Total project costs range widely from about $16,000 to nearly $17,000,000, reflecting the variability in required pipe length, geotechnical conditions, and required infrastructure enhancements in order to connect or develop an emergency intertie to a more reliable water source.
    - These costs do not include design, permitting, or mitigations, which can be substantial.

Managerial Connection Feasibility

While physical consolidation presents substantial financial and logistical challenges, managerial connections offer a more immediate and cost-effective alternative for improving small water system sustainability.

- **Proximity of Managerial Connections:**
    - Out of 74 public water systems evaluated for managerial connections, 61 have at least one potential connection within 10 minutes of travel time.
    - Among these, 34 systems have at least 3 viable managerial connections within 10 minutes.

- **Connection Density:**
    - The average number of managerial connections per system that are within 10 minutes is 3.2.
    - This suggests that many small systems are clustered close enough to benefit from shared administrative resources, potentially reducing operational costs and improving service reliability.

For a detailed breakdown of specific managerial connection opportunities, Appendix X provides a matrix plot illustrating travel times between different systems.

Summary of Findings

These results highlight the significant challenges of physical consolidation, primarily due to high costs driven by distance and geotechnical constraints. However, in contrast, the considerable sharing of pipeline paths among systems suggests substantial potential for cost savings if collaborative approaches are adopted. Systems that share pipeline segments could pool resources to reduce installation costs, making physical consolidation more financially viable in some cases.

Meanwhile, managerial connections offer a promising alternative, with a majority of systems having viable opportunities for administrative and operational collaboration within a short travel time, underscoring the importance of exploring managerial integration as a near-term strategy while continuing to assess long-term physical consolidation feasibility.

5.0 Individual Water System Results

Approximately 8,400 parcels in Santa Cruz County are currently served by domestic wells. Following the analysis described in Section 1.4, a total of 605 parcels were identified as being within a feasible distance for connection to a large water system.

The results highlight a number potential opportunities for transitioning domestic well users to a more reliable water supply. However, feasibility depends on additional factors such as regulatory requirements, variable financial situations, and site-specific property constraints, which are larger uncertainties. Figure 2 provides a visual representation of the identified parcels and their proximity to existing water mains.

6.0 Limitations

- Baseline pipeline costs are based on an estimated $220 per linear foot, sourced from the California State Water Resources Control Board's 2023 white paper report. Adjusting for inflation since then brings the estimated cost closer to $230 per linear foot, representing an approximate 6% increase in total cost not captured in the results.

- This estimate is inherently rough, as the State Water Board's 2023 report recommends a range of $155 to $220 per linear foot. Actual costs may vary based on site-specific conditions.
- Geotechnical criteria factors, which have a potentially significant impact on cost estimates, are primarily judgment-based. They are intended to recognize the likelihood of increased costs when encountering geotechnical constraints rather than providing precise cost adjustments. For specific cost factors associated with each constraint, refer to the script in Appendix X.
- The geotechnical criteria are based on the best available data layers for the county, but actual field conditions may vary significantly.
- Additional geotechnical factors that were not explicitly considered could further impact costs. For example, subsurface materials could influence excavation feasibility, trench stability, and necessary shoring requirements. Other factors, such as sensitive habitats that may require construction restrictions, additional mitigation, or permitting considerations, could also contribute to cost variability.
- Pressure-related costs are generalized, applying the same additional costs to all systems that exceed the minimum 50-foot elevation threshold. In reality, systems located significantly higher in elevation than their connection point are likely to incur substantially greater costs than those closer to the 50-foot threshold. A more refined approach could scale costs based on elevation differences, similar to the cost adjustment methodology used for slope factors, while also accounting for the necessary infrastructure to manage varying pressure demands. Additionally, pressure calculations were simplified by considering only the difference between sink and source elevations, meaning a negative elevation difference suggests a more cost-effective, gravity-fed system could be utilized. However, this approach does not fully capture variations in topography along the pipeline route. For example, an initial uphill climb before a subsequent downhill drop may still necessitate pressure enhancing infrastructure, even if the overall elevation difference appears favorable for gravity flow.
- The cost estimates are based on generalized unit costs and do not account for site-specific challenges such as traffic control, right-of-way constraints, permitting fees, or seasonal construction limitations.
- Pipeline installation is assumed to follow the existing road network. However, actual pipeline paths may vary based on site-specific constraints.
- Distance calculations include only the pipeline length along the road network up to the point where it is perpendicular to the defined well source. They do not account for the additional pipeline length required from the street to the actual water tie-in point on the property. Additionally, well source locations may be inaccurate, particularly for systems where the county lacked precise location data and had to default to locations based on parcel centroids.
- The cost estimates provide a general ballpark figure for potential costs across most systems in the county, given that distance is the primary cost driver.

- The pipeline cost estimates consider only installation costs. Other costs, such as service line installation, connection fees, administrative costs, CEQA compliance, contingency adjustments, regional cost adjustments, planning and construction factors, and inflation, must be considered for a full project cost estimate. These additional costs are detailed in the California State Water Resources Control Board's white paper report.
- The State Water Board also identifies additional potential costs not explicitly covered in their report, including expenses related to technical assistance, administration, and other regulatory requirements.

References

California State Water Resources Control Board. *Draft White Paper Discussion On: Proposed Drinking Water Cost Assessment Model Assumptions on Physical Consolidation (2023)*. Retrieved from https://www.waterboards.ca.gov

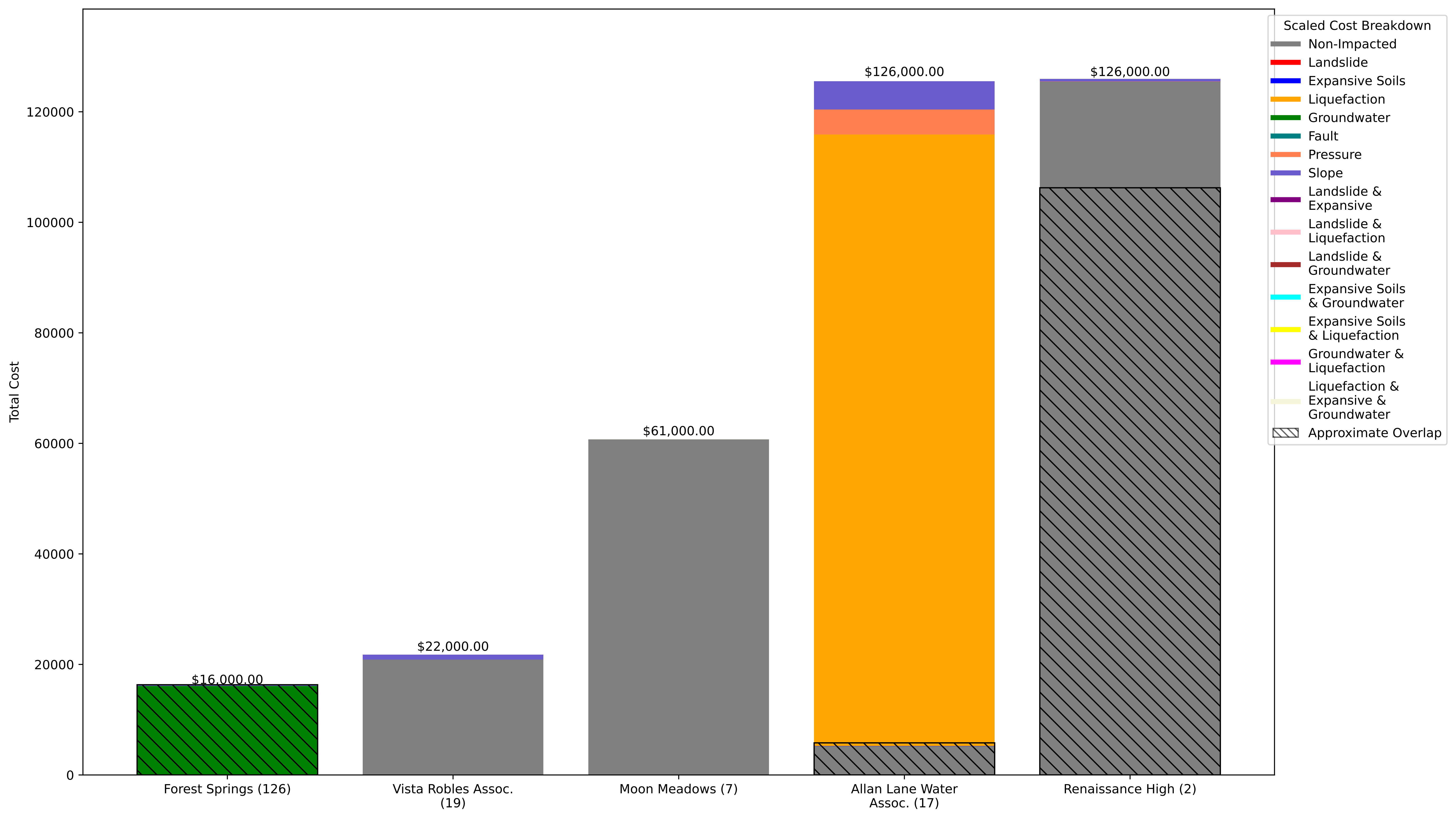
Figures

-Physical Consolidation Map- small water systems
- proximity map for induvial water systems

