appendix d

Groundwater Availability Memo

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TOLAY LAKE
REGIONAL PARK
Master Plan Project

Kennedy/Jenks Consultants

31 October 2012

Memorandum

To: Steve Ehert, Sonoma County Regional Parks

From: Michael Maley, PE, PG, CHg, Mike McLeod, PG

cc: John Baas, MIG, Inc.

Subject: Progress Report
Groundwater Assessment and Well Siting Analysis for Tolay Lake Regional Park
K/J 1264014*00

Kennedy/Jenks Consultants (Kennedy/Jenks) is pleased to submit this technical memorandum providing a progress report of our groundwater assessment for Tolay Lake Regional Park. In this technical memorandum, we present a progress report that discusses the initial findings of the groundwater assessment and recommendations for siting the test well. The purpose is to provide Sonoma County Regional Park staff an opportunity to review these initial findings.

Background

Determining the feasibility of groundwater as a water supply is critical in understanding park development options. Water is currently obtained from two springs on the property, and water from two perennial lakes on the upland (east side) part has been used for irrigation. However, springs and ponds are vulnerable to extended droughts and may not be a reliable water supply. Also, springs and ponds would require additional water treatment for use as a public drinking water supply making this option less feasible. There are no groundwater wells present on the Property. Therefore, Kennedy/Jenks recommends one test well will be drilled on Park Property to a depth of approximately 300 feet to provide subsurface information and to estimate potential well yields.

Geology Overview

The Tolay Lake valley is an elevated valley trending generally northwest-southeast. It is bounded on the northeast by the Sonoma Mountains and on the southwest by a low line of hills that separate it from the Petaluma Valley to the west. Tolay Creek flows from northwest to southeast down the middle of the valley. Tolay Lake was formed by a natural dam across Tolay Creek that was about 14 feet higher than the lake bed. The natural dam was breached in the 1860's, but was later rebuilt to its current condition (Florsheim, 2009).

The valley is underlain by Quaternary deposits and the Petaluma Formation composed primarily of silt, clay, with scattered sand or coarse-grained layers. The hills to southwest are mainly underlain by Franciscan Formation metamorphic rock and the hills to the northeast are underlain by volcanic rocks; mainly the Sonoma Volcanics but some sources distinguish an older volcanic unit (Donnell Ranch or Tolay Volcanics) along the valley perimeter. For ease of reference, we will refer to all the volcanic rocks as the Sonoma Volcanics in this technical memo. The distribution of these geologic formations follows the northwest-trending regional geologic structure.

The Tolay Lake basin is an elevated depression located within the Tolay Creek syncline and is bordered on the west by the northwest-trending Tolay fault and on the east by steep hills associated with the Adobe Creek anticline (Cardwell, 1958). The Rodgers Creek Fault is present in the Sonoma Mountains to the east of the Park Property. There are numerous associated faults with the Rodgers Creek Fault along the east side of the valley. Wagner and others (2002a, 2002b) show several fault contacts along the base of the hills to the east. The Tolay Fault is generally defined as the contact between the Franciscan and Petaluma Formations (DWR, 1974, 1982). Sources disagree on the precise alignment of the fault, but it is likely the Tolay Fault passes close along the foot of the hills along the southwest.

Springs are present in the valley and are larger and more numerous along the east side of the valley than on the west side. Maps and aerial photographs show several ponds and springs present in a northwest-trending alignment along the base of the hills to the east (Circuit Rider Productions Inc., 2006). The linear alignment of the ponds and springs appears to be associated with the Petaluma Formation-volcanic rock contact.

Literature Review of Potential Aquifers

Based on the local geology, Tolay Lake Regional Park is located within a Marginal Water Availability Area, as defined by the County planning department. We have reviewed data from the California Department of Water Resources for the area (DWR, 1975, 1982), the United State Geological Survey (USGS) including reports by Cardwell (1958) and geologic maps by Blake et al (2000) and Graymer et al (2002), and geologic maps from the California Geological Survey (Wagner et al, 2002a, 2002b). Rust (1996) conducted a geotechnical investigation of the site that included some shallow borings. Below is a summary of the descriptions of the local aquifers from those reports.

