Laguna-Mark West Creek Watershed Planning Scoping Study

Technical Memorandum

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Prepared for

SONOMA COUNTY WATER AGENCY

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PROJECT SCREENING TECHNICAL MEMORANDUM

Introduction

The Sonoma County Water Agency (Water Agency) administers several flood control zones including Zone 1A, the Laguna-Mark West Watershed (watershed), which historically has been focused on providing drainage and flood protection services, using property-based assessments as a funding source. The watershed includes the Laguna de Santa Rosa and Mark West Creek sub-watersheds, which drain to the Russian River. The groundwater system underneath the Santa Rosa Plain provides rural residential, municipal, agricultural, and industrial water supplies as well as baseflow to streams and surface water bodies. The watershed and the plain incorporate most of the major population centers in Sonoma County.

The Laguna-Mark West Watershed Planning Scoping Study encompasses an effort to identify the potential for projects within the watershed that provide flood protection and promote groundwater recharge and other watershed benefits, such as ecosystem, water quality, water supply, agricultural, open space, and other community benefits. The Water Agency has undertaken this project in active partnership with stakeholders, who have helped define project objectives, screening criteria, and project concepts for the primary purpose of reducing flood hazards and enhancing the reliability of local groundwater supplies.

Core and supporting project objectives were outlined in Technical Memorandum No. 1 dated March 11, 2011. The core project objectives are to reduce flood hazard and promote groundwater recharge within the watershed.

Flood alleviation projects that provide flow and volume attenuation through storage and infiltration can also promote recharge. In contrast, in-stream hydraulic capacity projects such as floodwalls and pipeline bypasses may provide flood reduction benefits but are not generally effective in reducing overall flood flows or volumes or in promoting groundwater recharge. The focus of this study is on methods that accomplish both objectives. Examples of project types or elements that may be combined include swale or floodplain expansion, detention or retention, forest restoration, bypass channel, sediment removal or reduction, channel or bank modification, and existing reservoir expansion. Projects that meet core objectives may, for example, have elements of detention, which holds back flow within a storage area and meters it out after the peak storm has passed through a structural outlet such as a pipe or weir. Retention, which holds back flow in a storage area and infiltrates it to the underlying surface, will also be considered. Because flow releases via detention typically occur more rapidly, the area required is smaller than for retention. For this type of project, the optimal configuration may be a combination of detention and retention such that peak flow reduction, project footprint, and recharge are optimized. Regional flood hazard reduction projects that promote recharge are optimally located upstream of the major topographic depression that is the Laguna floodplain. Therefore, areas in and downstream of the Laguna floodplain were screened out for these types of projects.

A Prioritized Project Study Area was developed by identifying areas that would accommodate a regional project meeting core objectives and screening out those that would not. Delineations of the 100-year storm from Federal Emergency Management Agency, Flood Insurance Maps Flood Insurance Rate Maps (1996 and revisions) and delineations provided by the Water Agency for the January 2006 storm were mapped.

Project objectives and the Prioritized Project Study Area were shared with stakeholders at a kickoff meeting held on April 27, 2011. Following the kickoff meeting, the soils and geologic data were updated, resulting in revisions to the Prioritized Project Study Areas. Refer to Hydrogeologic Update and Prioritized Project Area section for discussion of analysis and revisions.

Also following the kickoff meeting, the consultant team conducted one-on-one interviews with stakeholders who are active in the watershed in order to leverage information related to existing flooding problems and recharge opportunities to address core objectives. Because the Laguna-Mark West Watershed is urbanized, this effort included each municipality in the watershed, with expanded efforts to include other active stakeholders who offered assistance. As a result of this process, many project concepts took shape. In some cases, project concepts are based on records of local flooding problems, in others, regional projects with broader flood alleviation and recharge benefits were identified. Finally, consultant team members identified additional opportunities based on watershed knowledge and a revised Prioritized Study Area.

In order to track these concepts, they were numbered and entered into a GIS database. Refer to **Figure 1** for a map of project concepts, 100-year flooding, and January 2006 flooding. Where an opportunity could not be tied to a specific or a general location, the project ID is shown outside of the watershed boundary. Refer to the Project Concepts section for descriptions.

Hydrogeologic Update and Prioritized Project Area

The March 2011, Prioritized Project Study Area screened out soils and geology with low recharge potential based on recharge potential maps developed by the California Department of Water Resources (DWR). The DWR soil map of recharge potential used in this screening was developed in 1982 and was based on slope and permeability data from a Natural Resources Conservation Service Sonoma County Soil Survey[1]. The DWR geologic map of recharge potential was developed in 1975 and was based on slope and geologic unit permeability[2].

The Prioritized Project Study Area has been refined based on a recharge evaluation approach consistent with that taken by the Sonoma Ecology Center and the Water Agency in their Groundwater Recharge Mapping Project for the Sonoma Valley. The September 9, 2011, Todd Engineers Memorandum, included in **Appendix A,** documents the assumptions and methodologies and the results of these analyses.

The Todd Engineers Memorandum distinguishes between two types of projects: **natural recharge projects**, which occur near the surface with relatively minor excavation (depths up to six feet) and rely on underlying permeable soils, and **engineered recharge projects**, which require more extensive excavation (depths greater than six feet) and rely on underlying permeable geology. Examples of natural recharge projects are swales and expanded floodplains. Examples of engineered recharge projects are retention or detention basins.

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[1] DWR, February 1982, Evaluation of Groundwater Resources: Sonoma County, Bulletin 118-4

[2] DWR, December 1975, Evaluation of Groundwater Resources: Sonoma County, Volume 1: Geologic and Hydrologic Data, Bulletin 118-4

An evaluation of recharge potential based on soil coverage, with soil thickness typically ranging from four to six feet, is shown in **Figure 2**. An evaluation of recharge potential based on geology is shown in **Figure 3**. Refer to Project Concepts section for further discussion of natural versus engineered projects.

Revised Prioritized Study Areas for flood alleviation and recharge projects are shown in **Figure 4** and **Figure 5**. In order to target regions with flood alleviation potential, areas in and downstream of major floodplains were screened out. In order to avoid locating a project in a highly developed urban terrain, areas with imperviousness of 80% or greater[3] were screened out as well.

Figure 4 (natural recharge projects) depicts screened out areas with underlying soils with a moderate or less recharge potential and retained areas with soils that have a recharge potential of high or very high.

Figure 5 (engineered recharge projects) depicts screened out areas with underlying geology with a moderate or less recharge potential and retained areas with geology that has a recharge potential of high or very high.

Project Concepts

Following is a summary of project concepts that were developed as a result of interviews with stakeholders and through collaboration within the consultant team. Project concepts that are most responsive to the core objectives target regional flood problems and have either natural recharge potential or engineered recharge potential. All potential project concepts are listed, even those that don't respond to both core objectives. Many valuable ideas were put forth that have potential for further study under separate project initiatives or funding opportunities.

Flood reduction and natural recharge projects will occur close to existing grade and may take the form of swales, expanded floodplains, or some combination. Flood reduction and engineered recharge projects will consist of an online or offline, excavated, vegetated, detention or retention basin but may also incorporate swales and floodplain expansion. In addition, in-stream enhancements, terraced overbanks, improved riparian cover, seasonal wetlands, and other elements can be incorporated into both types of projects to increase ecological and water quality benefits. Until a specific site is selected and site-specific opportunities and constraints are identified, it is impossible to determine which of these elements are best to include. Therefore, specific project configuration, project elements, and descriptive project names are not defined at this stage. Because natural recharge projects spread out flow, slow it down, and filter it, it is assumed that some improvement to aquatic and/or riparian habitat will be made, and that ecological and water quality supporting objectives will be met.

Other types of projects that would contribute in some way to reducing flood flows whether via rain interception, reduction in capacity-reducing sediment, or other means, include: forest restoration, bypass channel, road or other improvements to reduce sediment input, channel bank improvements, and modifications to existing facilities including reservoirs. A handful of project concepts are categorized as miscellaneous and represent concepts that don't fall into primary categories. The attempt to categorize is not intended to limit potential elements to project concepts. For example, if a detention or retention basin project is selected because of underlying impermeable soil and permeable geology, other elements, such as sediment removal, floodplain expansion, may be incorporated or even required.

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[3] Todd, 2011, Figure 11

Numerical project identification and generalized information such as location, description, and project type are summarized in **Table 1** and described below. The project author field indicates the origin(s) of the project concept.

Projects with permeable underlying soils fall into the natural recharge project category, and projects with permeable underlying geology fall into the engineered recharge project category. Projects with permeable underlying soils and geology have the flexibility to have elements of either or both. Because natural projects reflect less land and environmental disturbance, incorporation of natural features is recommended where possible.

City of Rohnert Park

The City of Rohnert Park lies downstream of four creeks that are tributary to the Laguna (Copeland, Hinebaugh, Crane, and Five Creeks). Copeland Creek is known to host salmonids, and all four provide potentially suitable habitat. These creeks are channelized as they pass through the City, and the City works actively with Water Agency and its local creek committee to plan for and manage these recognized community assets. The Water Agency and City have also worked closely together to manage sediment, particularly in the Hinebaugh sub-watershed, which is a result of upper watershed land practices. The City has experienced flooding in severe storm events and has worked with the Water Agency to develop both capital improvement projects and enhanced maintenance practices to help mitigate this risk.

Rohnert Park has a well-developed network of 42 municipal water supply wells that draw from the Santa Rosa Plain Groundwater Basin. While groundwater levels under the City have historically been a concern, since the adoption of its 2000 General Plan and its 2004 Water Policy Resolution, the City has engaged in an active conjunctive management program which balances groundwater withdrawals with purchases from the Water Agency, recycled water use and increased water conservation. Regular monitoring of the groundwater levels in the City's well's illustrate recovery of historic groundwater levels and are indicative of the recharge potential in the area.

Rohnert Park's General Plan provides for planned growth within the City's approved Urban Growth limit. According to the General Plan, growth will occur in five major specific plan areas and two significant planned development areas that are generally located east and west of the current City limits. The City has worked extensively with development representatives to understand and mitigate the impacts of this growth. The City has recently updated its Public Facilities Finance Plan (November 2011), to provide a local funding source for detention facilities upstream of new development. The combination of local planning, funding and available infrastructure provides a sound base for building regionally significant projects.

Rohnert Park Project Concepts

(Project 1) A reach of Coleman Creek was rerouted into an 84" pipe that experiences sedimentation, making it difficult to maintain. Daylighting the creek and creating an expanded floodplain area with detention or retention and recharge components may reduce downstream flooding in the City and replenish groundwater. Following the historical creek alignment to access alluvial soils would maximize recharge opportunities.

(Project 2) Five Creek, located south of Coleman Creek, traverses the City and provides an opportunity for a project with multiple benefits. There may be opportunities for detention or retention and recharge with wetland features in the portion of the Five Creeks watershed downstream of the Sonoma Mountains and east of Petaluma Hill Road.

(Project 3) Two existing constructed wetland sites along Hinebaugh Creek may be candidates for modifications to maximize floodwater detention. Since these projects were constructed for mitigation purposes, however, it may be difficult to obtain approval from the Regional Water Quality Control Board.

(Project 5) Detention or retention and recharge or floodplain improvements on upper reaches of Copeland Creek could reduce flooding in the City of Rohnert Park and in the City of Cotati, which floods at the confluence of Copeland Creek and the Laguna de Santa Rosa (Laguna). The upper Copeland Creek watershed exhibits prime steelhead habitat, therefore, enhancing this area would serve multiple benefits and appeal to regulators.

Detention or retention and recharge or floodplain expansion in upper Crane Creek (Project 4) or lower Crane Creek (Project 6), the headwaters of Cook Creek (Project 8) and Five Creek (Project 7) to alleviate downstream flooding are also worth considering.

(Project 9) Education of vineyard owners to reduce groundwater drawdown would benefit all aquifer users.

(Project 10) The Copeland Creek Watershed Storm Water Detention, Groundwater Recharge, Habitat Restoration, and Steelhead Refugia Project is a multi-phase regionally integrated project located in and near the City of Rohnert Park. The first phase includes the reach of Copeland Creek from Highway 101 east to Snyder Lane and provides habitat enhancement, restoration, and sediment removal from Copeland Creek, which will reduce nutrients and pollutants entering the channel, improve surface water quality, increase the quantity and quality of habitat available for native wildlife, enhance stream conditions to support fisheries, and improve storm water management. The first phase also includes preliminary engineering and environmental work for the construction of detention basins to reduce peak flows in Copeland Creek sufficiently to contain the 100 year storm within the banks of the creek. Subsequent project phases will complete the design, environmental, permitting, and construction for the detention basins, complete trail construction and rehabilitation along Copeland Creek, increase preserved open space by 75 acres, and provide public access connectivity extending along the entire project length to the Crane Creek Regional Park. This multi-phased project will improve flood protection, reduce sediment deposition downstream where Copeland Creek flows to the Laguna De Santa Rosa, recharge groundwater, improve salmonid habitat, provide salmonid refugia off-stream, conserve energy resulting from reduced pumping and importation of potable surface water, and create a site for public access and education about the hydrology, the water cycle, fish habitat, and geomorphic processes in the Copeland Creek watershed.

Mark West Creek Watershed

According to the Russian River Coho Water Resources Partnership (Partnership), an estimated 190 adult coho salmon returned to the Russian River this year compared last year's average of less than four. Coho will be introduced into Mark West Creek by the Partnership (as well as Dutch Bill Creek, Grape Creek, Green Valley Creek, and Mill Creek). This indicates strong political will in the Mark West Creek watershed and opportunities for grant funding of projects which target improvement of salmonid habitat.

The upper Mark West Creek watershed extends from the headwaters of Mark West Creek to its confluence with Porter Creek and encompasses approximately 20,000 acres. The upper shed receives roughly 48 inches of rain annually. Land use modifications that have altered the upper shed include: clear cutting or burning of oak woodlands for grazing; grazing of goats which killed oak tree root sprouts, compacted the land, altered plant life, and effectively converted woodlands to grasslands; straightening of the creek to accommodate development; construction of roads; cutting and exportation of fir trees for shipyard construction; controlled burns and cessation of controlled burns have impacts on forest understory and associated ecology. Studies throughout the Mark West watershed are fragmented. The headwaters of Mark West and Santa Rosa Creeks were mapped by USGS at one time as potential recharge areas underlain by porous volcanic material.

Projects in the upper watershed would address source issues. By identifying sources of accelerated runoff/erosion, downstream sedimentation and resulting flooding can be alleviated. The upper watershed receives approximately twice as much rain as lower watershed areas, which creates a greater potential for groundwater recharge in the upper watershed. The citizens who reside in the upper shed represent a source of support for and potential involvement in restoration and related efforts.

Upper Mark West Creek Watershed Project Concepts
(Project 21) There are opportunities for ponding and infiltration of water on unused open space in the upper watershed.

(Project 22) A privately owned dam in the upper Markwest Watershed is a non-engineered, unshored dam that has released a significant amount of sediment due to land disturbance and could release significant quantities in the event of failure. Shoring of the dam would reduce sediment loads and risk of dam failure.

(Project 24) Purchasing conservation easements on existing Agricultural Preserves would remove tax relief incentives created by the Williamson Act for housing cattle.

(Project 25) Construction of in-stream check dams to create recharge pools upstream of anadromy in reaches with mild slopes. Effectiveness of recharge would have to be verified.

(Project 26) Forrest restoration projects in the upper shed would retard runoff, reduce erosion, and promote infiltration.

Road Conversion Project Concept
The California Department of Fish and Game (CDFG) has converted several miles of conventional roadway to sloped configurations, rolling dips, and other means which reduce point source flow and associated sediment loads and spread runoff in order to more closely mimic natural drainage patterns. Significant funding for these improvements was a result of temperature and water quality monitoring performed by the Sotoyome Resource Conservation District (Sotoyome RCD), which revealed excess fine sediments in streams. The Sotoyome RCD is currently actively looking for funds for a hydrologic study to support on-going sediment reduction efforts and to better understand watershed functions and watershed responses to various landuses.

(Project 23) Projects to improve additional rural roads to reduce sedimentation delivery to streams should be considered, especially in the upper shed. In addition, stormwater collection systems on County roads are designed without sufficient capacity which ultimately causes flooding and erosion. Upsizing existing hydraulic structures, or adding capacity by increasing the quantity would reduce flooding and erosion, especially large slugs of sediment and ponded water associated with road failure due to overtopping.

Mark West Creek Confluence Project Concept
The confluence of Mark West Creek with the Laguna has been manipulated over time to an unnatural, hooked alignment which regurgitates sediment, debris, and resulting backwaters onto adjacent property, as well as steelhead trout, which have been observed, stranded, on the Dennar Ranch property. As a result of Mark West Creek depositing its sediment load into the Laguna, the Laguna backwaters and exacerbates flooding problems.

(Project 30) Three reaches of vegetation suggest prior alignments, the northern-most of which appears in plan to be the least straight-lined and manipulated. A channel realignment or bypass channel connection might be designed to provide migration habitat for steelhead and coho and circumvent existing locations of steelhead stranding. In addition, a more direct, steeply graded path would increase energy for transport of sediment and debris than the existing alignment. High and low fish flows for target species and life cycles would have to be considered if the project was to succeed as providing passage, and the potential water rights of landowners might complicate a re-alignment or channel bypass project.

Reservoir Modifications
Modification of existing reservoirs to promote recharge might provide opportunities to capitalize on existing projects. Modifications could include increasing storage capacity through outlet modifications or expanding with a settling basin and dedicated recharge pool. Existing reservoirs that might be examined for optimization measures include the (Project 50) Brush Creek, (Project 52) Piner Creek, (Project 53) Fountain Grove, and (Project 54) Mantanzas Creek Reservoirs.

City of Santa Rosa

Urban reaches of Santa Rosa Creek and of its tributaries were improved in order to meet the 100-year flood during the 1960s. Since then, vegetation management protocol has evolved, and a vegetated riparian corridor is fostered. The City is evaluating the capacity of Santa Rosa Creek and its tributaries to determine the current level of protection. The City is partnered with the USACE in this effort. If Santa Rosa Creek is found to have insufficient capacity, reservoir adjustments made to Spring Lake may accommodate high flow.

The capacity of major creeks in the southwest region of the City is also being evaluated. The City is teamed with the Federal Emergency Management Agency (FEMA) for the evaluation of Naval Creek, Roseland Creek, and Colgan Creek. Per the *Santa Rosa Citywide Creek Master Plan Hydrologic/Hydraulic Assessment*, prepared by the City of Santa Rosa Public Works Department, February 2006, the Roseland Creek flood control channel downstream of Hearn Avenue was constructed in the 1970s by the Water Agency to convey 25-year flow.

Preliminary results of FEMA studies indicate that that Colgan Creek flooding has the most probable impact on homes and that Roseland Creek has trouble spots with flow exiting channel banks.

A Draft Citywide Creek Master Plan outlines the status of each of the City's major creeks by reach and makes recommendations for enhancement and maintenance. Creek restoration projects identified on Colgan and Roseland Creek may complement project concepts proposed herein.

City of Santa Rosa Project Concepts

The headwaters of (Project 40) Colgan Creek and (Project 41) Roseland Creek may provide opportunities for recharge and floodplain creation projects which would reduce the risk of downstream flooding. The Colgan Creek was channelized in sections between Petaluma Hill Road to Tood Road which were designed for the 25-year storm upstream of Bellevue Avenue and the 100-year downstream. The Roseland Creek flood control channel was constructed in the 1970s and designed to convey the 25-year storm. This region is home to the California Tiger Salamander habitat, and restoring vernal pools which have been stranded by channelization and floodplain loss would align strongly with supporting objectives.

(Project 42) The urban reach of Kawana Springs is channelized concrete which fills with sediment and causes flooding; detention or retention and sediment management in the upper shed may help to alleviate flood problems downstream.

(Project 43) The upper Matanzas Creek watershed may also provide opportunities for recharge and detention or retention or floodplain creation projects. An existing reservoir in the watershed provides significant flood reduction and may restrict how much remaining downstream flood alleviation is possible through a project here.

(Project 44) Southeast Greenway is a proposed greenway project lead by the Southeast Greenway Campaign. The project is located on Caltrans-owned open space and extends to Spring Lake on old Highway 12 right-of-way at Farmer's Lane. The project has many proposed elements, including linked trails, agricultural open space, creek daylighting, seasonal wetland/flood control, community gardens, and park extension.

(Project 45) Spring Creek was identified as a channelized stream that would benefit from restoration and enhanced flood control and recharge.

(Project 46) Forrest restoration projects in the Santa Rosa Creek headwaters would retard runoff, reduce erosion, and promote infiltration.

(Project 55) Flood reduction and natural recharge on Santa Rosa Creek, which traverses downtown Santa Rosa, would improve downstream flood conditions. Habitat improvements would benefit steelhead and rainbow trout and Chinook salmon. The creek is currently being evaluated for hydraulic capacity.

Laguna de Santa Rosa Pools

Deep pools are reported to have characterized the reach of today's Laguna channel that stretches between Highway 12 and Guerneville Road, and remnants of these pools remain. The deep water pools were connected in winter and separated in summer when floodplain flows subsided. Sediment deposition from perennial streams may have formed dams to contain the pools, which remained wet from stream runoff or local springs, or both. Pools likely served as low temperature, freshwater summer refuge for salmonids.

