Sonoma Valley Stormwater Management and Groundwater Recharge Scoping Study

Screening Evaluation and Prioritization Memorandum

Prepared for the Sonoma County Water Agency

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April 30, 2012

DW02050.00

Sonoma Creek at Glen Ellen, following the peak of the 2005-2006 flood event.
Image from the Sonoma Valley Historical Ecology Archive. Elaine Nealley, photographer.

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1 Introduction

The Sonoma County Water Agency (Water Agency) seeks to identify potential projects within the Sonoma Valley that can meet stormwater management and groundwater recharge goals. The Water Agency has contracted with ESA PWA, Daniel B. Stephens & Associates, Parker Groundwater, and other subconsultants to develop these project concepts, vet them with Sonoma Valley stakeholders, and help identify potential funding sources.

1.1 Project purpose

An immediate action of the Water Agency's 2010 Water Supply Strategies Action Plan is identification of projects within Water Agency flood control zones that reduce flooding and increase groundwater recharge. An important tool in identifying and improving water resource management in the Sonoma Valley is the 2007 Groundwater Management Plan (GMP). The GMP identifies stormwater recharge as a key action towards achieving groundwater sustainability. Other key actions identified in the GMP include groundwater banking, increased use of recycled water and conservation and other demand-reduction measures. The Sonoma Valley GMP goal – groundwater sustainability – cannot be reached without implementation of each of these actions.

The goal of the Sonoma Valley Stormwater Management and Groundwater Recharge Scoping Study is to develop one or more stormwater management/groundwater recharge projects that address the Key Project Purpose: reducing flood hazards and increasing opportunities for groundwater recharge within the Sonoma Creek watershed.

For the purposes of this effort, a project may consist of either a single facility or a suite of "elements" that function physically as stand-alone projects but collectively address core project objectives. For example, a single facility option might be a retention basin for stormwater that reduces the size of a flood peak while enhancing groundwater recharge. A multiple-element project might include a project to create a designated high flow bypass area for a creek, together with an educational and incentive program to encourage retrofitting of residences for onsite stormwater infiltration.

1.2 Effort to date

The Sonoma Valley Stormwater Management and Groundwater Recharge Scoping Study has thus far completed review of existing information, development of project objectives, prepared an assessment of flood hazard and groundwater issues, and crafted and implemented a draft general project opportunity screening and prioritization approach, as documented in this memorandum. We have held one county-wide meeting with potential project partners, including cities, other local entities, and non-governmental organizations, as well as one Sonoma Valley-focused meeting with identified stakeholders, including members of the Basin Advisory Panel and the associated Technical Advisory Committee, and other interested members of the public. Input received at these two meetings and from subsequent written comment has shaped the approach we have taken in this project effort and in revising draft project deliverables.

1.2.1 Project deliverables

Products generated to date include the following products:

- Reference inventory: a total of 75 documents and datasets related to stormwater and groundwater conditions in Sonoma Valley have been collected, scanned if not digitally available, organized, and collected into a single database.
- Project objectives framework: a document presenting a set of core and supporting objectives for the project.
- Issues assessment: a memorandum describing the project objectives and providing an overview of the flood hazard and groundwater setting within the Sonoma Valley.

1.2.2 Project objectives

Core and supporting project objectives were identified by the project team in consultation with the stakeholders. These were described in a Project Objectives framework document (draft distributed at the initial Stakeholders meeting on April 21, 2011).

Core project objectives include **both**:

1. Flood hazard reduction - Improve management of stormwater that contributes, directly or indirectly, to reduced flood hazards.
2. Groundwater recharge - increase beneficial recharge of groundwater, whether or not that recharged groundwater is directly accessible as water supply.

The core objectives are supported by a number of supporting project objectives, which may or may not be achieved by every project. Supporting project objectives include:

1. Water quality – Improve quality of surface water and/or groundwater supplies.
2. Water supply – Increase or improve water supply availability, reliability, and flexibility for domestic, municipal, industrial and agricultural use and for the environment.
3. System sustainability – Support energy and water efficiency and climate change resiliency of water management systems and developed supplies, as well as the ability of stream systems to be maintained by natural processes.
4. Ecosystem – Improve ecosystem function and/or habitat enhancement, especially for special status species.
5. Agricultural land – Preserve agricultural land uses.
6. Open space – Preserve and/or enhance open space.
7. Community benefits – Create and/or enhance recreation, public access, education, etc.

During our discussions with stakeholders, there was suggestion that this project seek to address flood "risks." Flood risk is defined to include both the probability of flooding and the expected costs of that flooding. We have elected not to limit this effort to concepts benefiting current land uses and investments and instead retained the more general language of "flood hazard" reduction, though "flood risk" reduction can be expected to receive higher priority for action.

1.3 Project process

With input from Sonoma Valley stakeholders, the Water Agency will develop a project that achieves the project purpose and satisfies the core objectives. The process being undertaken is illustrated in the flowchart below:

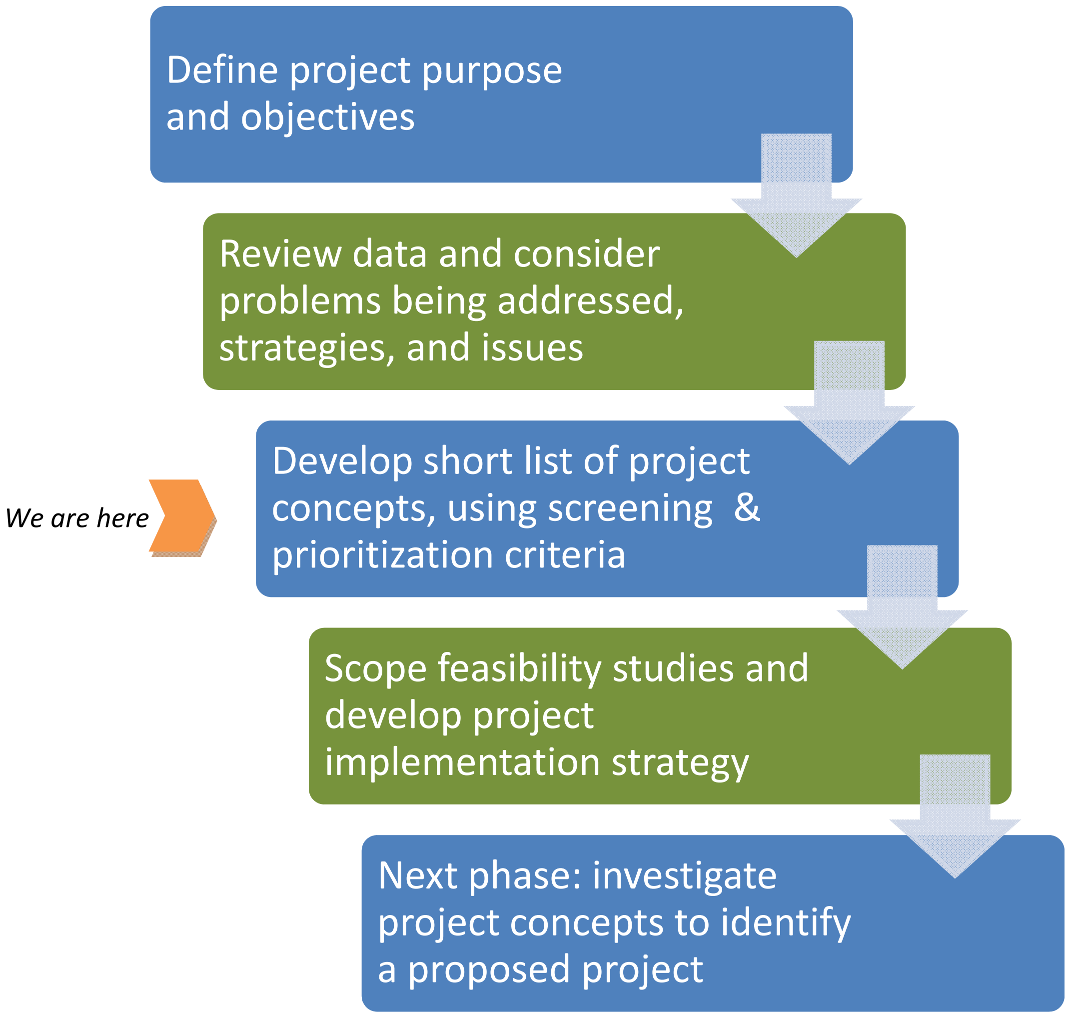


Figure 1. Project development process

After receiving input from the stakeholders of the Sonoma Valley on project concepts to consider, the Water Agency will further develop potential project concepts into specific project elements and a proposed project. The proposed project may consist of potential elements (e.g., facilities, programs, or other types of construction or land use change projects) grouped into a single project with an integrated budget and timeline. One or more proposed projects will ultimately be identified for further consideration, including development of needed additional feasibility studies and a funding strategy.

1.4 Purpose of this memorandum

This memorandum presents the basis for the screening and prioritization of project types considered for the purpose of this scoping study and concludes with the identification of a short list of project concepts: project types by location in the watershed. This short list will be considered for further investigation by the Water Agency.

An overview of the process being used to develop the project concept short list is shown in Figure 2 below.

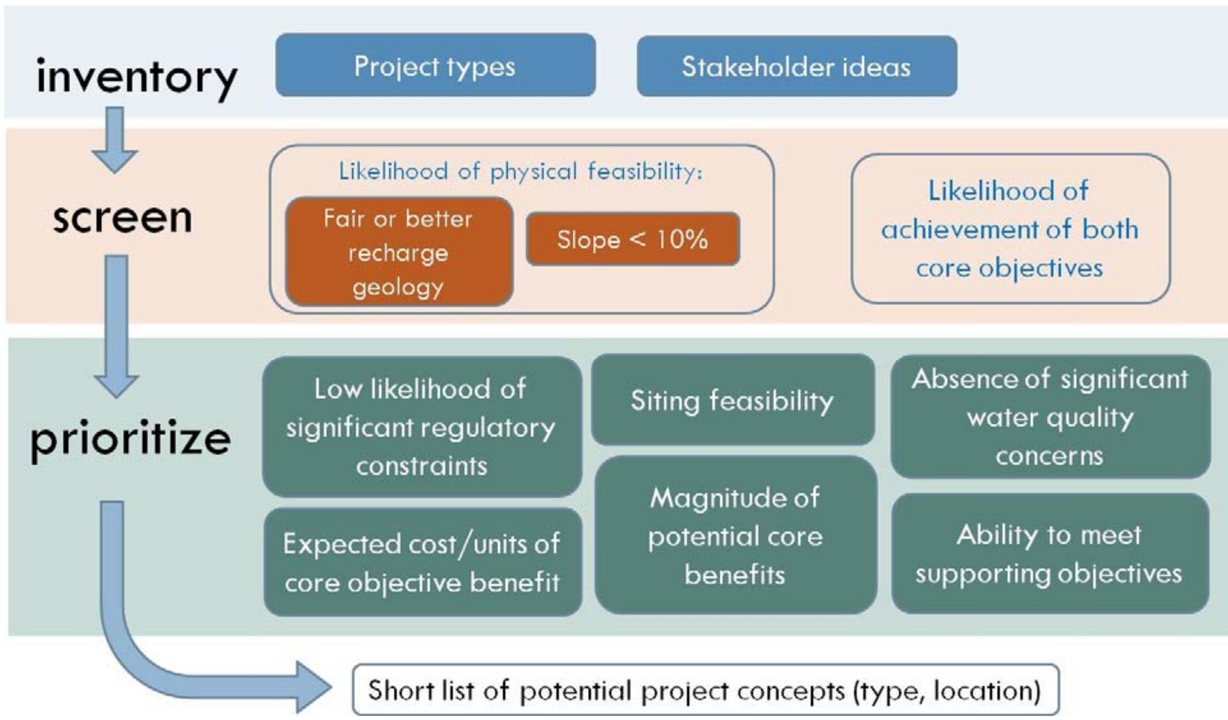


Figure 2. Flowchart of screening and prioritization process

1.5 Structure of this memorandum

Section 1 of this document presents background information on the overall project as well as the activities conducted to date. In **Section 2**, a survey of potential project types is presented and generally characterized. **Section 3** describes the screening process, which is based on 1) likelihood of physical feasibility based on two physical characteristics; and 2) likelihood of achievement of core objectives. Project types and locations that remain after the screening process are identified as project concepts. **Section 4** then describes and implements the prioritization criteria. We then conclude the memorandum with a brief discussion of next steps in **Section 5**.

2 Project types considered

For the purpose of the screening and prioritization process, we have evaluated the potential for generic types of groundwater recharge/flood hazard reduction measures. This process does not explicitly address specific project ideas that have been developed by the stakeholders or others, but will help to inform the broader context within which such projects are considered for further evaluation.

2.1 Requirements

As previously established during the development of Project Objectives, project types, or measures, considered for the purpose of this project must meet one or both of the core project objectives: flood hazard reduction and groundwater recharge. In this section, we provide an inventory of potential project types that may address at least one of the core project objectives. We note that any project that seeks to redirect stormflow, or modify existing wetlands or waterways, is likely to trigger a large array of regulatory and permitting requirements, as briefly addressed in the prior Issues Assessment (2011); here, we briefly highlight key regulatory constraints that are specific to each project type.

2.2 Sources

To develop the list of potential project types, we referenced the ideas presented by the stakeholders, published documents, and project team knowledge.

2.3 Potential project types or measures

This section provides a brief description of the potential project types or measures being considered as part of the Scoping study. Sections 2.3.1, 2.3.2, and 2.3.3 describe flood management measures: by decreasing flows, by increasing conveyance, and by modifying susceptibility to flood hazards, respectively. Section 2.3.4 describes measures to increase groundwater recharge, in some cases referencing similar measures that also fall in Section 2.3.1. Lastly, Section 2.3.5 describes measures to mimic natural site hydrology, generally known as Low Impact Development, or LID.