The Petaluma Formation, mid-to-late Pliocene in age, consists of folded continental and shallow marine to brackish-water deposits of clay, shale, and sandstone, with lenses of friable sandstone, conglomerate and nodular limestone. Abundant clay characterizes this unit and contains about 70 percent clay, shale, and clayey or shaley beds. The Petaluma Formation can yield moderate amounts of water when a well penetrates an appreciable thickness of sand and gravel. The Petaluma Formation is noted to provide supplies of good-quality water in quantities sufficient for domestic use, although wells tapping this formation are typically greater than 150 feet deep so as to intercept enough coarser-grained units in the usually compacted and fine grained sediments. Locally, higher yield wells have been developed. A 235-foot deep well in the

Petaluma Formation about four miles northwest of Tolay Lake was reported by Cardwell (1958) to have produced 350 gallons per minute (gpm). Conditions in the Petaluma Formation are variable across the area. Depth to groundwater can vary from near the surface to over 100 feet deep. Water quality is quite variable as well.

The Sonoma Volcanics are exposed along the crest of the Sonoma Mountains on the eastern edge of the study area. The volcanic rock is considered locally significant water producer where they are composed of tuff, scoria, and volcanic sediments. However, locations where the volcanic rock is dominantly lava flows and intrusive rocks are considered to be essentially non-water-yielding unless the rocks have been highly fractured. Because of this, the Sonoma Volcanics have highly variable water-yielding characteristics depending on the site-specific characteristics.

The Franciscan complex is the oldest geologic unit in the study area (Jurassic and Cretaceous age) and are exposed along the western and southwestern edges of the study area, and east of Lakeville Highway along Tolay Creek. The complex includes highly variable amounts of shale, sandstone, chert, greenstone, and serpentinite. The Franciscan complex generally contains only limited quantities of water in fractures. Normally, consolidated rocks containing water only in fractures are not considered to have a specific yield.

Review of Area Well Logs

Kennedy/Jenks reviewed 14 well logs provided by the Park Department (DWR, 2003) and 84 well logs from a recent request (DWR, 2012) by Kennedy/Jenks on behalf of the Park Department. The well logs included wells completed in each of the Petaluma Formation, Sonoma Volcanics and Franciscan Formation from areas near to Tolay Lake Regional Park and adjacent areas in the Petaluma and Sonoma Valleys. Some high producing wells included in the well log packages that were completed in the alluvial sediments of the Petaluma and Sonoma Valley, and do not have any relation to conditions near Tolay Lake.

There are several wells completed in the Petaluma Formation that are located along Stage Gulch Road about 1 to 3 miles north of the Park. The logs confirm that conditions in the Petaluma Formation are variable and well production is dependent upon the lithology encountered. Of eleven wells located along Stage Gulch Road and completed in the Petaluma Formation, five have low well yields of 10 gpm or less, whereas six had well yields of 15 to 40 gpm. The higher yield wells occurred on both the east and west side of the valley.

Wells completed in the Sonoma Volcanics ranged from 0 to 500 gpm. Most of the higher yield wells in the Sonoma Volcanics were located on the east flank of the Sonoma Mountains in the Sonoma Valley. Wells located further up in the Sonoma Mountains in locations more analogous to Tolay Lake Regional Park had well yields that varied from 0 to 100 gpm. This indicates that the well yields in the volcanic rocks are also variable depending upon the lithology.

Two wells were completed in the Franciscan Formation had initial pumping rates of 15 to 50 gpm; however, they showed high drawdown over a short interval of pumping indicating that these rates are not sustainable and that the long-term pumping rate would be more in the 1 to 10 gpm range. There were two wells completed along Lakeville Highway that were dry and subsequently abandoned. These wells are open to the alluvial sediments to the west and groundwater drains from the hills towards the Petaluma Valley.

There are no groundwater wells present on Tolay Lake Regional Park. Kennedy/Jenks did review the geotechnical logs from the Rust (1996) report. One borehole TC-B4, located about 1,000 feet northeast of the existing farm buildings, is a 50-foot borehole that contained over 13 feet of sandstone. The sandstone was present from a depth of 37 feet to the bottom of the borehole, so the total sandstone thickness is unknown. This indicates that the Petaluma Formation does contain significant sandstone layers at Tolay Lake Regional Park. A deeper test well is needed to evaluate whether additional sandstone layers are present at depth. If sufficient sandstone layers are present, a Petaluma Formation well could be a viable option for Tolay Lake Regional Park.

Well Driller's Perspective

Kennedy/Jenks discussed well drilling with Brandon Burgess (personal communication, 2012) of Weeks Drilling regarding his experience drilling water wells in the Tolay Lake area. In general, Mr. Burgess considered the Sonoma Volcanics as the more favorable potential aquifer. He noted that Weeks Drilling recently completed a well estimated at 50 gpm in the Sonoma Volcanics north of Tolay Lake Regional Park.