Removal of sediment from the channel is part of the Water Agency's maintenance program to preserve hydraulic capacity. Within this reach between Highway 12 and Guerneville Road, in 2010, sediment was removed from the Laguna by the Water Agency to reduce upstream flooding in Sebastopol. Under certain circumstances, sediment can result in the growth of aquatic vegetation and weeds that can recruit more sediment and further plug up the stream. Per Honton and Sears, 2006, such vegetation might include Ludwigia, Himalayan blackberry, multi-trunked willows, Arundo donax. Ludwigia is an invasive aquatic primrose vine choking the reach of the Laguna between Occidental Road and the Bellevue-Wilfred Flood Control Channel with its biomass, which reduces channel capacity and aggravates existing flooding. Since Ludwigia thrives in shallow warm water, conversion of a reach of the Laguna to deep pools might assist in its eradication.

Laguna Pools Project Concepts

(Project 31) Enhancement of deep water pools in their speculated historical location, or (Project 32) creation of pools in areas selected to provide flood hazard reduction and groundwater recharge, or enhancement of pool remnants may provide recharge, flood control, and salmonid habitat benefits. Backwater channels, offline pools, or floodplain expansion in this area might also be worth considering, but further land use evaluations must be made.

Larkfield-Wikiup

For customers that don't own and rely on a drinking water well for its potable use, California American Water Company provides treated groundwater supplemented with supplies purchased from the Water Agency. The Water Agency is conducting a Groundwater Management Study in the Santa Rosa Plain and is looking for funding partners. California American Water Company is planning to participate. Little groundwater data are available in Larkfield Wikiup, and aquifers are confined with limited supply and drawdown capacity in the summer. Storage of late rains in the aquifer for summer use to supplement water supply would be ideal.

Larkfield Wikiup experiences some local flooding problems which do not warrant regional projects. Such incidences include the intersection of Carriage Lane and Pheasant Lane, Wikiup Bridge Way off of West Springs Road, and southeast of Barnes Road and River Road, within the City of Santa Rosa's boundaries. These locations are included for completeness but were not itemized as projects and screened because they represent problem locations and not actual projects.

Larkfield-Wikiup Project Concepts

(Project 70) Mark West Creek runs through town and is relatively urbanized with residential neighborhoods encroaching on the channel. Resident back yards abut sloughing channel banks, and evidence of channel incision has been observed. It appears that the 100-year flow is contained in the banks, however, an evaluation of creek capacity has not been conducted. Addressing bank incision would reduce sediment input into the creek.

(Project 71) At 300 Mark West Station Road adjacent to Mark West Creek, California American Water owns a 7-acre field adjacent to a neighborhood of approximately 65 residents whose well draw downs have been compromised in recent years. The field provides an opportunity for groundwater recharge. Shallow and deep groundwater monitoring data are available at this location.

Town of Windsor

There are five major creeks that flow through the Town of Windsor including, Windsor Creek, East Windsor Creek, Pool Creek, Pruitt Creek and Starr Creek. Localized flooding is cataloged on maps for maintenance purposes. The tributary drainage area to the Town of Windsor is approximately 17,600 acres, and the majority of runoff is conveyed through a network of creeks that discharge to Windsor Creek, which drains to Mark West Creek. Sotoyome Creek, in the northwestern portion of the Town, discharges to the Russian River.

Several stormwater master plans have been prepared for the Town of Windsor, most recently in 1999. The master plans have identified a number of potential detention alternatives with one of them currently constructed at Hiram Lewis Park on Windsor Creek. Other identified locations include potential sites on Airport Creek, Pruitt Creek, Pool Creek, Starr Creek, Gumview Creek, and Sotoyome Creek. The City is just beginning the process of updating their stormwater master plan to provide additional information on capacity and urban flooding potential.

The Town has a single groundwater well that it uses intermittently. Primary water supply is drawn from the Town's own Russian River wells (which are permitted under the Water Agency's overall water rights) and the Water Agency's Santa Rosa Aqueduct. The Town has recently completed a Water Master Plan that anticipates expanded groundwater use through new wells and potentially an aquifer storage and recovery project.

Town of Windsor Project Concepts

(Project 80) A groundwater banking study currently underway indicates possible passive recharge opportunities in the upland area southeast of town near Pruitt Creek and Pool Creek which could potentially reduce flooding near Highway 101 from Pruitt Creek. Potential projects could consist of detention or retention and recharge or floodplain expansion.

(Project 81) Opportunities for detention or retention and recharge and flood reduction exist along Pruitt Creek. Flow in Pruitt Creek exits the channel and floods nearby roads and a field in an area within the urban growth boundary that has not yet been annexed upstream of Highway 101. The road was closed as a result of the 2005 flood.

City of Sebastopol

The existing storm drain system in the City of Sebastopol (City) adequately conveys the storm flows of the two major waterways - Zimpher Creek and Calder Creek – and a third significant watershed (Healdsburg Avenue watershed), all of which traverse downtown and discharge through outfalls onto undeveloped area and into the Laguna de Santa Rosa (Laguna) at the east end of town.

Incidences of nuisance flooding which occur at storm drain inlets are short in duration. The majority of the collection system consists of underground pipe with reaches of creek surfacing for short stretches. Downtown Sebastopol is highly urbanized with tight storm drain corridors that limit opportunities for creek daylighting. The City's proximity to the Laguna makes it susceptible to backwater flooding when the Laguna rises due to flooding in the Russian River.

The City's potable water is supplied by groundwater accessed through municipal wells. The majority of groundwater recharge is thought to occur in the City's western upland area, with the remainder (approximately 17%) occurring east of the Laguna de Santa Rosa, however, pending USGS studies will provide further information.

City of Sebastopol Project Concepts

The Morris Street outfall of the Healdsburg Avenue watershed is the northernmost outfall. The Laguna backwaters and floods low lying streets bordered by a nearby parking lot, baseball field, and community center.

The outfall of Zimpher Creek is located to the North of State Route 12, and east of Morris Street.

Upstream, Zimpher Creek runs through Libby Park through underground storm drain pipes and a section of open channel. Diversion into a surface feature is conceivable but unlikely to have regional benefits.

To the South of Highway 12, the City owns the Village Park mobile home park which contains an open area formerly used for camping during the summer season. The campground area is often flooded during the rainy season. The City has terminated the campground use, and plans future conversion of the property to a park use. This area could benefit from conversion and park dedication to detention or retention and recharge.

The outfall of Calder Creek is on the Railroad Forest property, east of Petaluma Avenue (SR 116) and just North of the Joe Rodota Trail. The surrounding property is frequently littered and would benefit from permanent clean up. The outfall has undergone improvements and clean up such as installation of a weir to widen the outfall area and non-native plant removal, however, sedimentation in the upstream storm drain persists. Upstream storm drain pipes traverse a tight corridor of City owned land with little room for daylighting.

(Project 90) The undeveloped area between the three outfalls and the Laguna may provide opportunities for recharge and/or environmental enhancements, which could provide regional benefits, particularly if undertaken alongside improvements at the outfalls.

(Project 91) The reach of Calder Creek that runs through Ives Park is concrete and rock, and localized flooding occurs in the park during peak flow. The City is currently conducting a study to evaluate the feasibility and benefits of transforming this reach of creek into a naturalized, safely accessible, meandering waterway through realignment and laying back of the banks. Passive recharge could result from such a transformation depending on underlying soils and/or geology.

City of Cotati

The City of Cotati is at the upper end of the Laguna-Mark West watershed and the southern end of the Santa Rosa Valley. The grade-break that separates the Laguna-Mark West watershed from the Petaluma River watershed is just south of the City limits, so a relatively small portion of the watershed is actually tributary to the City. The upper reaches of the Laguna de Santa Rosa (also known locally as Cotati Creek) pass through the City in a combination of channels and closed conduits.

In addition to Cotati Creek, the primary creeks within the 10.4 square mile watershed that contributes runoff to and through the City of Cotati limits are Copeland Creek and Washoe Creek. The creeks have been channelized for flood protection purposes in their downstream sections. There are approximately 30 stormwater discharge points to the Laguna. Only the lower reach of Copeland Creek flows through the City boundary with the balance of the watershed flowing through Rohnert Park. The other creek watersheds are generally highly urbanized. The City's Storm Drainage Master Plan indicates that there is some flooding potential in downtown Cotati from undersized facilities.

The Laguna de Santa Rosa Foundation sponsors a local advocacy group, Cotati Creek Critters, that works with the City and the Water Agency to facilitate restoration of the upper reaches of the Laguna.

Cotati also has developed community water supply wells that draw from the Santa Rosa Plain Groundwater Basin. According to the City's 2010 Urban Water Management Plan, the City currently receives its primary water supply from the Water Agency and operates its wells as a separate water supply source. The City of Cotati directly adjoins the City of Rohnert Park and draws water from the same portion of the groundwater basin. The localized recovery of groundwater levels described for the City of Rohnert Park, has also benefited groundwater levels in Cotati's wells.

The City is currently updating its General Plan but historically has had a slow-growth policy and its primary efforts are focused on infill development and redevelopment.

City of Cotati Project Concepts

There may be opportunities along a Cotati Creek tributary for detention or retention and recharge (Project 100). Project 5, identified in interviews with the City of Rohnert Park and reinforced by consultant team knowledge of this watershed, would also benefit the City of Cotati.

Project Elements for Consideration

Russian River Biological Opinion

While the Laguna-Mark West watershed and associated flood control operations are not the focus of the Russian River Biological Opinion (RRBO) or its Reasonable and Prudent Alternative, the RRBO provides ecological context. Evaluations of historical and current habitat conditions with respect to salmonids may influence how selected projects might be configured to benefit listed species.

As described in the RRBO, citing Smith Consulting (1990) and the Laguna de Santa Rosa Foundation, the Laguna de Santa Rosa historically consisted of oak woodland and savanna, riparian forests, streams, lakes, and perennial and seasonal freshwater wetlands. Salmonids likely used the perennial streams within the Laguna de Santa Rosa watershed for spawning and rearing. The RRBO identifies the Laguna as having critical migration habitat for steelhead. Mark West Creek is identified as exhibiting critical habitat for Chinook (spawning, rearing, and migration) and steelhead (spawning, rearing, and migration).

The RRBO divides the discussion of current conditions of habitat in the Laguna –Mark West watershed (using Zone 1A nomenclature) into floodways and natural waterways. Typically the lower, urban reaches are managed as flood control channels and the upper reaches of creeks are managed as natural waterways.

Generally, in-stream complexity in the straightened and channelized floodways is lacking.

The natural segments of Santa Rosa Creek are described as exhibiting fair condition for migration and exhibit lack of riparian cover, pools, and high flow refugia. Spawning habitat in the natural reaches of Santa Rosa Creek is fair, and rearing conditions are fairly good. The headwaters of the Creek are located in the Hood Mountain Regional Park and are protected. Fountain Grove Creek and Hood Mountain Creek are the only two tributaries that are not managed at least in part as flood control channels.

Natural waterways in the Rohnert Park-Cotati area are in poor to fair condition due to loss of in-stream habitat. Spawning habitat in Rohnert Park-Cotati is poor, with the exception of Copeland Creek, with a well shaded upper portion within the Fairfield/Osborn Preserve. Rearing in natural reaches of waterways in the Rohnert Park-Cotati area is poor due to high temperatures, lack of riparian cover, and degraded water quality. Copeland Creek retains fair rearing habitat.

There may be opportunities to integrate improvements to habitat or removal of migration barriers along the Laguna, Mark West Creek, or appropriate tributaries, into one or more project solutions and/or to coordinate work with efforts to respond to the RRBO.

Draft Fish Habitat Enhancement Feasibility Study

The "Draft Fish Habitat Enhancement Feasibility Study, Dry Creek, Warm Springs Dam to the Russian River, Sonoma County" prepared in March 2011 for the Water Agency by Inter-fluve with Sanders & Associates Geostructural develops pool-riffle habitat concepts using high summer flow range and preferred depths, velocities, and required channel width. In-stream elements including riffle pools and large woody debris and off-channel elements such as boulder clusters, side channels, backwater channels, and backwater ponds might be integrated into flood hazard reduction and groundwater recharge projects where listed species reside or where they may reside again in future as a result of barrier removal projects. Flood hazard reduction and natural or engineered recharge projects with pool-riffle channel morphology may benefit from these elements.

Low Impact Development

Low impact approaches to development (LID), documented in the Water Agency's *Water Smart Development Guidebook*, can contribute on localized scales to flood hazard reduction and groundwater recharge. While LID projects would not screen well for meeting these objectives on a regional level, LID should be considered as a potential project element of a regional project as it may broaden funding eligibility and is likely to receive support.

Project Screening and Evaluation

Project Concepts and Project Objectives Screening

Using GIS datasets of key soil, hydrologic, geologic, and other natural resource conditions, and projects were evaluated on how well they met core objectives. Project locations were evaluated and adjusted where appropriate to further curtail flooding or promote recharge. Underlying soil and recharge potential layers were examined, Google Earth was used as a visual tool, knowledge of the watershed was considered, and each project was examined with the goal of optimization to meet objectives.

The potential for each project concept to meet core and supporting objectives was evaluated as shown in **Table 2**. This evaluation revealed numerous project concepts that met both core objectives. This made it possible to screen for supporting objectives, which is advantageous since many individual supporting objectives are aligned with funding opportunities as are projects with multiple benefits. Projects that did not meet both core objectives and at least two of the supporting objectives were screened out for the purpose of this study but may succeed under different funding arrangements. The projects that passed this level of screening are presented as selected projects in **Table 3**.

Projects that meet both core objectives tend to reside along the band of the revised Prioritized Study Area that lies outside of major urban areas and within the band of permeable soils or geology that extends from northwest to southeast, along the base of lower elevations of the Mayacamas Mountains, as they transition to the Santa Rosa Plain below. This region is sufficiently downstream to capture a reasonable tributary area and near enough to (and generally upstream of) the urban areas to potentially impact flooding and recharge. Further analysis of these projects at the feasibility level will better define their potential for reducing flooding and promoting recharge. As Todd 2011 notes, candidates include Copeland, Crane, and Five creeks east of Rohnert Park, and Pool, Wright, and Windsor creeks east of Windsor. The project concept for Pool Creek is downstream of the confluence of Pool and Wright creeks and therefore preferable from a flood reduction stand point. In addition, a tributary has been identified near Windsor, and creeks to the east of Santa Rosa present opportunities, as does a parcel owned by California American Water Company that is in a primary location for recharge.

Selected projects provide an opportunity to explore the development of flood hazard mitigation and groundwater recharge projects in the Laguna Mark West Watershed. Project definition will occur in later stages of planning, after appropriate studies have been conducted to allow for site identification and associated constraints and opportunities. The exception to this is Project 10, the Copeland Creek Watershed Storm Water Detention, Groundwater Recharge, Habitat Restoration, and Steelhead Refugia Project, which is further along in planning with defined siting, layout, and project elements.

With the exception of the Southeast Greenway project, descriptive project naming presented below is hypothetical and is intended to exemplify possible project elements. It is not an attempt to further define the project.

Project 1, Coleman Creek Daylighting, Floodplain Expansion, and Natural Recharge Project.

Project 10, Copeland Creek Watershed Storm Water Detention, Groundwater Recharge, Habitat Restoration, and Steelhead Refugia Project.

Project 44, Southeast Greenway, A Greenway to Spring Lake and Beyond

Project 45, Spring Creek Floodplain Expansion and Natural Recharge Project

Project 55, Santa Rosa Creek Backwater Pond and Natural Recharge Project.

Project 80, Pool Creek Trails, Detention, Retention and Recharge Basin.

Project 81, Pruitt Creek Terraced Floodplain, Detention, and Recharge Basin.

Screened Project Concepts and Preliminary Feasibility

A preliminary, comparative assessment of construction cost, regulatory constraints, and funding potential was made to the seven screened projects. Because project sites have not been selected and conditions are unknown, this assessment is preliminary and will change as project concepts are further narrowed and developed.

Preliminary feasibility was assessed on a comparative basis examining relative difficulty and assigning ratings of “least”, “average”, or “difficult”. Construction was divided into two categories: access and excavation potential. Construction access is difficult if the general project location is remote and high in the mountains and least difficult if located in the valley. Natural projects have the potential to require less excavation and are considered to have a least difficult excavation potential. Engineered projects require six or more feet of excavation by definition and are categorized as difficult.

Regulatory constraints were rated in a similar fashion. Project 1, on Coleman Creek, has relatively low potential for habitat impacts and will revive a reach of creek that has been buried underground, improve floodplain function, and will be seen as beneficial by regulators. This project was assigned a least difficult assessment for regulatory compliance.

Project 10, on Copeland Creek, is categorized as difficult since it is located on an important steelhead run and headwater area valued highly by National Marine Fisheries Service and California Department of Fish and Game. While the project will bring benefits to steelhead, it will be carefully scrutinized.

Project 44, in Santa Rosa, is categorized as least difficult because it does not require extensive in-stream construction and has many beneficial elements.

Project 45, on Spring Creek, is categorized as least difficult because it replaces hard-scaped stream conditions with naturalized, permeable conditions. This is strongly supported by regulatory agencies.

Project 55, on Santa Rosa Creek, is considered least difficult because the resource benefits outweigh potential impacts.

Project 80, on Pool Creek, and Project 81, on Pruitt Creek, are both considered to have difficult regulatory constraints because of resource sensitivity and the potential for special status species such as California Tiger Salamander and Foothill Yellow-legged Frog.

A preliminary funding assessment considers available local match, which greatly increases funding opportunities and positions projects well for state and federal grants. This effectively evaluates the ease with which projects may be funded: projects with identified funding sources will be considered easier to implement than those that do not. The upcoming stakeholder meeting will provide an opportunity to verify stakeholder ability to commit matching funds to screened projects. A place-holder value of “average” was entered in this category for the purpose of this analysis.

Because most state and federal grant programs are multi-year programs that accept applications in annual cycles, the funding assessments scores should be regularly revisited. As local sponsors develop and budget for their projects, additional local matching funds may be programmed and projects that do not currently score well under this criterion could move up the list.

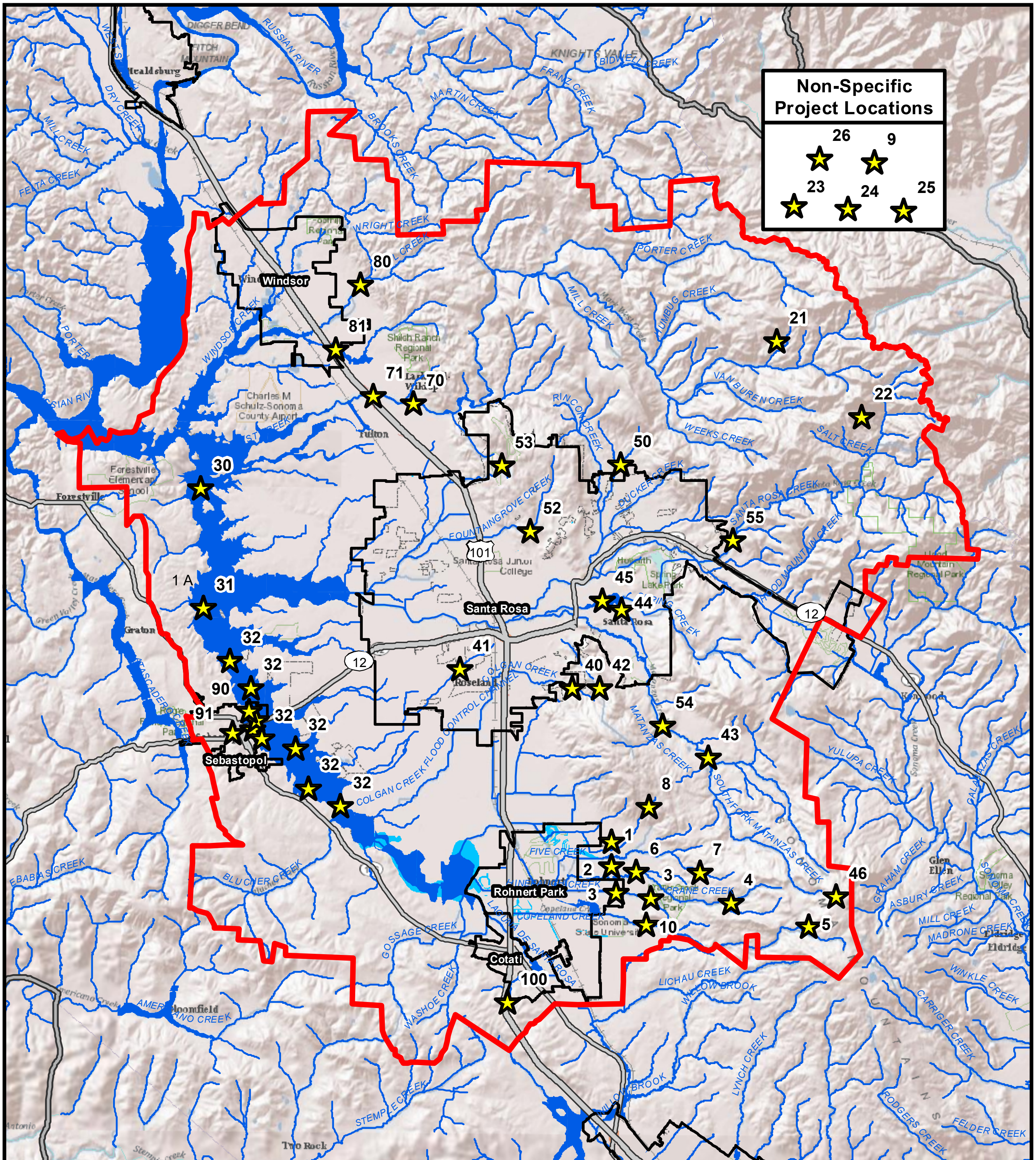
The packaging of several projects from throughout the watershed within a programmatic application represents another funding strategy. This would allow local matching funds to be leveraged for the highest regional benefit and would further enhance alignment with objectives as well as maximize the number of beneficiaries because projects from multiple local sponsors would be included in the request.