Table 1 below provides a list of each of the project types or measures described in the subsequent sections.

Table 1. Measures to reduce flood hazards and enhance groundwater recharge

Category	Strategy	Project type
Flood management		
	Decrease flood flows	
		In-line detention basins
		In-line retention basins
		Off-line detention basins
		Off-line retention basins
		High-flow diversions
		Floodplain attenuation
	Increase conveyance	
		Urban drainage infrastructure improvements
		Flow constriction improvement
		Channel clearing
		Levees and floodwalls
	Modify susceptibility to flooding	
		Relocation/land use changes

Category	Strategy	Project type
Groundwater recharge		
	Enhance groundwater recharge	
		In-line detention basins for recharge
		In-line retention basins for recharge
		Off-line detention basins for recharge
		Off-line retention/recharge basins for recharge
		Infiltration galleries
		Self-cleaning infiltration trenches
		Vadose wells for recharge
In-lieu of pumping		
		Above-ground or underground storage tank for use in lieu of pumping
Low impact development		
	Mimic natural site hydrology	Infiltration-based approaches
		Detention-based approaches

2.3.1 Measures that decrease flood flows

In-line detention basins

Detention basins (dry ponds, extended detention basins) provide temporary storage for surface runoff and are used to decrease peak flow. They collect runoff from an area and release it at a slower, controlled rate, thereby reducing streamflow. In-line facilities are located on the drainageway. In-line detention basins store and route the entire flood hydrograph. Therefore, in-line basins must be designed to store large volumes of water and generally require construction of a weir or dam structure.

Benefits

- Can be sized to detain a range of storms
- Simple to construct and maintain
- Can be combined with other purposes (stormwater quality enhancement, erosive flow reduction, recharge, habitat, recreation, aesthetic)

General regulatory constraints

- Can pose a barrier to fish passage; for Sonoma Creek and its tributaries, this would likely include steelhead, a special status species
- Requires major modification of stream channel and mitigation for disturbances. Due to environmental and permitting constraints, in-line detention facilities are not typically implemented in California.
- Larger detention basins may be regulated by the California State Division of Safety of Dams

Similar to in-line detention basins, in-line retention basins are located on the drainageway itself, and decrease flood flows by attenuating discharge behind an impoundment. Retention basins contain a persistently ponded area, whereas detention basins empty between storms. Retained water may be used directly for water supply, including recharge. In-line basins store and route the entire flood hydrograph and therefore must be designed to store large volumes of water. They generally require construction of a weir or dam structure. When designed for dual purposes of detention and retention, in-line basins are often actively managed, with flood-hazard detention goals dominating operation during the runoff season and water supply retention goals dominating during the dry season. This type of operation requires more complex outlet facilities and management systems.

Benefits

- Can be sized to detain a range of storms
- Can range from simple to quite complex to construct and maintain
- Can be combined with other purposes (stormwater quality enhancement, erosive flow reduction, recharge, habitat, recreation, aesthetic)

General regulatory constraints

- Can pose a barrier to fish passage; for Sonoma Creek and its tributaries, this would likely include steelhead, a special status species
- Requires major modification of stream channel and mitigation for disturbances
- Due to environmental and permitting constrains, in-line detention facilities are not typically implemented in California
- Larger basins may be regulated by the California State Division of Safety of Dams

Off-line detention basins

Off-line detention basins are located adjacent to the stream channel and receive runoff from larger storm events. Flow into off-line basins is controlled by a high-flow diversion from the drainageway, such as a weir or a culvert. Off-line detention basins typically receive flow only during high-runoff storm events. They are typically smaller and store water less frequently than in-line basins.

Benefits

- Can be sized to detain a range of storms
- Simple to construct and maintain
- Are typically smaller than in-line facilities
- Can be combined with other purposes (stormwater quality enhancement, erosive flow reduction, recharge, habitat, recreation, aesthetic)
- Do not pose a barrier to fish passage

General regulatory constraints

- Requires minor modification of stream channel for purposes of constructing diversion
- Larger basins may be regulated by the California State Division of Safety of Dams

Off-line retention basins

Off-line retention basins (wet ponds) are facilities adjacent to the drainageway that provide storage for surface runoff. Retention basins have permanent ponding areas that store flow for a much longer duration, typically throughout the year. In addition to permanently ponded storage, retention basins often have temporary storage that is only used during high runoff events.

Benefits

- Can be sized to detain a range of storms
- Simple to construct and maintain
- Are typically smaller than in-line facilities
- Can be combined with other purposes (stormwater quality enhancement, erosive flow reduction, recharge, habitat, recreation, aesthetic)
- Do not pose a barrier to fish passage

General regulatory constraints

- Requires minor modification of stream channel for purposes of constructing diversion
- Larger basins may be regulated by the California State Division of Safety of Dams

<u>High-flow diversions</u>

High-flow diversions redirect excess flows away from developed areas using natural or artificially constructed bypass channels or conduits. Such diversions require an adjacent low-lying area or an area with landuses compatible with infrequent inundation. An example of a high-flow diversion is the Yolo Bypass in the Sacramento River Basin and the "oxbow" bypass recently constructed by the US Army Corps of Engineers for the Napa River Flood Control Project in downtown Napa. If such a diversion alters the timing of flood flows, it may increase or decrease flood risks downstream of the return point.

Benefits

- Reduces the need for more expensive measures, such as detention and conveyance improvements
- Can be integrated with other land uses (agriculture, wetlands, recreation)

General regulatory constraints

- Land must be zoned for compatible uses
- Requires minor modification of stream channel for purposes of constructing diversion

<u>Floodplain attenuation</u>

Floodplain attenuation refers to reconnecting a stream to a floodplain and using the floodplain area to detain flows. Excess runoff is temporally stored in adjacent flooded areas, and returns to the channel after flood stages have receded. Floodplain attenuation requires a large floodplain area and land uses that are compatible with periodic inundation.

Benefits

- May reduces the need for more expensive measures, such as detention and conveyance improvements
- Can be integrated with other land uses (agriculture, wetlands, recreation)

General regulatory constraints

- Land must be zoned for compatible uses
- Requires minor modification of stream channel for purposes of constructing diversion

2.3.2 Measures that increase conveyance

"Increased conveyance," as used in this document, is assumed to mean increased ability to convey water within a given horizontal footprint or stage. Thus, measures that are designed to reduce flood stage by modifying channel conditions (e.g., improve flow constrictions) are included here, as are measures that increase stage but reduce the horizontal extent of floodwaters (e.g., levees). Any measure that increases conveyance in one reach has the potential to increase flow rates downstream, effectively transferring flood hazards from one area to another. As a result, such projects must be evaluated for this possibility during feasibility analysis.

Urban drainage infrastructure improvements
In areas that experience localized urban flooding, improving storm drainage infrastructure can reduce the frequency of flooding. This can be accomplished through a number of methods including increasing the capacity of storm drains, providing cross-connections and bypasses, removing poorly drained low-points, and improving stormdrain inlets.

Benefits

- Provides improved drainage in flood-prone urban areas

General regulatory constraints

- Can increase flooding in receiving channels downstream

Flow constriction improvement
Flow constrictions within the channel such as bridge crossings, culverts, or other localized constrictions can cause upstream backwater effects that result in flooding. Improving flow constrictions refers to measures that raise, replace or remove existing infrastructure and constrictions to improve the conveyance capacity of a drainageway.

Benefits

- Provides improved channel conveyance
- Improves the level of service of flooded bridges and other infrastructure

General regulatory constraints

- Can increase flooding in receiving channels downstream

Channel clearing
Vegetation growth or sedimentation can reduce the conveyance capacity of drainageways. This measure refers to the removal of vegetation and sediment from channels through mechanical means.

Benefits

- Provides improved channel conveyance

General regulatory constraints

- Riparian vegetation provides habitat for many species. Removal of vegetation would disturb important habitats. This type of project would require multiple permits from resource agencies and mitigation measures.
- Can increase channel velocities, resulting in increased erosion

- Can increase flooding in receiving channels downstream

Levees and floodwalls
Levees and floodwalls are structural measures that protect a portion of the floodplain from flooding, up to a certain design level. They are built parallel to the drainageway to prevent flooding on adjacent lands. Levees refer to engineered earthen embankments that prevent flooding, while floodwalls are concrete structures that are typically used in urban areas where levees are infeasible.

Benefits

- Prevents floodplain inundation

General regulatory constraints

- Ongoing maintenance and inspection are necessary
- Can require significant disturbance of the stream channel
- Can increase upstream water surface elevation (stage)

2.3.3 Measures that modify susceptibility to flooding

Floodproofing
Floodproofing consists of modifications of structures, their sites, and building contents to keep water out or reduce effects of water entry to structures where it causes damage. Examples of floodproofing include raising structures above flood elevations, protecting structures with local dikes, and using flood resistant materials and building practices. Generally floodproofing is used to reduce damage to structures, and not necessarily to provide for occupancy during floods.

Benefits

- Reduces damage to structures in flooded areas
- Can be combined with floodplain attenuation to promote natural processes
- Can be used where other measures are infeasible

General regulatory constraints

- (Typical)

Relocation/land use changes
This measure refers to relocating susceptible structures outside of the floodplain or implementing land use changes that are more compatible with flooding. Structure relocation can be expensive and is more likely to be implemented in rural areas.

Benefits

- Avoids losses associated with flooding
- Can be combined with floodplain restoration to promote natural processes
- Can be used where other measures are infeasible

General regulatory constraints

- None

2.3.4 Measures to enhance groundwater recharge

In-line detention basins
In-line detention basins increase recharge to the extent they provide longer periods or increased inundation area for infiltration. They operate by capturing runoff from a drainage area and releasing it slowly over time. Detention of water in a basin for recharge may be limited to short durations if the basin is also being used to achieve attenuation of flood peaks, as the storage volume must be available to accommodate subsequent stormflows to be effective. Like any recharge facility, an in-line detention basin must have adequate separation from groundwater to allow effective function and avoid water quality concerns. To promote recharge, the floor of the basin may be maintained to remove fine-grained materials and facilitate infiltration.

Additional information related to detention basin use for stormwater management, benefits and general regulatory constraints for in-line detention basins is provided in Section 2.3.1.

In-line retention basins
In-line retention basins increase recharge from runoff. They capture runoff from a drainage area and retain it, thereby increasing both the inundated area and the time within which water can infiltrate into the ground. As retention basins have permanent ponding areas that store flow for a much longer duration, retention basins may provide more recharge than is typically provided by detention basins. If water is retained in a basin for recharge or use and not actively managed for floods (e.g., released prior to the arrival of the next storm), it reduces the capacity of the basin to also detain flood flows. Like any recharge facility, an in-line retention basin must have adequate separation from groundwater to allow effective function and avoid water quality concerns. To promote recharge, the floor of the basin may be maintained to remove fine-grained materials and facilitate infiltration.

Additional information related to retention basin use for stormwater management, benefits and general regulatory constraints for in-line retention basins is provided in Section 2.3.1.

Off-line detention basins
Off-line detention basins may be used for recharge of stormwater runoff. If used to reduce flood peaks, such basins are typically designed to accept only runoff from larger storm events. As they typically are smaller and store water less frequently than in-line basins, such basins typically provide less recharge than in-line detention basins given the same basin area. Like any recharge facility, an off-line detention basin must have adequate separation from groundwater to allow effective function and avoid water quality concerns. To promote recharge, the floor of the basin may be maintained to remove fine-grained materials and facilitate infiltration.

Additional information related to their use for stormwater management, benefits and general regulatory constraints for off-line detention basins is in Section 2.3.1.

Off-line retention basins
Like off-line detention basins, off-line retention basins (wet ponds) are facilities adjacent to the drainageway that provide storage for surface runoff. As retention basins have permanent ponding areas that store flow for a much longer duration, retention basins may provide more recharge than typically provided by detention basins. If water is retained in a basin for recharge or use and not actively managed for floods (e.g., released prior to the arrival of the next storm), it reduces the capacity of the basin to also detain flood flows. Like any recharge facility, an off-line retention basin must have

adequate separation from groundwater to allow effective function and avoid water quality concerns. To promote recharge, the floor of the basin may be maintained to remove fine-grained materials and facilitate infiltration.

Additional information related to stormwater management, benefits and general regulatory constraints for off-line retention basins is in Section 2.3.1.

Infiltration galleries

In areas where above-ground detention/retention basins are not appropriate, infiltration galleries may be used to achieve groundwater recharge. Infiltration galleries are facilities that intercept and redirect surface water to a porous subsurface zone for infiltration. They typically involve shallow excavation and placement of perforated pipe within a gravel bed that is then backfilled with additional gravel and overlain with topsoil. They may be designed and constructed to accommodate a range of runoff volumes. Like any recharge facility, an infiltration gallery must have adequate separation from groundwater to allow effective function and avoid water quality concerns. Below ground design makes removal of fine-grained materials more difficult; a pre-sedimentation system may reduce clogging and contribute to increased life span.

Benefits

- Provides recharge in locations where above ground facilities are not appropriate
- Can be constructed from prefabricated components

General regulatory constraints

- Depending on depth, may be subject to more stringent water quality standards and permitting requirements.

Self-cleaning infiltration trenches

Self-cleaning trenches are similar to infiltration galleries but are linear and include an overflow outlet. They have a smaller footprint than detention/retention basins and can be used in location with limited access, such as along the side of a roadway or in between infrastructure, etc. Like an infiltration gallery, self-cleaning infiltration trenches intercept and redirect surface water to a porous subsurface zone for infiltration. They facilities self-clean by automatically flushing to an outlet when inflow exceeds infiltration capacity. They require particular attention to design to ensure that their self-cleaning feature functions properly. Like any recharge facility, an infiltration trench must have adequate separation from groundwater to allow effective function and avoid water quality concerns. As they are typically smaller and may receive water less frequently than detention/retention basins, self-cleaning infiltration trenches typically provide less recharge than basins.