Mr. Burgess believes that water would be found by drilling in the Petaluma Formation, but considers the Petaluma Formation as being more uncertain as a water producer because of the high percentage of fine-grained sediments. He noted that wells completed in the Petaluma Formation have a typical depth range from 280 to 500 feet and well yields range from 5 to over 50 gpm. His experience is that one in four wells drilled in the Petaluma Formation will have well yields at the higher end of the range and that the remainder of the wells are typically near the lower end of the range.

Mr. Burgess noted that there are few wells completed in the Franciscan Formation in the Tolay Lake area, and he considers the Franciscan Formation as having the lowest potential for producing groundwater. He said that their typical procedure is to see if they encounter fractures in the upper 40 feet; if so they'll keep drilling. If in this zone, they encounter silt, clay, and/or greenstone with few fractures, they'll abandon the hole and move elsewhere and try again.

Kennedy/Jenks also discussed drilling methods and anticipated drilling rates in the Tolay Lake area. For a well in the Sonoma Volcanics, Mr. Burgess would recommend drilling with a downhole air-hammer. If the borehole stays open, they would continue with the downhole hammer to the total depth. Downhole air-hammer methods are fast and because air is used the detection of water and flow measurements are easier. He anticipated the drill rate in the volcanic rocks using this method to be about 300 feet per day. If the borehole starts in fine material or the borehole won't stay open they will switch to mud rotary.

If drilling the Petaluma Formation, Mr. Burgess recommended drilling with mud rotary from the start. In fractured rock or the Petaluma Formation, he anticipated that the drilling rate using mud rotary would be about 150 feet per day.

Mr. Burgess said the 'rock drilling' surcharge ($12 per foot of drilling) on their budget estimate would be used if the drilling rate starts drops below 100 feet per day and that call is made in the field. Based on his experience, he doesn't anticipate that this surcharge would be necessary in the Tolay Lake area. No rock drilling surcharge would be necessary if they drill with downhole air-hammer.

Groundwater Supply Assessment

Based on the available geology and groundwater data, the Sonoma Volcanics appear to have the highest potential for development of one or more groundwater wells especially in the hills on the eastern side of the valley. The presence of a number of springs and ponds along the eastern side of the valley further confirms that groundwater is present in this area. Area well logs indicate that the Sonoma Volcanics are a relatively consistent aquifer with well yields from 10 to over 100 gpm. The Tolay Lake Regional Park includes a large area of the volcanic rocks that should be highly fractured due the proximity the Rodgers Creek Fault and other associated mapped faults. Therefore, the Sonoma Volcanics appear to have good potential for providing a sustainable water supply for the Park.

The Petaluma Formation underlies the valley. The Petaluma Formation is primarily composed of fine-grained sediments, but can be a relatively good groundwater producer if enough sand and gravel layers are intercepted by the well. Area well logs support that the Petaluma Formation is capable of 15 to 50 gpm is sufficient sand layers are present. However, the character of the Petaluma Formation is heterogeneous and groundwater production is also highly variable. Geotechnical boreholes show that shallow sandstone layers are present. Since there are no deep groundwater wells completed in the Petaluma Formation in Park, we are unsure what the production capacity of the Petaluma would be here without installing a test well.

The Franciscan Formation that underlies the majority of the western hills is considered a poor water-bearing unit and existing well logs indicate that wells can produce low flow rates for only a short time and with substantial drawdown. There are springs located in the hills to the west of the existing farm buildings but these appear to be small and ephemeral. Wells in the Franciscan Formation may also be more vulnerable to drought and low water conditions. Therefore, wells in the Franciscan Formation are not recommended.

Infrastructure and Logistics Assessment

In evaluating the location of a potential water supply well, it is important to incorporate infrastructure and logistical considerations as well as the groundwater potential into the decision. Since the project is for a regional park, there are also archeological, historical and aesthetic considerations to be included. Below is a brief summary of the primary infrastructure and logistical issues present at Tolay Lake Regional Park.

The water supply to the Park is currently sourced from a spring on the east side of the valley. It is conveyed by a pipeline to a tank near the vineyard and then across Tolay Lake to a tank near the buildings. The pipeline was original infrastructure from when the site was an active farm. It may be possible to connect a new well to the tank near the vineyard and use the existing pipeline for conveyance across the valley. However, we do not currently know the condition of the existing pipeline and whether it may be required to be replaced as part of the Master Plan. If a new pipeline is required, it would present a substantial cost to construct a new pipeline across the valley.