Conclusion

The stakeholder engagement process brought forward an array of projects throughout the watershed that address a wide range of core and supporting objectives. A revised Prioritized Study Area and a qualitative screening process allowed for an evaluation of these projects and identified a group of seven project concepts that meet the core objectives and two or more supporting objectives of this study. A preliminary feasibility assessment of construction cost and regulatory constraints shows that several screened project concepts are likely to require an average or less construction effort, suggesting that none be ruled out at this juncture on the basis of construction cost alone. Three project concepts may have rigorous regulatory compliance efforts, and these three projects are balanced with relatively low construction cost potential. A preliminary funding potential assessment can be completed at the stakeholder meeting, which will verify results of the preliminary feasibility analysis, which suggest that that no project be excluded on the basis of difficult implementation potential, and that Project 1, on Coleman Creek, Project 45, on Spring Creek, and Project 55, on Santa Rosa Creek, may be the easiest three to implement.

The next phase of this Scoping Study will include a Feasibility Study Scoping wherein identification of data gaps will be made and a scope of work for a future Feasibility Study will be developed. In addition, a Funding Support task may be initiated in which specific funding related goals and funding priority guidelines would be developed.

FIGURES



\\corp\wkprojects\sro\02243 - SCWA\02243-10-003 Watershed Planning Zone 1A\08-GIS\Maps\Figures\Figure 1 - Floodplain.mxd - 10:57:13 AM

Zone 1A
City Limits
Streams
Project Concepts
100 Year Floodplain
January 2006 Flooding

0 7,500 15,000 ft

1 inch = 16,000 feet printed at 8.5x11

N

Sources: ESRI: Basemap; Sonoma County GIS: Blueline Streams, City Limits; SCWA GIS: Zone 1A Boundary and January 2006 Flooding; FEMA: 100 Year Floodplain.

Cartography	Date	Project #
AF	1/18/2012	0224310003

Figure 1
Floodplain

Watershed Planning Zone 1A, Laguna Mark West Watershed

Sonoma County Water Agency

WINZLER & KELLY

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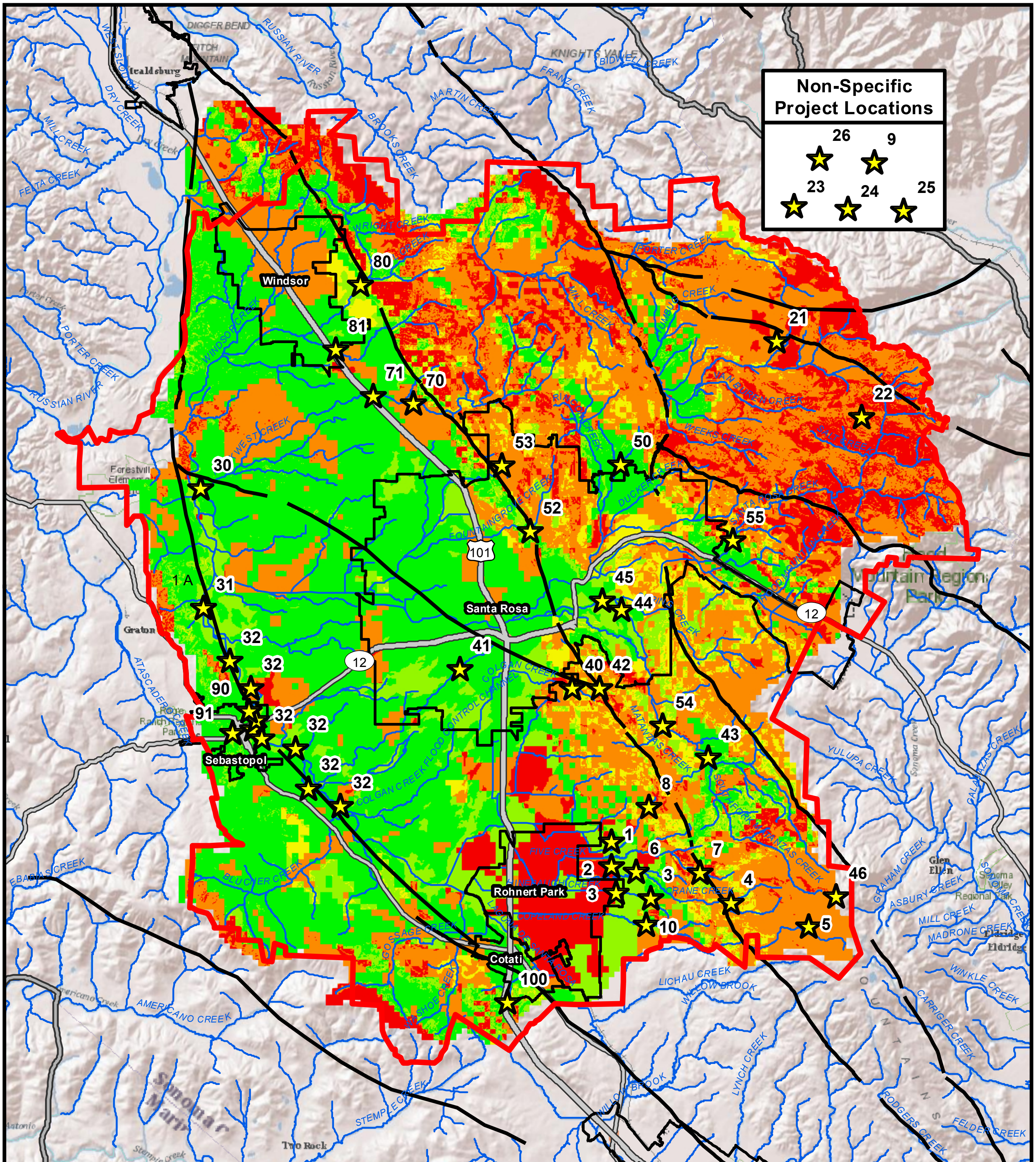

Zone 1A	
City Limits	
Fault	
Streams	
Project Concepts	

Soil/Natural Recharge Potential

- 8 - 10 (Very High)
- 7 - 8 (High)
- 6 - 7 (Moderate)
- 4 - 6 (Low)
- 1 - 4 (Very Low)

0 7,500 15,000 ft

1 inch = 16,000 feet printed at 8.5x11

N

Sources: ESRI: Basemap; Sonoma County GIS: Blueline Streams, City Limits; SCWA GIS: Zone 1A Boundary; Todd Engineers: Recharge Potential.

Cartography	Date	Project #
AF	11/15/2011	0224310003

Figure 2
Natural Recharge Potential

Watershed Planning Zone 1A, Laguna Mark West Watershed

Sonoma County Water Agency

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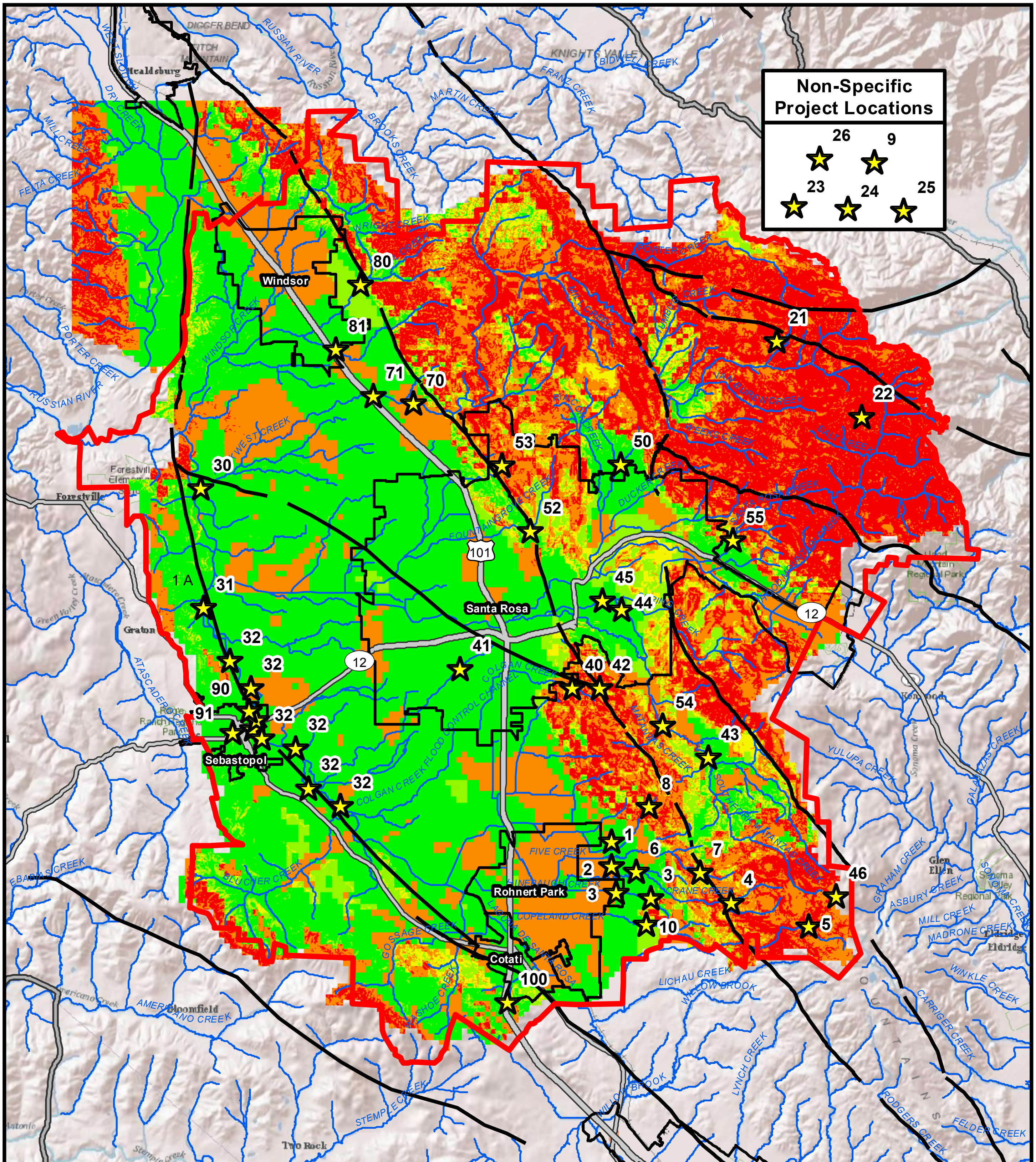

Zone 1A	**Geologic/Engineered Recharge Potential**
City Limits	8 - 10 (Very High)
Fault	7 -8 (High)
Streams	6 - 7 (Moderate)
Project Concepts	4 - 6 (Low)
	1 - 4 (Very Low)

0 7,500 15,000 ft

1 inch = 16,000 feet printed at 8.5x11

N

Sources: ESRI: Basemap; Sonoma County GIS: Blueline Streams, City Limits; SCWA GIS: Zone 1A Boundary; Todd Engineers: Recharge Potential.

Cartography	Date	Project #
AF	11/15/2011	0224310003

Figure 3
Engineered Recharge Potential

Watershed Planning Zone 1A, Laguna Mark West Watershed

Sonoma County Water Agency

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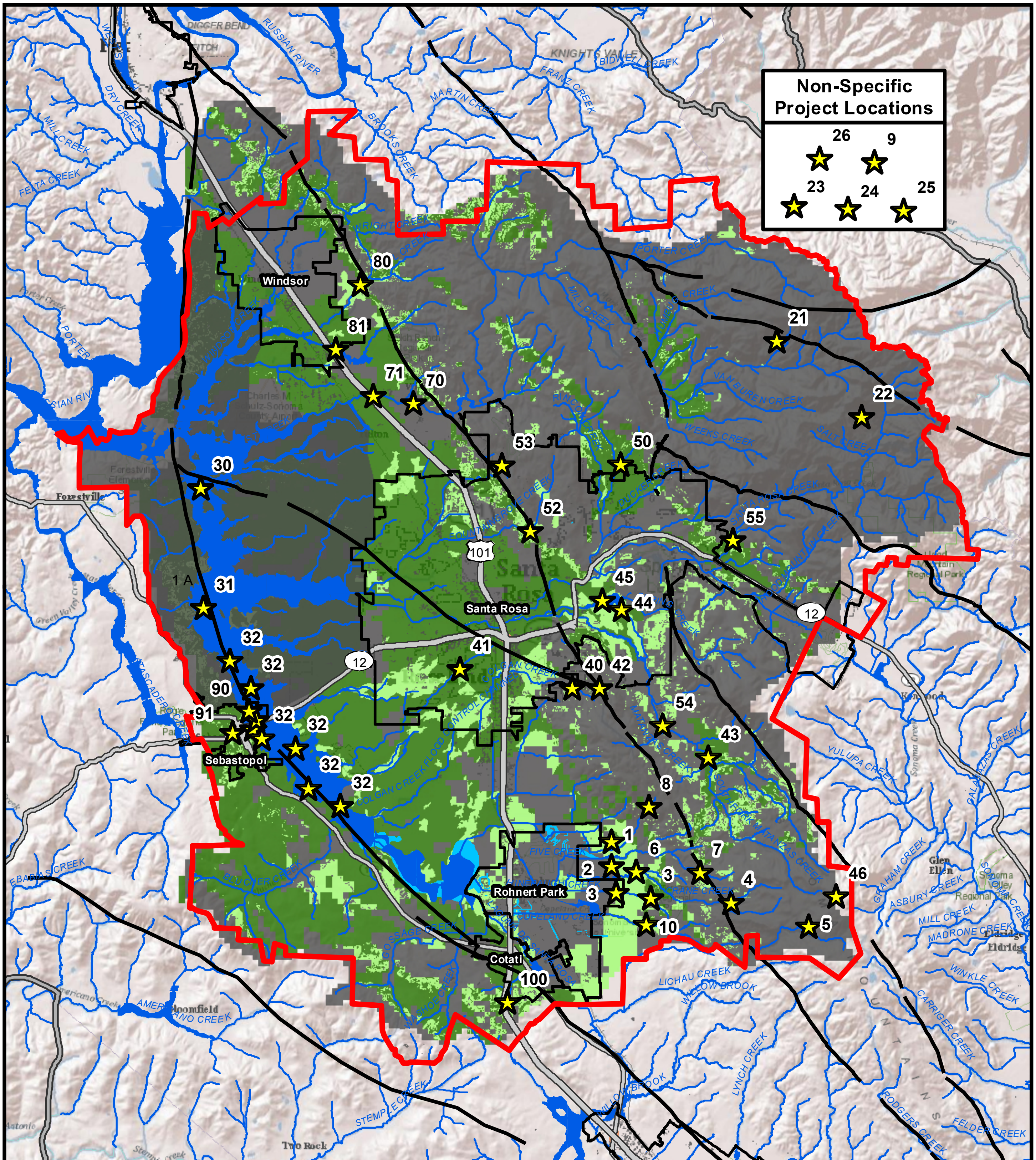

Zone 1A	100 Year Floodplain
City Limits	January 2006 Flooding
Fault	Screened Out Area
Streams	**Natural Recharge Potential**
Project Concepts	8 to 10 (Very High)
	7 to 8 (High)

0 7,500 15,000 ft

1 inch = 16,000 feet printed at 8.5x11

Sources: ESRI: Basemap; Sonoma County GIS: Blueline Streams, City Limits; SCWA GIS: Zone 1A Boundary and January 2006 Flooding; FEMA: 100 Year Floodplain; USGS: % Impervious; Todd Engineers: Recharge Potential.

N

Cartography	Date	Project #
AF	1/18/2012	0224310003

Figure 4 - Revised Study Area for Flood Hazard Reduction and Natural Recharge Projects

Watershed Planning Zone 1A, Laguna Mark West Watershed

Sonoma County Water Agency

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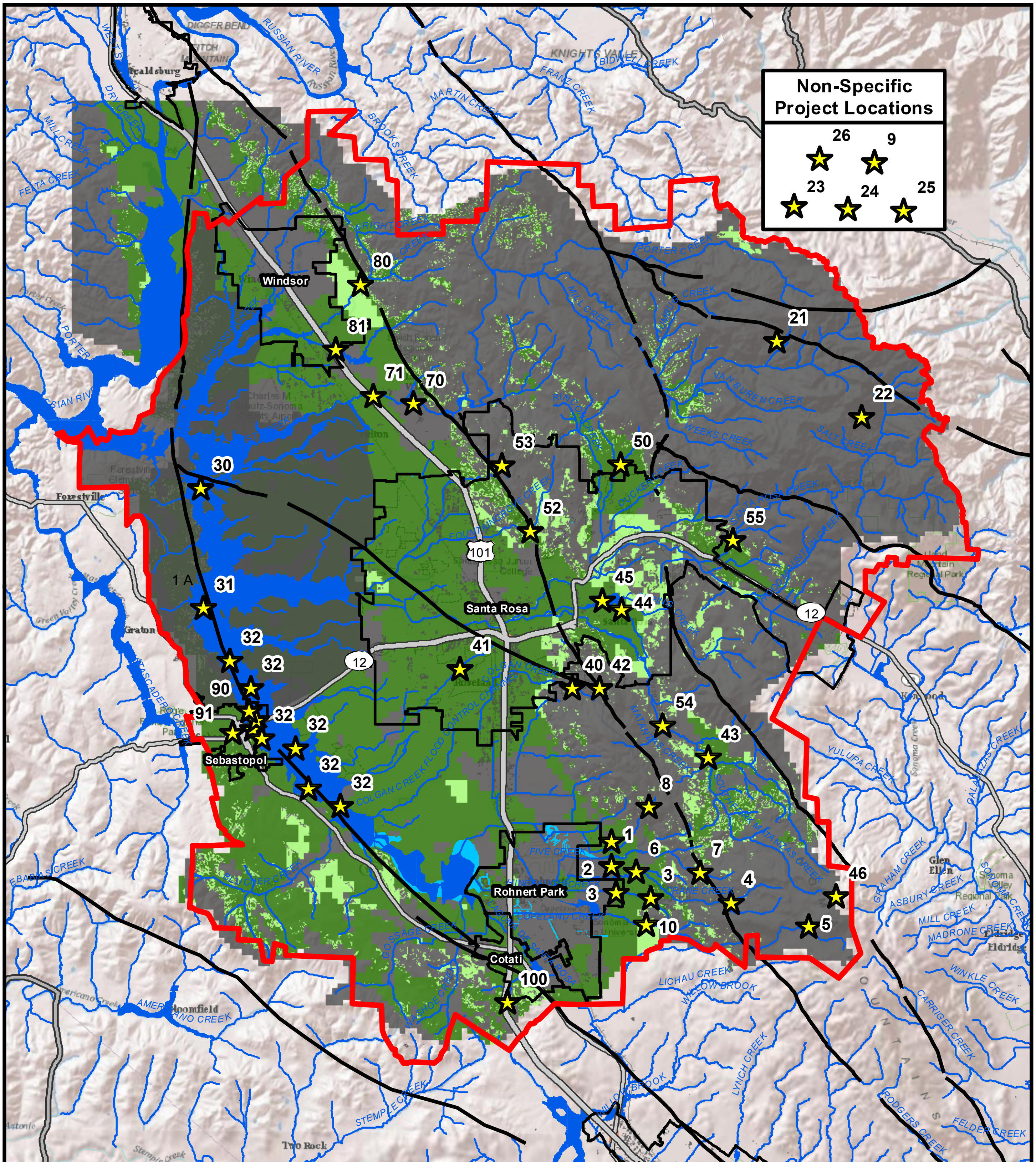
\\corp\wkprojects\sro\02243 - SCWA\02243-10-003 Watershed Planning Zone 1A\08-GIS\Maps\Figures\Figure 5 - Revised Study Area for Flood Engineered Reduction and Natural Recharge Projects.mxd - 10:29:13 AM



Zone 1A
City Limits
Fault
Streams
Project Concepts

100 Year Floodplain
January 2006 Flooding
Screened Out Area

Engineered Recharge Potential
8 to 10 (Very High)
7 to 8 (High)

0 7,500 15,000 ft

1 inch = 16,000 feet printed at 8.5x11

Sources: ESRI: Basemap; Sonoma County GIS: Blueline Streams, City Limits; SCWA GIS: Zone 1A Boundary and January 2006 Flooding; FEMA: 100 Year Floodplain; USGS: % Impervious; Todd Engineers: Recharge Potential.