Benefits

- Provides recharge in locations where above ground facilities are not appropriate
- Self-cleaning feature allows for maintenance of infiltration rates and removal of fines

General regulatory constraints

- Depending on depth, may be subject to more stringent water quality standards and permitting requirements.

Vadose wells

Vadose wells are wells completed in the vadose zone above unconfined aquifers; these are also known as "dry wells" because they do not intercept saturated aquifer materials. The well depth and diameter varies depending on the geology and amount of runoff expected; they are completed with a center pipe and the annular space between the pipe and the wall of the borehole filled with sand. These wells have a relatively short life span (5-10 years) due to clogging and difficulty of maintenance.

Benefits

- Provides recharge in locations where above ground facilities are not appropriate
- Low cost to construct and no maintenance required

General regulatory constraints

- Depending on depth, may be subject to more stringent water quality standards and permitting requirements.

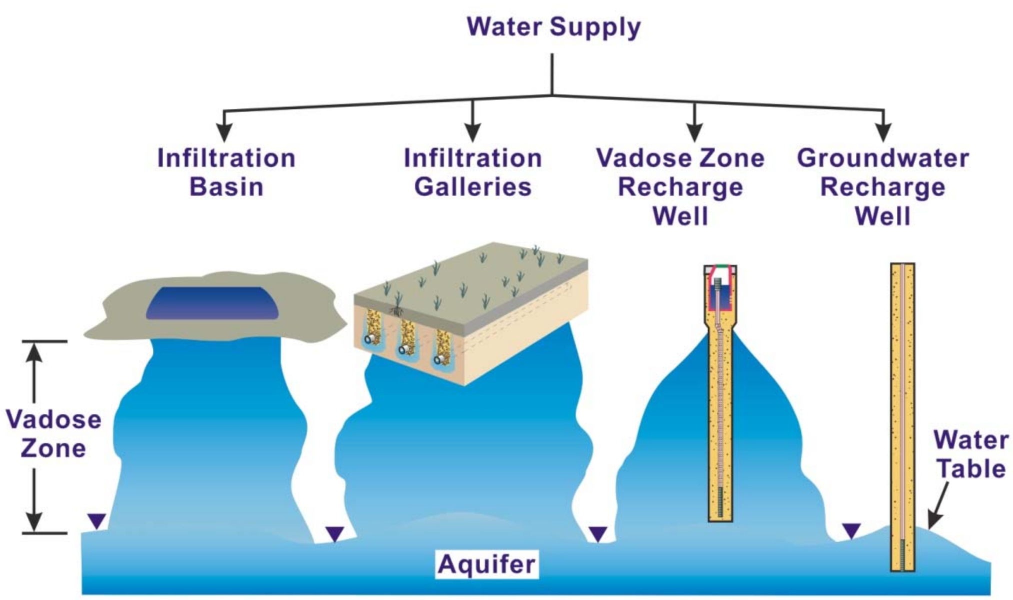


Figure 3. Groundwater recharge methods

2.3.5 Measures to reduce groundwater pumping (in-lieu of pumping)

Above-ground or underground storage tank

Above-ground or underground tanks may be used to store stormwater for later use as water supplies in lieu of groundwater pumping. Tanks can be designed and constructed out of a variety of materials to accommodate a range of water volumes. Underground tanks are generally more expensive to construct than above-ground tanks.

Benefits

- Provides water storage and/or in-lieu supplies in areas that may not be appropriate for recharge.
- Tanks can provide longer term water storage in order to accommodate differences between the timing of stormwater capture and the ability of the aquifer to receive additional water resources.

General regulatory constraints

- (Typical)

2.3.6 Measures to mimic natural site hydrology (Low impact development, or LID)

Low impact development (LID) refers to a variety of strategies to more closely mimic the natural hydrologic regime through infiltration, filtration, and detention. LID can have multiple benefits, including reducing storm water pollutants, limiting stream channel erosion, and promoting groundwater recharge. LID design measures are generally focused on smaller, more frequent storms and have limited ability to affect larger storms that are associated with flooding. LID design measures are included in this document, recognizing that although they may have limited flood management benefits except for very small storm events, they may be used in combination with other elements to meet project goals.

Infiltration-based approaches

Infiltration-based LID approaches are facilities that rely on filtering stormwater through soil (either native soil or an engineered soil mix). By filtering runoff, infiltration-based facilities can remove pollutants and reduce impacts to pre-development site hydrology. Infiltration-based LID features must have adequate separation from groundwater. Examples of infiltration-based LID approaches are:

- Infiltration basins
- Bioretention
- Pervious pavement
- Infiltration trenches
- Vegetated swales
- Vadose wells (also known as dry wells)

Benefits

- Groundwater recharge
- Pollutant removal
- Aesthetics
- Can reduce channel erosion

General regulatory constraints

- (Typical)

Detention-based approaches

Detention-based LID facilities rely on detaining stormwater to remove pollutants and regulate discharge. Pollutants are generally removed from stormwater by detaining flow for an amount of time and allowing pollutants to settle out. Detention-based LID facilities can also be used to mimic the natural hydrologic regime of by storing discharge and slowly releasing it over time. Detention-based LID facilities include:

- Bioretention
- Constructed wetlands
- Detention vaults
- Cisterns and rain barrels
- Wet ponds
- Detention ponds

Benefits

- Pollutant removal
- Aesthetics
- Can reduce channel erosion
- Can enhance recharge

General regulatory constraints

- Depending on depth, may be subject to more stringent water quality standards and permitting requirements.

3 Screening

The purpose of the screening process is to eliminate project types relative to locations within the watershed that do not clearly show potential to achieve the project objectives of flood hazard reduction and groundwater recharge.

The previously-developed Project Objectives identify the need for the project developed under the scoping study to meet both core objectives: flood hazard reduction and groundwater recharge. We have previously acknowledged that it would be possible to combine multiple elements that collectively met both objectives into a single project. However, for the purpose of identifying a priority project list, we have elected to apply the most straightforward approach to meeting both core objectives, which is to seek to identify potential project concepts that could meet **both** core objectives.

Thus, for the purposes of the Scoping Study, the screening process has been developed to screen out project types that do not have this dual capacity. In some cases, the ability for a given project type to meet both core objectives is restricted to only certain parts of the watershed, and this limitation is also accounted for in the screening process.

Because of the very general information being relied upon for the purpose of this assessment, it is possible that some project concepts will be eliminated at this stage that might actually turn out to be appropriate once additional scrutiny is applied and/or more detailed information is obtained. As a watershed-wide scoping study, this effort cannot afford to be exhaustive. We are seeking to identify the short list of projects that make the most sense for the Water Agency to initially investigate further, and expect the approach being taken to yield an attractive short list of projects that warrant consideration.

In discussion about the limitations of the screening and prioritization process, Water Agency staff have acknowledged that two types of projects may be included in the ultimate project developed through the

Sonoma Valley Scoping Study process, whether or not they are included on the shortlist generated by this process:

1. Low Impact Development (LID)
2. Ecosystem enhancement

As part of a larger groundwater recharge/flood hazard management project, both of these project types have the potential to 1) bring additional cost-share dollars to the table, 2) significantly increase the attractiveness of a proposed project to funding agencies (see, for example, the Integrated Regional Water Management project guidelines: http://www.water.ca.gov/irwm/guidelines.cfm), and 3) generally broaden public support for a project among the communities of the Sonoma Valley.

While the scoping study is expected to focus on larger-scale projects to achieve the greatest level of core benefits, Water Agency staff also recognize that the stakeholders have expressed strong interest in small-scale distributed projects that may fall outside the recommendations of this Screening Evaluation Memorandum. Thus, at the time an integrated project proposal is ultimately being formulated for the purposes of seeking grant funding, the Water Agency may identify and develop additional project elements—not among those specifically recommended by this memorandum—for inclusion in the proposed project. These supplemental elements will be considered to enhance partnering and funding opportunities and to broaden and strengthen community support for the proposed project as a whole.

3.1 Effectiveness

As supported by the material presented in Section 2.3, some measures or project types may be used to address either flood hazard reduction or groundwater recharge, but are not anticipated to accomplish both core objectives. We have eliminated such project types from further consideration.

Project types that are not expected to effectively address both core objectives include the following:

Project type	Reasoning
Urban drainage infrastructure improvement	Does not enhance recharge
Flow constriction improvement	Does not enhance recharge
Channel clearing	Does not enhance recharge
Levee and/or floodwall	Does not enhance recharge
Vadose well	Capacity limitations constrain stormwater infiltration potential

The retained project types, designed for dual objectives, include the following:

1) In-line detention/recharge basins
2) In-line retention/recharge basins
3) Off-line detention/recharge basin
4) Off-line retention/recharge basin
5) High flow diversion/recharge
6) Floodplain attenuation/recharge
7) Above-ground or underground storage tank/recharge

8) Infiltration gallery/detention
9) Self-cleaning infiltration trench/detention
10) LID

3.2 Physical feasibility

The retained project types identified in Section 3.1 above were then considered relative to coarse-level information available with regard to physical conditions in the watershed to allow an assessment of potential project type feasibility relative to location within the Sonoma Valley watershed. In the sections below, factors related to the physical feasibility of flood hazard reduction are first described and assessed in Section 3.2.1. Section 3.2.2 provides a similar treatment based on groundwater recharge potential.

3.2.1 Flood hazard reduction potential

The nature of flood hazard reduction potential varies within the watershed based on several variables. Key physical factors affecting flood hazard reduction potential are the runoff characteristics of the watershed, channel slope, and the control exerted by the downstream tidal boundary.

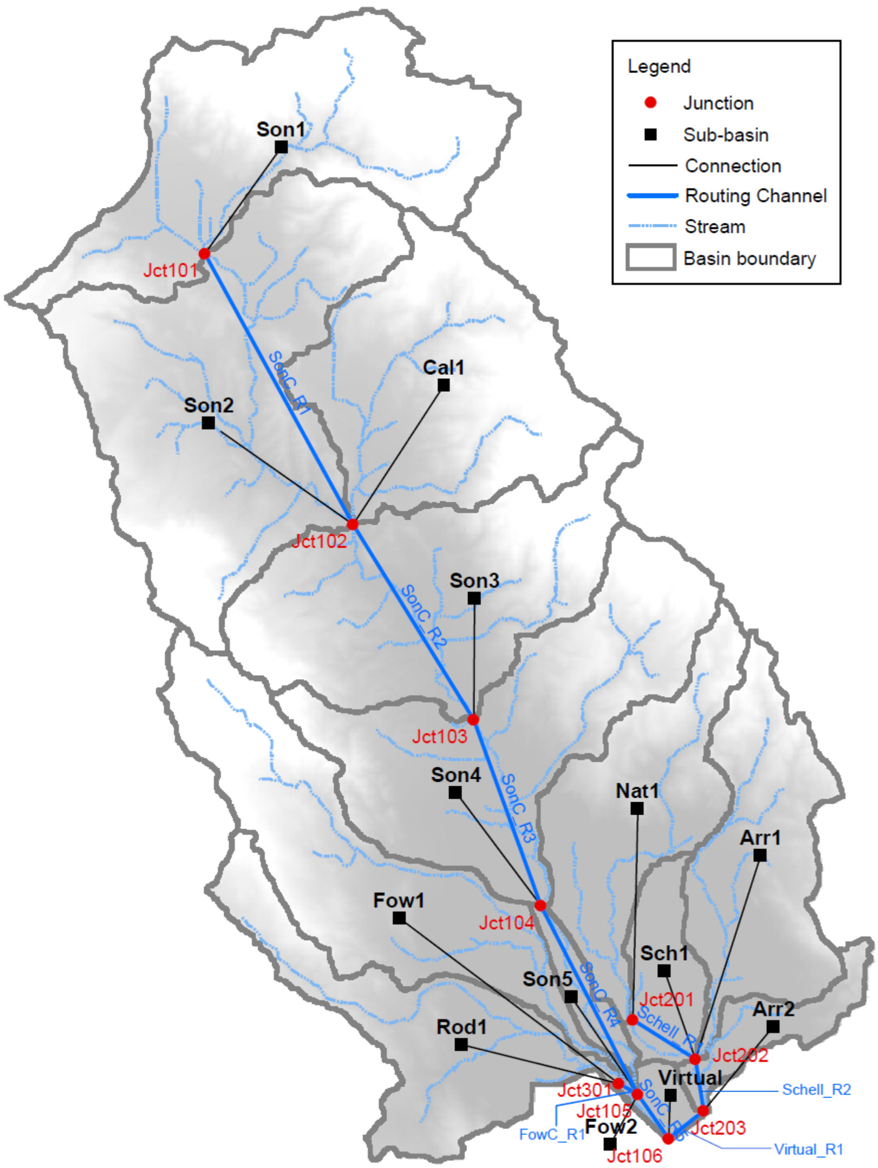
Lower Sonoma Creek watershed

As a first step, we considered the potential for flood hazard reduction available in lower Sonoma Creek, below Highway 121. The combination of the abrupt transition from the steeply-sloped channel of Sonoma Creek to the very shallow slopes of the bayshore lands – largely, former tidal wetlands—from approximately Highway 121 to the downstream tidal boundary at San Pablo Bay—create very challenging physical circumstances for flood hazard reduction in the lowest reaches of Sonoma Creek. Recent analysis conducted by ESA PWA (report in progress) suggests that the opportunities to reduce flood hazards in larger events (10-year recurrence interval or larger) in the lowest reaches of Sonoma Creek include land use changes, floodproofing, levees or floodwalls, and relocation of existing non-compatible uses or at-risk structures.