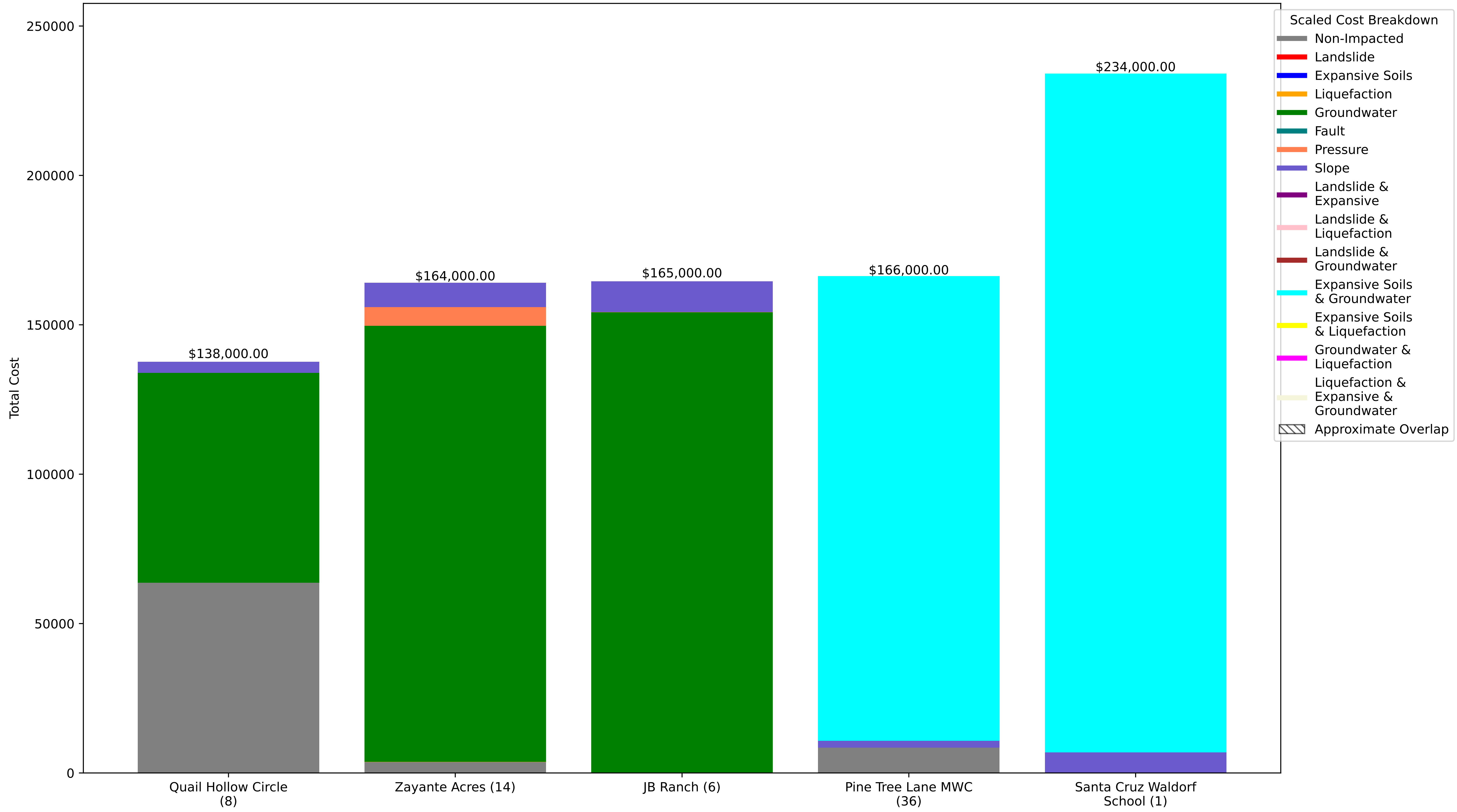
Appendix

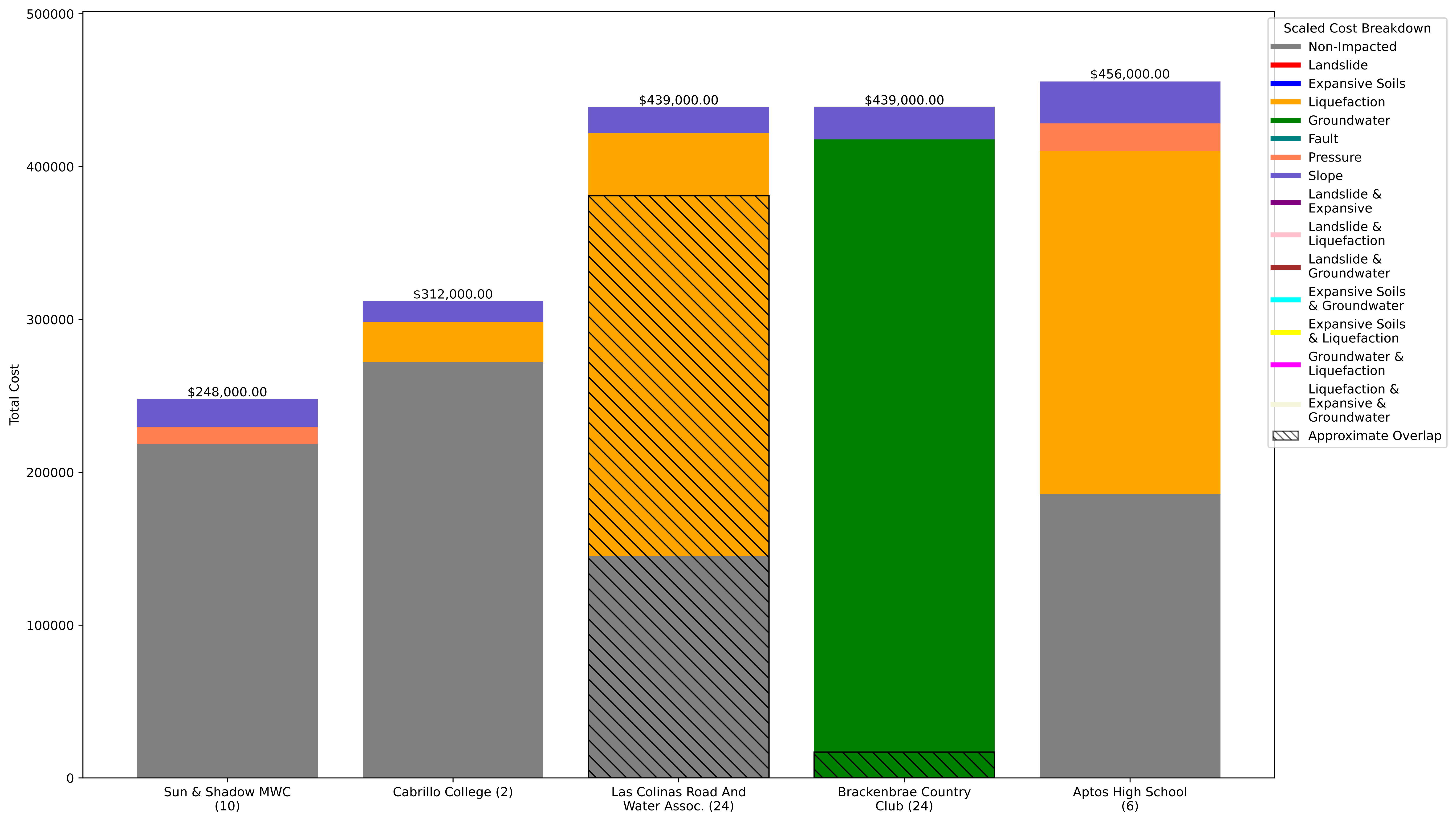
-bar charts
- matrices
- scripts. Plotting script for matrix necessary?
-final gis table for phys. consolidation?


Legend
San Lorenzo Valley Water Mains
Watsonville Water Mains
City of Santa Cruz Water Mains
Scotts Valley Water Mains
Soquel Creek Water Mains
Central Water Mains
Small_Water_Systems
100 - 186 Connections (Outside WSA)
15 - 100 Connections (Outside WSA)
0 - 14 Connections (Outside WSA)
15 - 100 Connections (Inside WSA)
0 - 14 Connections (Inside WSA)
Distance to Water Main
0 - 2000 feet
2000 - 5000 feet
5000 - 65637 feet
Overlapping Paths
Large Water System (200+ connections)
N
0 0.5 1 2 3 4 Miles
County of Santa Clara, County of Santa Cruz, Bureau of Land Management, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA

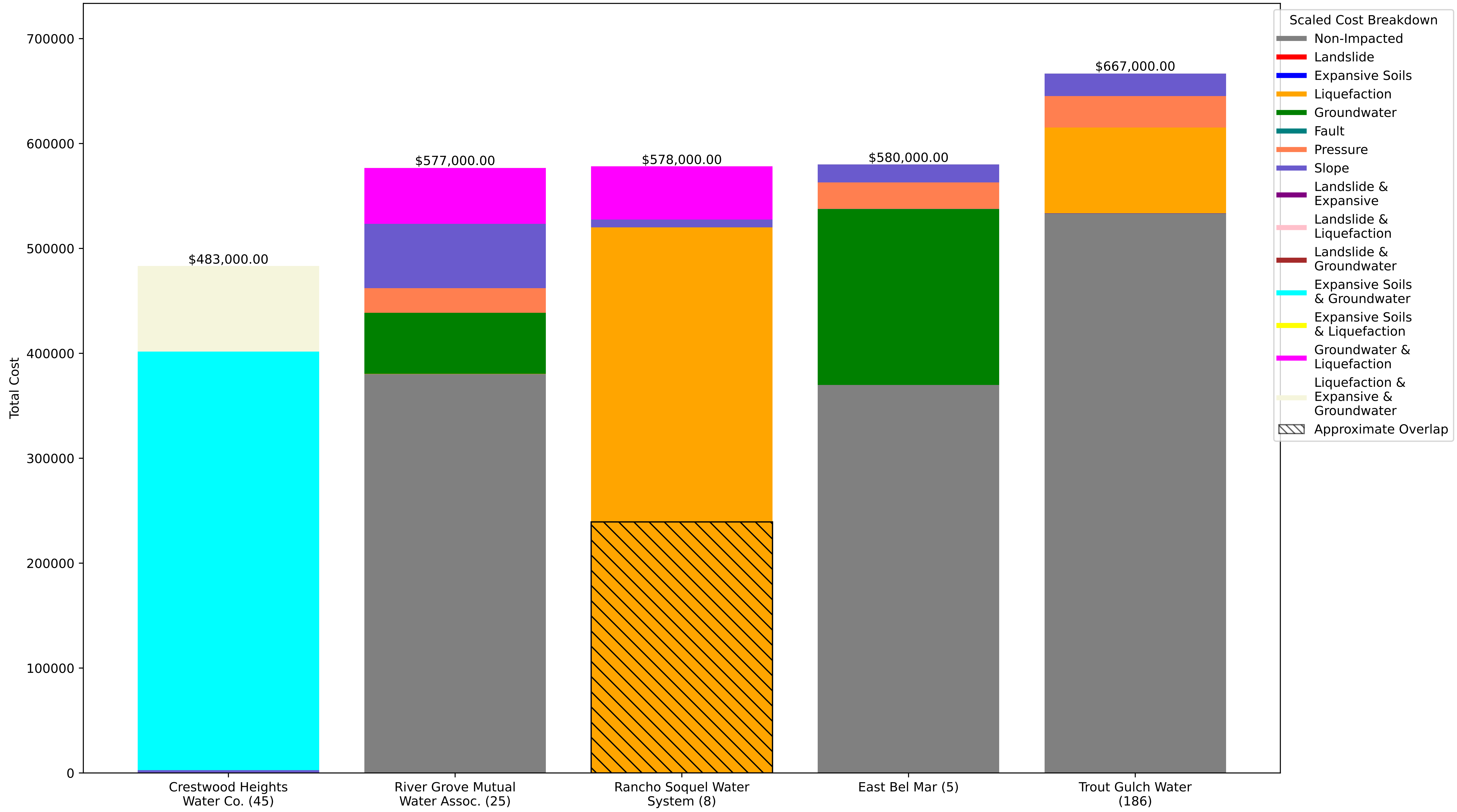


Total Cost
0
20000
40000
60000
80000
100000
120000
$16,000.00
$22,000.00
$61,000.00
$126,000.00
$126,000.00
Forest Springs (126)
Vista Robles Assoc. (19)
Moon Meadows (7)
Allan Lane Water Assoc. (17)
Renaissance High (2)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

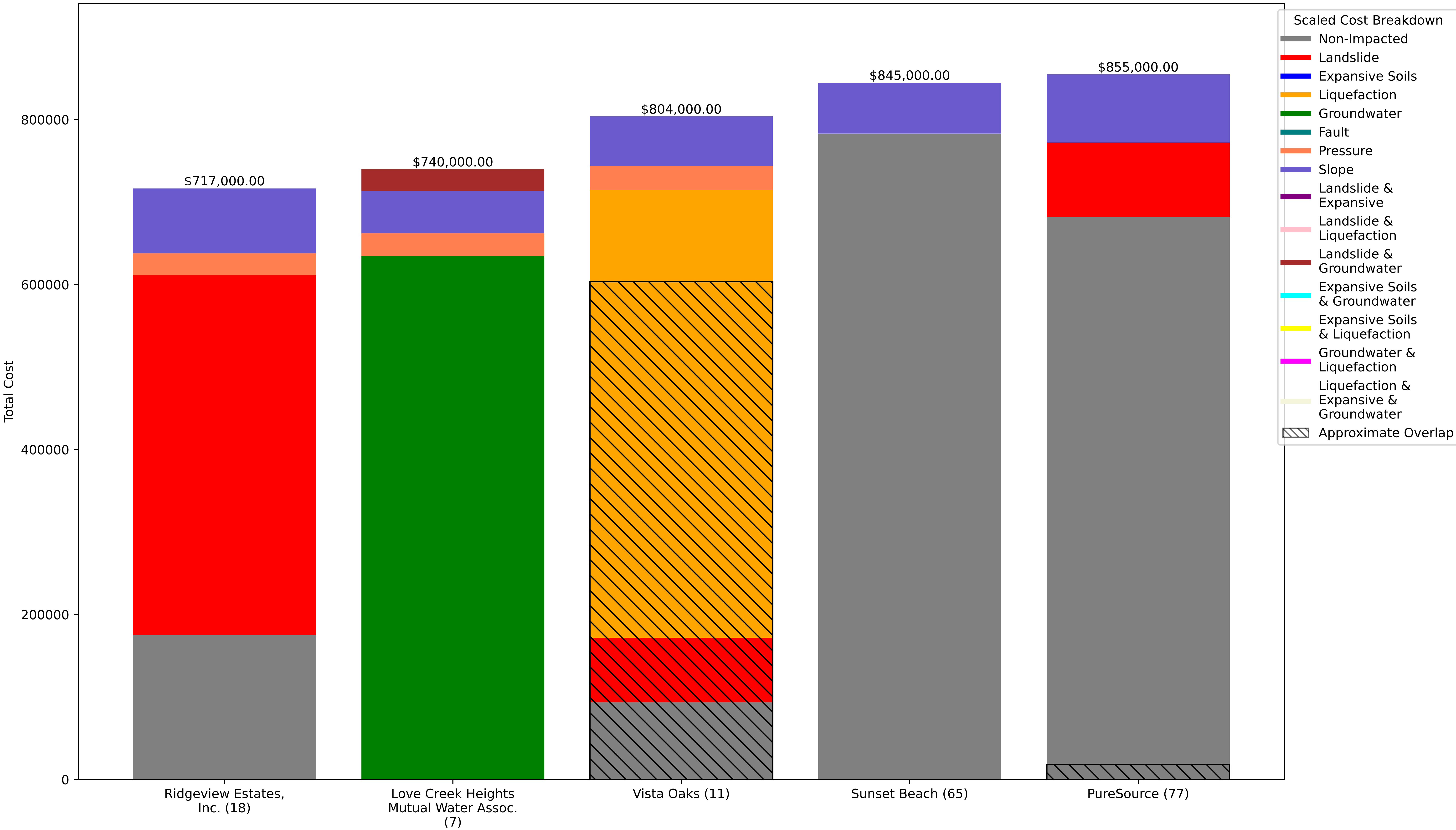

Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap
Total Cost
250000
200000
150000
100000
50000
0
$138,000.00
$164,000.00
$165,000.00
$166,000.00
$234,000.00
Quail Hollow Circle (8)
Zayante Acres (14)
JB Ranch (6)
Pine Tree Lane MWC (36)
Santa Cruz Waldorf School (1)



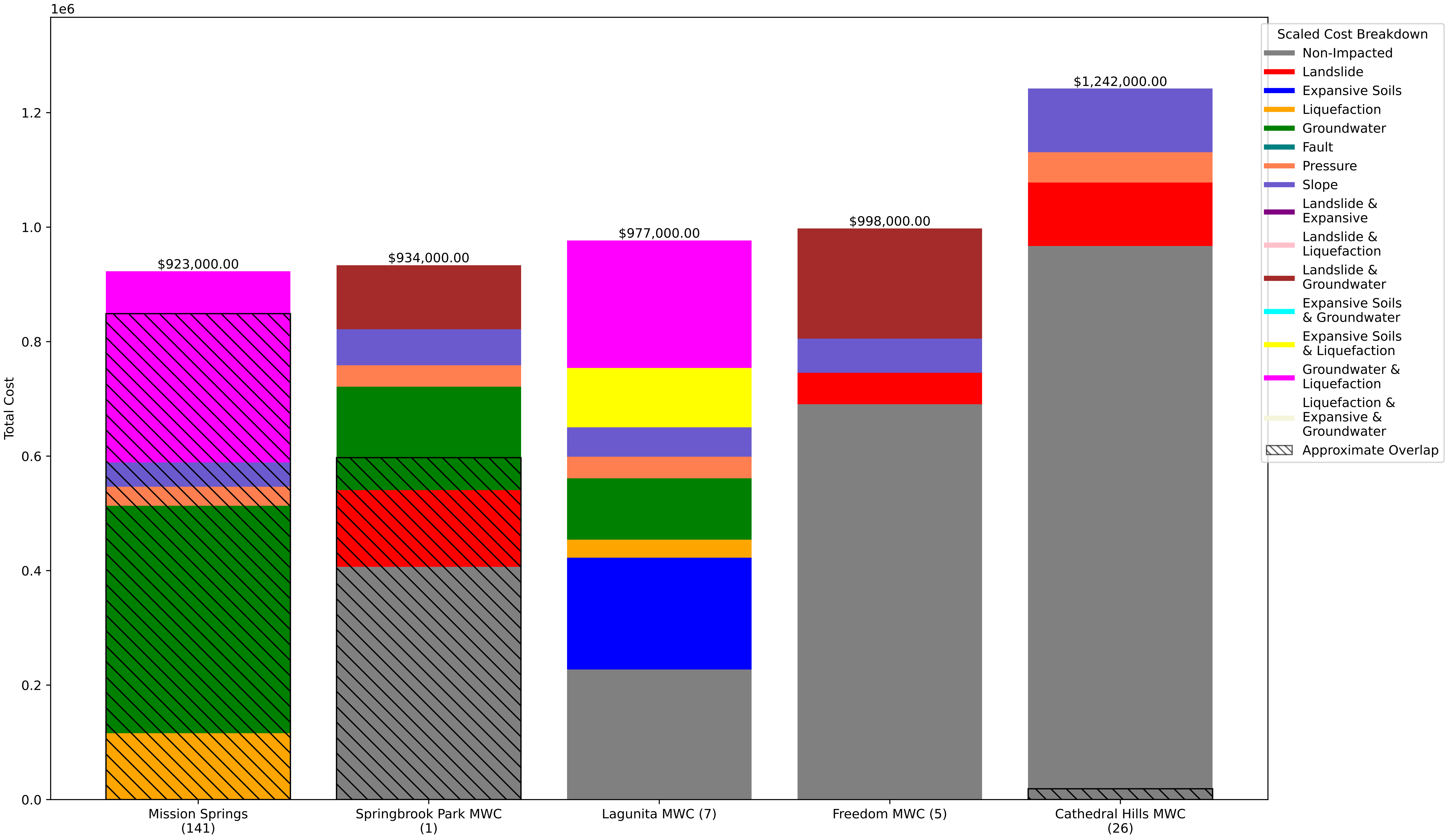
Total Cost
500000
400000
300000
200000
100000
0
$248,000.00
$312,000.00
$439,000.00
$439,000.00
$456,000.00
Sun & Shadow MWC (10)
Cabrillo College (2)
Las Colinas Road And Water Assoc. (24)
Brackenbrae Country Club (24)
Aptos High School (6)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