N

Cartography	Date	Project #
AF	1/18/2012	0224310003

Figure 5 - Revised Study Area for Flood Hazard Reduction and Engineered Recharge Projects

Watershed Planning Zone 1A, Laguna Mark West Watershed

Sonoma County Water Agency

WINZLER & KELLY

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TABLES

Laguna-Mark West Watershed Planning Scoping Study
Project Concepts Summary
Table 1

Project Information				Project Type										
				Flood Hazard Reduction							Other		Groundwater Recharge	
Project Identifier	Location	Description	Author	Swale or Floodplain Expansion	Detention or Retention Basin	Forest Restoration	Bypass Channel	Sediment Removal or Reduction	Channel or Bank Modification	Modification to Existing Facility	Creek Daylighting	Miscellaneous	Natural Recharge	Engineered Recharge
1	Rohnert Park	Coleman Creek	Stakeholder	1							1		1	
2	Rohnert Park	Five Creek	Stakeholder		1									1
3	Rohnert Park	Hinebaugh Creek	Stakeholder							1				
4	Rohnert Park	Crane Creek (upper)	Consultant & Stakeholder		1									1
5	Rohnert Park	Copeland Creek (upper)	Consultant & Stakeholder	1										
6	Rohnert Park	Crane Creek (lower)	Consultant & Stakeholder		1									1
7	Rohnert Park	Five Creek	Consultant & Stakeholder		1									1
8	Rohnert Park	Cook Creek	Consultant & Stakeholder		1									1
9	Rohnert Park	Educate Vineyard Owners	Stakeholder									1		
10	Rohnert Park	Copeland Creek Watershed Storm Water Detention, Groundwater Recharge, Habitat Restoration, and Steelhead Refugia Project	Water Agency	1	1			1	1				1	1
21	Upper Mark West	Retention Pond	Stakeholder		1									
22	Upper Mark West	Donnels Dam	Stakeholder					1		1				
23	Upper Mark West	Road Improvements	Stakeholder					1		1				
24	Upper Mark West	Conservation Easement Purchase	Stakeholder									1		
25	Upper Mark West	In-Stream Check Dams	Stakeholder		1									
26	Upper Mark West	Forest Restoration	Stakeholder			1								
30	Mark West Confluence	Channel Realignment or Bypass	Stakeholder				1							
31	Laguna de Santa Rosa	Pools	Stakeholder						1					
32	Laguna de Santa Rosa	Pools	Stakeholder						1					
40	City of Santa Rosa	Colgan Creek	Consultant		1									1
41	City of Santa Rosa	Roseland Creek	Consultant		1									1
42	City of Santa Rosa	Kawana Springs	Consultant		1			1						1
43	City of Santa Rosa	Matanzas Creek	Consultant		1									1
44	City of Santa Rosa	Southeast Greenway	Stakeholder	1	1						1	1	1	1
45	City of Santa Rosa	Spring Creek	Stakeholder	1	1				1				1	1
46	City of Santa Rosa	Forest Restoration	Stakeholder			1								
50	City of Santa Rosa	Brush Creek Reservoir	Consultant		1					1				1
52	City of Santa Rosa	Piner Creek Reservoir	Consultant		1					1				1
53	City of Santa Rosa	Fountain Grove Reservoir	Consultant		1					1				1
54	City of Santa Rosa	Matanzas Creek Reservoir	Consultant		1					1				1
55	City of Santa Rosa	Santa Rosa Creek	Consultant	1					1				1	1
70	Larkfield-Wikiup	Mark West Creek Erosion	Stakeholder						1					
71	Larkfield-Wikiup	300 Mark West Station Rd	Stakeholder		1									1
80	Town of Windsor	Pool Creek Watershed	Consultant		1									1
81	Town of Windsor	Pruitt Creek at Hwy 101	Stakeholder		1									1
90	City of Sebastopol	Outfalls to Laguna	Stakeholder & Consultant								1	1		
91	City of Sebastopol	Calder Creek Enhancement	Stakeholder								1		1	
100	City of Cotati	Cotati Tributary	Consultant		1									1

Note:
1. Project type is indicated by a value of "1".
2. Until a specific site is selected and site-specific opportunities and constraints are identified, it is impossible to determine specific project configuration and project elements, therefore, descriptive project names are not defined at this stage.
3. Categorization by project type is meant to clarify the project configuration at this stage and is not intended to limit potential project elements. For example, if a detention or retention basin project is selected because of underlying impermeable soil and permeable geology, other elements, such as floodplain expansion, may be incorporated in future phases of study.

Laguna-Mark West Watershed Planning Scoping Study
Project Concepts Screening
Table 2

Project Information			Core Objectives Summary		Supporting Objectives							Both Core Objectives Satisfied?	Number of Satisfied Supporting Objectives
Project Identifier2	Location3	Description4	Flood Hazard Reduction	Groundwater Recharge	Water Quality	Water Supply	System Sustainability	Ecosystem	Agricultural Land	Open Space	Community Benefit		
1	Rohnert Park	Coleman Creek	1	1	1		1				1	TRUE	3
2	Rohnert Park	Five Creek	1	1	1							TRUE	1
3	Rohnert Park	Hinebaugh Creek	1									FALSE	0
4	Rohnert Park	Crane Creek (upper)	1	1	1							TRUE	1
5	Rohnert Park	Copeland Creek (upper)	1		1			1				FALSE	2
6	Rohnert Park	Crane Creek (lower)	1	1	1							TRUE	1
7	Rohnert Park	Five Creek	1	1	1							TRUE	1
8	Rohnert Park	Cook Creek	1	1	1							TRUE	1
9	Rohnert Park	Educate Vineyard Owners				1	1					FALSE	2
10	Rohnert Park	Copeland Creek Watershed Storm Water Detention, Groundwater Recharge, Habitat Restoration, and Steelhead Refugia Project	1	1	1			1		1	1	TRUE	4
21	Upper Mark West	Retention Pond			1							FALSE	1
22	Upper Mark West	Donnels Dam	1		1		1	1				FALSE	3
23	Upper Mark West	Road Improvements	1		1		1	1				FALSE	3
24	Upper Mark West	Conservation Easement Purchase						1				FALSE	1
25	Upper Mark West	In-Stream Check Dams										FALSE	0
26	Upper Mark West	Forest Restoration	1		1			1				FALSE	2
30	Mark West Confluence	Channel Realignment or Bypass	1		1		1	1	1			FALSE	4
31	Laguna de Santa Rosa	Pools			1			1				FALSE	2
32	Laguna de Santa Rosa	Pools			1			1				FALSE	2
40	City of Santa Rosa	Colgan Creek	1	1	1							TRUE	1
41	City of Santa Rosa	Roseland Creek	1	1	1							TRUE	1
42	City of Santa Rosa	Kawana Springs	1	1	1							TRUE	1
43	City of Santa Rosa	Matanzas Creek	1	1	1							TRUE	1
44	City of Santa Rosa	Southeast Greenway	1	1	1		1	1	1	1	1	TRUE	6
45	City of Santa Rosa	Spring Creek	1	1	1			1				TRUE	2
46	City of Santa Rosa	Forest Restoration	1		1			1				FALSE	2
50	City of Santa Rosa	Brush Creek Reservoir	1	1		1						TRUE	1
52	City of Santa Rosa	Piner Creek Reservoir	1	1		1						TRUE	1
53	City of Santa Rosa	Fountain Grove Reservoir	1	1		1						TRUE	1
54	City of Santa Rosa	Matanzas Creek Reservoir	1	1		1						TRUE	1
55	City of Santa Rosa	Santa Rosa Creek	1	1	1			1				TRUE	2
70	Larkfield-Wikiup	Mark West Creek Erosion	1		1							FALSE	1
71	Larkfield-Wikiup	300 Mark West Station Rd		1	1	1						FALSE	2
80	Town of Windsor	Pool Creek Watershed	1	1	1			1				TRUE	2
81	Town of Windsor	Pruitt Creek at Hwy 101	1	1	1			1				TRUE	2
90	City of Sebastopol	Outfalls to Laguna			1			1				FALSE	2
91	City of Sebastopol	Calder Creek Enhancement		1	1			1			1	FALSE	3
100	City of Cotati	Cotati Tributary	1	1	1							TRUE	1

Note:
1. A value of "1" indicates the project concept can meet the objective.
2. Detention or retention and recharge basins provide water quailty benefits because in addition to enhancing infiltration, they would be configured with sedimentation basins.
3. To avoid redundancy with the groundwater recharge core objective, water supply improvements are attributed to projects that might reduce aquifer draw down (Project 9), where an existing groundwater study has identified an area as having significant recharge capacity (Project 71), and to those that expand existing reservoirs (Projects 50, 52, 53, 54).
4. Projects that reduce required maintance, energy use, or the need for human activity are considered to improve system sustainability.
5. In addition to projects with clearly defined ecosystem benefits (reforestation, creek daylighting, floodplain expansion), detention or retention projects in streams with listed species are credited with ecosystem benefits as they would be configured with elements to enhance their habitat.

Laguna-Mark West Watershed Planning Scoping Study
Screened Projects
Table 3

Project Identifier	Location	Description	Meets Core Objectives?	Number of Satisfied Supporting Objectives
1	Rohnert Park	Coleman Creek	TRUE	3
10	Rohnert Park	Copeland Creek Watershed Storm Water Detention, Groundwater Recharge, Habitat	TRUE	4
44	City of Santa Rosa	Southeast Greenway	TRUE	6
45	City of Santa Rosa	Spring Creek	TRUE	2
55	City of Santa Rosa	Santa Rosa Creek	TRUE	2
80	Town of Windsor	Pool Creek Watershed	TRUE	2
81	Town of Windsor	Pruitt Creek at Hwy 101	TRUE	2

Laguna-Mark West Watershed Planning Scoping Study
Preliminary Feasibility
Table 4

Project Information			Project Type											Preliminary Feasiblity - Estimated Effort to Implement									
			Flood Hazard Reduction							Other		Groundwater Recharge											
Project Identifier	**Location**	**Description**	**Swales or Floodplain Expansion**	**Detention or Retention Basin**	**Forest Restoration**	**Bypass Channel**	**Sediment Removal or Reduction**	**Channel or Bank Modification**	**Modification to Existing Facility**	**Creek Daylighting**	**Miscellaneous**	**Natural Recharge**	**Engineered Recharge**	Construction Access		Construction Excavation Potential		**Construction**	**Regulatory Constraints**		**Funding Effort[3]**	**Overall Effort to Implement[3]**
1	Rohnert Park	Coleman Creek	1							1		1		least	1	least	1	**1.0**	least	**1**	**2**	1.3
10	Rohnert Park	Copeland Creek Watershed Storm Water Detention, Groundwater Recharge, Habitat Restoration, and Steelhead Refugia Project	1	1			1	1				1	1	least	1	average	2	**1.5**	highest	**3**	**2**	2.2
44	City of Santa Rosa	Southeast Greenway	1	1						1	1	1	1	average	2	average	2	**2.0**	least	**2**	**2**	2.0
45	City of Santa Rosa	Spring Creek	1	1		1						1	1	average	2	average	1	**1.5**	least	**1**	**2**	1.5
55	City of Santa Rosa	Santa Rosa Creek	1	1				1				1	1	highest	3	average	2	**2.5**	least	**1**	**2**	1.8
80	Town of Windsor	Pool Creek Watershed		1									1	least	1	average	2	**1.5**	highest	**3**	**2**	2.2
81	Town of Windsor	Pruitt Creek at Hwy 101		1									1	least	1	average	2	**1.5**	highest	**3**	**2**	2.2

Notes:

1. Project type is indicated by a value of "1".

2. The least anticipated implementation effort is assigned a value of one, an average effort is assigned a value of two, and the highest anticipated effort is assigned a value of three.

3. Funding commitment to be verified at stakeholder meeting.

4. Until a specific site is selected and site-specific opportunities and constraints are identified, it is impossible to determine specific project configuration and project elements, therefore, descriptive project names are not defined at this stage.

5. The attempt to categorize by project type is not intended to limit potential elements of project concepts. For example, if a detention or retention basin project is selected because of underlying impermeable soil and permeable geology, other elements, such as floodplain expansion, may be incorporated in future phases of study.

6. Due to underlying permeable soils and geology, Projects 10, 44, 45, and 55 could include swales and floodplain expansion and detention or retention. It was assumed for this analysis that all of these elements might be included.

APPENDIX A

TODD ENGINEERS

GROUNDWATER · WATER RESOURCES · HYDROGEOLOGY · ENVIRONMENTAL ENGINEERING

January 17, 2012

MEMORANDUM

To: Iver Skavdal – Winzler & Kelly

From: Sally McCraven, PG, CHg, CEG
Iris Priestaf, PhD
Edwin Lin, PG, CHg

Re: Santa Rosa Plain Groundwater Recharge Potential Mapping

2490 Marina Square Loop, Suite 215 · Alameda, CA 94501-1080 · 510/747-6920 · Fax 510/747-6921

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1. Santa Rosa Plain Hydrogeology

This overview of Santa Rosa Plain hydrogeology is largely excerpted from the *Groundwater Primer for the Santa Rosa Plain (*September 2010) available on the Sonoma County Water Agency (SCWA) webpage (http://www.scwa.ca.gov/files/docs//projects/srgw/GW101_09302010_final.pdf).

The Santa Rosa Plain includes the Cities of Santa Rosa, Rohnert Park, Cotati, Sebastopol, Town of Windsor, and unincorporated areas of Sonoma County (Figure 1). The groundwater basin is bounded on the northwest by the middle reach of the Russian River floodplain and by the upland hills of western Sonoma County on the remaining western boundary. The southern end of the Santa Rosa Plain is marked by a series of low hills just south of Cotati, which form a drainage divide that separates the Santa Rosa Plain from the Petaluma Valley. The Santa Rosa Plain is bounded to the east by mountains. Santa Rosa Creek, Mark West Creek, and the Laguna de Santa Rosa provide the main surface drainage for the area.

The groundwater system beneath the Santa Rosa Plain provides rural residential, municipal, agricultural, and industrial water supplies, and baseflow to streams and surface water bodies. There are over 12,000 permitted water wells in the basin. Future growth in population and demand for water coupled with constraints on existing surface water sources are likely to increase stresses on the region's groundwater resources.

The geology of the Santa Rosa Plain groundwater basin is very complex due to the wide variety of geologic units in the basin and the numerous fault zones in the region. In the Santa Rosa Plain, thick sedimentary layers and volcanic rocks overlie bedrock and are capable of storing and yielding large quantities of groundwater. The four main geologic units that form the primary aquifers in the Santa Rosa Plain are sedimentary deposits of the Alluvium, Glen Ellen Formation, Wilson Grove Formation, and Petaluma Formation, and the Sonoma Volcanics. These geologic units are shown on the Geologic Map for the basin in Figure 1. The basin's best water-producing units are stream channels filled with alluvial sands and gravels; basin-fill alluvium and alluvial fan deposits that connect the Santa Rosa Plain with its bordering hills; and massive sandstone units of the Wilson Grove Formation extending beneath the basin from the low western hills. The Sonoma Volcanics, a thick sequence of lava flows present along the eastern boundary of the basin, and the Petaluma Formation, a shale and sandstone unit that extends beneath much of the deeper portions of the basin, produce variable amounts of water. The basin is divided by northwest trending faults, which may serve as groundwater barriers, and also offset the rock units.

Recent studies conducted by the USGS (McPhee et al., 2007; Sweetkind, el al., 2010) have revealed the basin is subdivided into two primary compartments termed the Windsor sub-basin in the north and the Cotati sub-basin in the south, which are separated by the Trenton Ridge, a concealed bedrock basement ridge. These two areas represent the deepest parts of the basin and range from 6,000 to 10,000 feet deep. The USGS lithologic conceptual model (Figure 2) displays a west to east transition from dominantly marine sands (Wilson Grove Formation and transition to Petaluma Formation) to heterogeneous continental sediments (Petaluma Formation).

1.1 Groundwater Recharge and Discharge in the Santa Rosa Plain

Groundwater within the Santa Rosa Plain is generally present under unconfined conditions, except locally in the vicinity of clay or silt horizons where conditions may be semi-confined or confined. Significant natural recharge locations are stream channels located along the eastern portions of the basin and outcrops of permeable sedimentary units along the southwestern margin of the basin.

Clay-rich sediments cover portions of the central southern Santa Rosa Plain, and extend northward along the Laguna de Santa Rosa, impeding water infiltration. Groundwater is removed from the basin through wells and leaves the basin as both subsurface outflow and groundwater discharge to the Laguna de Santa Rosa. Groundwater generally flows from the recharge areas (e.g., highlands to the east and west of the basin) toward discharge areas (primarily the Laguna de Santa Rosa). This general pattern can be disrupted locally due to exchanges with other surface water features within the basin, the presence of fault zones and the pumping of groundwater from water wells.

1.2 Groundwater Level Trends

Groundwater levels are not routinely measured in the Santa Rosa Plain. In general, groundwater levels in shallow aquifers fluctuate seasonally with rainfall and are largely stable over time. In contrast, groundwater level trends for deeper water wells show a combination of trends over time. Some wells show overall stability, some show overall declining trends and some show historical declining trends followed by recent increases in groundwater levels. The greater occurrence of declining groundwater level trends within the deeper zone wells is likely related to both the larger sized wells completed in deeper zones and the greater amount of time these deeper zones require to recharge.

1.3 Groundwater Quality

Recent USGS work assessing water quality conditions in Santa Rosa Plain groundwater has not yet been published. According to a California Department of Water Resources (DWR) study of the basin, few wells tested for water quality contained constituents over the recommended concentration for drinking water (DWR, 1982). Many wells produced water with aesthetic problems such as high concentrations of iron, manganese, or high hardness. Private well owners questioned about groundwater quality reported many complaints about the color and/or taste of the water. Although high iron, manganese, and hardness have been reported in groundwater from some portions of the Santa Rosa Plain basin, the overall quality of groundwater in the Santa Rosa Plain is good. With respect to agriculture, areas with elevated boron concentrations in groundwater (greater than 2.0 mg/L) have been reported south of Windsor and north of the City of Rohnert Park (DWR, 1982). Arsenic at concentrations above the maximum contaminant level (MCL) associated with dissolution from naturally-occurring sediments are reported in wells in the Santa Rosa Plain (Kulongoski et al., 2006).

1.4 Ongoing USGS Study

The most recent basin-wide studies of the Santa Rosa Plain Groundwater Basin were completed over 25 years ago. As part of an ongoing program intended to enhance the current knowledge regarding groundwater resources within Sonoma County, the United States Geological Survey (USGS) initiated a five-year cooperative study of groundwater resources within the Santa Rosa Plain Groundwater Basin in 2005. The cooperative study is being conducted by the USGS in partnership with the SCWA, County of Sonoma, City of Santa Rosa, City of Rohnert Park, City of Sebastopol, City of Cotati, Town of Windsor, and Cal-American Water Company. The study is currently planned to be published in 2012. Results from the study will provide important tools for basin management. Recent data compiled and available from the USGS were incorporated into this analysis to the extent possible.

2. Recharge Potential Methodology

DWR assessed areas of natural recharge in Sonoma County in studies published in 1975 and 1982. The recharge assessment in the 1975 study was based on mapping of geologic unit permeability (DWR, 1975) and slope. The 1975 study concluded that natural recharge takes place along much of the stream channel deposits, alluvial fan deposits, selected areas of alluvium, and much of the surficial area of the

Wilson Grove Formation. Where these areas are of gentle slope, a significant amount of water can infiltrate naturally and enter the groundwater basin.

The DWR (1982) map of recharge was based on slope and permeability data from a U.S. Department of Agriculture (USDA) Natural Resources Conservation Services (NRCS) Sonoma County Soil Survey. The DWR (1982) study used three recharge classifications (Recharge Areas, Potential Recharge Areas, and Slow Recharge Areas) based on soil type (infiltration rate) and topographic slope using the general methodology of Muir and Johnson (1979). Soil permeability and slope were considered the most important factors in determining the recharge potential.

Another methodology that can be used to assess potential recharge is the commonly used USEPA DRASTIC method (Aller et al. 1987) developed to assess groundwater sensitivity to contamination. The USEPA DRASTIC method predicts aquifer sensitivity based on seven hydrogeologic variables: **D**epth to Water, Net **R**echarge, **A**quifer Media, **S**oil Media, **T**opography, **I**mpact of Vadose Zone, and Aquifer Hydraulic **C**onductivity. To calculate a DRASTIC score, each variable is divided into a numerical range and then multiplied by a prescribed weighting factor. To calculate a DRASTIC index score, the weighted values for each variable are summed.

Most recently, the Sonoma Ecology Center and SCWA conducted a Groundwater Recharge Potential Mapping Project for the Sonoma Valley, which developed an approach for assessing recharge (Sesser, et al., 2011). Objectives for this study were twofold: to delineate areas of significant rainfall recharge and to identify areas with potential for enhanced recharge. Their approach weighted and summed vegetation (10%), slope (15%), soil (25%), and geology (50%) to produce a groundwater recharge map.