Other approaches were found to have very limited potential for application in this setting. Modifications to creek channels or high flow diversion would affect the distribution of flood flows, but would in part simply shift flood hazards from one location to another in the interconnected drainages of lower Schell and Sonoma Creeks. The effectiveness of channel modification in affecting flood levels would also be limited due to the backwater effects of the tidal boundary, often elevated by storm surge during major rainflood events. Because of tidal backwater, enlargement of tidal slough channels, whether through direct modification (dredging) or natural tidal scour (resulting from restoration of tidal prism and the resulting increase in the tidal exchange, as might result from managed breaching of subtidal areas for tidal wetland restoration), would be most likely to increase drainage rates, rather than reducing flooding extents or peak elevations. Tidal backwater effects are also expected to increase over time, as a result of sea level rise relative to local land elevations. Additionally, measures to lower flood stage within the lowest reach of Sonoma Creek, such as by the use of local detention, channel modification, or floodplain detention, was found to have only localized benefit: the effects of stage lowering on upstream flood elevations were quickly lost as channel slope increased. This expected effect was extended to Sonoma Creek's other lowest tributary subbasins as well. Lastly, we determined that detention or retention of flood flows in the higher elevations of these most downstream subbasins were found not effective in the reduction of flood hazards. We reached this conclusion because of the relatively limited development and habitation in the upper subbasin reaches combined with the ineffectiveness of these measures in reducing flood hazards in bayshore lands, where flooding is primarily controlled by tidal elevations.

Middle and upper Sonoma Creek watershed

For the purposes of examined the flood hazard reduction potential through actions in the remainder of the Sonoma Creek watershed, we first considered the stormwater runoff conditions. An existing surface water hydrology model for the Sonoma Creek watershed upstream of Highway 121 was used to evaluate the runoff characteristics of the watershed. Figure 4 below shows a schematic of the model. Gray lines indicate subbasin boundaries; subbasin names are identified by a black square labeled with a three-letter code and a number.



HEC-HMS Sub-basin ID	Subbasin outlet description
Son1	Sonoma Creek at Lawndale
Son2	Sonoma Creek above Calabazas Creek
Cal1	Calabazas Creek at Sonoma Creek
Son3	Sonoma Creek at Aqua Caliente Road
Son4	Sonoma Creek below Dowdall Creek
Nat1	Nathanson Creek at Schell Creek
Fow1	Fowler Creek above Rodgers Creek
Arr1	Arroyo Seco at Schell Creek
Sch1	Schell Creek above Arroyo Seco
Son5	Sonoma Creek at Highway 121
Arr2	East Arroyo Seco at Schell Creek
Fow2	Fowler Creek at Sonoma Creek
Rod1	Rodgers Creek at Fowler Creek

Figure 4. Surface water hydrology model schematic, upper and middle Sonoma Creek watershed (from PWA, 2004)

This model, initially calibrated to a small flood event (PWA, 2004), was later calibrated to the flood of record in the basin, December 30, 2005 - January 1, 2006 (PWA, 2008). Results from this model were used to evaluate the relative contributions of tributary sub-watersheds and local areas draining to specific reaches of Sonoma Creek to flood flows at the peak of a large flood event.

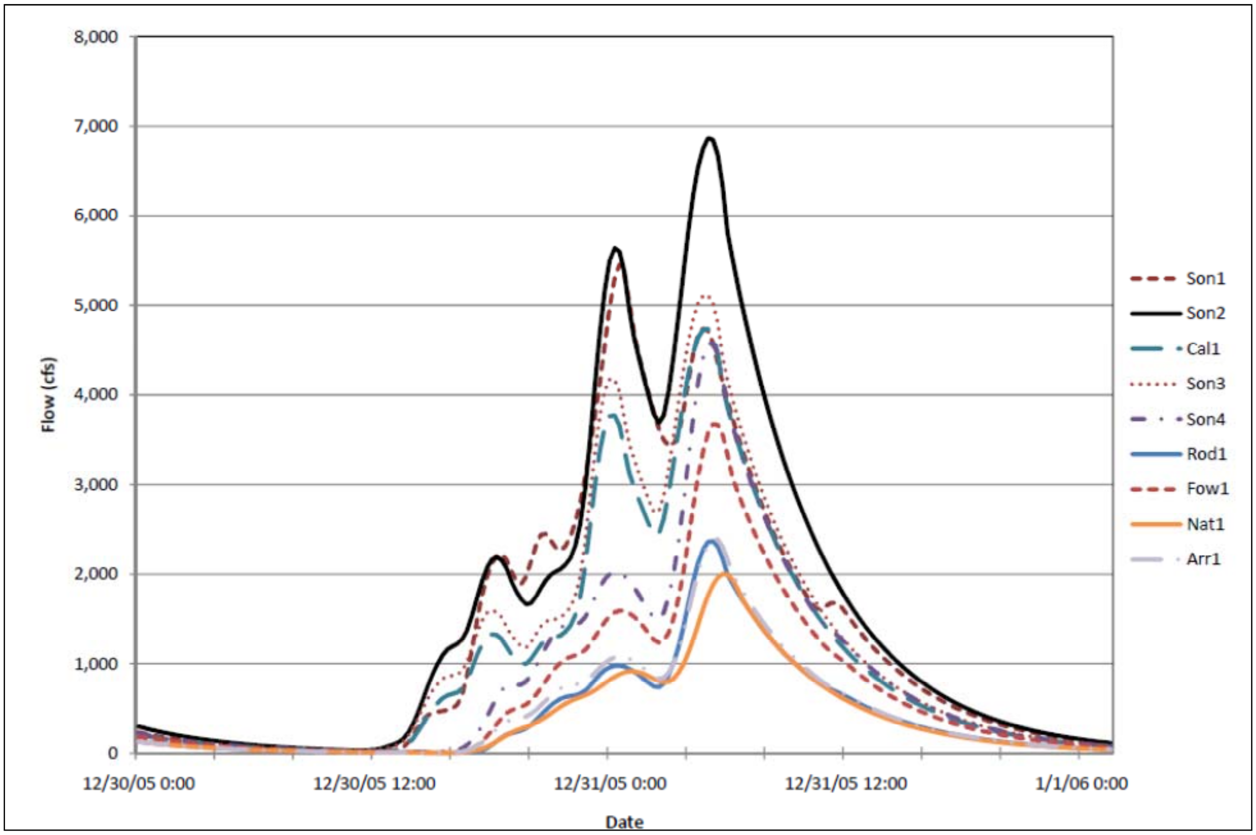


Figure 5. Subbasin contributions to peak flood flows on Sonoma Creek at the outlet of subbasin Son4 (below Dowdall Creek, derived from model of December 31, 2005 flood event described in PWA, 2008)

Based on the near-coincidence of all of the peak flood flows coming from the contributing subbasins as shown in Figure 5, we concluded that measures to reduce peak flood flows from any subbasin upstream of approximately Dowdall Creek (above Leveroni Road; Junction 104 in the model) could be expected to also reduce peak flows downstream.

A final physical constraint considered with respect to the suitability of surface water subbasins to support certain measures or project types was ground slope. Floodplain attenuation, high flow diversion, and detention or retention basins, whether in-line or off-line, require lands with fairly low slopes to be reasonably practical to construct. Additionally, floodplain attenuation and high flow diversion projects require extended reaches adjacent to or near the floodplain with fairly low slopes to be practical and appropriate for this project type. Low ground slope is a variable that was also included in the screening for potential recharge areas, as described in Section 3.2.2 below.

For screening purposes, no additional assessment of physical constraints to achieving flood hazard reduction was made. Thus, some project types with only very modest or theoretical potential to reduce flood hazards have been retained among the screened project types.

3.2.2 Recharge potential

Using readily-available geospatial data, the Sonoma Valley watershed was reviewed to identify areas with apparent potential for groundwater recharge, or "opportunity areas."

Review of previous investigations
The Sonoma Ecology Center (SEC) conducted a study to identify areas of relative naturally-occurring potential recharge (SEC and SCWA, 2011). During this study, SEC developed a Recharge Potential map layer by combining the evaluation and ranking of four elements: vegetation, soil, slope, and geology.

As part of this study, a geology panel analyzed the geologic formations of Sonoma Valley and classified them into a simplified set of thirteen classes with similar water infiltration characteristics which were used to develop a "Simplified Geology" map of the Sonoma Valley Watershed. The simplified geology was based on the detailed geologic maps of the Glen Ellen, Kenwood, Sears Point and Sonoma Quadrangles (California Geological Survey). SEC then ranked each unit of the Simplified Geology map according to its suitability for naturally occurring recharge (by surface application or infiltration); the following categories were used to develop a Ranked Geology map:

- Poor (rank 1)
- Poor to Fair
- Fair (rank 2)
- Fair to Good
- Good (rank 3)
- Good to very good

DBS&A reviewed the work completed by SEC, the detailed geologic maps, and the USGS Scientific Investigations Map 2956 (Graymer et al., 2007) and reached the following conclusions:

1. Simplified Geology map: The categorization is appropriate.
2. Rankings for each unit of the Ranked Geology map: Generally, the poor and poor to fair categories are accurate indicators of the suitability of those areas for recharge by surface infiltration. Likewise, the good to very good rankings are accurate indicators of recharge by surface infiltration. However, the categories of fair to good often have broad ranges of categorization. Full assessment of the recharge potential of a particular site and the development of particular project elements will require further evaluation using more site-specific information.

Despite the need for additional site-specific information, the SEC ranking of the Simplified Geology provides a useful broad level for screening of the entire watershed for initial absorption rates. Additional review of subsurface geology will be needed for more detailed evaluation of potential project areas in future project phases. However, the SEC ranking of 2 (Fair) or more should not be used to completely rule out any particular area of the watershed at this stage.

Stakeholder list of potential project locations
A public meeting was held on April 21, 2011 in conjunction with the quarterly meeting of the Basin Advisory Panel, Sonoma Valley Groundwater Management Program. During that meeting and during

follow-up communications with stakeholders, the following ideas for small projects, project types, or project locations[1] were raised:

- Adobe Canyon (SCWA-funded, SEC/PWA-developed project concept)
- Carriger-Sonoma Creek flow constraint removal
- Eighth Street swale by railroad tracks for recharge
- Eraldi Park on 5th Street West
- Ernie Smith Park
- Calabazas Creek drainage
- Los Guilicos – detention and rainwater harvesting
- Third Street linear swale – detention, rain garden and recharge basin.
- Project type: creek stabilization – use an excavator to stabilize with concrete barriers and use a check dam to raise up the creek level.
- Project type: Multi-purpose ball fields – recreation, recharge, retention
- Project type: create a backyard swale and fill with rock to help with recharge and provide surge protection.
- Project type/location: Schellville and Glen Ellen – Rainwater harvesting, stormwater storage, retention, detention.

Broad level screening to identify potential project locations based on groundwater recharge potential

While the SEC study is an important study, it is different than the current focus of the Sonoma Valley Scoping Study in that it focuses on potential for naturally-occurring recharge and the target of this study is to evaluate potential project areas for managed (artificial) recharge. While surficial cover of vegetation and soil are quite important when evaluating the potential for naturally occurring recharge, these factors could be modified during development of a managed aquifer recharge project and are of less importance for the current study.

The project team first assembled the following data in GIS format:

- Ranked geology of the Sonoma Valley Watershed (created by SEC)
- Slope

We then used the GIS platform to identify potential recharge opportunity areas to augment the stakeholder-identified list, including:

- Upper Nathanson Creek
- Boyes Hot Springs
- Sonoma Valley Regional Park
- Sonoma Valley County Sanitation District lands along 8th Street

Based on the relevant factors and available data, each of the areas identified in the preceding list and on Plate 1 shows potential for a recharge project based on physical attributes. A review of the stakeholder potential project locations compared to the potential recharge areas identified through the GIS process, indicated that only one (Calabazas Creek Drainage) likely falls outside the area considered suitable for potential recharge projects, as indicated by Plate 3.

[1] Note: we have omitted from this list several specific project locations owned by entities that preferred not to have these properties identified as possible sites at this time.

3.3 Screened project types by location

The next step in the screening process was to identify the locations which appear to be physically-feasible for retained project types—those with potential to achieve both flood hazard reduction and groundwater recharge as identified in Section 3.1. Retained project types are listed in Table 2 below by each hydrologic subbasin in which they appear to be physically feasible, based on the assessment provided in Section 3.2 above. (See Figure 4 or Plate 1 for subbasin locations.) Within each subbasin, each project—with the exception of above-ground or underground storage tank/recharge projects, which may provide in-lieu water supplies—must also be located at a location within the watershed that is classified as recharge-suitable, or that having a recharge ranking of fair (rank 2) or better (rank higher than 2), with a groundslope of 10 percent or less, as shown in Plate 2. Note that the most downstream subbasins in the watershed have a limited array of feasible flood hazard reduction options and are not generally suitable for groundwater recharge projects, as described in the preceding sections. The following subbasins have therefore been screened out for all retained project types: Lower Sonoma Creek, Fow2, and Arr2.

Table 2. Retained project types by hydrologic subbasin

Project type	**Subbasins where potential exists to meet both core objectives** (listed in approximately upstream to downstream order; see Figure 4 or Plate 1 for subbasin boundaries, Plate 2 for lower-slope, recharge-suitable areas)
1) In-line detention/recharge basins	▪ Son1 ▪ Son2 ▪ Cal1 ▪ Son3 ▪ Son4 ▪ Nat1 ▪ Fow1 ▪ Arr1 ▪ Rod1 *NOTE: Specific locations would be limited to lower-slope, recharge suitable areas of subbasins where there is also the potential to reduce flood hazards (see discussion in Section 3.2.1 above).*
2) In-line retention/recharge basin	*(Same subbasins as listed for in-line detention/recharge basin)*
3) Off-line detention/recharge basin	*(Same subbasins as listed for in-line detention/recharge basin)*
4) Off-line retention/recharge basin	*(Same subbasins as listed for in-line detention/recharge basin)*

Project type	**Subbasins where potential exists to meet both core objectives** (listed in approximately upstream to downstream order; see Figure 4 or Plate 1 for subbasin boundaries, Plate 2 for lower-slope, recharge-suitable areas)
5) High flow diversion/recharge	▪ Son1 ▪ Son2 ▪ Son3 ▪ Son4 ▪ Nat1 ▪ Fow1 ▪ Arr1 ▪ Rod1 *NOTE: Specific locations would be limited to lower-slope, recharge-suitable portions of all subbasins, where there is the potential to reduce flood hazards or which includes low-slope pathways for floodwaters.)*
6) Floodplain attenuation/recharge	*(Same subbasins as listed for high flow diversion/recharge)*
7) Above-ground or underground storage tank/recharge	▪ Son1 ▪ Son2 ▪ Cal1 ▪ Son3 ▪ Son4 ▪ Nat1 ▪ Fow1 ▪ Arr1 ▪ Rod1 *Note: Specific locations for the storage component could occur wherever stormwater flows are available and diversion of stormwater flows could reduce flood hazards; the recharge component could occur in recharge-suitable areas or, through in-lieu substitution, in any location where groundwater pumping occurs.*
8) Infiltration gallery	*(Same subbasins as listed for in-line detention/recharge basin)*
9) Self-cleaning infiltration trench	*(Same subbasins as listed for in-line detention/recharge basin)*
10) LID	*(Same subbasins as listed for in-line detention/recharge basin)*

4 Prioritization

Prioritization of the project types/locations that succeeded in passing through the screening process was completed to determine which should be advanced to the feasibility stage.