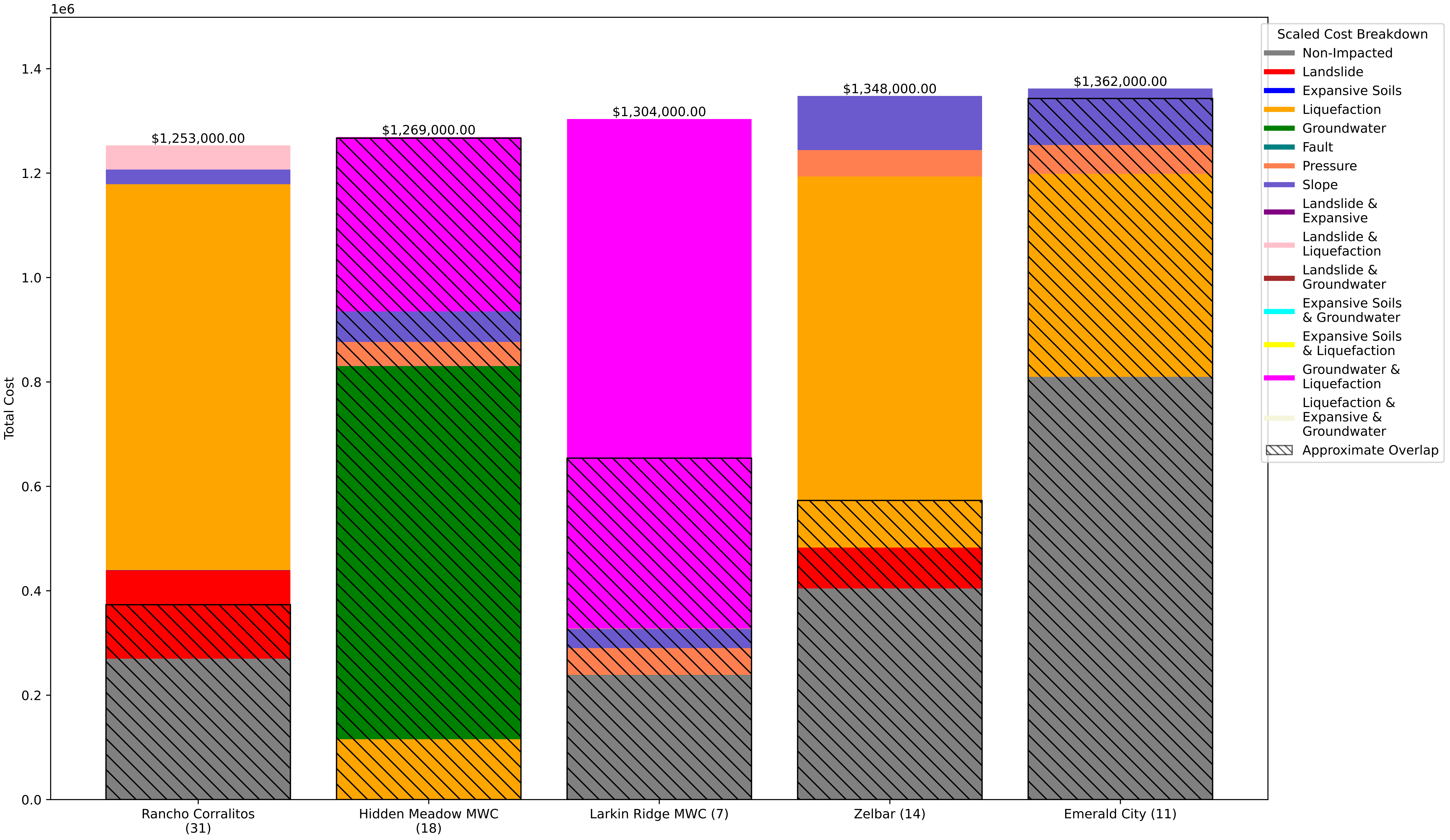


Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap
Total Cost
0
100000
200000
300000
400000
500000
600000
700000
$483,000.00
$577,000.00
$578,000.00
$580,000.00
$667,000.00
Crestwood Heights Water Co. (45)
River Grove Mutual Water Assoc. (25)
Rancho Soquel Water System (8)
East Bel Mar (5)
Trout Gulch Water (186)

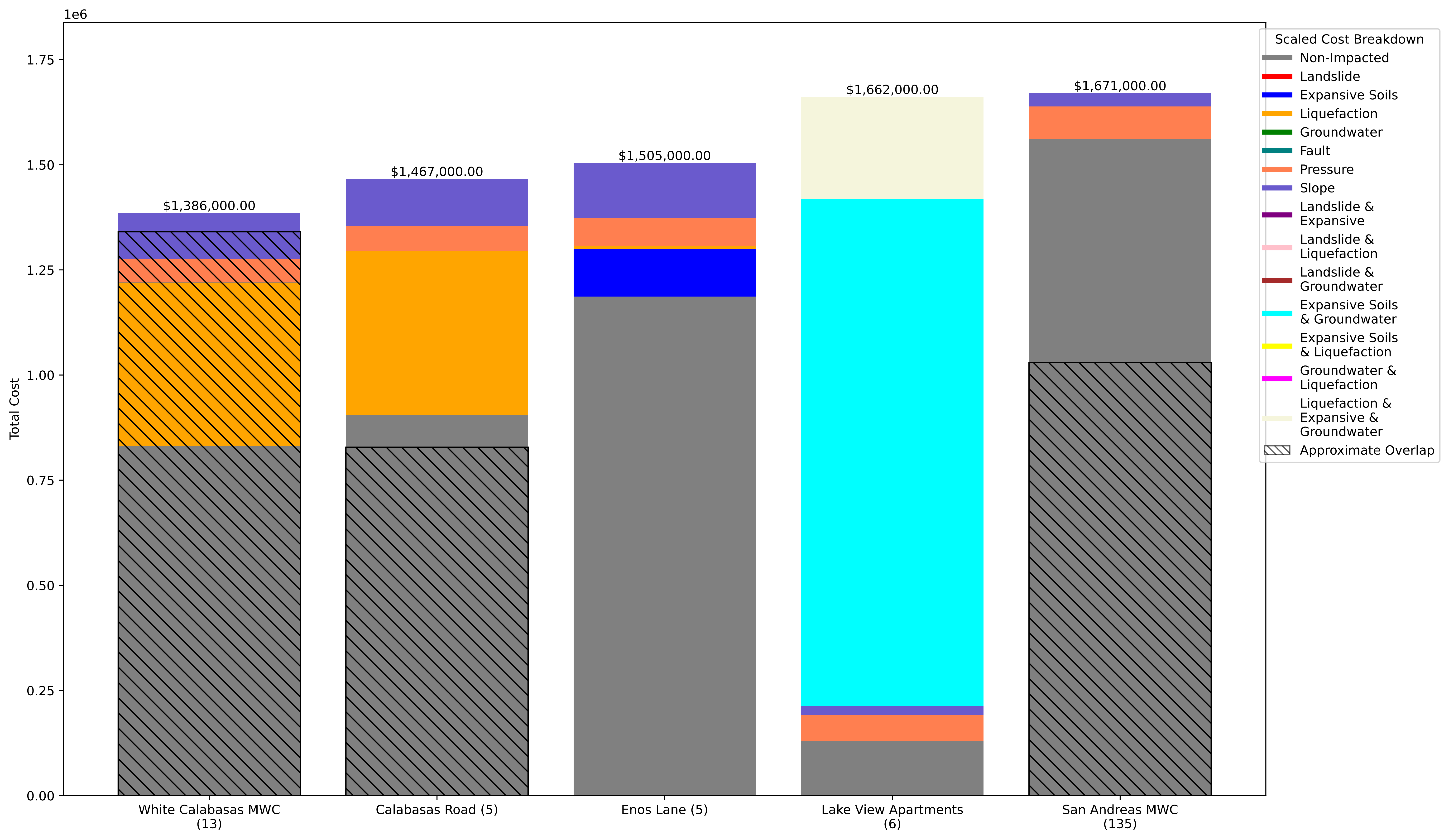


Total Cost
800000
600000
400000
200000
0
$717,000.00
$740,000.00
$804,000.00
$845,000.00
$855,000.00
Ridgeview Estates, Inc. (18)
Love Creek Heights Mutual Water Assoc. (7)
Vista Oaks (11)
Sunset Beach (65)
PureSource (77)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