3. Approach

For this analysis, recharge potential is considered for two general types of recharge projects – **natural recharge projects** and **engineered recharge projects**. Natural recharge projects would involve distribution of water to swales, small retention facilities, and land spreading with minimal alteration of the natural topography and near surface materials. Engineered projects would include spreading basins and vadose zone wells. Aquifer storage and recovery wells are not considered, as a separate study is currently underway to evaluate this type of basin management project. For engineered projects, it is assumed that if surficial soils are impermeable and thin (i.e., less than six feet thick), they can be bypassed (vadose zone well) or excavated (spreading basins).

The **natural** potential recharge mapping incorporates soil permeability, slope, and shallow geologic unit permeability (0 to 50 feet below ground surface (ft-bgs)). The weighting of each parameter – slope (20%), soil (30%), and geology (50%) -- is generally based on other similar studies and guidance (Sesser et al., 2011; Aller et al., 1987; DWR, 1975; DWR, 1982; and Muir and Johnson, 1979) and sensitivity analysis. Vegetation was not included as a factor (as was done for the Sonoma Valley Project) because it is considered transient and can change from year to year.

The **engineered** potential recharge mapping incorporates and weights two factors: slope (50%) and shallow geologic unit permeability (50%). The weighting was developed in a similar manner to the natural recharge potential mapping. Additional factors, including vegetation, imperviousness, public and protected lands, agricultural land, critical habitat, environmental release sites, stream buffer, and depth to water are considered and superimposed on the engineered recharge potential map to further screen potential sites.

3.1 Soil

Soil data were downloaded from the USDA NRCS online 1972 soil survey database. The data base includes information on soil type, permeability, and thickness as well as other parameters. The soil permeability was averaged for the soil column and weighted as shown in Table 1. Higher infiltration rates represent higher recharge potential.

Table 1 Soil Infiltration Rate Ranking

Infiltration Rate (inches per hour)	Recharge Ranking
>2	10 – very high
0.75 - 2	8 - high
0.5 – 0.75	6 - medium
0.2 – 0.5	4 - low
<0.2	2 – very low

Figure 3 shows the soil recharge ranking map.

3.2 Slope

Topographic data were downloaded from the USGS 10-meter Digital Elevation Model. ArcGIS was used to calculate slopes. Slopes were divided into seven classes and ranked from one to ten as shown in Table 2. Higher percentage slopes represent lower recharge potential as runoff rates are higher in steeper areas with less opportunity to percolate.

Table 2 Slope Recharge Ranking

% Slope	Recharge Ranking
0 – 5	10
5 – 10	8
10 – 15	6
15 – 20	4
20 – 25	3
25 – 30	2
30 - 70	1

Figure 4 shows the slope recharge ranking map.

3.3 Geology

As part of ongoing studies on the Santa Rosa Plain, the USGS prepared 3-dimensional geologic models of the plain (Sweetkind, 2010). The new lithologic and stratigraphic models delineate thickness, extent, texture class, and distribution of subsurface geologic units based on review and interpretation of data from 2,683 well logs. The USGS characterized 16 depth-discrete layers of geology with respect to stratigraphic unit (Glen Ellen Formation, Wilson Grove Formation, Neogene volcanic, Petaluma Formation, and undifferentiated basement) and texture class (coarse-grained, intermediate-grained, fine-grained, tuff, and basalt). Figure 5 shows the combined stratigraphic-texture class for the shallowest layer (0 to 50 ft-bgs). This is the layer used to assess recharge potential. Table 3 provides a description of each numbered texture class shown in Figure 5. The stratigraphic texture class for the shallowest layer (0 to 50 ft-bgs) was ranked from one to ten as shown in Table 3. Figure 6 shows the shallow geology recharge ranking based on the relative permeability indicated by the stratigraphic unit-texture class.

Table 3 Geology Recharge Ranking

GEOLOGY (0'-50')						
Stratigraphic Unit	Texture Class					
	Undifferentiated	Coarse	Intermediate	Fine	Tuff	Basalt
Glen Ellen Formation						
Texture Class	1000	1001	1002	1003	1004	1005
Recharge Ranking	10	10	6	2	2	1
Wilson Grove Formation						
Texture Class	2000	2001	2002	2003	2004	2005
Recharge Ranking	10	10	6	2	2	1
Neogene Volcanics						
Texture Class	3000	3001	3002	3003	3004	3005
Recharge Ranking	2	5	4	3	2	1
Petaluma Formation						
Texture Class	4000	4001	4002	4003	4004	4005
Recharge Ranking	2	10	6	2	2	1
Mesozoic Basement						
Texture Class	5000	5000	5000	5000	5000	5000
Recharge Ranking	1	1	1	1	1	1
Stratigraphic unit with undifferentiated texture call assigned the texture most typical of the formation.						

3.4 Natural Aquifer Recharge Potential

The natural recharge potential ranking was the sum of the slope, soil, and geology rankings with slope weighted 20 percent, soil weighted 30 percent, and geology weighted 50 percent. The ranking was divided into five classes as shown in Table 4. Figure 7 illustrates the distribution of natural recharge potential ranking.

Table 4 Natural Potential Recharge Ranking

Recharge Potential	Recharge Ranking
Very High	8- 10
High	7 - 8
Moderate	6 - 7
Low	4 - 6
Very Low	1-4

3.5 Engineered Aquifer Recharge Potential

As discussed above, soil is not a significant component of recharge potential for engineered aquifer recharge projects, because it is likely bypassed (vadose zone wells) or excavated (spreading basins). Figure 8 shows soil depths provided in the USDA NRCS online 1972 soil survey database. Typically the NRCS samples soils to approximately six ft-bgs. Thus, total soil thickness for areas shown as greater than six feet is unknown. The map shows soil thicknesses of four to six feet over much of the groundwater basin. Accordingly, soil is not included in the estimation of engineered aquifer recharge potential.

The engineered aquifer recharge potential ranking was the sum of the slope and geology rankings with both slope and geology weighted 50 percent. Similar to the natural aquifer recharge ranking, the ranking was divided into five classes as shown in Table 5. Figure 9 illustrates the distribution of engineered aquifer recharge potential ranking.

Table 5 Engineered Potential Recharge Ranking

Recharge Potential	Recharge Ranking
Very High	8- 10
High	7 - 8
Moderate	6 - 7
Low	4 - 6
Very Low	1-4

3.6 Other Factors

Figure 10 shows only areas with very high engineered aquifer recharge rankings. This figure will provide the base for considering and overlaying other criteria affected potential recharge sites. Other factors considered include imperviousness, public and protected lands, agriculture type, critical habitat, environmental release sites, depth to water, and stream buffers.

3.6.1 Imperviousness

The 2001 National Land Cover Database (NLCD) of percentage impervious surfaces was downloaded and areas with percent impervious from 50 to 100 are plotted in Figure 11. Urban areas with high percentages of impervious surface areas are less likely to have land available for engineered recharge projects.

3.6.2 Public and Protected Lands

A GIS shape file of public and protected land was provided by the Sonoma County Agricultural Preservation and Open Space District (SCAPOSD). Figure 12 shows various public and protected lands. While protected lands may limit engineered aquifer recharge projects, publically owned lands—such such as land owned by the local cities or SCWA—may provide accessible land for recharge projects.

3.6.3 Agriculture Type

An agriculture type shape file was developed and provided by SCWA. The agriculture data were most recently updated in 2008. Figure 13 shows vineyards and other agricultural areas. These areas may provide areas where natural recharge could be enhanced with the cooperation of the land owners.

3.6.4 Critical Habitat

The United States Fish and Wildlife Service (USFWS) prepares critical habitat maps. Figure 14 shows critical habitat for the California Red-Legged and California Tiger Salamander. Effective September 2011, the USFWS designated of 47,383 acres of land on the Santa Rosa Plain as critical habitat for the California Tiger Salamander.

Designation of critical habitat does not affect land ownership or establish a refuge, wilderness, reserve, preserve or other conservation area. It does not allow government or public access to private lands. Critical habitat is protected through provisions of the Endangered Species Act that require Federal agencies to consult with the USFWS on actions they carry out, fund, or authorize that may adversely affect critical habitat. It does not mean that projects cannot go forward, but means that Federal agencies must consult with the USFWS to make sure critical habitat is not destroyed or adversely modified. In this way, critical habitat protects areas that are currently unoccupied by the species, but are needed for the recovery of the species.

Impacts of critical habitat designation on potential recharge projects will need to be assessed.

3.6.5 Environmental Release Sites

Environmental release sites in the Santa Rosa Plain were assessed through use of the California state online Geotracker database. Active leaking underground storage tank (LUST) and other active cleanup sites are shown in Figure 15. These represent sites where soil and or groundwater was been impacted by releases of contaminants and have not been fully remediated. Groundwater recharge in the vicinity of these sites has the potential to mobilize contaminants in the vadose zone and disperse and dilute contaminants in groundwater. A more detailed assessment of environmental release sites is recommended once recharge site locations are refined.

3.6.6 Depth to Groundwater

Figure 16 shows a depth to water map based on groundwater elevation contours prepared by the USGS for fall 1990. As shown in the figure, areas with very shallow groundwater are found mostly along the Laguna de Santa Rosa on the west side of the basin; under fall 1990 conditions. Shallow depth to water is an indication of limited available aquifer storage capacity. Depth to groundwater should be considered and verified in the process of refining potential recharge projects.

3.6.7 Stream Buffers

Figure 17 show a 1,500 foot corridor along the major streams and creeks on the plain along with USGS gage station locations. Given that the source of potential recharge is stormwater, it is likely that recharge facilities would need to be located near to the creeks and streams unless engineered conveyance facilities are built.

4. Findings and Conclusions

Based on soils, slope, and geology, large portions of the Santa Rosa Plain exhibit high to very high recharge potential. While there are additional small areas of high and very high recharge potential in the uplands areas of the east side watershed, recharge in these areas would provide limited and local benefits. One goal of potential recharge projects is to reduce flooding. Figures 18 and 19 show areas of flooding along with areas of high and very high recharge potential for natural and engineered recharge potential rankings, respectively. Recharge projects sited in high and very high recharge potential areas and upstream of flood prone areas offer multiple benefits.

Based on Figures 18 and 19, optimal areas for recharge projects are found along the east side of the Sana Rosa Plain along several creeks above flood prone stretches including Copeland, Crane, and Five creeks east of Rohnert Park; and Pool, Wright, and Windsor creeks east of Windsor. Flood prone areas along the east side of the basin along Mantanzas, Spring, and Mark West creeks limit opportunities for recharge projects on the plain near these creeks. While recharge in the eastern uplands areas of the watershed may be feasible, recharge in these areas is unlikely to benefit groundwater users in the basin. The east side creeks drain a much larger watershed area compared with the small number of creeks draining the much smaller west side watershed. Larger watersheds mean larger volumes of storm water availability for capture and recharge. Given the small contributing watershed area, Wright, Gossage, and Blucher creeks on the west side of the basin are likely too small to provide significant recharge volumes.

5. Recommendations

This memorandum provides a screening of recharge potential on the Santa Rosa Plain. The GIS recharge potential maps can be used to zoom in to local areas. Once local potential recharge areas are defined, additional site specific studies are recommended. These may include:

- Installation and visual logging of soil borings to the water table
- Collection of soil samples every five feet or at changes in lithology and analysis for laboratory horizontal and vertical permeability and chemical composition
- Installation of groundwater monitoring wells
- Aquifer testing
- Groundwater quality testing
- Percolation tests
- Tracer studies
- Application of USGS groundwater model to assess fate of recharged water and effects of groundwater extraction on recharge water

6. References

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Figures

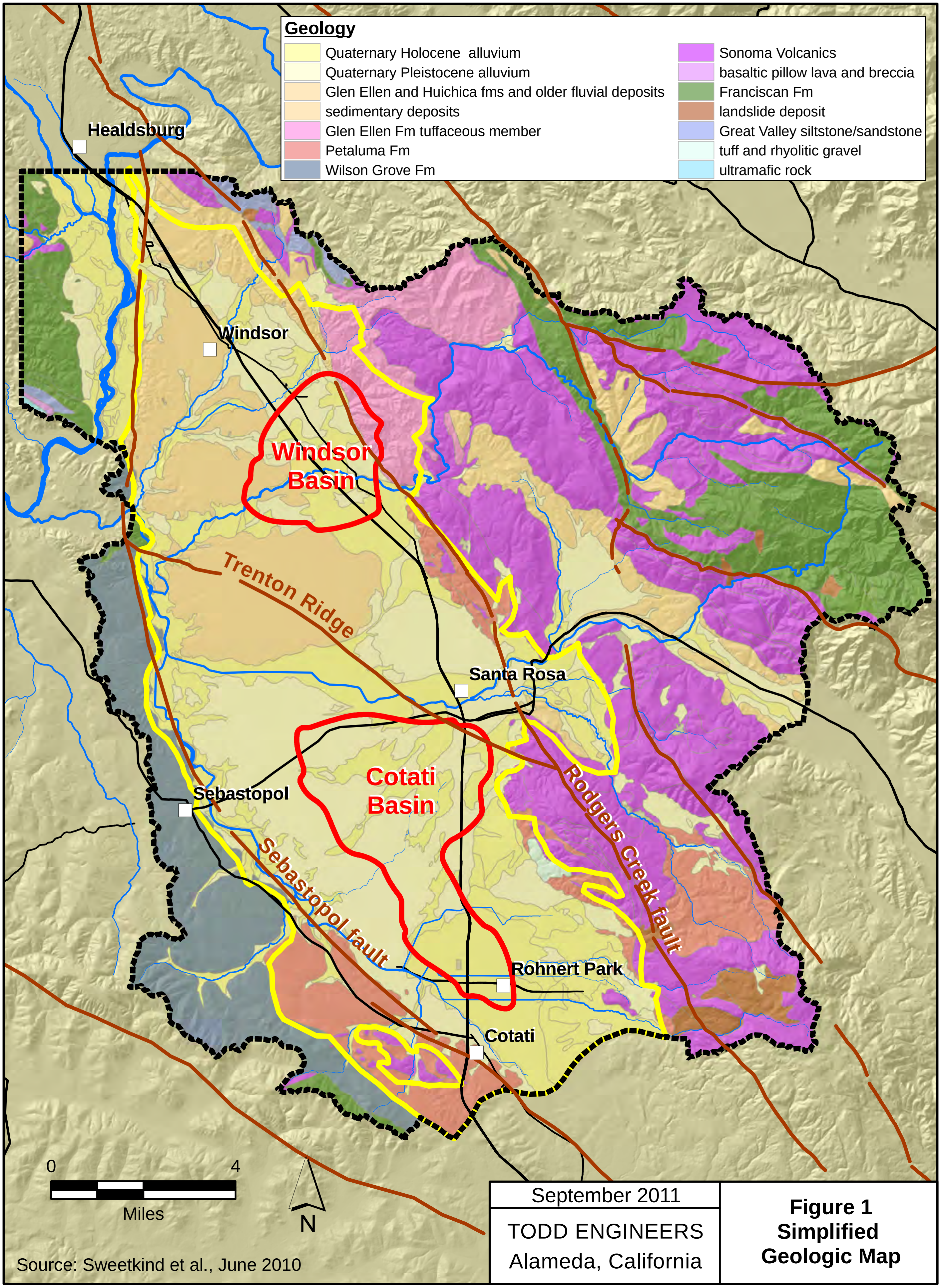
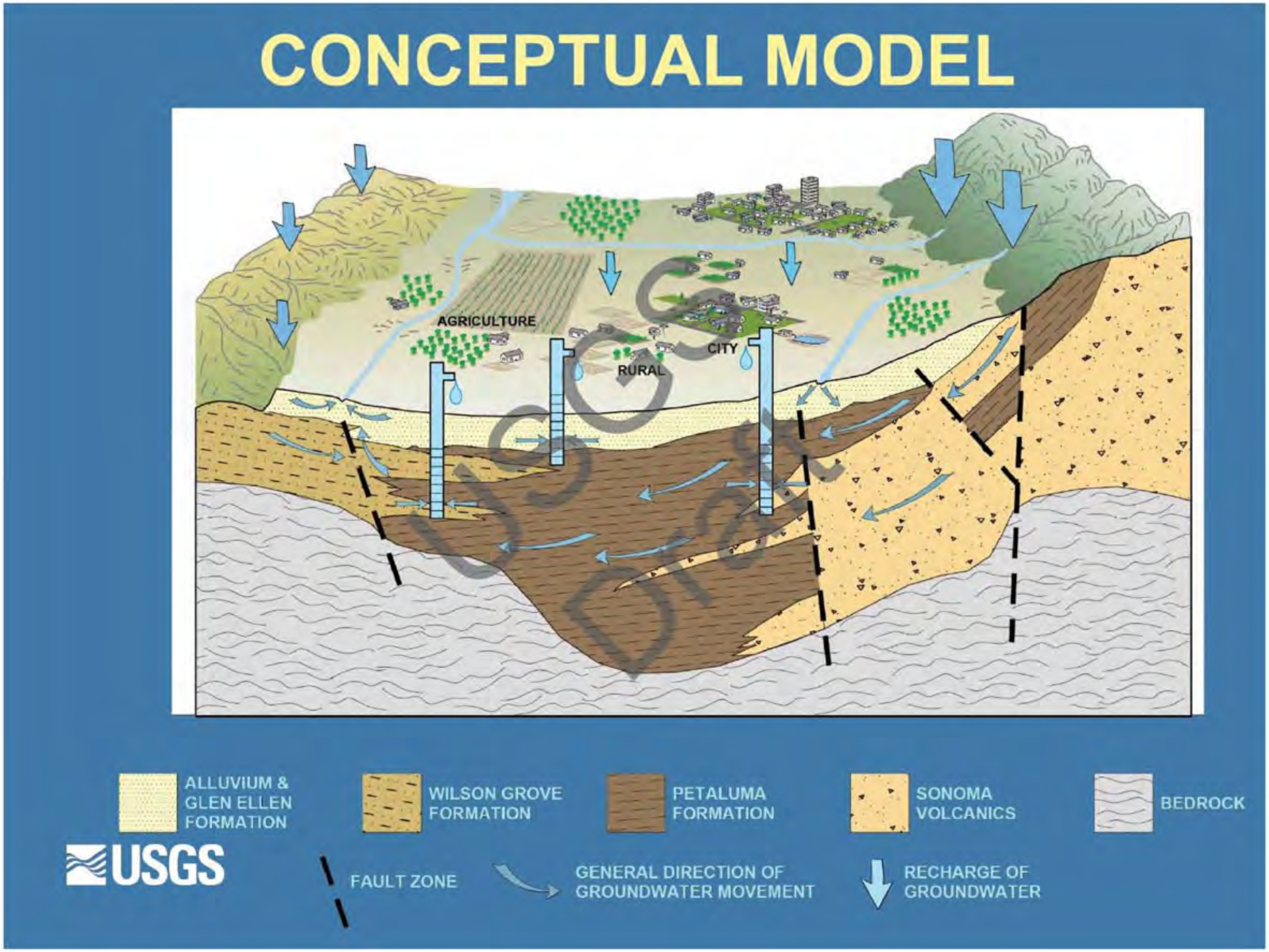


Figure 1
Simplified Geologic Map



Source: Draft USGS Presentation to SCWA, 2011

September 2011	**Figure 2**
TODD ENGINEERS Alameda, California	**USGS Conceptual Cross Section of Santa Rosa Plain**