The well would require electrical power to operate the pump and bringing in power can be expensive and power poles can be visible from a distance. Currently, electricity is available on the western side of the valley near the existing farm buildings. However, it is about one mile across the valley from the existing farm buildings. Power is not available on the property on the eastern side of the valley, but power is available on the property to the north of the Park, but is still about a half mile or more from potential well sites.

Access to the eastern side of the valley was described by Park personnel as being inaccessible during wet weather conditions, potentially from December through May. This is due to high water from Tolay Lake flooding the road across the valley and the nature of the clay-rich adobe soils. Both of these conditions can limit the ability to move equipment trucks and drill rigs across the site to both initially construct the well and to maintain the well, tank and pipeline once a well is in operation. A viable water supply would require that the well and supporting infrastructure be accessible throughout the year in case repairs are necessary.

The California Department of Public Health requires setbacks from potential pollution sources based on the California Well Standards (DWR 1981, 1991) and the Drinking Water Source Assessment and Protection (DWSAP) Program (CDPH, 2000). Near the existing farms buildings the relevant setbacks include:

- 50 feet from any sewer line
- 100 feet from a septic tank or subsurface leachfield
- 150 feet from cesspool or seepage pit
- 100 feet from animal or fowl enclosure

Another siting criterion by CDPH is that the well must be out of the 100-year floodplain and/or above an elevation that may be subject to flooding. We would need to confirm that the well site is above the highest potential lake level so that the well would not be subject to flooding.

Based on infrastructure and access issues, the western side of the valley is preferable to the eastern side. If a viable well can be found near to the existing farm buildings, this would provide the Park Department with substantial savings in capital and maintenance costs.

Recommendation

Kennedy/Jenks' recommendation is to use the test well to evaluate whether the Petaluma Formation near the existing farm buildings can sustain a viable groundwater supply well which would provide substantial cost savings for the Park. The available hydrogeologic data suggest a reasonable potential for a viable water supply well in the Petaluma Formation. This site is considered to be less sensitive to wet weather conditions than areas on the east side of the valley and is, therefore, logistically easier to construct this year. We would recommend a location to the south and east of the existing buildings that is sufficiently far from wastewater facilities to be protective of water quality. The fine-grained and layered character of the Petaluma Formation would also provide water quality protection from potential near-surface sources. We would construct the well with a sanitary well seal of 50 to 100 feet to further help protect water quality from near-surface sources.

If a Petaluma Formation well on the west side of the valley is found to not be viable, then the efforts should be shifted to the Sonoma Volcanics in the hills along the east side of the Park. The available information suggests that there is sufficient groundwater supply in the Sonoma

Volcanics to supply the Park. However, as noted above, there are potential infrastructure, access and logistical issues that could substantially increase the cost of this option. Kennedy/Jenks recommends that the groundwater assessment will include the eastern hills only if a well is not viable in the Petaluma Formation.

If the Petaluma Formation can provide a viable groundwater supply well for the Park, a well in the Sonoma Volcanics would not be necessary. Therefore, constructing a well in the Sonoma Volcanics should be considered only if necessary, and the timing should be postponed to allow more time to thoroughly consider the issues related to this location.

The initial recommendations of this technical memo are for discussion purposes, and Kennedy/Jenks will continue the data review. These are considered preliminary recommendations as the groundwater assessment is ongoing, but provide Regional Parks staff the opportunity to comment on these initial findings. We can set a time for a meeting or teleconference to discuss this further.

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appendix e

Wastewater Treatment Options Memo

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TOLAY LAKE
REGIONAL PARK
Master Plan Project

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July 29, 2014

John Bass
Senior Environmental Planner
MIG, Inc.
800 Hearst Avenue
Berkeley, CA 94710

Subject: **Waste Disposal Options and Preliminary Wastewater System Plan**
Tolay Lake Regional Park, Sonoma County, California

Dear John:

Fall Creek Engineering, Inc. (FCE) is pleased to present to you this letter report describing the requirements for and a presentation of alternatives for an onsite wastewater treatment and disposal system at the Tolay Lake Regional Park (park). The park is located between the Petaluma River and the Sonoma Valley, and is in the Tolay Creek watershed, which is a sub-basin of the Sonoma Creek hydrologic area that drains to San Pablo Bay (Figures 1 and 2).[1]

The park includes 15 buildings, a seasonal lake, hiking trails, a picnic area, numerous pre-historic resource sites, and sensitive habitats, as well as rare, threatened and endangered species. The park is currently accessible to the public on weekends by permit only. The park hosts environmental education activities, offers guided tours and hosts an annual Fall Festival.[2]

As part of a two-year Master Planning process at the park, Fall Creek Engineering (FCE) has been retained to evaluate alternative wastewater improvements to accommodate expanded visitor services and facilities in the Park Center, located in the northwest portion of the park on the western shore of Tolay Lake. FCE has identified options for wastewater disposal and reuse of treated effluent. The results are summarized in this report.