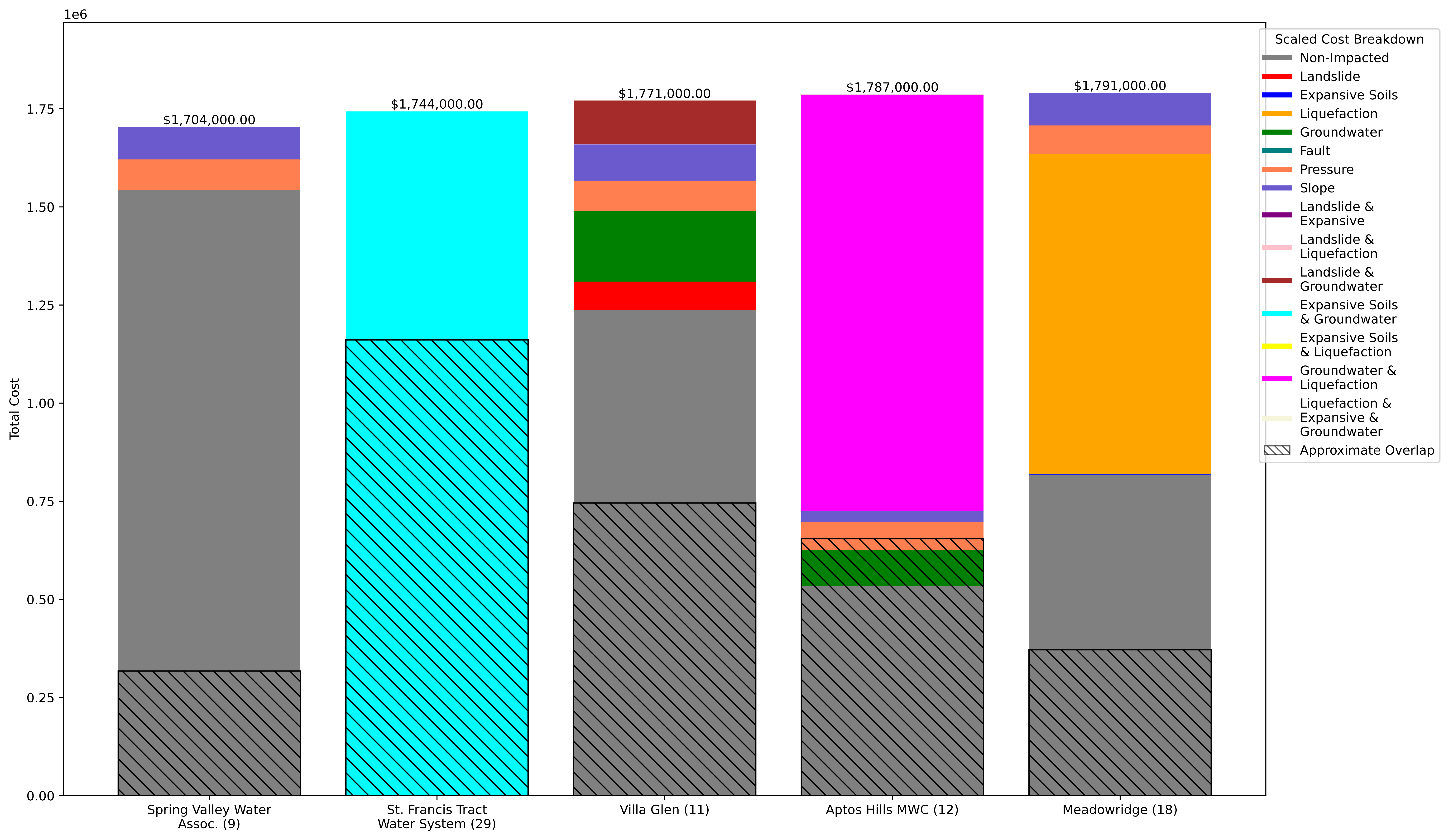

1e6
Total Cost
1.2
1.0
0.8
0.6
0.4
0.2
0.0
$923,000.00
$934,000.00
$977,000.00
$998,000.00
$1,242,000.00
Mission Springs (141)
Springbrook Park MWC (1)
Lagunita MWC (7)
Freedom MWC (5)
Cathedral Hills MWC (26)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