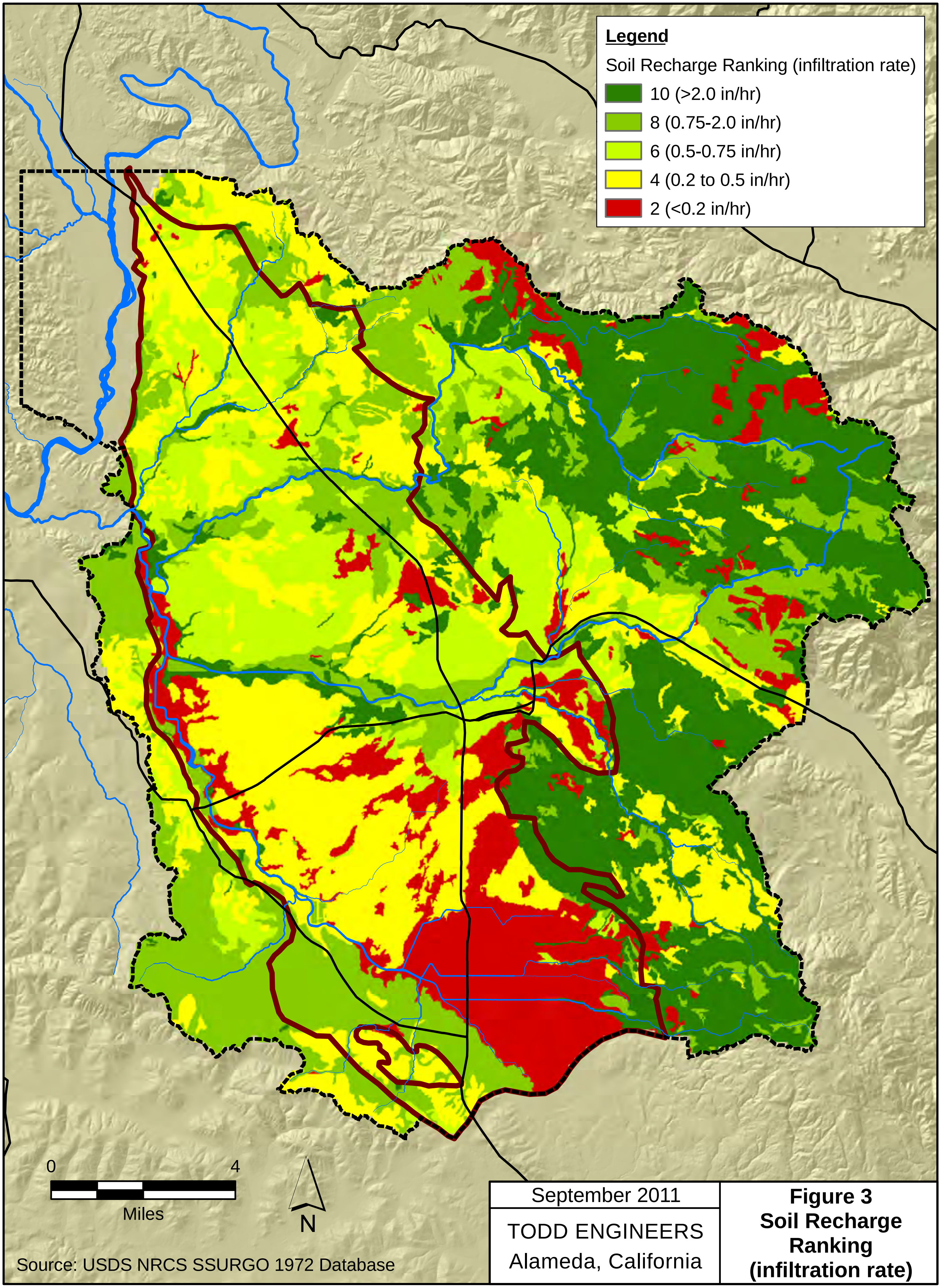


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Figure 3
Soil Recharge Ranking (infiltration rate)

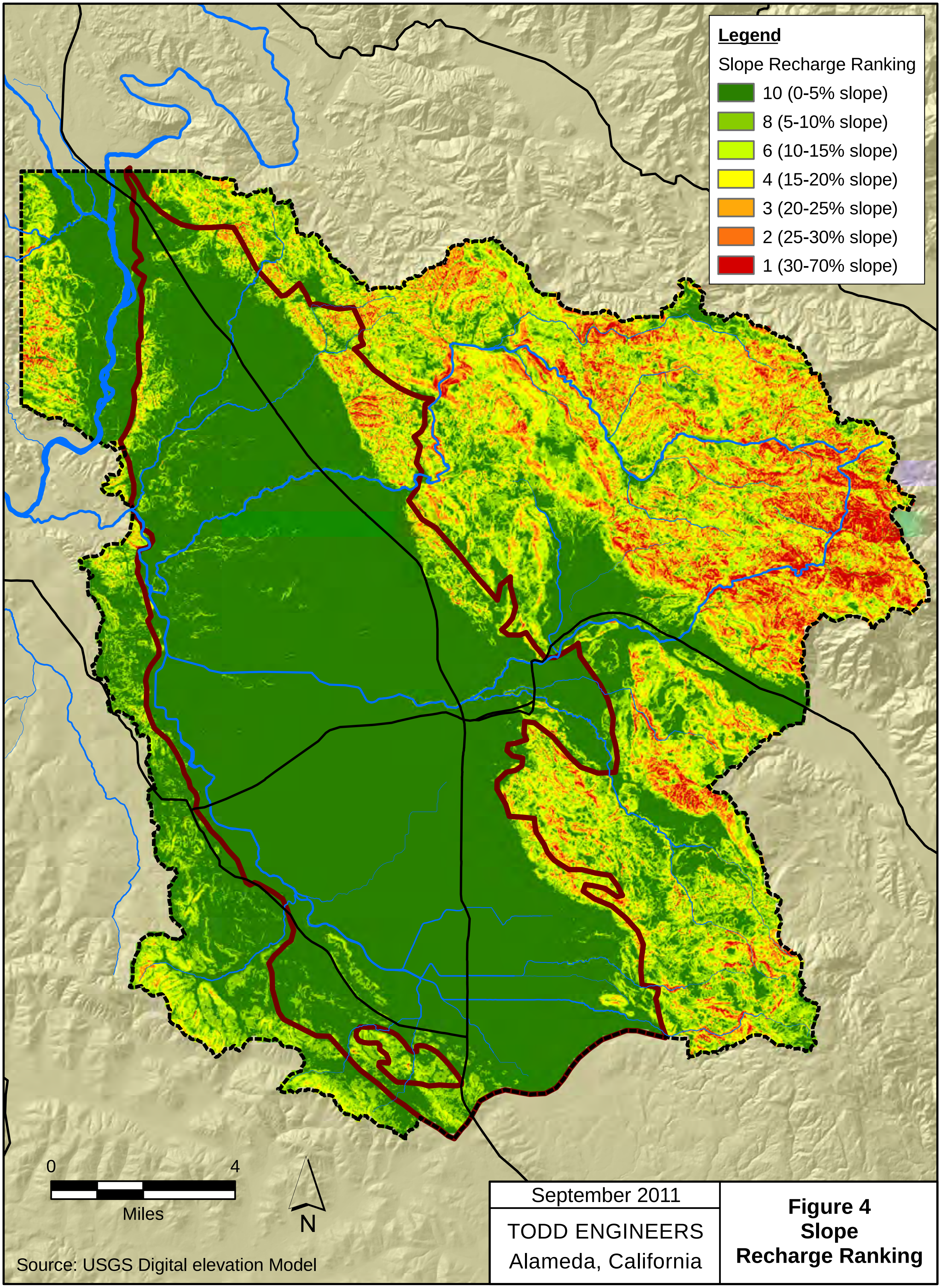

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Figure 4
Slope
Recharge Ranking

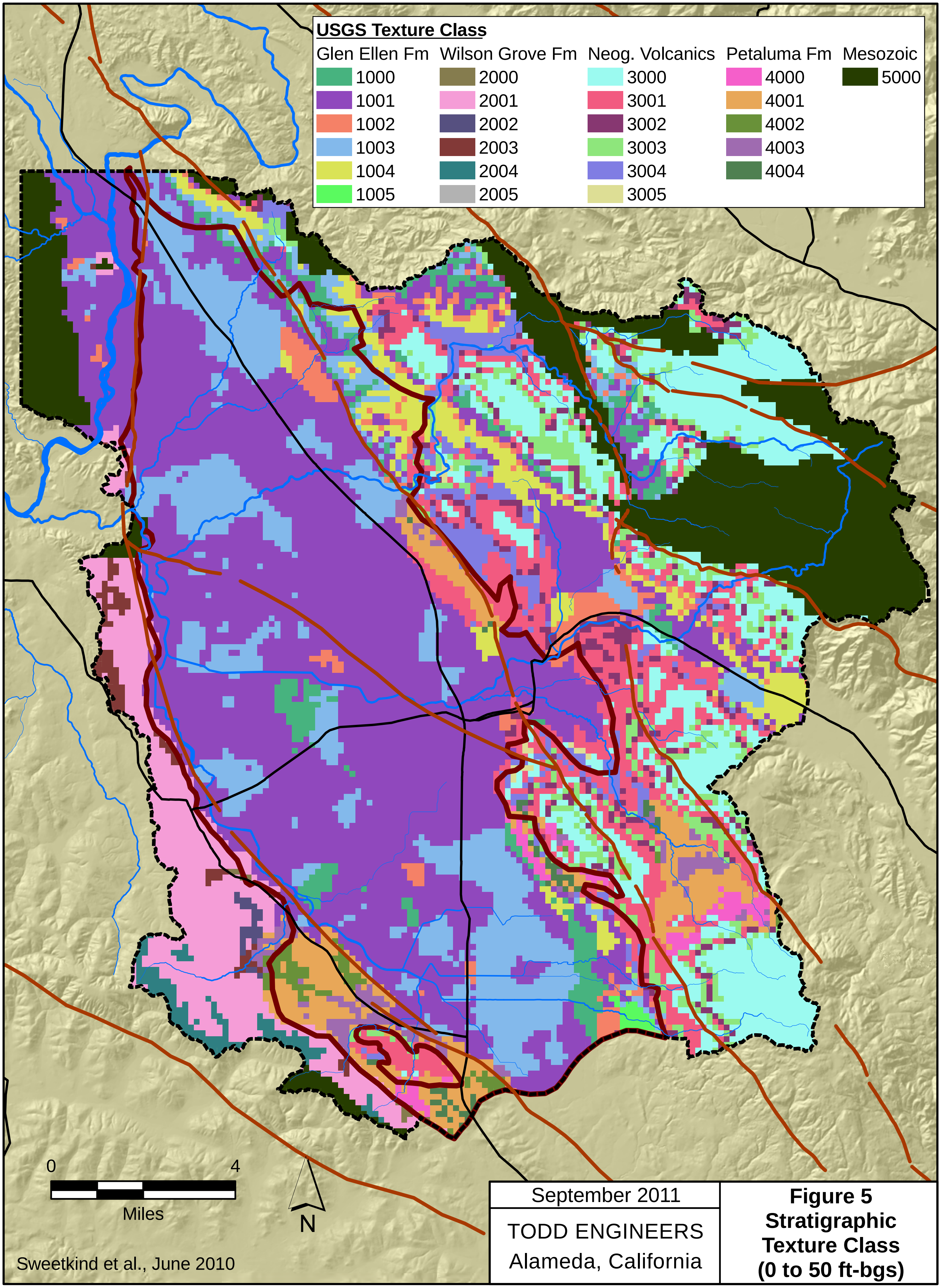

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Figure 5
Stratigraphic Texture Class
(0 to 50 ft-bgs)

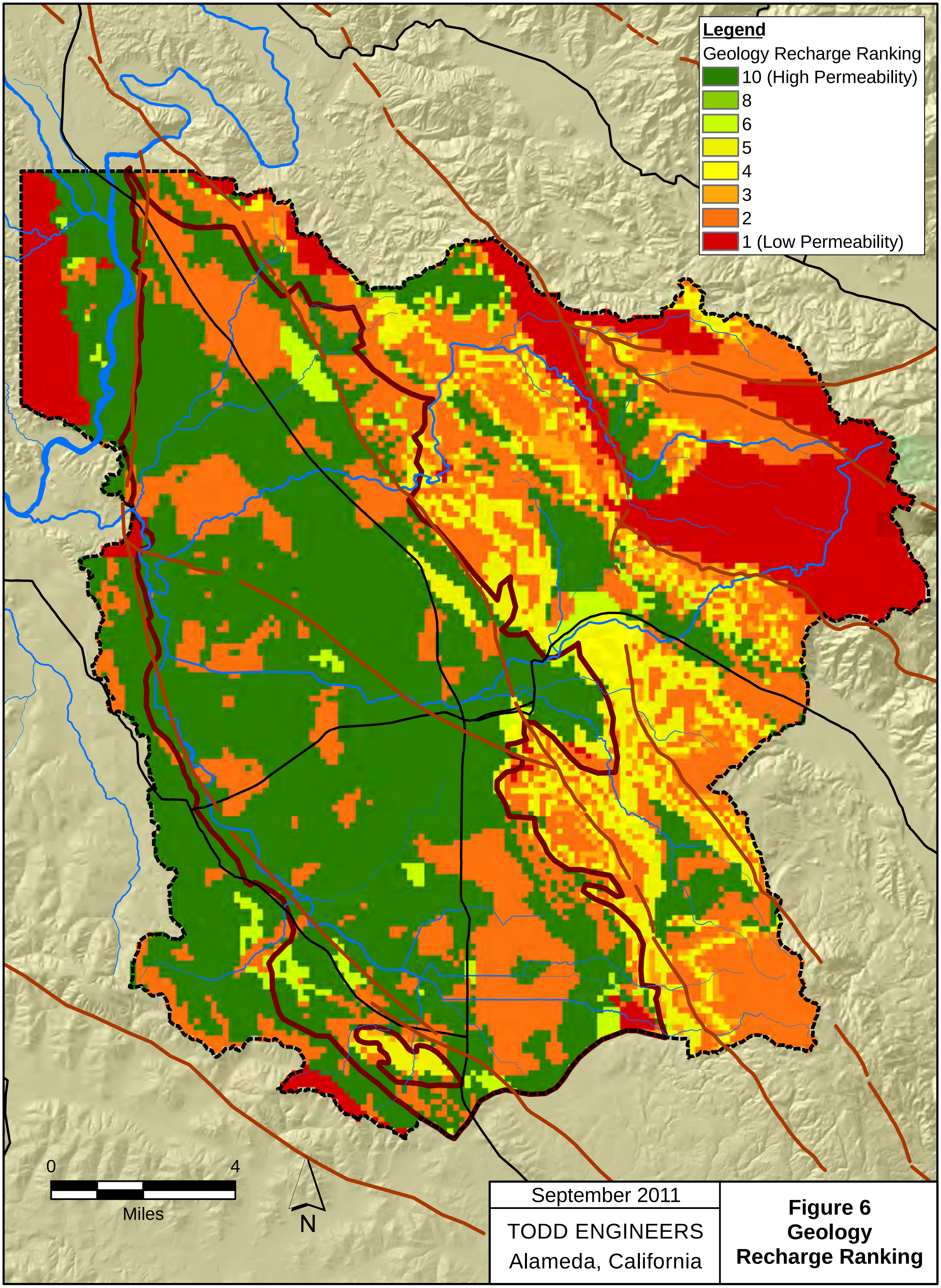
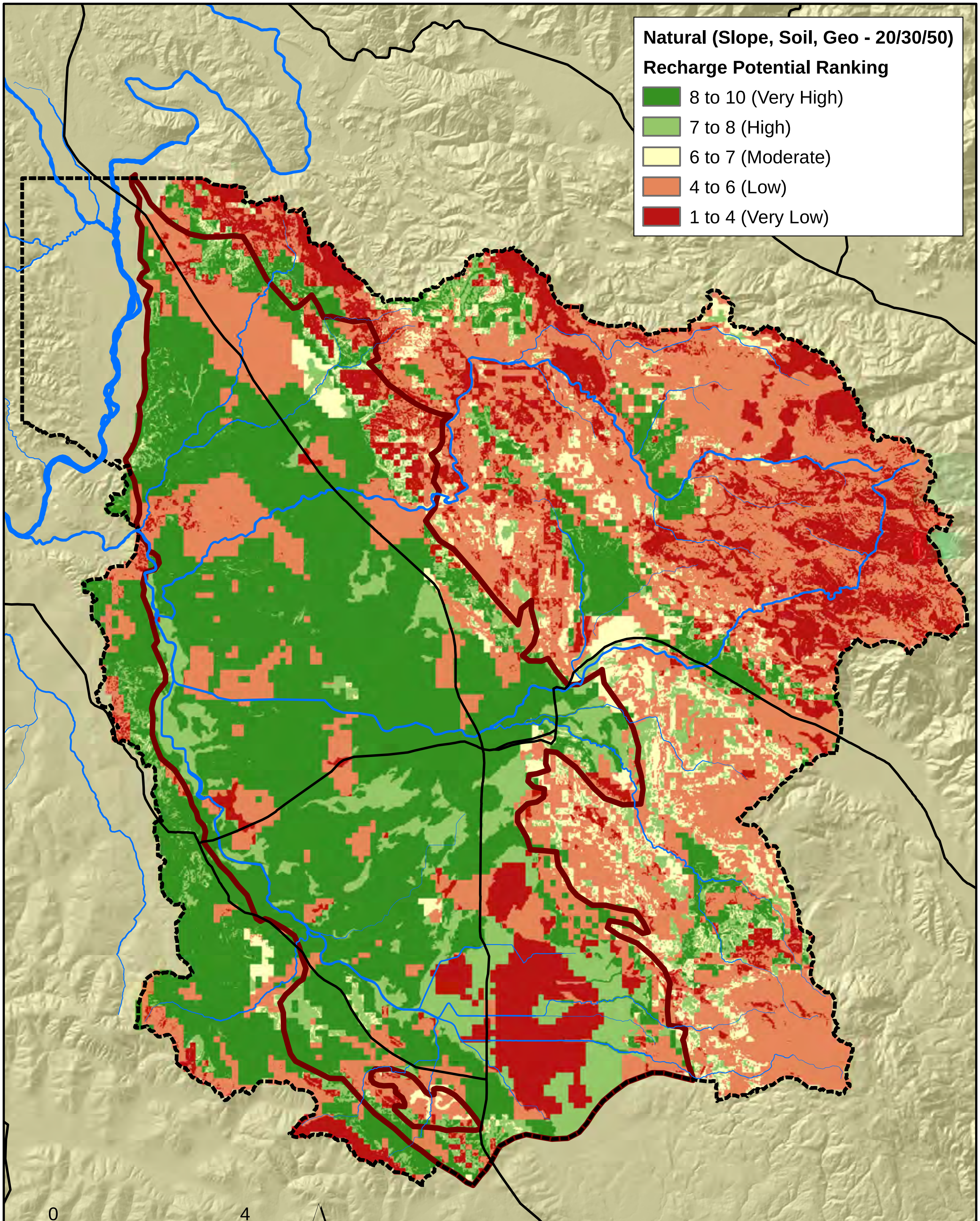


Figure 6
Geology
Recharge Ranking



September 2011	**Figure 7**
TODD ENGINEERS Alameda, California	**Natural Recharge Potential Ranking**