The scope of work for this evaluation consisted of the following tasks:

1. Review of existing information related to the on-site wastewater system, soil and groundwater conditions, and critical resource issues.

2. Limited site evaluation to characterize soil conditions and cultural resources in the proposed redevelopment area, and improvements needing wastewater facilities.

3. Recommendation for alternative wastewater approaches, including the capacity and location of new wastewater facilities for the property and preliminary cost estimates for alternative wastewater systems

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[1] Tolay Creek Riparian Enhancement Plan, November 2009, developed for Sonoma Land Trust by West Coast Watershed with assistance from Rob Evans & Associates.
[2] http://parks.sonomacounty.ca.gov/About_Us/Project_Details/Tolay_Lake_Regional_Park_Master_Plan.aspx

1. EXISTING SETTING AND SITE CONDITIONS

The existing wastewater treatment system on the site includes a conventional septic tank and leachfield system that has experienced intermittent problems since coming under County management. Repairs have been completed as needed to keep the system operational and serve the existing facilities and uses at the site. Water service to the site is currently provided by a spring off-site. The existing leachfield serving the property is located beneath the proposed Visitor Center Location. The existing system is not adequate to effectively manage and treat the estimated wastewater flows as the number of visitors to the park is expected to dramatically increase over the next 30 years.

Soils

The soils on the site are classified by the Natural Resources Conservation Service (NRCS) Soil Survey as predominantly Clear Lake Clay Loam and Diablo Clay. Attachment A includes a soil map of the Tolay Lake Regional Park master plan area, with regions mapped predominantly as either Clear Lake Clay Loam or Diablo Clay, and is described below:

Clear Lake Clay Loam (CcA): This soil consists of clay formed under poorly drained conditions and typically occupies flat basin areas. The soil is characterized as having a very shallow depth (3-5 feet) to seasonal high water table, low permeability (0.06 to 0.2 inches per hour) and high shrink-swell potential. Because of the slow infiltration rate and high groundwater table, these soils have a very high runoff potential.[3] This soil series is not well suited for subsurface wastewater disposal and are prone to clogging.

Diablo Series (DbC, DbD, and DbE): The Diablo series consists of well-drained clay soil occupying slopes of varying steepness (2-9 percent (DbC), 9-15 percent (DbD) and 15-30 percent (DbE) slopes). These soils also display low permeability, high shrink-swell potential and very high runoff potential. The hazard of erosion is high for these soils and increases with increasing percent slope. These soils are also not well suited for subsurface wastewater disposal and is prone to clogging.

In January 1996 a geotechnical assessment of the Tolay Lake Regional Park area was completed for the City of Santa Rosa and the U.S. Army Corps of Engineers to evaluate alternative reservoir sites and pipeline routes.[4] This study included test pits and seismic studies to evaluate soil and geologic conditions within the Tolay Lake vicinity, though the closest of the sample locations was 2,500 feet from the master plan area. The test pit logs indicate a predominance of silty clay and sandy clay soils within the top 1-5 feet, consistent with the soils encountered by FCE investigation, described below.

On May 5, 2014, FCE and a team of County employees conducted a limited site evaluation to characterize soil conditions within the Master Plan area. FCE characterized soil conditions at eight (8) soil boring locations across the site, as shown on Figure 3. The hand borings were completed using a 2" hand auger to a depth of 4 to 6 feet. Soil logs describing the borings including the type and condition of the soil encountered, are included in Attachment B. Consistent with the

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[3] Hydrologic Feasibility Analysis, Kamman Hydrology and Engineering, Inc.

[4] Rust Environmental and Infrastructure, January 1996, Geotechnical Assessment of Alternative Reservoir Sites and Pipeline Routes Volume 1 – Report, Santa Rosa Subregional Long-Term Wastewater Project.

NRCS soil survey and nearby test pits sampled in 1996, the soil is predominantly clay loam and silty clay. Due to the fine grain soil texture and high swell potential, these soils are not well suited for subsurface disposal of wastewater from a conventional wastewater system using only septic tanks and leachfield disposal trenches to treat and dispose of the wastewater.