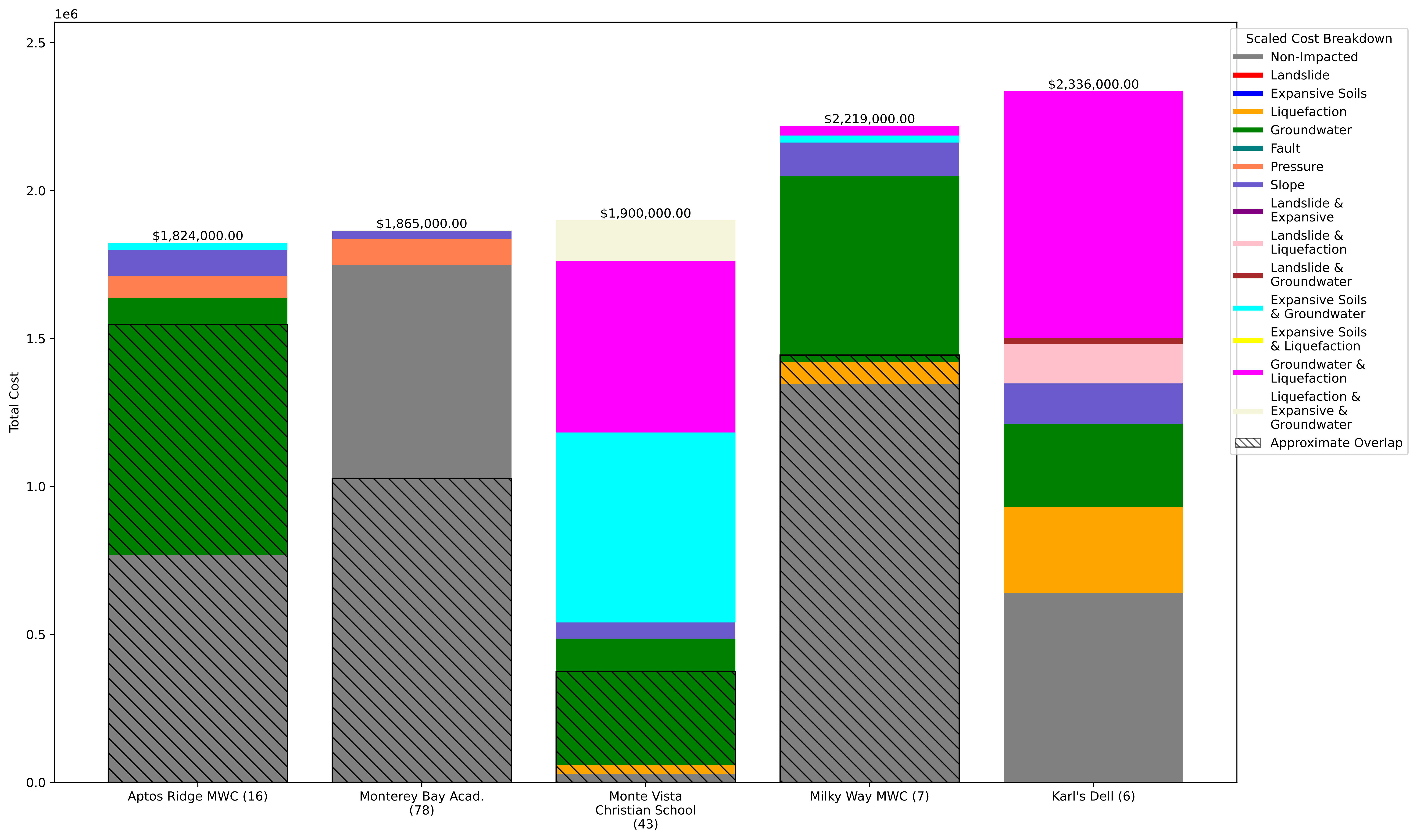


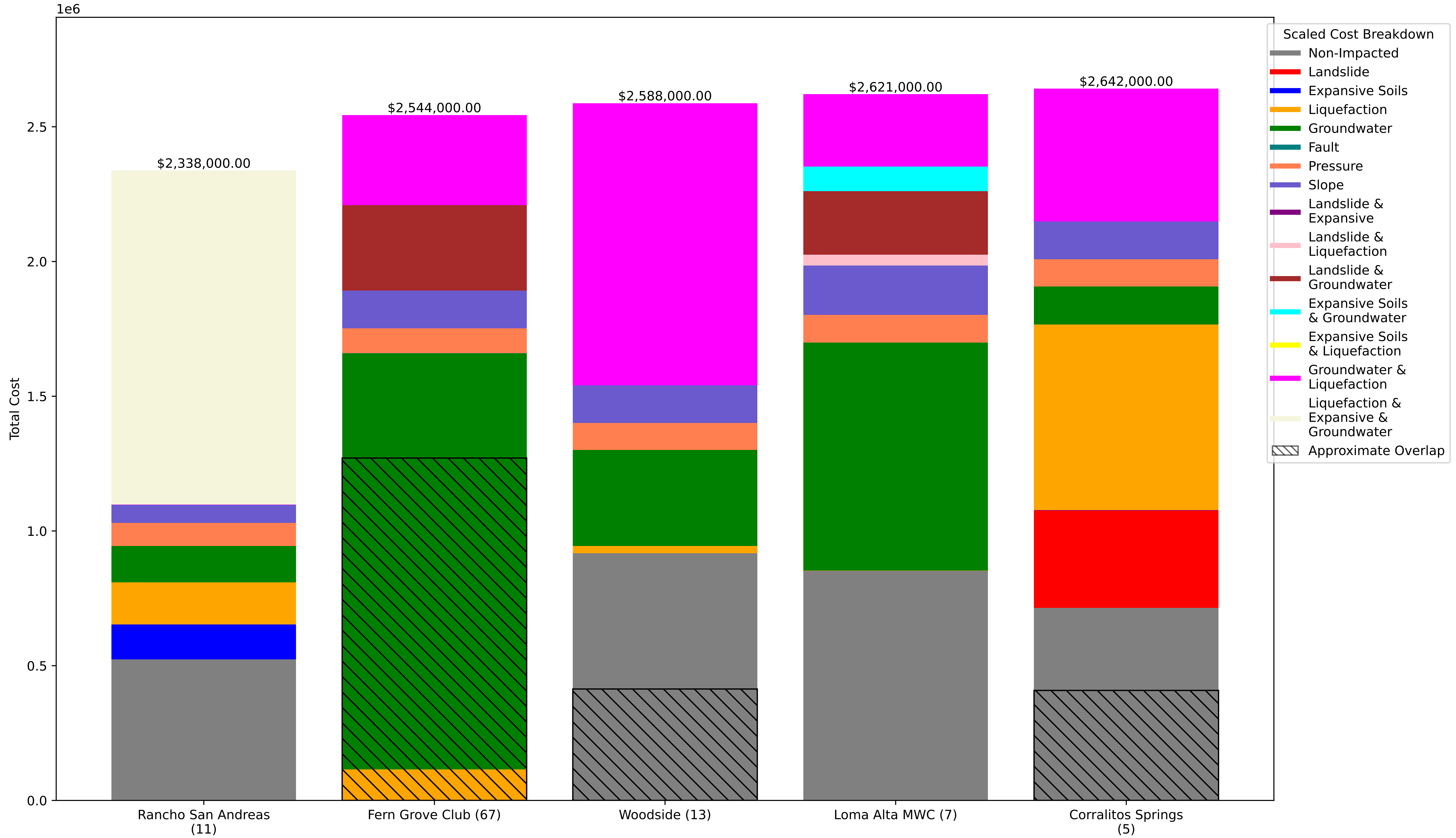
1e6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Total Cost
$1,253,000.00
$1,269,000.00
$1,304,000.00
$1,348,000.00
$1,362,000.00
Rancho Corralitos (31)
Hidden Meadow MWC (18)
Larkin Ridge MWC (7)
Zelbar (14)
Emerald City (11)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

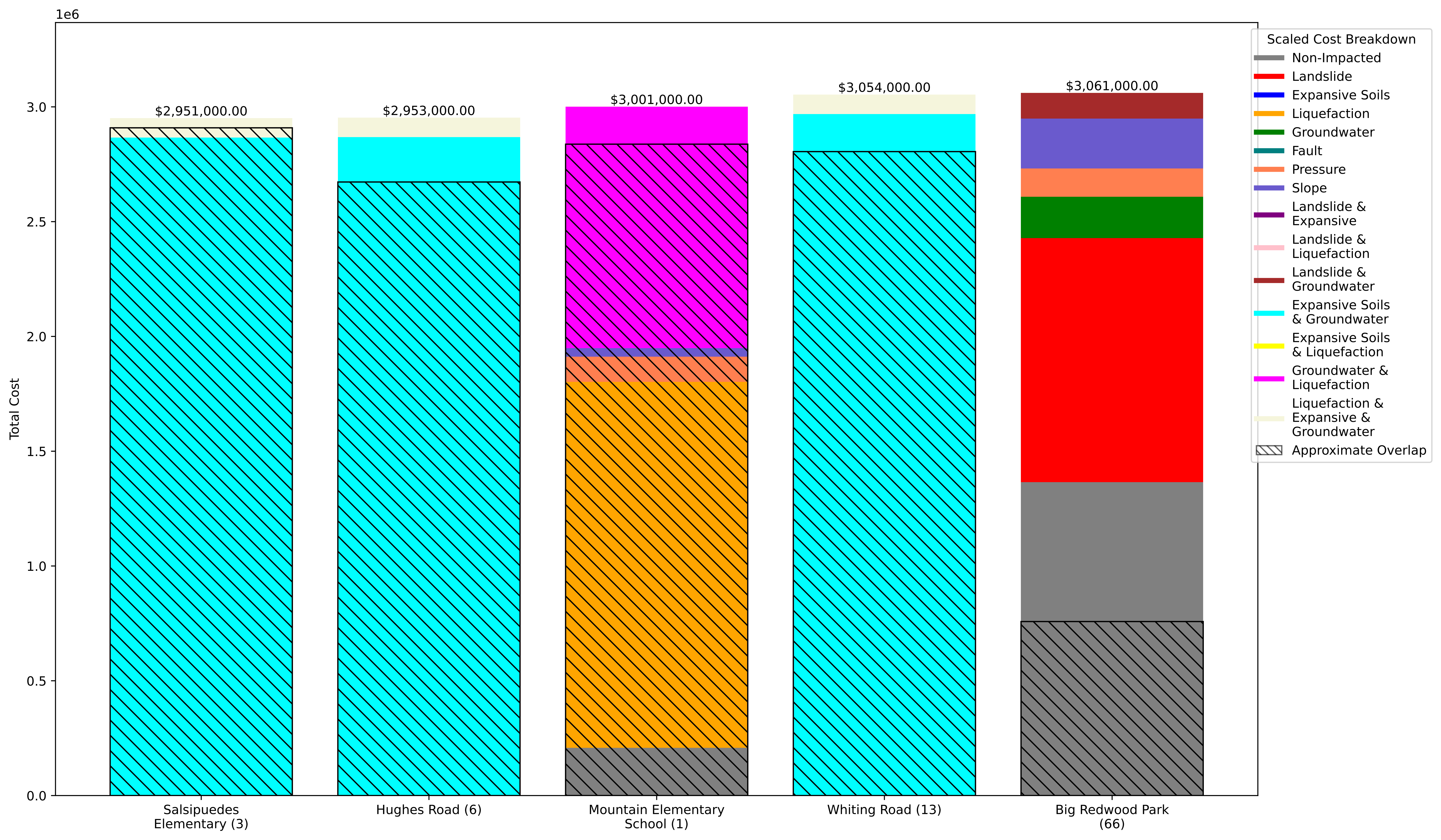


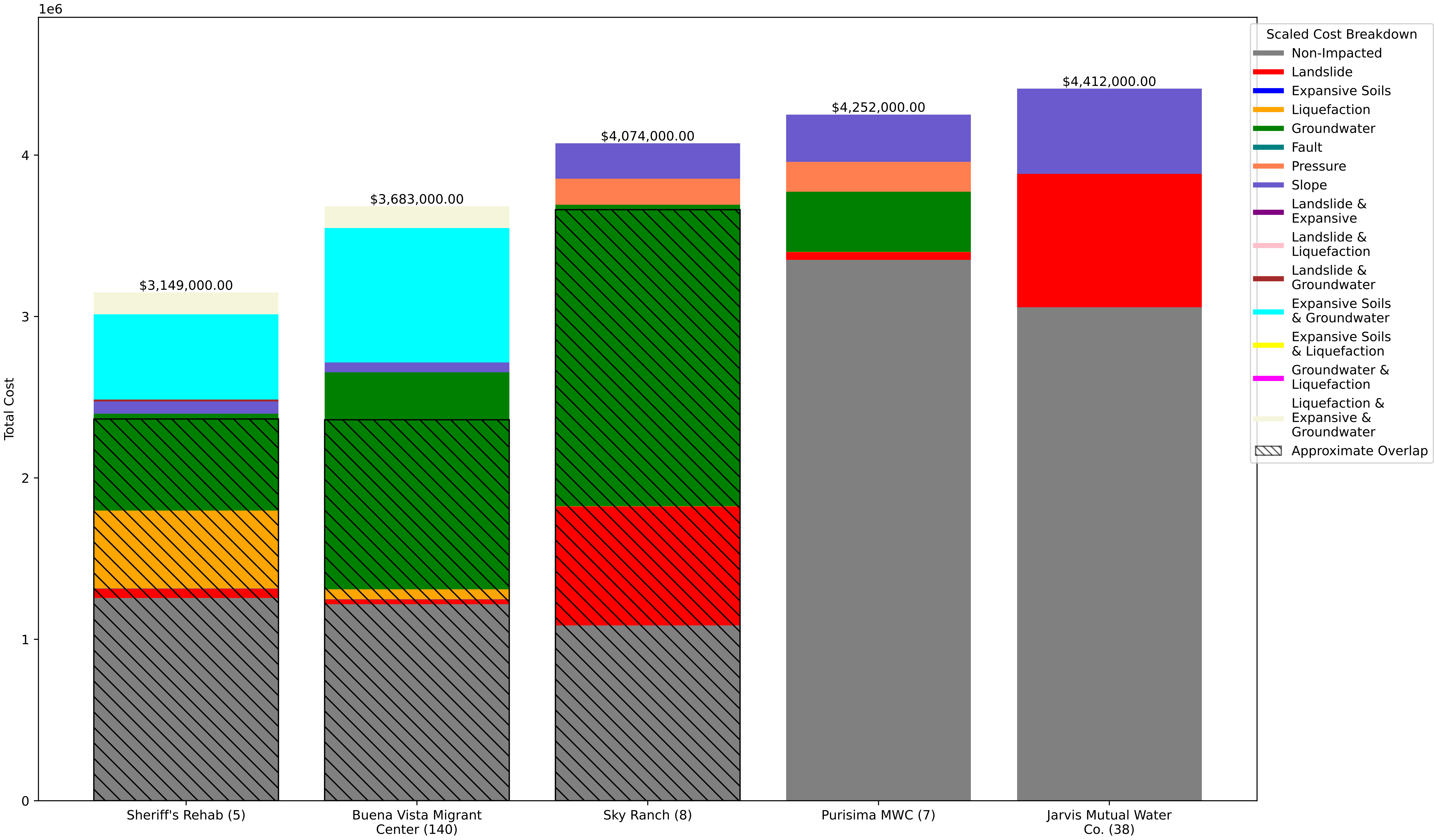
1e6
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Total Cost
$1,386,000.00
$1,467,000.00
$1,505,000.00
$1,662,000.00
$1,671,000.00
White Calabasas MWC (13)
Calabasas Road (5)
Enos Lane (5)
Lake View Apartments (6)
San Andreas MWC (135)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap


1e6
$1,704,000.00
$1,744,000.00
$1,771,000.00
$1,787,000.00
$1,791,000.00
Total Cost
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
Spring Valley Water Assoc. (9)
St. Francis Tract Water System (29)
Villa Glen (11)
Aptos Hills MWC (12)
Meadowridge (18)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

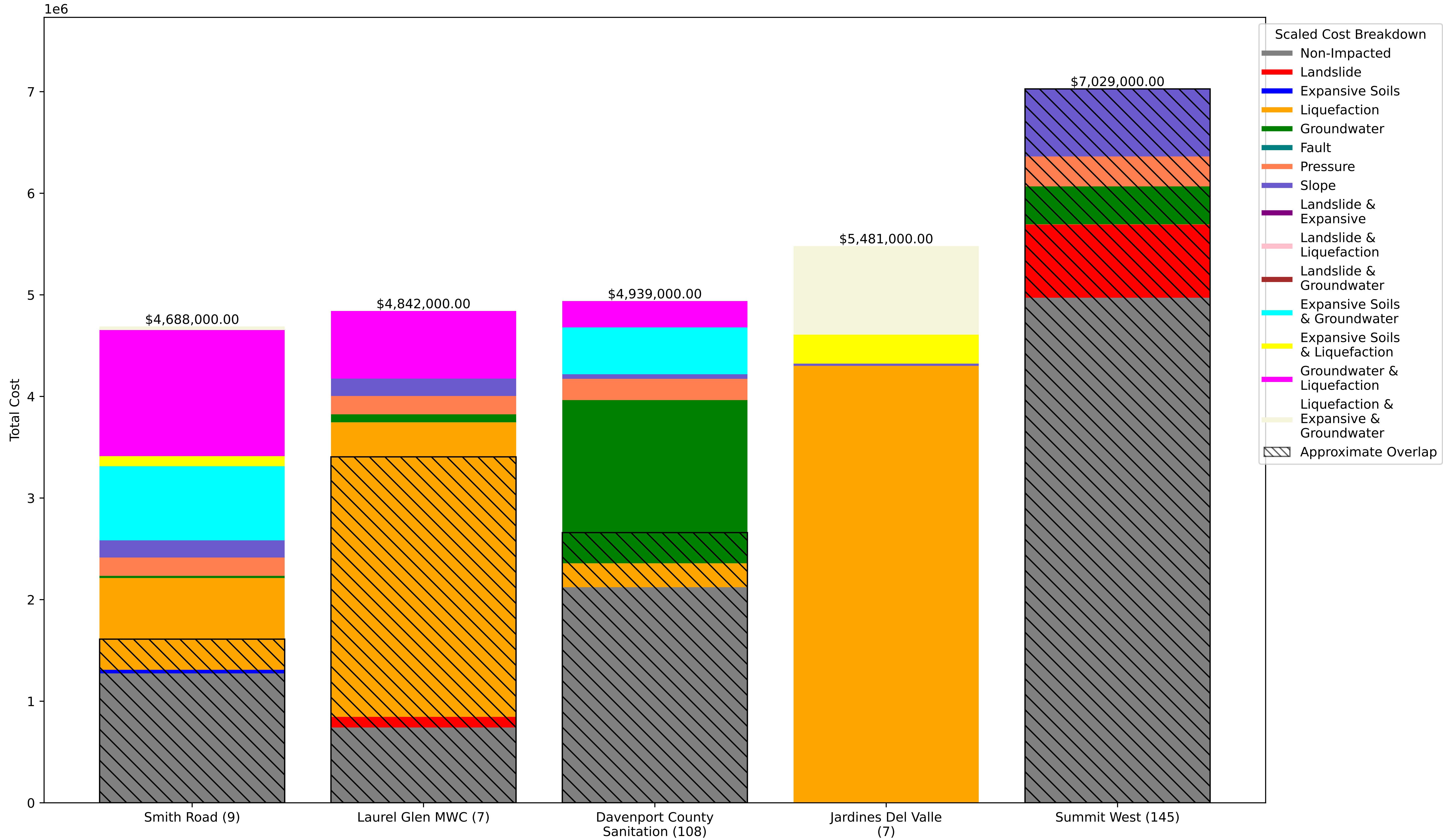

1e6
2.5
2.0
1.5
1.0
0.5
0.0
Total Cost
$1,824,000.00
$1,865,000.00
$1,900,000.00
$2,219,000.00
$2,336,000.00
Aptos Ridge MWC (16)
Monterey Bay Acad. (78)
Monte Vista Christian School (43)
Milky Way MWC (7)
Karl's Dell (6)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

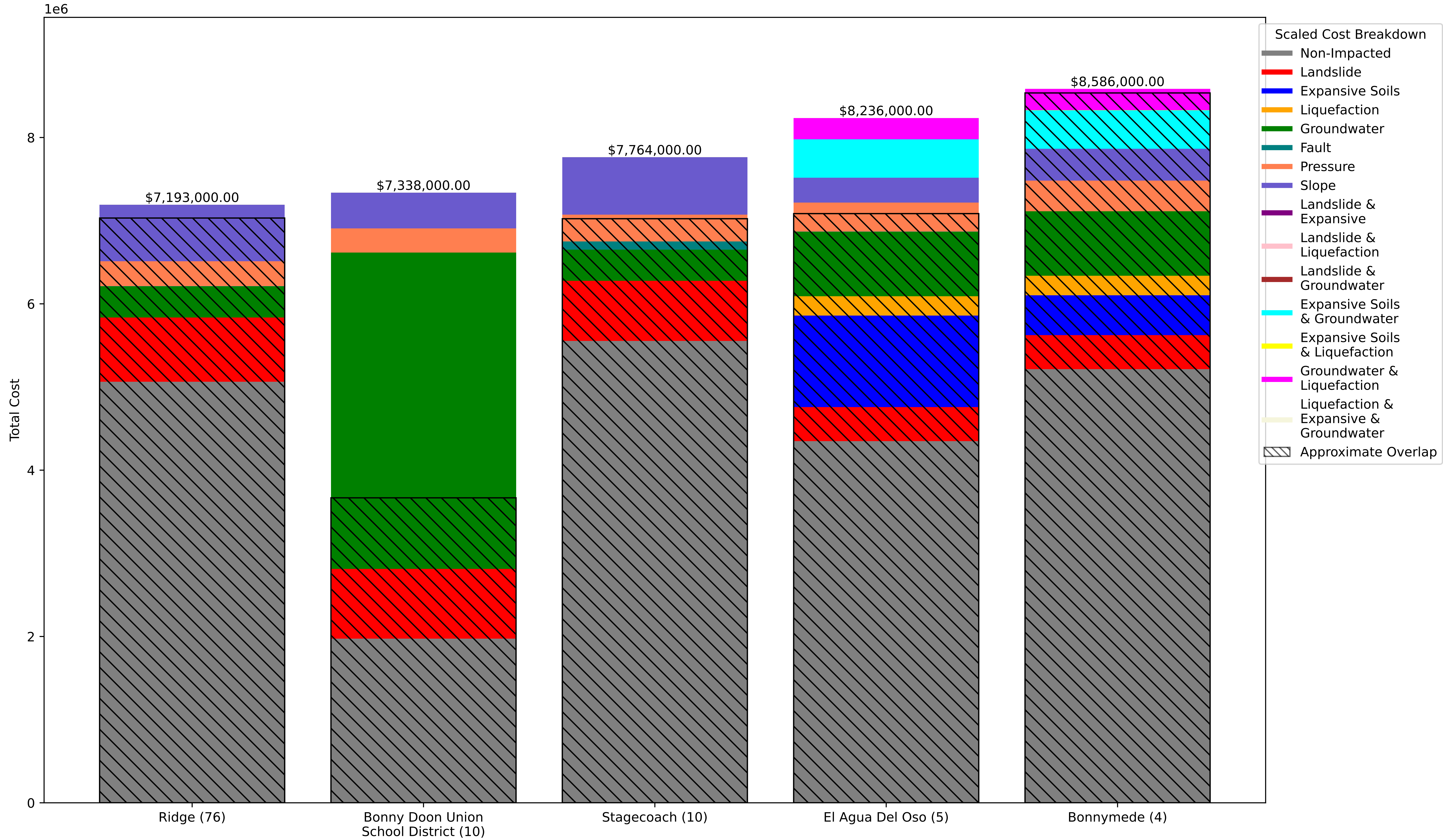

1e6
2.5
2.0
1.5
1.0
0.5
0.0
Total Cost
$2,338,000.00
$2,544,000.00
$2,588,000.00
$2,621,000.00
$2,642,000.00
Rancho San Andreas (11)
Fern Grove Club (67)
Woodside (13)
Loma Alta MWC (7)
Corralitos Springs (5)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap


1e6
Total Cost
3.0
2.5
2.0
1.5
1.0
0.5
0.0
$2,951,000.00
$2,953,000.00
$3,001,000.00
$3,054,000.00
$3,061,000.00
Salsipuedes Elementary (3)
Hughes Road (6)
Mountain Elementary School (1)
Whiting Road (13)
Big Redwood Park (66)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap

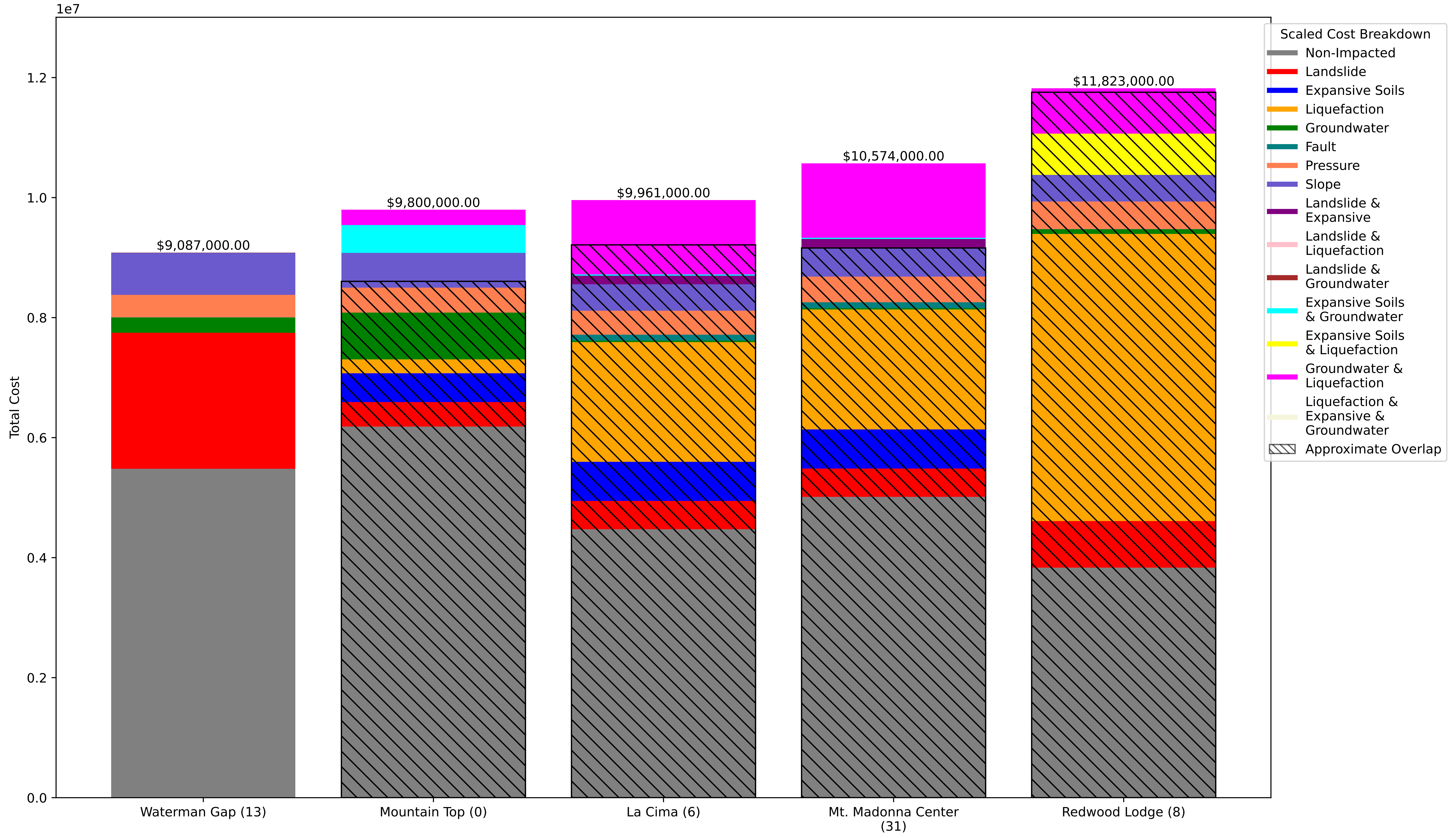


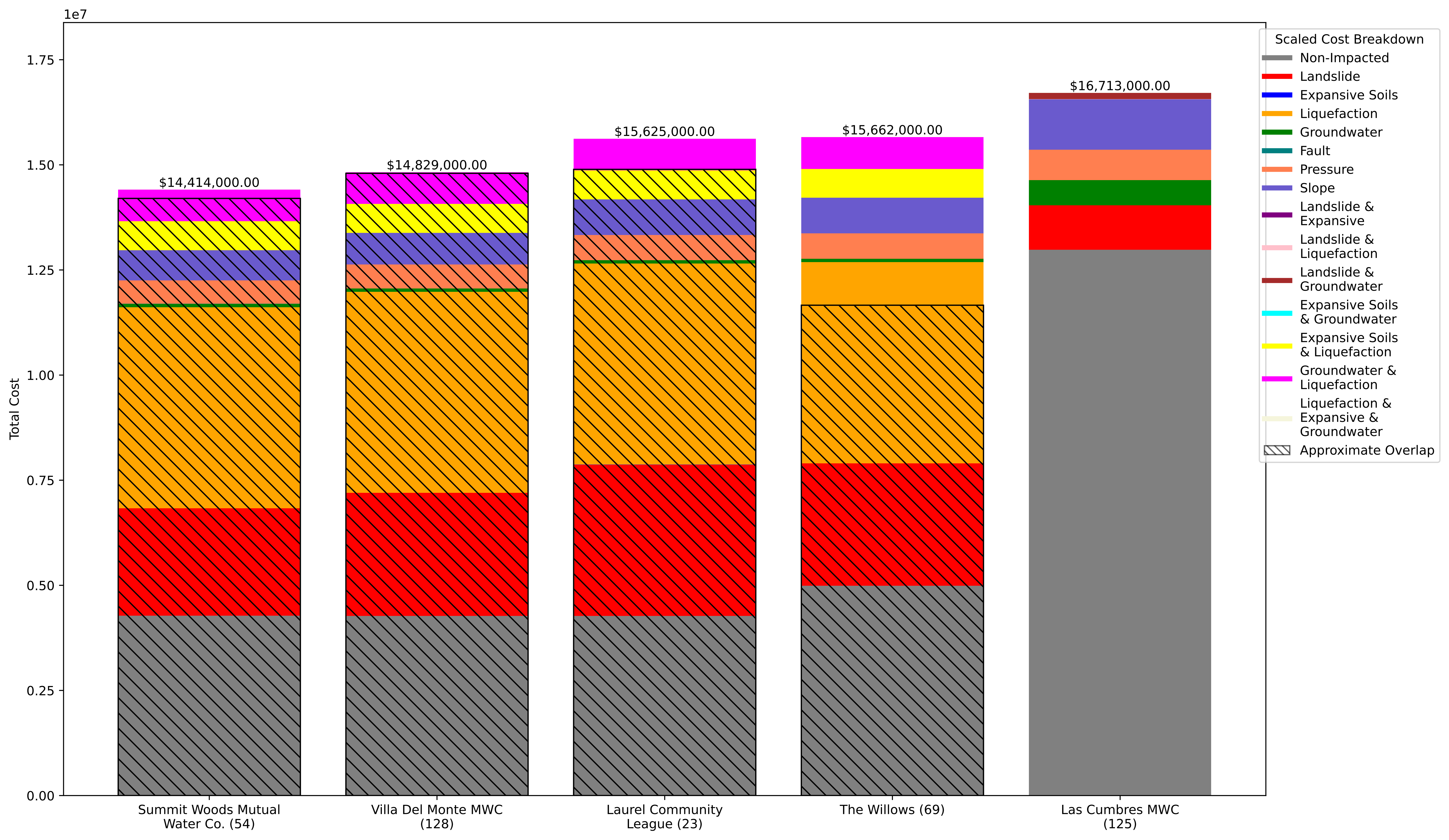
1e6
Total Cost
0
1
2
3
4
$3,149,000.00
$3,683,000.00
$4,074,000.00
$4,252,000.00
$4,412,000.00
Sheriff's Rehab (5)
Buena Vista Migrant Center (140)
Sky Ranch (8)
Purisima MWC (7)
Jarvis Mutual Water Co. (38)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap


1e6
Total Cost
$4,688,000.00
$4,842,000.00
$4,939,000.00
$5,481,000.00
$7,029,000.00
Smith Road (9)
Laurel Glen MWC (7)
Davenport County Sanitation (108)
Jardines Del Valle (7)
Summit West (145)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap



1e6
Total Cost
0
2
4
6
8
$7,193,000.00
$7,338,000.00
$7,764,000.00
$8,236,000.00
$8,586,000.00
Ridge (76)
Bonny Doon Union School District (10)
Stagecoach (10)
El Agua Del Oso (5)
Bonnymede (4)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap


1e7
Total Cost
0.0
0.2
0.4
0.6
0.8
1.0
1.2
$9,087,000.00
$9,800,000.00
$9,961,000.00
$10,574,000.00
$11,823,000.00
Waterman Gap (13)
Mountain Top (0)
La Cima (6)
Mt. Madonna Center (31)
Redwood Lodge (8)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap


1e7
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Total Cost
$14,414,000.00
$14,829,000.00
$15,625,000.00
$15,662,000.00
$16,713,000.00
Summit Woods Mutual Water Co. (54)
Villa Del Monte MWC (128)
Laurel Community League (23)
The Willows (69)
Las Cumbres MWC (125)
Scaled Cost Breakdown
Non-Impacted
Landslide
Expansive Soils
Liquefaction
Groundwater
Fault
Pressure
Slope
Landslide & Expansive
Landslide & Liquefaction
Landslide & Groundwater
Expansive Soils & Groundwater
Expansive Soils & Liquefaction
Groundwater & Liquefaction
Liquefaction & Expansive & Groundwater
Approximate Overlap