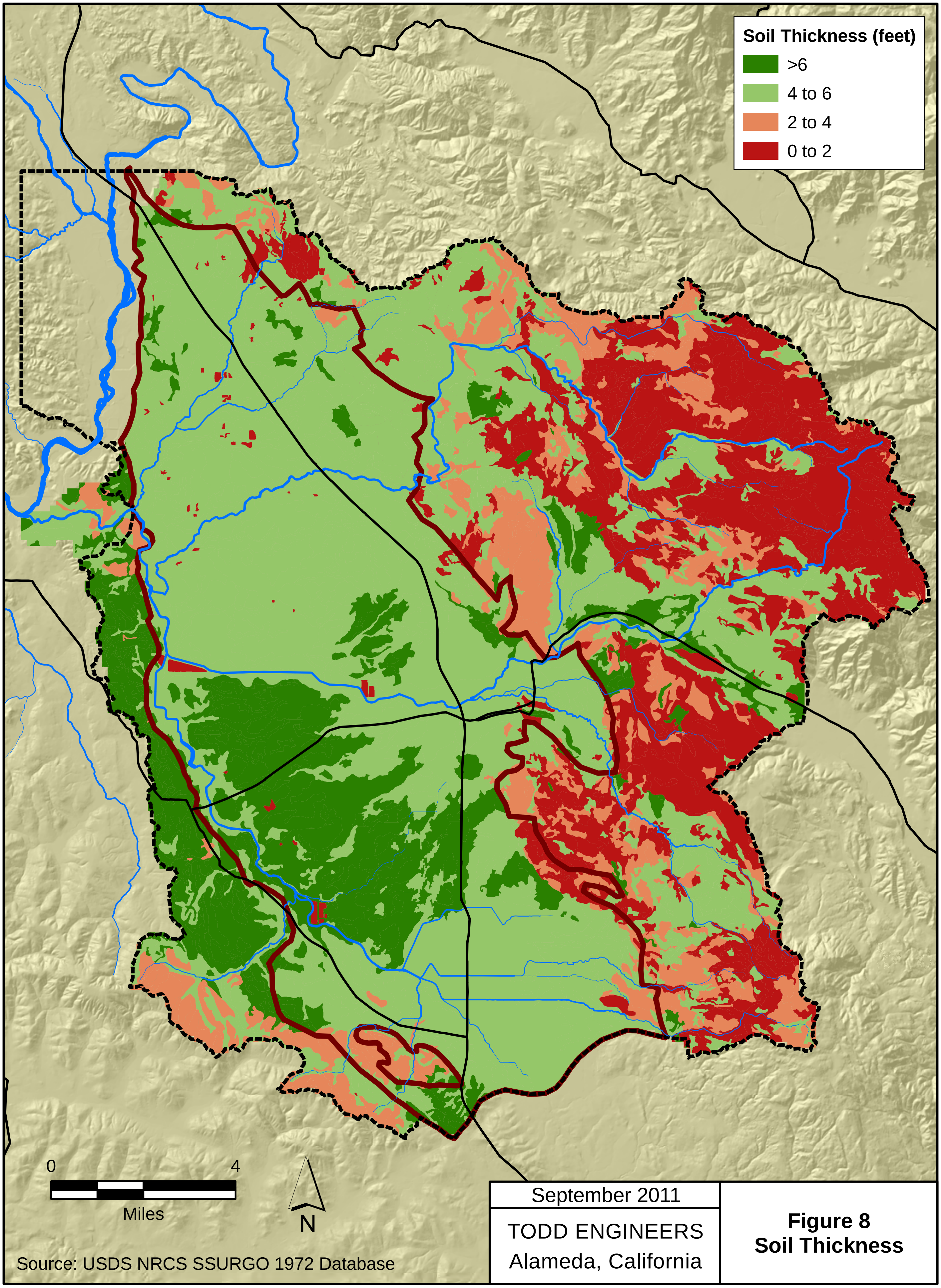


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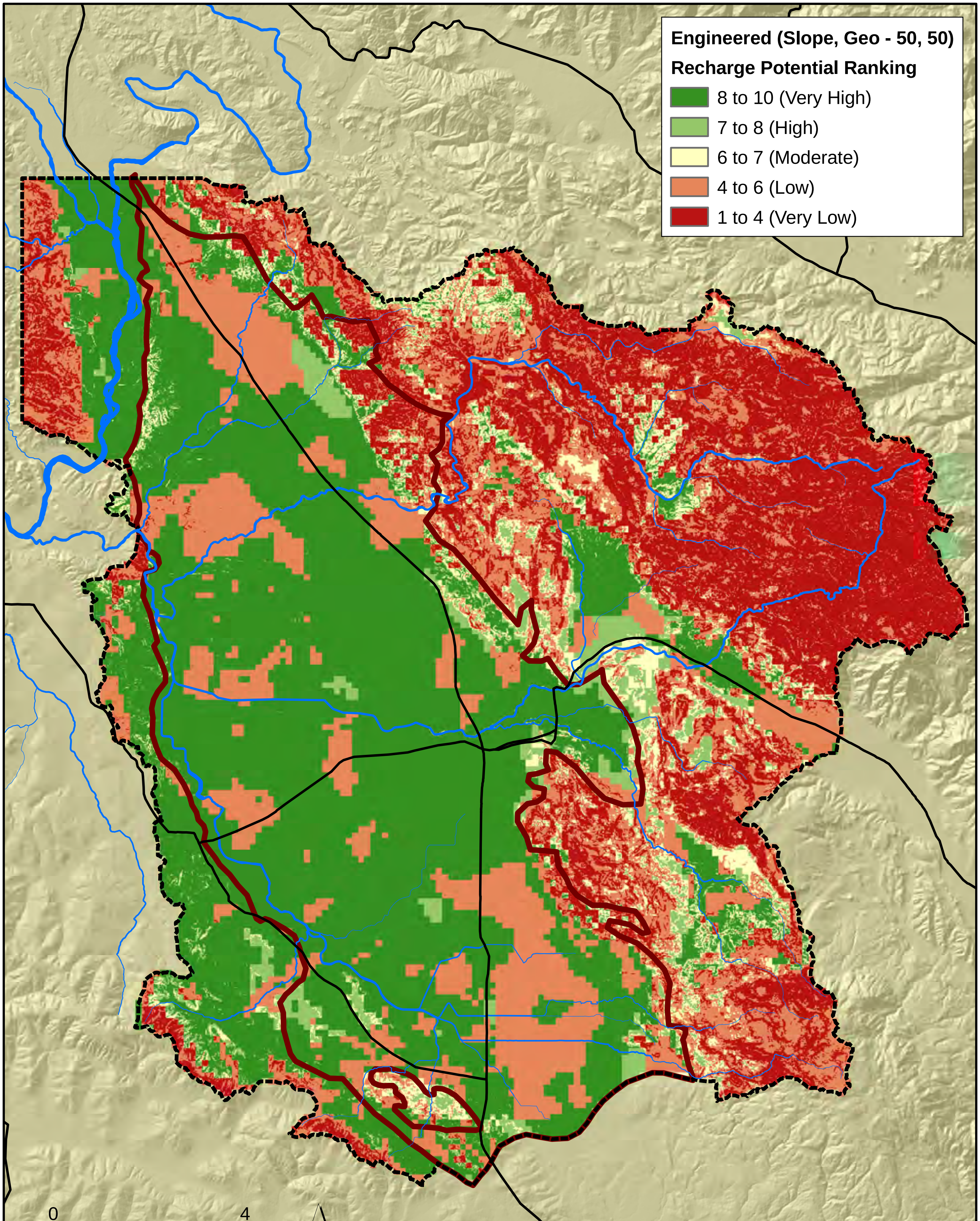
Figure 8
Soil Thickness



September 2011	**Figure 9**
TODD ENGINEERS Alameda, California	**Engineered Recharge Potential Ranking**

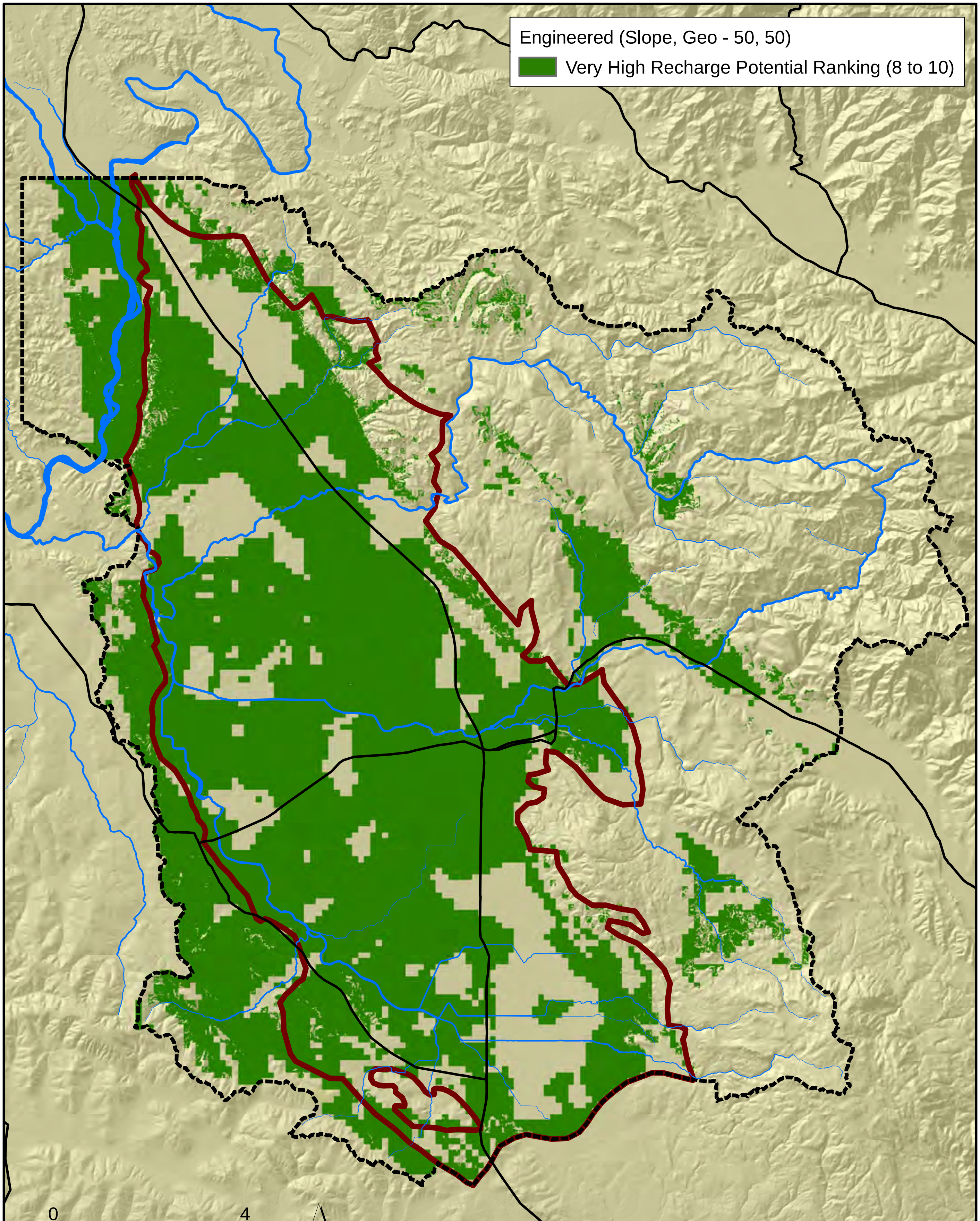


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Figure 10
Very High Engineered Recharge Potential Ranking

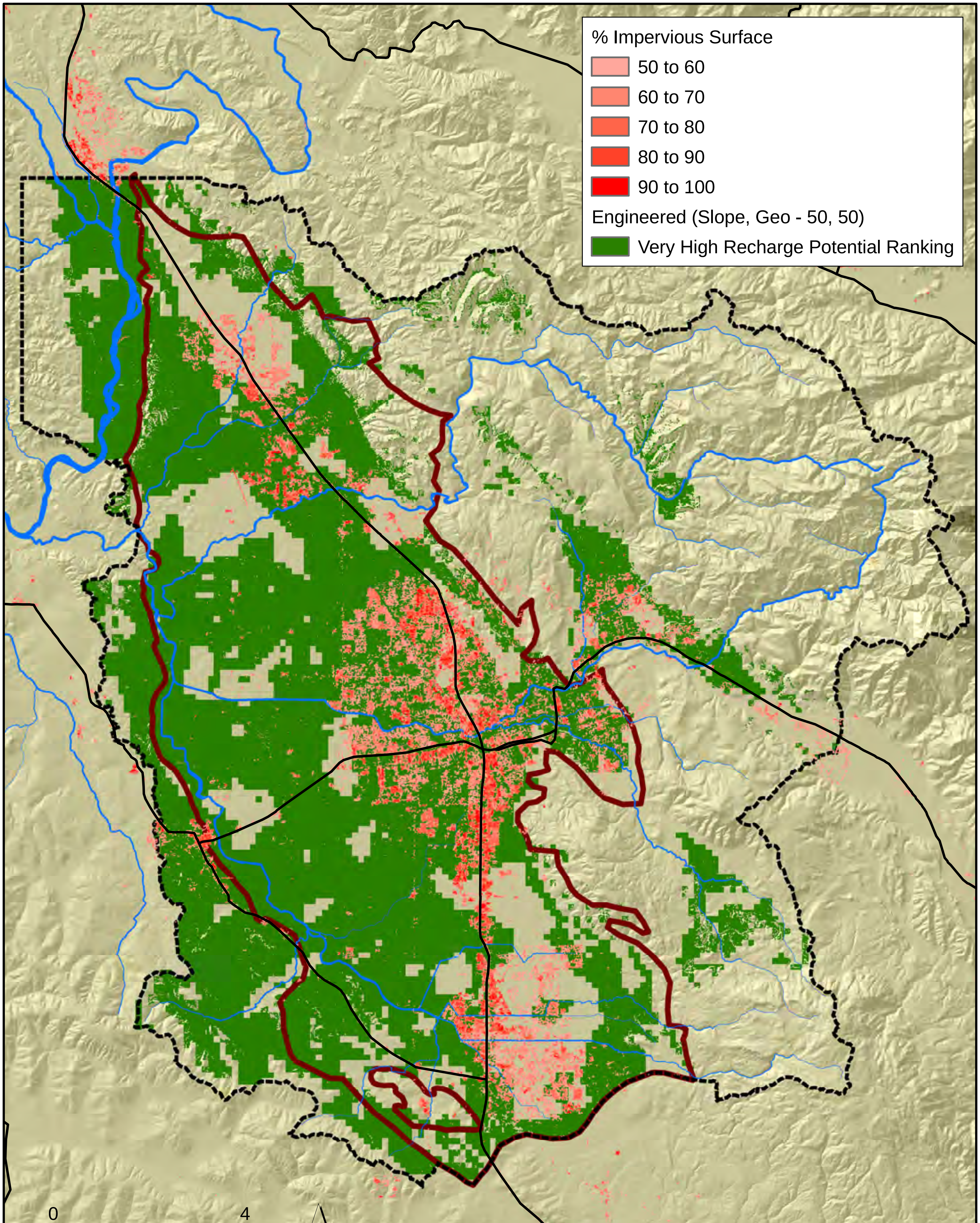

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Figure 11
Percent Impervious Surfces

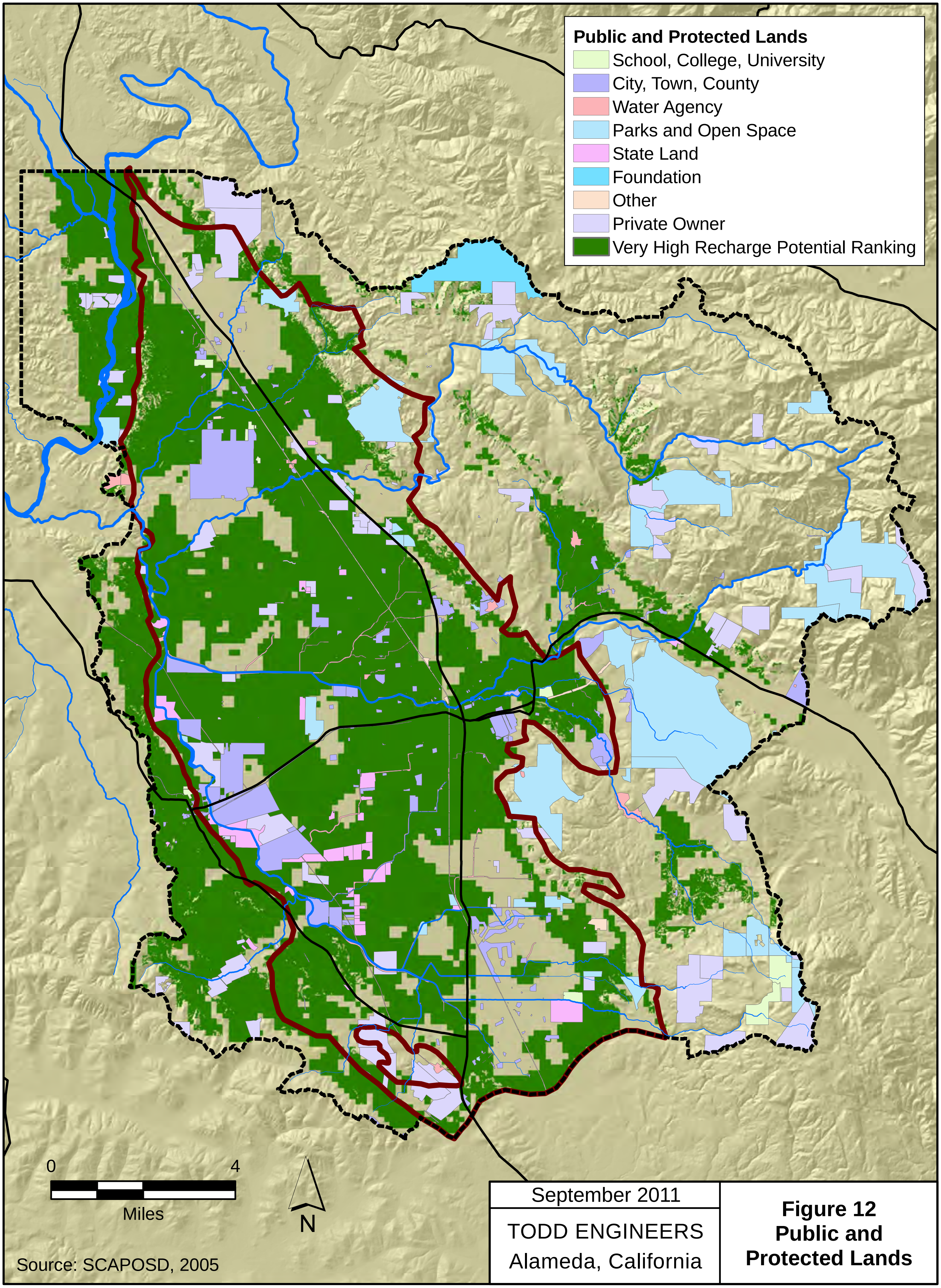

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Figure 12
Public and Protected Lands