We note that projects to divert stormwater flows to recharge have the potential to affect water rights, an issue that is not specifically addressed in this document or this screening and prioritization process. Water rights issues can be quite complex, with many as-yet unclear legal implications for the kind of recharge projects being contemplated as part of this scoping study. It is possible that some potential project types and locations may raise more significant water rights concern than others. Water rights considerations will need to be evaluated as part of the project feasibility analysis and addressed at the project development stage.

4.1 Approach

The prioritization process adopted for the scoping study uses a step-wise approach, with project types and/or locations that were assigned a lower priority during one step not being considered in subsequent steps in the prioritization process. Only project types that were retained through the screening process, as identified in Table 2, are evaluated in the prioritization process.

- **Step 1**: Prioritization of project types based on criteria related to implementation feasibility and cost.
- **Step 2**: Prioritization of project locations based on areas of greatest potential impact relative to the core objectives.
- **Step 3**: Prioritization based on potential to effectively address one or more of the supporting objectives.

One of the key characteristics of any project coming out of this scoping study is that it has a strong potential to be implementable. Two important factors that help determine whether a potential project may be implementable include a) a lack of significant regulatory constraints and b) reasonable cost per unit volume, particularly relative to other potential projects. The first step in the potential project prioritization process was to evaluate potential project types based on these two criteria. Failure to meet either of them was used to assign a low priority to certain project types and those project types were not considered during subsequent prioritization steps.

The second step in the prioritization process was to evaluate whether the potential project locations were in areas of highest priority relative to the two core objectives, flood hazard reduction and groundwater recharge, as described in Section 4.3 below. Projects that did not fall in these areas were assigned a low priority for the purposes of this scoping study and were not considered further in the prioritization process.

The last step in the prioritization process was to evaluate the remaining potential project types and locations based on their potential to effectively address one or more of the supporting objectives and the absence of significant water quality concerns. The project types and locations that were given the highest priority based on this final step were included in the Priority Project Concept List, provided in Section 4.5.

Because basins will need to accomplish significant levels of both retention and detention to achieve the highest levels of both core objectives combined, we will refer to them in the remainder of this document simply as in-line basins and off-line basins, rather than also noting their need to be qualified as detention/retention/recharge basins.

Similarly, infiltration galleries, self-cleaning infiltration trenches, and LID projects advancing to the prioritization stage will need to be designed to address both groundwater recharge and flood hazard reduction. We will assume that dual purpose is implicit by the advancement of the project type to the prioritization stage, and refer to them simply by their generic project type name.

4.2 Step 1: Implementation feasibility

For the purposes of evaluating implementation feasibility, we first considered the likelihood of significant regulatory constraints. We then evaluated siting feasibility and cost, broadly taking into account potential project effectiveness. Project types with significant anticipated implementation feasibility challenges were identified as low priority for the purpose of this scoping study and dropped from further consideration.

Project types determined to have low potential for implementation feasibility are identified below, together with the basis for that conclusion. At the end of this section, the project types and locations that pass an initial implementation feasibility test in Step 1 are summarized in Table 3.

High likelihood of significant regulatory constraints

In-line basins

As described in Section 2.3.1, in-line basins typically raise very significant regulatory constraints and challenges, particularly on steelhead streams like Sonoma Creek. For this reason, we have identified these types of facilities as low priority.

Evaluation result: All in-line basins have a low priority in all subbasins

Low likelihood of siting feasibility

High-flow diversion/recharge and floodplain attenuation/recharge

Two of the remaining project types can have significant land requirements, as well as limited potentially feasible lands: high-flow diversions and floodplain attenuation. High-flow diversions, which route high flows through an alternative path, require a broad overland path (e.g., at minimum, 2-3 times the width of the channel being diverted from to allow shallow flow of a large quantity of water during flood flows) or buried conduit right-of-way and, if overland, low slope (to reduce scour hazards). The path for the diversion must convey flows from the channel at an upstream location and convey them to a suitable receiving point downstream, usually downstream on the same channel. The type of corridor required for this project type often crosses multiple parcel lines, involving multiple landowners. Flood hazard reduction benefits typically accrue only within the bypassed reach of channel. Floodplain attenuation requires a broad swath of land adjacent to the channel for an extended length to achieve its purpose. Typically a floodplain is reconnected with a stream by removal or setting back of levees, which are not present along most of upper and middle Sonoma Creek, or excavation to lower a currently disconnected floodplain. In our experience, a minimum of a thousand feet or more in width and several thousand feet in length is required to achieve significant change in a flood peak. Flood hazard reduction benefits typically accrue downstream of a flood attenuation project, because it reduces the outgoing flood peak, though it may also lower upstream water levels, providing upstream flood relief as well. For both project types, flood- compatible land uses would be required on these lands.

Both of these types of projects are managed analogs of naturally-occurring floodplain features, and their function and presence may be greatly affected by watershed development. No known locations of floodplain attenuation currently occur within the Sonoma Creek watershed; given the confinement of most large flood flows within a narrow swath adjacent to the channel in most of the watershed as shown on the current FEMA floodplain maps, floodplain attenuation appears unlikely to occur as a significant factor in the watershed at present. High-flow diversions do, however, occur in the watershed under present conditions. Based on our review of FEMA floodplain mapping and our own knowledge of the watershed, existing high-flow diversion locations within the Sonoma Creek watershed include:

- The east side of Sonoma Creek downstream of Adobe Canyon, both upstream and downstream of Highway 12
- Between the next two drainages to the south of Adobe Canyon
- On Dowdall Creek near Petaluma Avenue
- At lower Carriger Creek, downstream of Leveroni Road
- Upstream of Highway 121, where multiple high flow breakouts occur between the streams that converge in that area, such as Rodgers and Fowler Creeks, Fowler and Sonoma Creeks, and, during floods, Sonoma and Schell Creeks

Existing high-flow diversion areas may have a greater potential for incorporation into a flood management and recharge project; implementation feasibility there will likely be greater.

Given their limited area of effectiveness for flood hazard reduction (only the bypassed reach); the requirement for flood-compatible land use conditions and low ground slope; and the limited potential locations for such flow paths parallel to channels, we conclude that high-flow diversion/recharge projects have a lower likelihood of implementation feasibility except within the subareas of subbasins where concentrated flood damages have been documented to the extent currently known: the most upstream reach of Sonoma Creek (Son1) and Nat1. For Son1, existing high flow diversion flowpaths already exist; as a result, implementation feasibility there (e.g., as envisioned in the Adobe Canyon project) may be greater than in the Nat1 subbasin, where the potential for conflicts with current land uses are probably much more significant.

Evaluation result: High-flow diversion/recharge project types have a low priority everywhere, except in the subbasins Son1 and Nat1

In general, because of the significant and very particular land requirements for a floodplain attenuation project type (contiguous, low-slope area adjacent to the channel of perhaps ~100-1000's of acres to be effective at flood hazard reduction), as well as the potential need for a change in current land uses, floodplain attenuation/recharge projects are expected to have low likelihood of implementation feasibility.

Evaluation result: Floodplain attenuation/recharge project types have a low priority in all subbasins

Likelihood of high cost per unit benefit

Part of the challenge to assessing the relative potential of project types in a given location to achieve the core objectives of flood hazard reduction and groundwater recharge per unit cost is that the benefits—both as absolute values and as a function of cost—will vary with project size. Project types that provide small amounts of benefit but do so at small cost may be constructed in multiples to increase the quantity of benefit provided. The creation of multiple project elements may come with a higher initiation and administrative cost that should be accounted for; otherwise, project benefits for any project type should be considered as feasible to increase through multiple project installations even if individual installations have inherent capacity limits.

For the purposes of this prioritization process, we have interpreted the flood hazard reduction core objective to attribute greater significance to flood hazard reduction for larger magnitude, less frequent flood events, when the highest level of hazard typically exists. Thus, project types with benefits only during smaller flood events are inherently considered to provide more modest flood benefits. For the purposes of the scoping study, we consider reduction of flood hazards during flood events at the 10-year recurrence interval or more to be of the greatest benefit.

Diversion of flood flows to recharge, with or without temporary storage to attenuate peak flood flows, at a level significant enough to affect flood hazards during 10-year or larger flood events, requires a large capture volume. For example, we previously found that storage of approximately 240 acre-feet[2] was needed to reduce peak flows enough (by ~61%) to keep 10-year flood flows from leaving the channel in the Adobe Canyon area (PWA, 2010). For comparison, a reference multi-use ball field in Santa Rosa (at Slater Middle School) has a capacity of about 8 acre-feet. Typical LID capture volumes are much, much less -- typically much less than a hundredth of an acre-foot (or much less than about 450 cubic feet). In the remainder of this prioritization step, we will use cost per unit storage—relying on the amount of stored or captured water for each project type as an approximate measure of its flood hazard reduction benefit or recharge potential—as a means of identifying the least cost-effective project types for achieving the core objectives.

Above-ground or underground storage tank

Per unit of stored water, constructed tanks cost more than most other remaining project types. In addition, a tremendous number of large tank installations would be required to reduce flood hazards in 10-year or larger events.

Evaluation result: Above-ground or underground storage tank project types have a low priority in all subbasins

Of the remaining project types, infiltration galleries and self-cleaning trenches are typically somewhat more expensive per unit of water stored than off-line basins. LID projects, which might take the form of direct implementation, or some form of support for decentralized implementation, are difficult to assess in terms of cost without making specific assumptions as to project type. High-flow diversion project costs will vary dramatically depending on specific site conditions. We have decided to advance all of these project types to Step 2:

[2] An acre-foot is a volume unit of measure equal to a one-foot depth of water on a one-acre area.

Table 3. Project types, by location, for advancement to prioritization Step 2

Project types	Locations
1) Off-line basin	*In lower-slope, recharge-suitable portions of all subbasins except where flood hazard reduction potential from storage is negligible:* ▪ Son1 ▪ Son2 ▪ Cal1 ▪ Son3 ▪ Son4 ▪ Nat1 ▪ Fow1 ▪ Arr1 ▪ Rod1
2) High flow diversion/recharge	*Approximately along existing high-flow pathways:* ▪ Son1 ▪ Nat1
3) Infiltration gallery	*(As for off-line basins)*
4) Self-cleaning infiltration trench	*(As for off-line basins)*
5) LID	*(As for off-line basins)*

4.3 Step 2: Greatest potential core benefits

We next evaluated project types/locations to identify which had the greatest potential to achieve the desired core benefits. Flood hazard reduction is considered first; then groundwater recharge; then both core objectives together.

4.3.1 Flood hazard reduction benefits considerations

Based on the near-coincidence of flood peaks along the mainstem of Sonoma Creek and most of its tributary subbasins, as indicated by Figure 5 and discussed in Section 3.2.1, we expect diversion of stormwater flows to recharge to be effective at an approximately equivalent level throughout most of the Sonoma Creek watershed above Highway 121. However, diversion of stormwater flows to recharge in upstream areas will have the ability to provide benefits for the whole of the system downstream (with the exception of areas where flooding during such an event is controlled by tidal backwater, primarily the Lower Sonoma Creek subbasin). Additionally, outside of the lowest reaches of Sonoma Creek, currently available documentation of flood damages suggests that areas near Kenwood and the City of Sonoma have experienced the greatest damages during recent large flood events. We have therefore prioritized flood hazard reduction actions by surface water subbasin as shown in Plate 1. As displayed on this plate, the highest priority is given to actions in the subbasins draining to these two areas, with a decreasing level of priority attributed to projects in more downstream subbasins. The relationship of these subbasins to the physical feasibility screening zones and the identified potential project locations identified in Section 3.2.2 is shown on Plate 3.

4.3.2 Recharge benefits considerations

In terms of thinking about facilities with respect to recharge effectiveness, the size of the recharge facility is only part of the equation. An additional limiting factor is the source of stormwater supplies for recharge. If stormwater flows are diverted out of stream channels, diversions will likely be limited to a fraction of the highest flows occurring during flood events as a means to avoid triggering changes to channel shape and loss of ecologic function. Thus, significant recharge benefits are not likely to occur if the only water supplied for recharge comes from diversion of only some percentage of the flows during relatively infrequent storm events. For that reason, we have considered recharge benefits for different facility types assuming stormwater contributions for recharge will be supplied from stormwater conveyance units (e.g., stormdrains, culverts, or ditches), which carry runoff from regularly occurring storm events to stream channels, in addition to the contributions from direct channel diversions in significant flood events. The amount of water supplied to a facility from a stormwater conveyance unit can vary dramatically depending on the area contributing it; the contributing area may be as little as a few hundred square feet or many acres. Engineered stormdrain systems are often sized to convey up to the 10-year storm event, but not larger events. At any given site, the opportunities to tap stormwater flows will be different. Since we cannot identify the opportunities to tap such flows without identifying specific project locations, we will simply assume all facility types to be equally able to tap stormwater flows.