Cultural Resources

Numerous areas of prehistoric and historic value exist on the site. The wastewater collection, treatment and disposal systems will need to be carefully located and monitored during construction to minimize disturbance to nearby areas of archeological significance. A more detailed description of cultural resources in and around the park can be found in, *Tolay Lake Regional Park, Baseline Documentation, Prepared for Sonoma County Agricultural Preservation and Open Space District, Prepared by Circuit Rider Productions, Inc, June 2006.*

Environmental Resources

The proposed wastewater system improvements are proposed to be located at least 100 feet away from the perimeter of Tolay Lake and from any delineated wetland or stream on the property. Figure 4 identifies the known water features and wetlands with the required 100 foot setback. The extent of natural wetlands and required setbacks to these areas do not present a constraint on the amount of land available for wastewater treatment and disposal.

Climate data were obtained for the site vicinity from California Irrigation Management Information System (CIMIS) Station 144, which has been recording climate data in eastern Petaluma since August 25, 1999[5] and is located approximately 6.7 miles northwest of the park. Table 1 summarizes the average monthly precipitation and evapotranspiration (ETo) rates over the 15 years of record. Evapotranspiration refers to the water lost through evaporation from the soil and surface water bodies, and transpiration from plants.

Table 1. Average Park Monthly Precipitation and Evapotranspiration (ETo)

Month	Rainfall (in)	ETo (in)
January	3.03	1.27
February	4.20	1.70
March	2.93	3.10
April	1.48	4.31
May	1.01	5.21
June	0.41	6.20
July	0.10	6.33
August	0.03	5.24
September	0.03	4.43
October	0.95	3.10
November	1.64	1.63
December	3.82	1.15
Total	**19.63**	**43.67**

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[5] http://wwwcimis.water.ca.gov/cimis/frontStationDetailData.do?stationId=144

2. PROPOSED SITE AND USES

The Master Plan project vision recognizes the park as sacred land with deep spiritual significance, with site features reflecting California's long and storied heritage. The Master Plan improvements would expand upon services to provide an inspirational and educational outdoor recreation destination for all ages and cultures in a thriving, ecologically rich and fully restored landscape.[6]

The Tolay Lake Master Plan site layout proposes a combination of preserving, replacing or renovating existing structures, and constructing a new Visitor Center and Native American ceremonial space. Two site improvement areas, the Equestrian Center and the Native American ceremonial space, will be served by dry wastewater facilities (i.e., pump out options), whereas the more centrally located Visitor Center, residences, park office and Granary building will be managed with a new wastewater system. The following sections estimate the wastewater flow for the planned uses at the park and describe the wastewater treatment alternatives considered. Once a well for future potable water supply for the site has been secured, separation between the proposed wastewater and water systems will need to be incorporated into the site plan, typically 10 feet setback for all water lines and 100 feet for water wells.

3. WASTEWATER FLOW ANALYSIS

The size and relative cost of a new wastewater treatment and disposal/reuse system are based on the flows into the system. FCE has estimated the potential flows using the master plan site layout and assumptions about future park usage assuming daily and peak visitor usage. Approximately 135,000 visitors are expected during the early spring and summer months, 30,000 visitors during winter, and 200,000 visitors during the late summer and fall. It is assumed that approximately 67% of the weekly park visitors will occur on the weekend. Table 2 summarizes the assumed seasonal and weekend peak visitors distribution. The analysis also assumes eight people will live on-site in permanent residences and four people will work in the on-site administrative facilities.

Table 2. Master Plan Prediction for Future Visitors to Tolay Regional Park[7]

Site Use	Seasonally	Months	Monthly	Weekly	Peak per day on Weekends
Early Spring/Summer	135,000	3	45,000	11,250	3,770
Winter	30,000	3	10,000	2,500	840
Remaining Months	200,000	6	33,330	8,330	2,790
		Average	**30,415**	**7,603**	**2,548**

Table 3 summarizes the estimated flows from the Visitor Center, residences, park office and Granary building, based on the assumed future site use and on published per capita daily unit flows values. On an average weekend the estimated wastewater flow rate is 13,350 gallons per day with a peak weekend flow of 19,460 gallons per day.

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[6] Tolay Lake Regional Park Master Plan: Public Workshop #2, January 16, 2014.

[7] J. Bass, personal communication, May 30, 2014.