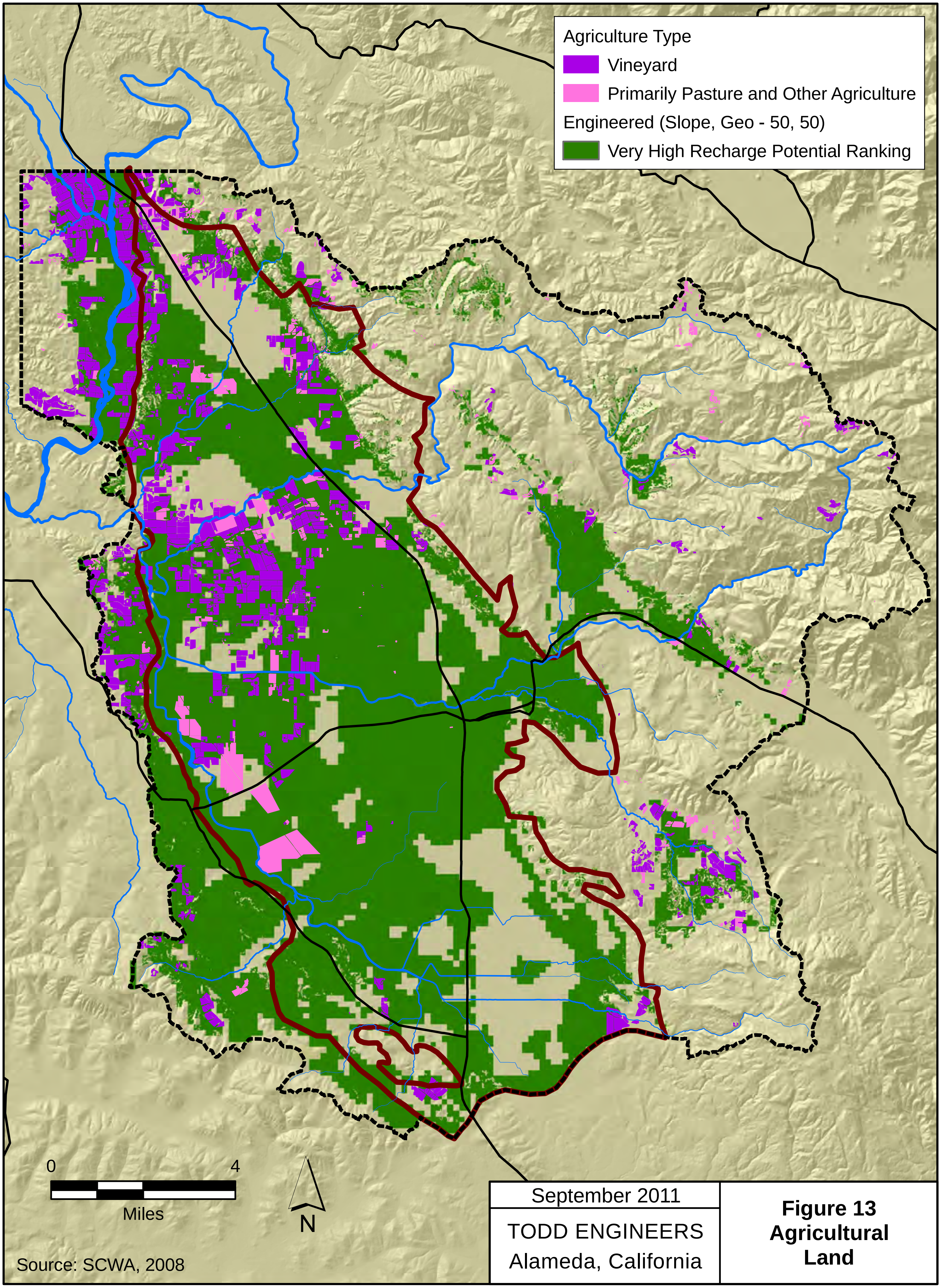

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Figure 13
Agricultural Land

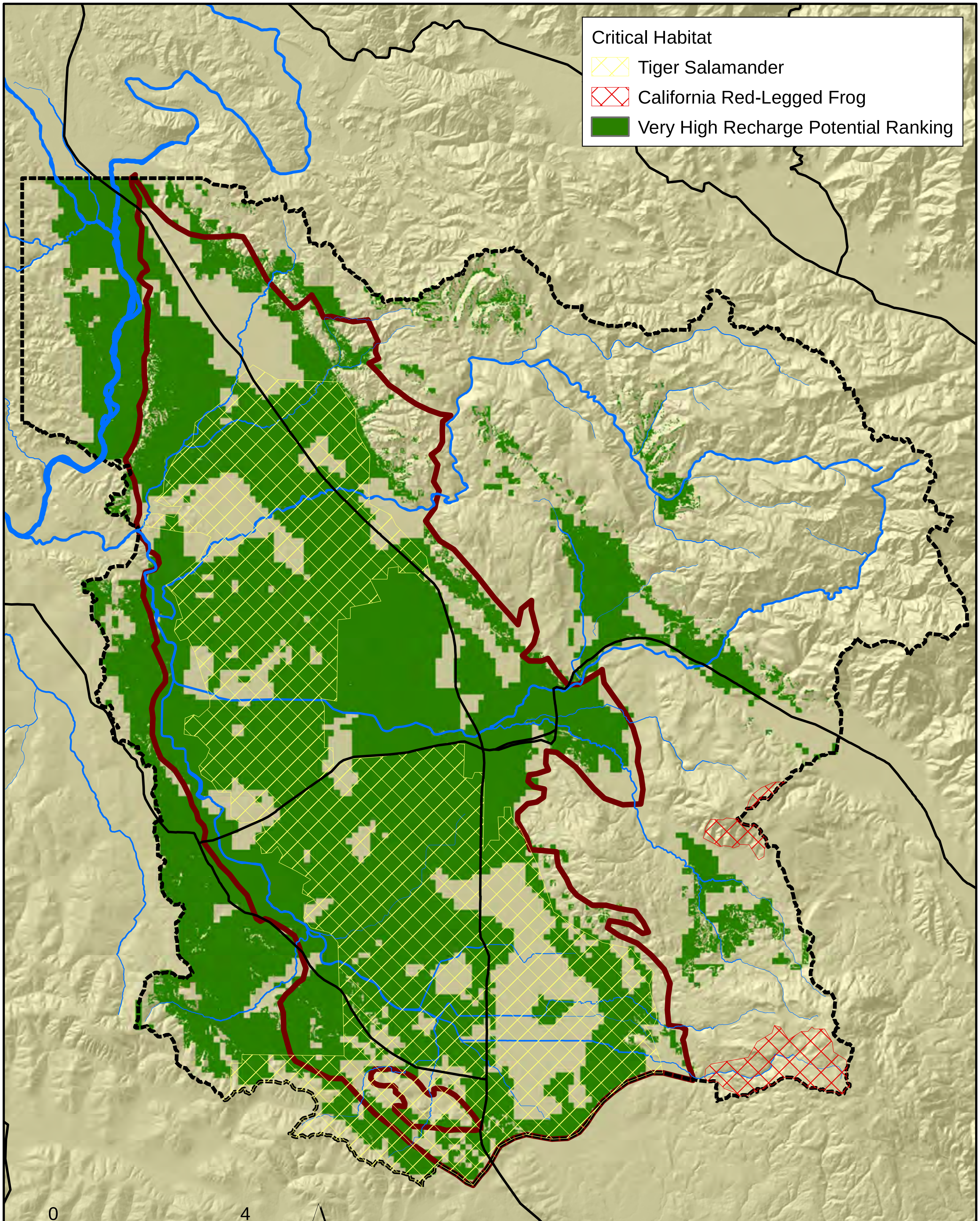

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Figure 14
Critical Habitat

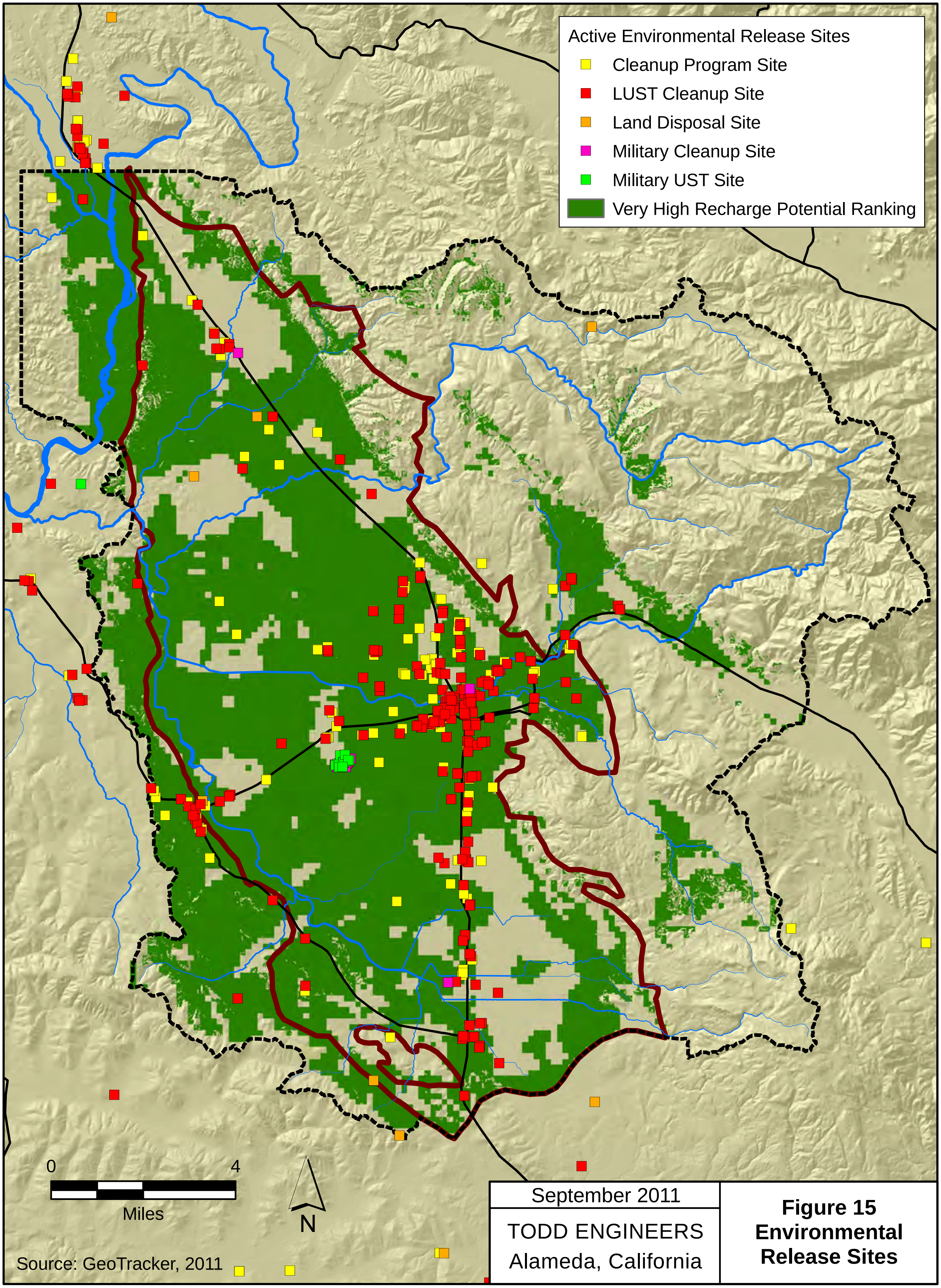

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Figure 15
Environmental Release Sites

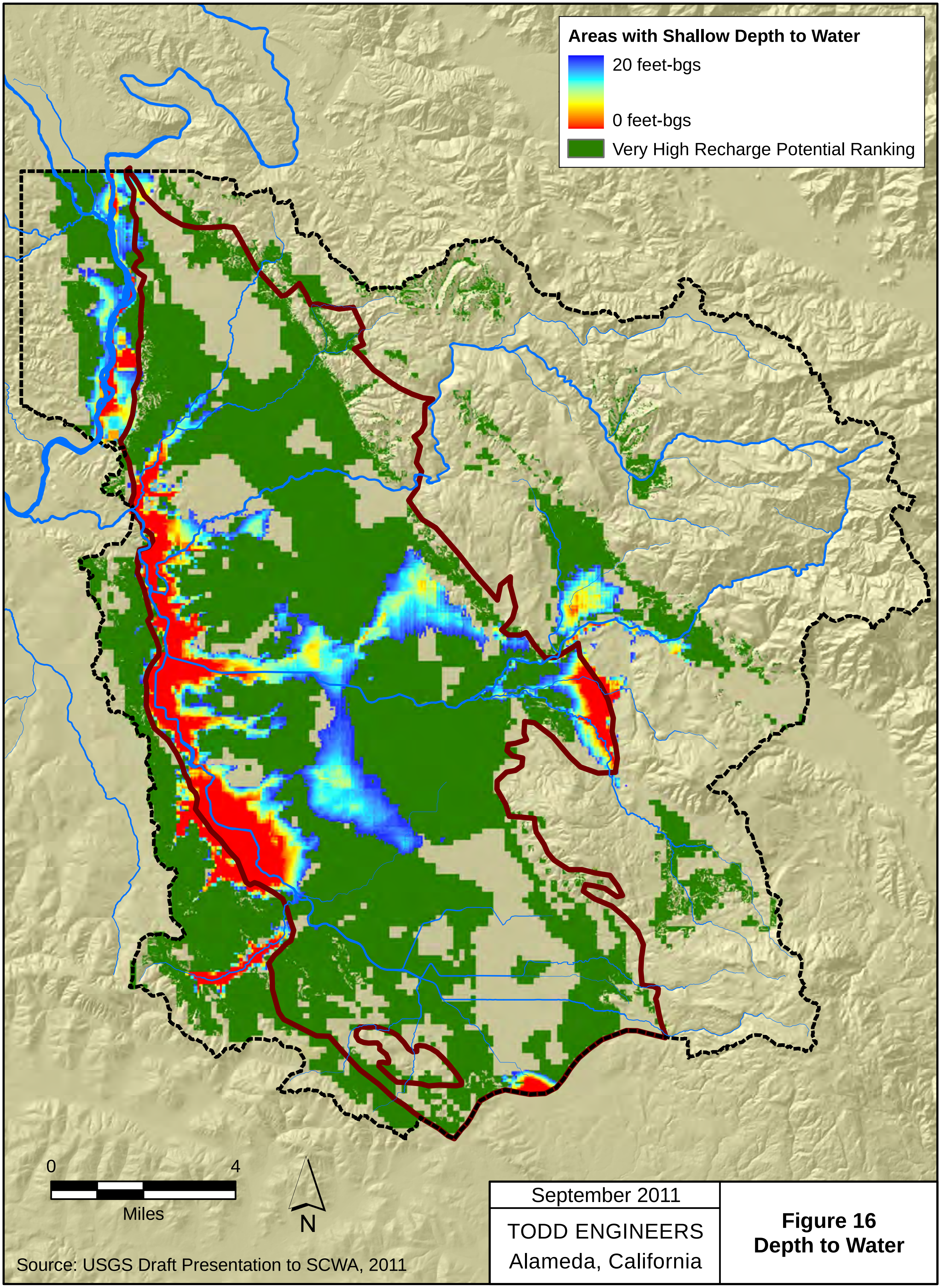

Figure 16
Depth to Water

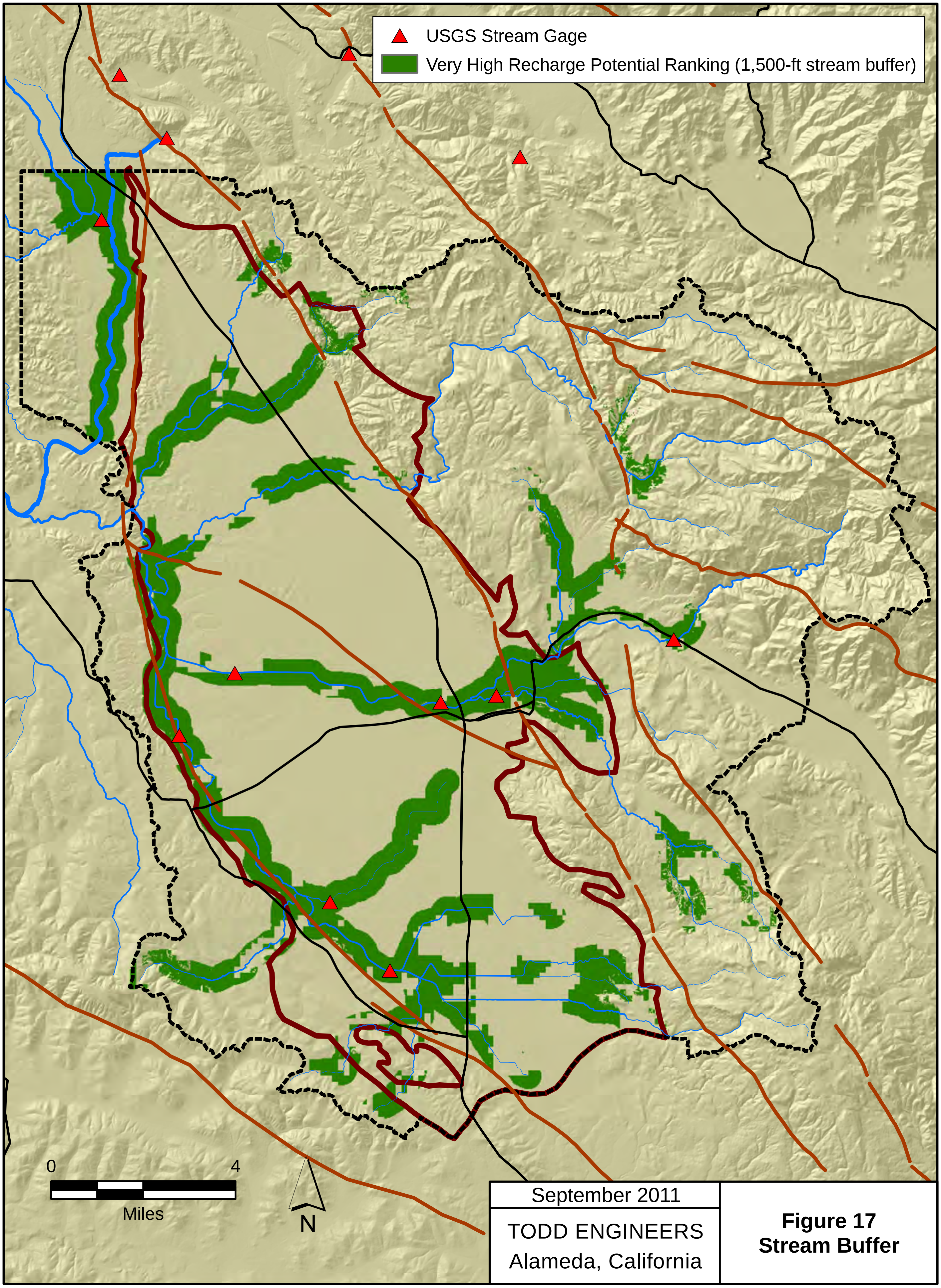

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Figure 17
Stream Buffer

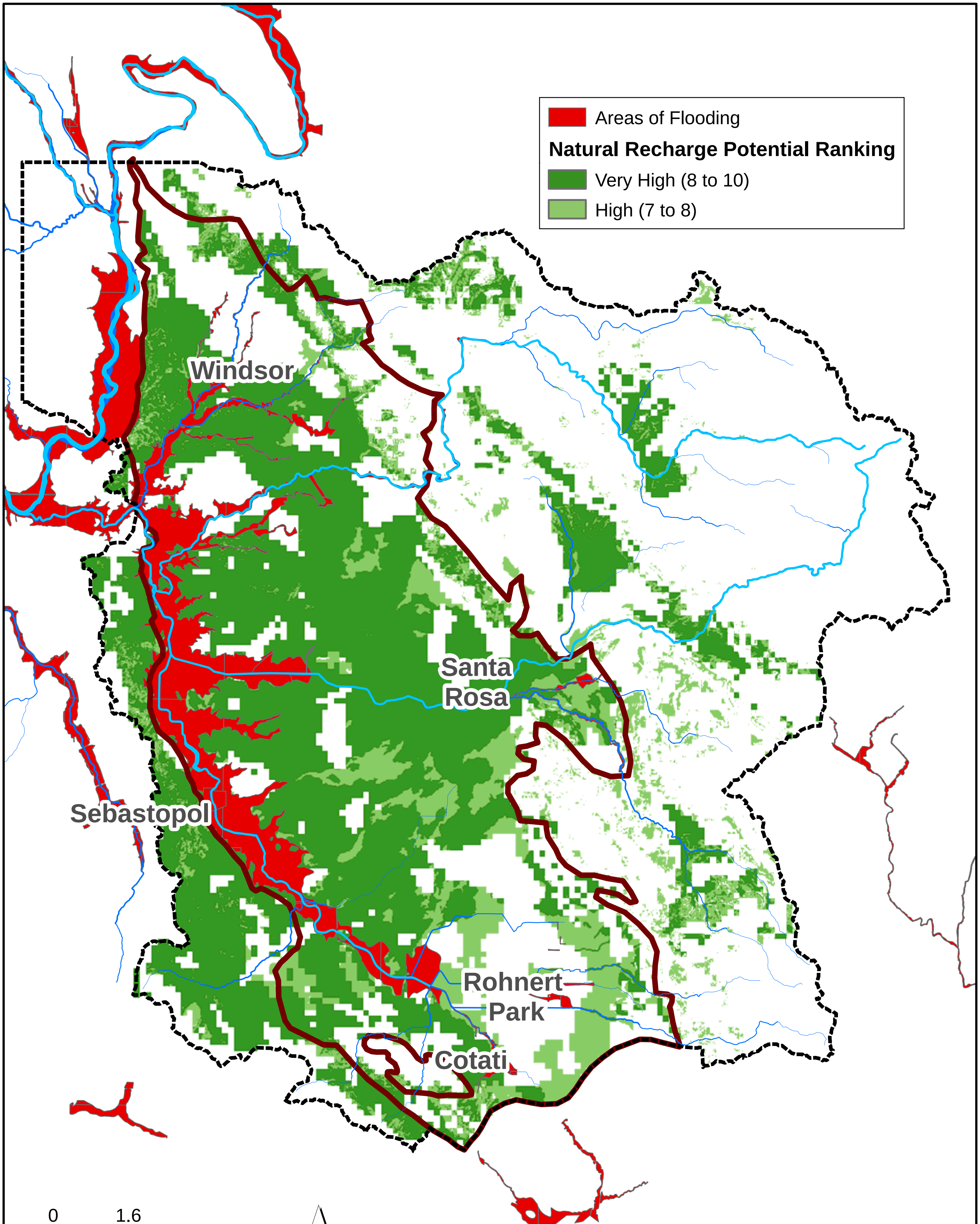

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Figure 18
Nat. High Recharge Flooding

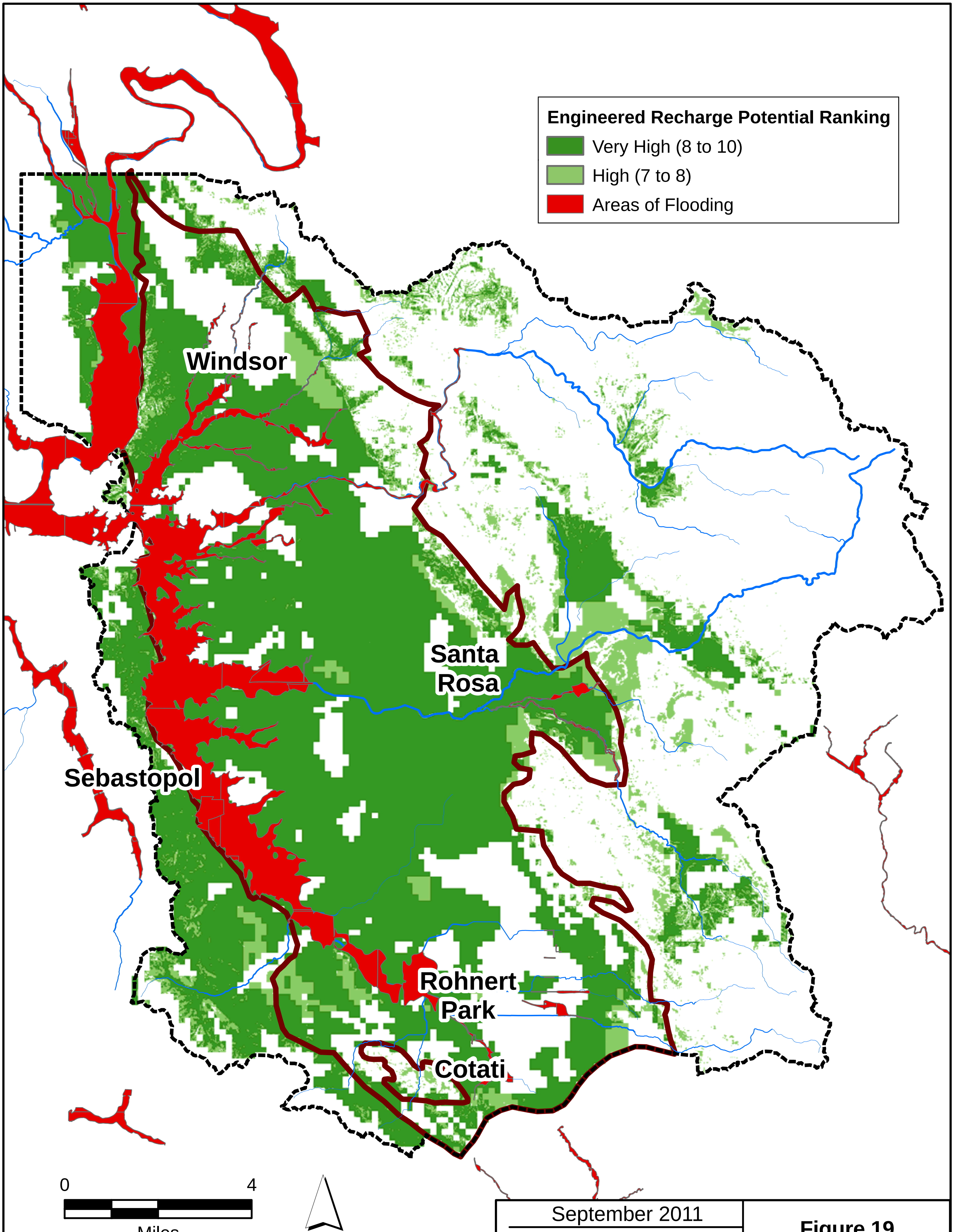

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Figure 19
Eng. High Recharge Flooding