Over the past 30 years, Sonoma Valley has experienced rapid population growth and land use changes. There has been a significant increase in irrigated agriculture, predominantly vineyards, which rely primarily on groundwater for their water supply. Groundwater levels have declined in some portions of the Sonoma Valley, especially in El Verano, Carriger Creek and southeast of the City of Sonoma, and can be attributed to increased localized groundwater withdrawals for various uses (Farrar, 2006). Pumping depressions have developed in areas southeast of the City of Sonoma and in the vicinity of El Verano/Carriger Creek. Based on stakeholder input, it is desirable to focus groundwater recharge in these areas. We have identified the surface water subbasins within which these pumping depressions lie as the highest priority groundwater recharge locations:

- Nat1
- Sch1
- Arr1
- Western portion of Son4.

Water percolating into the ground may, or may not, however, flow to the zone of pumping depression even when the recharge facility overlies it. The pumping depressions are primarily located in deeper aquifers (more than 200 feet deep), and there may be limited ability for recharge from the surface to reach the affected aquifer. Therefore, while these surface water subbasins are identified as desirable geographic areas to recharge, it is also recognized that additional data will be needed to assess whether these are unconfined, semi-confined or confined aquifer systems that appear to have depressions and whether shallow recharge features will reach these aquifer systems or simply drain back into nearby watercourses. This is a factor which will need to be evaluated in a subsequent stage of this project, such as at the feasibility analysis stage. If recharge cannot effectively get water to the affected aquifer, a project intended for that purpose may be reduced in priority or eliminated from further consideration.

4.3.3 Combined flood hazard reduction and recharge benefits

The retention of water for recharge can only occur at the expense of potentially lost flood flow capture volume, assuming the volume committed to retaining water could otherwise be made available as temporary flood detention storage. Since the facilities being contemplated are required to meet both flood hazard reduction and groundwater recharge objectives, we will assume that only a small fraction of the contemplated facility can be used to retain water for recharge when larger flood flows are expected. We will assume that all project types to be equally affected by this constraint for the purpose of our assessment of achievement of core benefits.

Given the prioritization of subbasin areas detailed in the preceding two subsections, measures to achieve both flood hazard reduction and groundwater recharge can be in part prioritized by location. Measures that lie within the following three subareas will be most desirable for meeting the flood hazard reduction objective *or* recharging groundwater near the pumping depressions while being within higher priority flood hazard reduction zones:

- Nat1
- Son1
- Western portion of Son4

The next most promising subbasin areas based on flood hazard reduction priority and positioning upslope of the pumping depressions are:

- Son2
- Cal1
- Son3

Other subbasin areas are not as well-positioned to contribute to meeting the core objectives, and should therefore be eliminated from consideration at this step.

It is noteworthy that many of the identified potential project locations fall within either the highest priority areas for flood hazard reduction (upper Sonoma Creek or upper Nathanson Creek) or in the areas of greatest need for groundwater recharge (the groundwater depressions in El Verano and southeast of the City of Sonoma):

- Adobe Canyon (SCWA-funded, SEC/PWA-developed project concept)
- Eighth Street swale by railroad for recharge
- Eraldi Park on 5th Street West
- Ernie Smith Park
- Several ball fields
- Los Guilicos
- Third Street linear swale
- Upper Nathanson Creek

Given that there are several prioritized potential project types within several subbasins, we further suggest that making the following project types a low priority: those that would likely require a very large number of installations to reduce flood hazards in 10-year or larger flood events, or self-cleaning infiltration trenches and LID.

It may or may not be feasible to design a sufficient number of self-cleaning infiltration trenches within the highest priority subbasins to reduce flood hazards in those relatively large flood events, but it would likely be significantly more difficult (and probably more costly) to achieve an equivalent level of benefit using this project type compared to off-line basins, high-flow diversions, and infiltration galleries.

Like self-cleaning infiltration trenches, LID carries significant uncertainty with regard to its ability to achieve a comparable level of flood management benefits as these other project types. First, it would require a large number of installation sites. Second, it would require a large percentage of currently impervious area to be effectively reconnected to infiltration in the highest priority subbasins areas to accomplish the desired flood hazard reduction benefit. Using land cover data for the watershed from prior hydrologic modeling (PWA, 2004), we estimate that there are approximately 3,000 acres of impervious area overlying the fair-or-better recharge geology within the Sonoma Creek watershed. An example can clarify the limitations this poses: A 10-year storm generates about 3 inches of rain (varies with location in the watershed and the duration of the storm), and about 20% of that will be caught in tree canopy and other depressions that will not allow infiltration, leaving about 2.4 inches of runoff (0.2 feet). Thus, it would take about 1200 acres, 40% of the estimated impervious area, to be able capture 240 acre-feet of runoff in a 10-year event (0.2 feet x 1200 acres), assuming it can be retained for infiltration. Third, the implementation cannot be restricted to the highest priority subbasins and still capture the large volume of stormwater desired to affect flood hazards in 10-year and larger flood events (reference size: 240 acre-feet[3]).

With a focus on the potential for achievement of core benefits, therefore, our highest priority set of project types by location is reduced to those shown in Table 4.

Table 4. Project types, by location, for advancement to prioritization Step 3

Project types	**Locations**
1) Off-line basin	*In lower-slope, recharge-suitable portions of the following subbasins:* ▪ Son1 ▪ Son4 ▪ Nat1
2) High-flow diversion/recharge	*Approximately along existing high-flow pathways:* ▪ Son1 ▪ Nat1
3) Infiltration gallery	*(As for off-line basins)*

[3] As described in Section 4.2, we previously found that storage of approximately 240 acre-feet was needed to reduce peak flows enough (by ~61%) to keep 10-year flood flows from leaving the channel in the Adobe Canyon area (PWA, 2010). We have used that estimate to approximate the minimum scale of desired detention for this project.

4.4 Step 3: Supporting objectives and absence of water quality concerns

Since none of the prioritized project subbasins remaining in Table 4 have broad water quality concerns, water quality will not be used in general project location prioritization. Rather, more detailed water quality information will be used in feasibility analysis and siting for specific project concepts.

The ability to address supporting objectives is not readily assessed based on project type alone, but we have performed an initial assessment of the prioritized project types in Table 5 below.

Table 5. Potential for prioritized project types to address supporting objectives

	Good potential to address supporting objectives		
Supporting Objectives	**Off-line basins**	**High-flow diversions**	**Infiltration galleries/ trenches**
Water Quality Improve water quality of surface water and/or groundwater.	X	X	X
Water Supply Increase or improve water supply availability, reliability and flexibility for domestic, municipal, industrial and agricultural use and for the environment.	X		X
System Sustainability Support energy and water efficiency and climate change resiliency of water management systems and developed supplies, as well as the ability of stream systems to be maintained by natural processes.	X	X	X
Ecosystem Improve ecosystem function and/or habitat enhancement, especially for listed species.	X	X	
Agricultural Land Preserve agricultural land use.	X	X	X
Open Space Preserve and/or enhance open space.	X	X	
Community Benefits Create and/or enhance recreation, public access, education, etc.	X		X

Our assessment suggests that all three of the remaining project types have good potential to also address the supporting project objectives. Off-line basins probably have the greatest potential to broadly address these objectives, with high-flow diversions and infiltration galleries following. Based on these results, we will retain all project concepts from Step 2 through Step 3.

Table 6. Project types, by location, for advancement from Step 3 to the priority list

Project types	Locations
1) Off-line basin	*In lower-slope, recharge-suitable portions of the following subbasins:* ▪ Son1 ▪ Son4 ▪ Nat1
2) High-flow diversion/recharge	*Approximately along existing high-flow pathways:* ▪ Son1 ▪ Nat1
3) Infiltration gallery	*(As for off-line basins)*

4.5 Priority list of project concepts

The screening and prioritization process outlined above suggests that the appropriate focus for the Sonoma Valley scoping study will be on one or more off-line storage basins in lower-slope, recharge-suitable portions of the following subbasins:

- Son1
- Son4
- Nat1

The scoping study should also evaluate opportunities in these subbasins for flood hazard-reducing, high-flow diversions—around areas with high flood risks—that can be routed through zones with high potential for recharge:

- Son1
- Nat1

In locations where an infiltration gallery might be preferable or more feasible than an above-ground detention basin to accomplish both flood hazard reduction and groundwater recharge, an infiltration gallery should also be evaluated.

Additionally, potential high-flow diversion sites as described above should also be evaluated.

The cumulative storage goal along each waterway (Sonoma Creek and Nathanson Creek) to meet flood hazard reduction goals of reducing flood hazards in a 10-year or larger flood event is expected to be on the order of 100 - 500 acre-feet, based on the findings in our previous analysis for the Adobe Canyon project (PWA, 2010). We recommend that multiple project locations to address this goal be sought and evaluated, starting with the largest feasible storage option and looking at 1-2 incrementally smaller potential project sites along each waterway. This prioritization will result in four to six project concepts.

For the purpose of identifying the most advantageous project locations, it will be desirable to consider potential locations with the lowest ground slopes and highest recharge capabilities. Plate 4 differentiates between zones with ground slopes of 0-5% and 5-10% for the areas with recharge rankings of fair (rank 2) or better. Plate 5 provides the same information except that it uses areas with recharge rankings of good (rank 3) or better, showing what current data suggests are the most advantageous recharge areas in green.

Previously-identified project sites[4] that should be considered for the above priority project types include the following:

- Adobe Canyon (SCWA-funded, SEC/PWA-developed project concept)
- Eraldi Park on 5th Street West
- Ernie Smith Park
- Several ball fields – recreation, recharge, retention
- Los Guilicos
- Upper Nathanson Creek

Plate 6 provides an overlay of previously-identified project sites on a map that also indicates project prioritization based on flood hazard reduction and physical feasibility (low ground slope and good recharge potential). The same information is shown on Plate 7, but also includes identification of the locations of zones of groundwater depression.

5 Next Steps

The Water Agency will consider input from the stakeholders and other interested members of the public in developing the final version of this screening memorandum. A meeting with regulatory agencies will be held after the stakeholder meeting to also solicit their input to the proposed priority list of projects. The Water Agency will work with the consultant team to identify appropriate revisions after considering all of the input that has been received. At that point this memorandum will be finalized.

The next phase of the Sonoma Valley Scoping Study will be the development of scoping for future feasibility studies for the priority project concepts. This phase of effort will include identification of information and data gaps as well as developing scopes of work and budgets for the priority project concepts as identified in Section 4.5. An implementation strategy will also be developed to identify what will be required to develop these general project concepts into a specific project design, along with timelines, phasing, information needs, and funding opportunities. A subsequent phase of project effort will then be initiated to start the process of project development, beginning with project concept refinement and feasibility analyses.

[4] Note: we have omitted from this list several specific project locations owned by entities that preferred not to have these properties identified as possible sites at this time.

6 References

ESA PWA, Daniel B. Stephens & Associates, and Parker Groundwater. 2011. Sonoma Valley Stormwater Management and Groundwater Recharge Scoping Study: Issues Assessment. Prepared for the Sonoma County Water Agency. October 19. Available at: http://www.scwa.ca.gov/files/Sonoma_Final_Issues%20Assessment.pdf.

Farrar, C.D., Metzger, L.F., Nishikawa, T., Koczot, K.M., and Reichard E.G. 2006. Geohydrological Characterization, Water-Chemistry, and Ground-Water Flow Simulation Model of the Sonoma Valley Area, Sonoma County, California with a section on Basement Rock Configuration Interpreted from Gravity Data by Victoria E. Langenheim, U.S. Geological Survey Scientific Investigations Report 2006-5092.

Graymer, R.W., Brabb, E.E., Jones, D.L., Barnes, J., Nicholson, R.E., and R.E. Stamski. 2007. Geologic Map and Map Database of Eastern Sonoma and Western Napa Counties, California. Pamphlet to Accompany US Geological Survey Scientific Investigations Map 2956.