Table 3. Estimated Wastewater Flow Rates from Future Park Visitors

Wastewater Flow Rate				
Source	**People**	**gallon/(person x day)**	**gallons/day**	**Refernce**
Full-time Residents	8	70	560	Metcalf and Eddy, 1991, Table 2-9 (pg 27), Typical value
Office	4	13	52	Metcalf and Eddy, 1991, Table 2-10 (pg 28), Typical
Visitors				PRMD, Section 19, number 9-2-8, pg 44, estimate for picnic parks (toilet waste only), gallons per picnicker is 5 gpd. Visitor estimate based on peak weekend usage per season.
Early Spring/Summer				
Picnic Parks (visitor/day)	3,770	5	18,850	
Winter				
Picnic Parks (visitor/day)	840	5	4,200	
Remaining Months				
Picnic Parks (visitor/day)	2,790	5	13,950	
average (visitors/day)	2,548	5	12,740	
Total (average)			**13,350**	**gal/day**
Total (peak)			**19,460**	**gal/day**

The total average wastewater flow rate was calculated as the sum of the flow rate from full-time residents, office and the average number of visitors. The total peak wastewater flow rate was calculated as the sum of the flow rate from full-time residents, office and visitors during the high use periods that are assumed to occur during early spring and summer months.

4. WASTEWATER COLLECTION SYSTEM

A new wastewater collection system will be installed to collect wastewater from the main residences, Visitor Center, offices, and the restored Granary building and convey it to a central septic tank and lift station. The wastewater collection system will be a network of gravity sewer lines and a septic tank effluent pump (STEP) system that pumps liquid to the proposed wastewater treatment system. The STEP system consists of a septic tank to retain solids and a pump system to convey liquid waste to the treatment system.

The preliminary plan proposes to install a small diameter gravity sewer system that will convey untreated wastewater to the STEP system. The STEP system will be located adjacent to the Historical Barn and Goat Corral. The STEP system will include a dual chamber septic tank to capture solids before they are pumped up to the wastewater treatment site. A small dedicated pump tank will be installed after the septic tank to house a duplex pump system. Due to the potential for high groundwater, FCE recommends installing a dual-chambered 10,000 gallon concrete or anchored fiberglass septic tank followed by a 3,000 gallon pump tank.

Figure 4 presents a preliminary layout of the proposed gravity sewer pipelines and step system. The wastewater collection system will be designed to meet the Sonoma County Public Works standards and the requirements of the Uniform Plumbing Code. The retrofitted Granary building, which will include a commercial kitchen, will have oil/water separators below the sinks and a gravity style grease trap installed as part of the collection system.

5. WASTEWATER TREATMENT ALTERNATIVES

Due to poor soil conditions and high groundwater conditions in the vicinity of the proposed improvements, design and construction of a conventional wastewater treatment system with a septic system and leachfields was not considered a feasible alternative without additional treatment of the wastewater. There are a variety of alternative wastewater treatment technologies that can be used to meet County and State requirements for the site. FCE has conducted an evaluation of three alternative wastewater treatment systems: (1) a packed bed textile filter system manufactured by Orenco Systems, Inc. (OSI), (2) a multi-stage trickling filter system manufactured by Acqualogic, Inc. (AQL); and (3) a combined trickling filter and constructed wetland treatment system. The evaluation describes and compares each system considering capital costs, operation and maintenance requirements, energy costs, land requirements, operator skill level, and reliability.

All three treatment systems are biological treatment systems that can produce highly treated wastewater that can be filtered, disinfected and reused for pasture irrigation or landscape irrigation for restoration projects on the property.

Alternative #1 – OSI Advantex Packed Bed Treatment System

The Advantex textile biological filtration system, manufactured by Orenco Systems, Inc., is a widely used treatment system that can produce a high quality effluent. The system is a relatively easy system to operate and maintain, but tends to be relatively expensive compared to the other treatment alternatives.

The system treats the water using biological filters that consist of sheets of textile media packed into a fiberglass box and wastewater is intermittently sprayed over the media. Wastewater is recirculated through the textile filters at a high rate (three times a day) to keep the filter wet and improve the treatment of the water. Bacteria and other organisms colonize the textile media and treat the wastewater as it trickles across the surface of the media. This technology is referred to as pack bed fixed film treatment. Due to the relatively high density of the media, the application rate of the wastewater over the media is lower than other types of fixed film biological treatment systems, such as high rate trickling filters. As water flows through the textile filter, the organic waste is reduced, and typically the ammonia-nitrogen in the raw wastewater is converted to nitrate-nitrogen by nitrifying bacteria that grow naturally in the filters. The recycled water from the textile filters is returned to the primary/recirculation tank. The water in the primary/recirculation tank is anoxic or anaerobic (devoid of oxygen), which is the optimum condition for denitrifying bacteria which consume the nitrate-nitrogen and convert the nitrate-nitrogen to nitrogen gas, reducing the nitrogen in the wastewater.