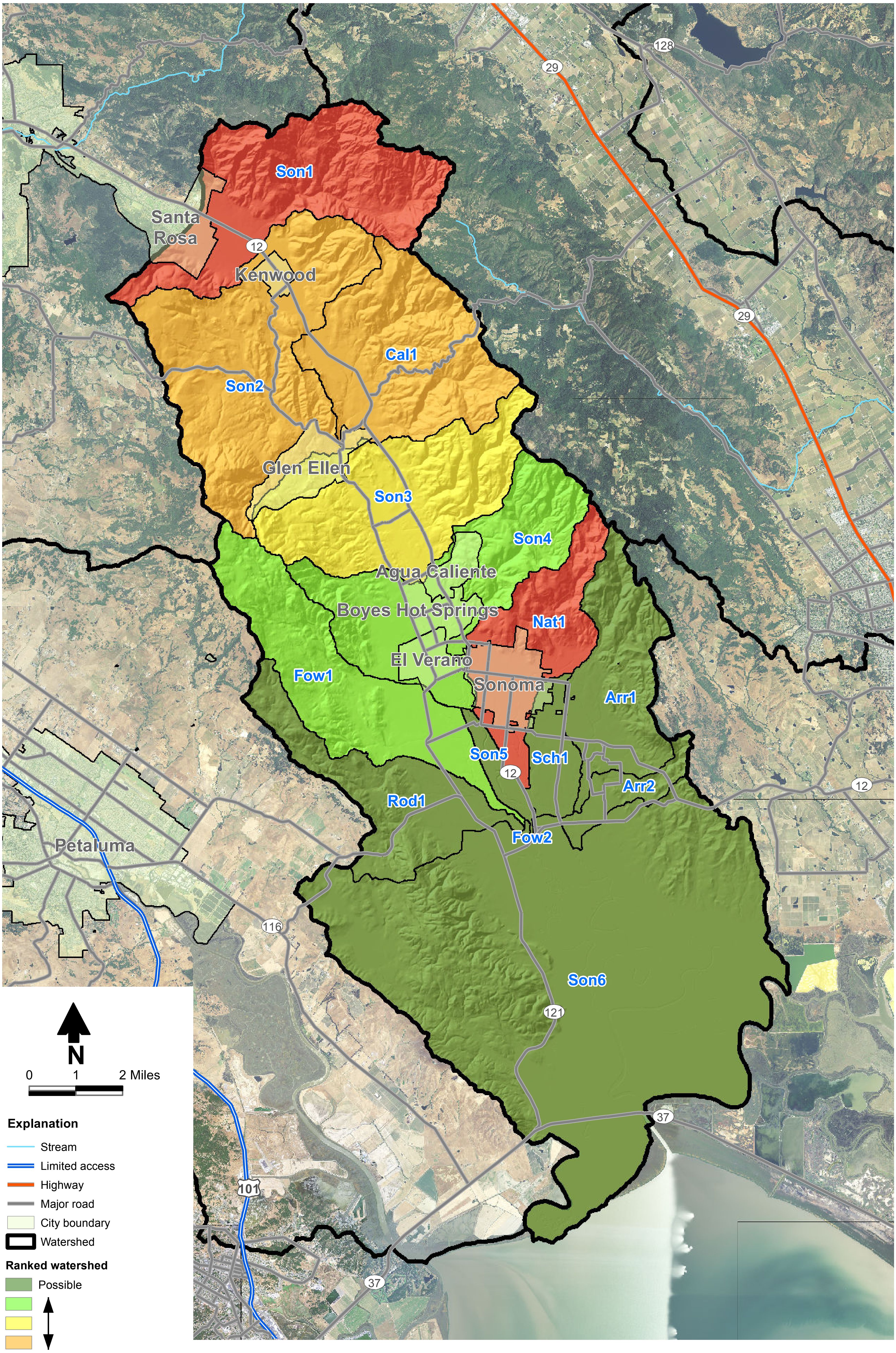
PWA (Philip Williams and Associates, Ltd.). 2004. Sonoma Creek and Tributaries Basin Hydrologic Investigation. Prepared for the U.S. Army Corps of Engineers, San Francisco District Office. PWA Ref. Number 1411-21.

PWA (Philip Williams and Associates, Ltd.). 2008. Sonoma Creek Flood Management and Habitat Enhancement Project: Hydraulic Model Development. Prepared for the Southern Sonoma County RCD. PWA Ref. Number 1844.

PWA (Philip Williams & Associates, Ltd.). 2010. Sonoma Creek Kenwood Reach Conceptual Alternatives for Flood Hazard Reduction and Groundwater Recharge Enhancement. Prepared for Sonoma Ecology Center. PWA Ref. Number 1968.00.

SEC (Sonoma Ecology Center) and SCWA (Sonoma County Water Agency). 2011. Sonoma Valley Groundwater Recharge Potential Mapping Project. SEC Report No. 20100922.

S:/PROJECTS/WR10.0085_SCWA/GIS/MXDS/FIGURES/PLATES/PLATE_1_FLOOD_HAZARD_REDUCTION_POTENTIAL_BY_SUB_WATERSHED_11X17.MXD 113101



SONOMA VALLEY STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE SCOPING STUDY

Flood Hazard Reduction Potential by Subbasins

ESA PWA Parker Groundwater

4/30/2012

JN WR10.0085

Plate 1

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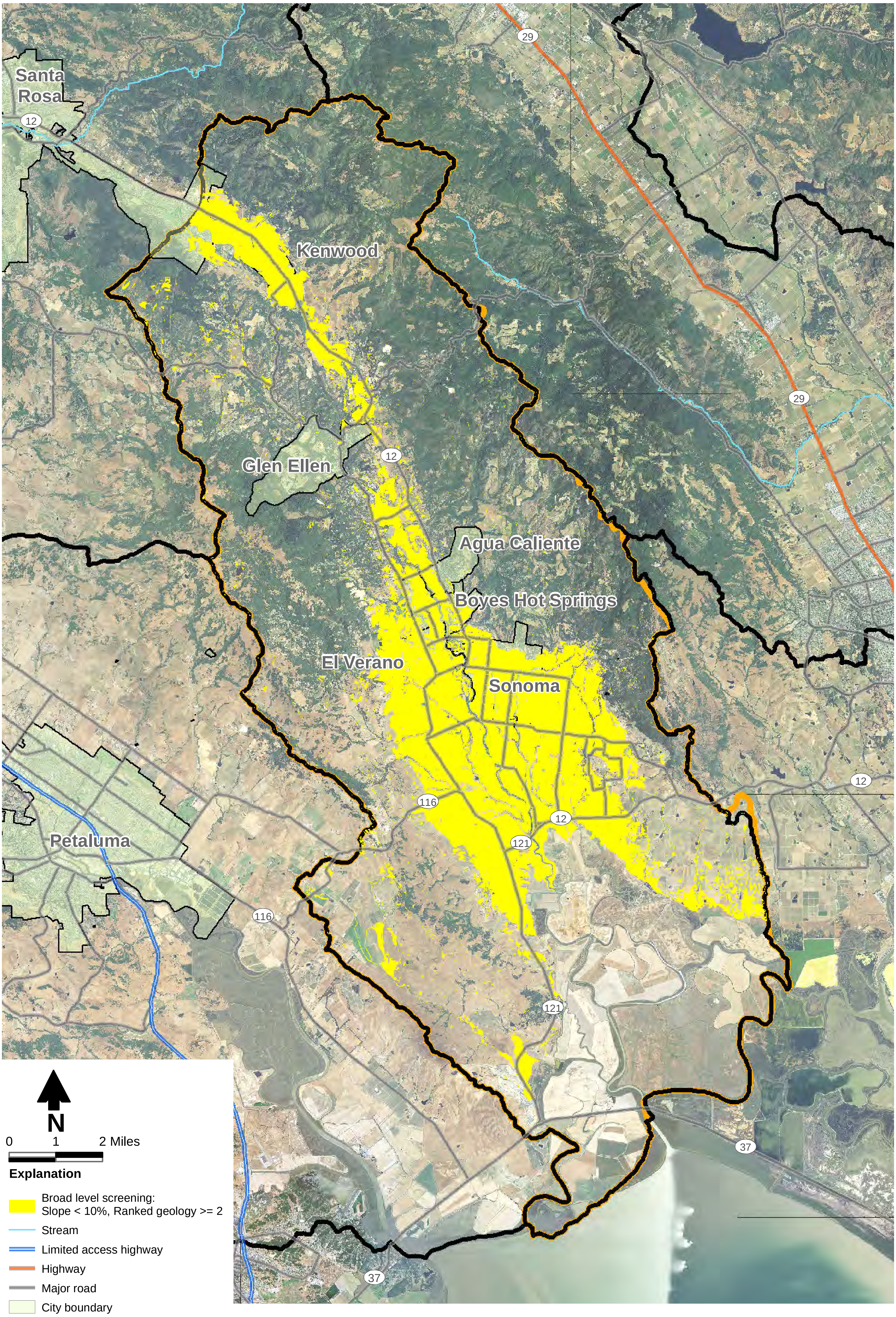


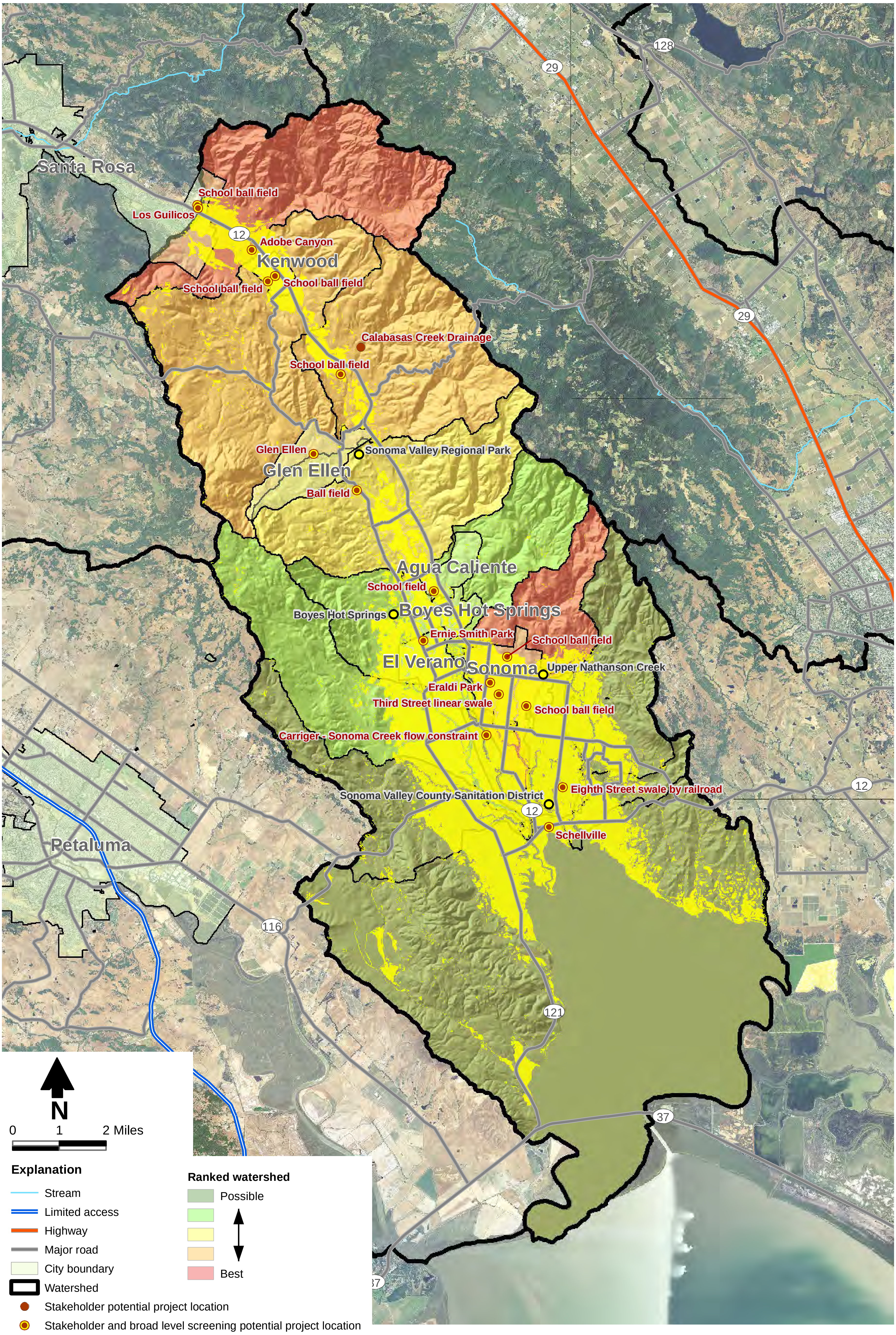
SONOMA VALLEY STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE SCOPING STUDY

Areas with Slope Less Than 10 Percent and Areas with Geologic Recharge Potential Greater than or Equal to Fair

Plate 2

10/13/2011

JN WR10.0085



Explanation

- Stream
- Limited access
- Highway
- Major road
- City boundary
- Watershed
- Stakeholder potential project location
- Stakeholder and broad level screening potential project location
- Additional potential project location identified through broad level screening
- Broad level screening: Slope <10%, Ranked geology >= 2

Ranked watershed

- Possible
- Best

ESA PWA Parker Groundwater

Plate 3

SONOMA VALLEY STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE SCOPING STUDY

Flood Hazard Reduction Potential by Subbasins and Physical Feasibility Screening

10/13/2011

JN WR10.0085

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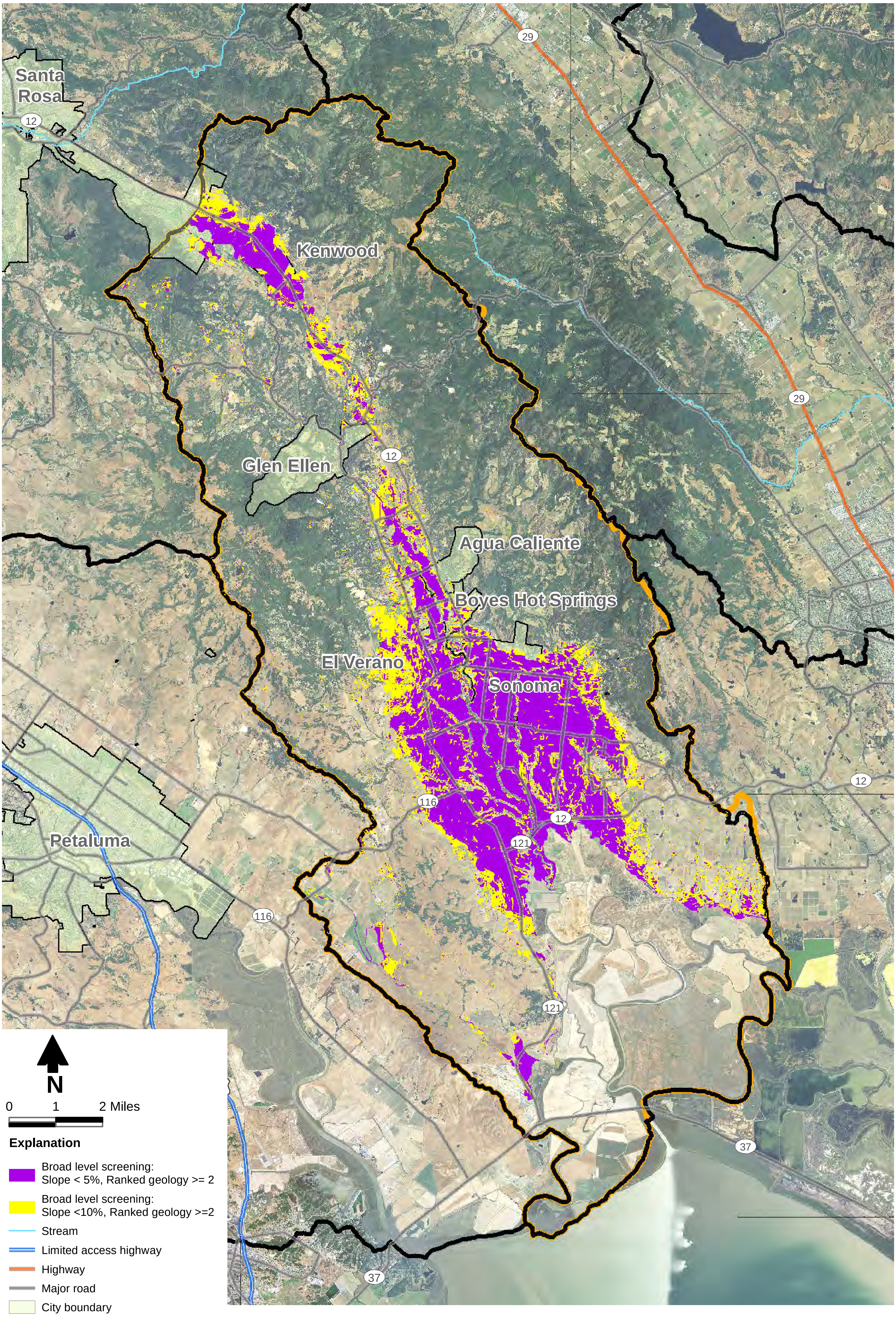


SONOMA VALLEY STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE SCOPING STUDY

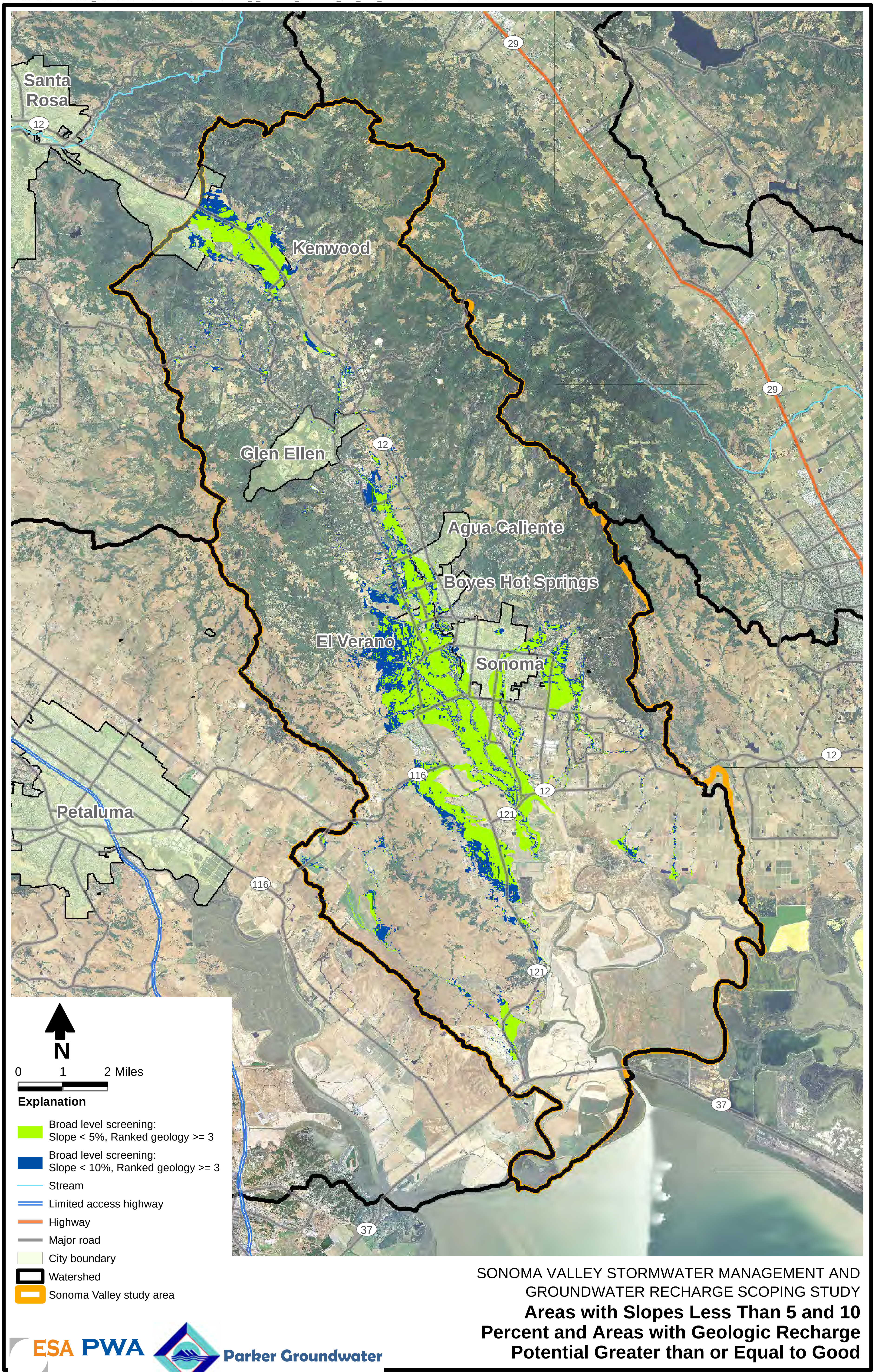
Areas with Slopes Less Than 5 and 10 Percent and Areas with Geologic Recharge Potential Greater than or Equal to Fair

Plate 4

ESA PWA Parker Groundwater

10/13/2011

JN WR10.0085



SONOMA VALLEY STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE SCOPING STUDY

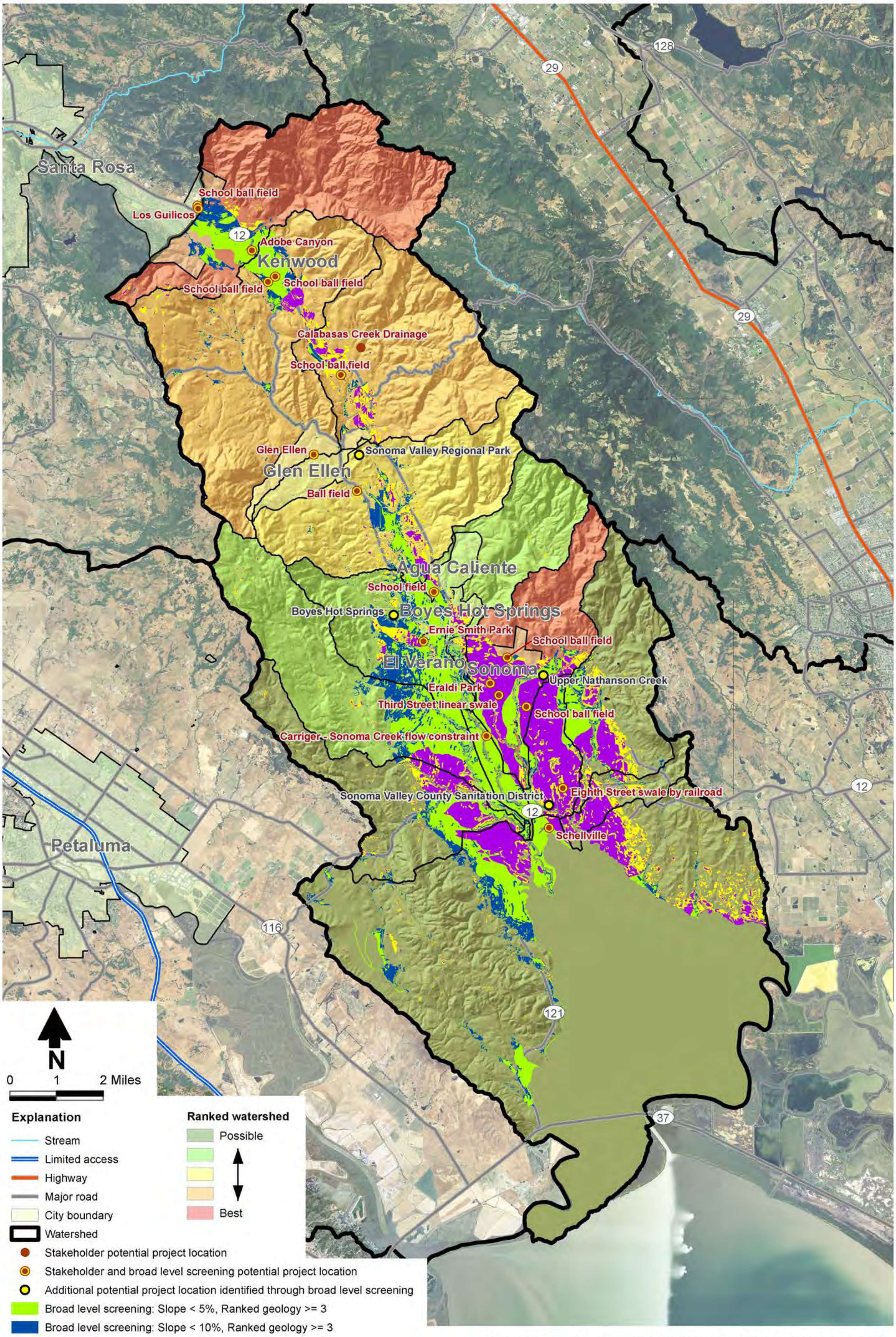
Areas with Slopes Less Than 5 and 10 Percent and Areas with Geologic Recharge Potential Greater than or Equal to Good

ESA PWA Parker Groundwater

Plate 5

10/13/2011

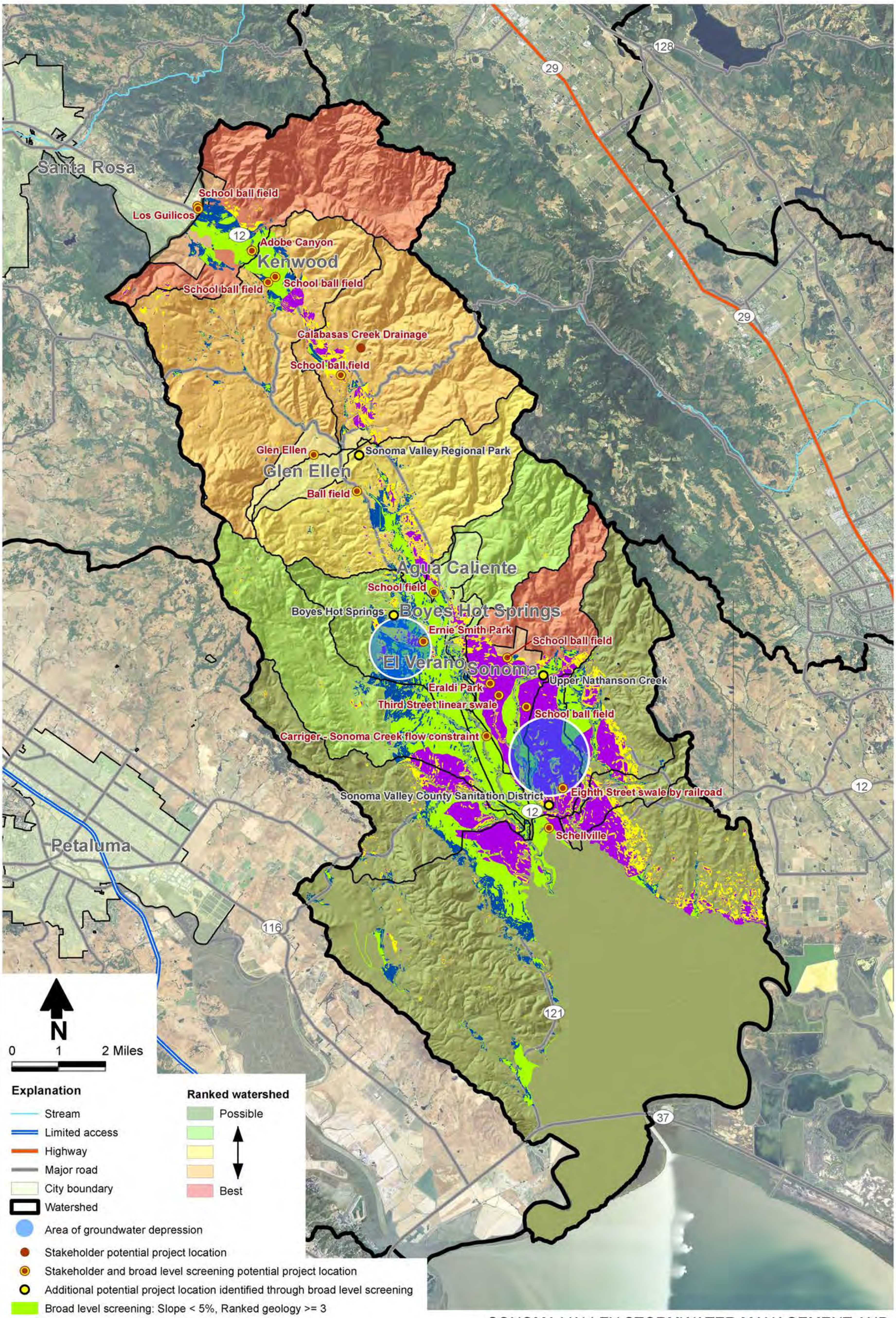
JN WR10.0085



SONOMA VALLEY STORMWATER MANAGEMENT AND GROUNDWATER RECHARGE SCOPING STUDY

Project Prioritization with Flood Hazard Reduction and Physical Feasibility

ESA PWA Parker Groundwater



SONOMA VALLEY STORMWATER MANAGEMENT AND
GROUNDWATER RECHARGE SCOPING STUDY

Project Prioritization with Flood Hazard Reduction, Physical Feasibility, and Areas of Groundwater Depression

ESA PWA   Parker Groundwater

Plate 7