The system consists of a large primary clarification/recirculation tank fitted with a pump system, a eight textile filters located in parallel plumbed treatment pods, and a final effluent pump tank. The sizing of the system is based on design criteria provided by the system manufacturer.

Based on the projected peak flow of 19,460 gallons per day, the Advantex System would consist of the following components:

- A 60,000 gallon primary clarifier/recirculation tank with a duplex pumping system;
- Eight (8) Advantex 100 Treatment Pods;

- A 3,000 gallon effluent pump tank and pump system; and
- A duplex manual clean disk filter system.

A process flow schematic of this system is shown in Diagram A.

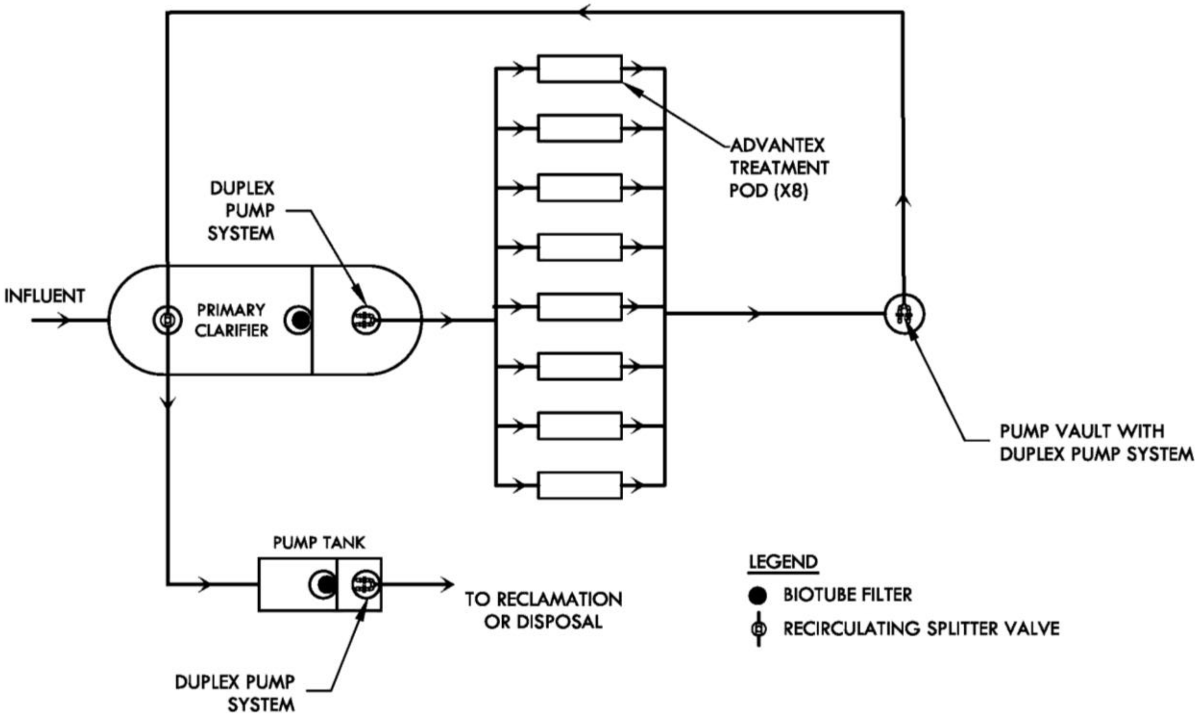

Diagram A. Typical Advantex Packed Bed Treatment System Schematic (Not to Scale)

The area required for the Advantex system is approximately 2,000 square feet.

Figure 5 shows a schematic layout of the Advantex treatment system in three potential locations within the park. One potential location is directly east of the Old Stone Floor Barn where wastewater can enter the treatment system via gravity from the collection system. A second location is near the Modern Barn and new equipment shed. The third potential location is adjacent to the Duck Pond. The Modern Barn and Duck Pond locations require additional energy for pumping collected wastewater to these higher elevations for treatment.

Alternative #2 – Acqualogic Trickling Filter Treatment

The Acqualogic system is similar to the Advantex system and uses a fix film biological treatment system. However, the trickling filters are designed as high rate biological treatment systems using a substantially high application rate that reduces the amount of filter area required to achieve a similar level of treatment. The multi-stage trickling filter system also recirculates the water over two or three stages of trickling filters set up in series and returning the water from the trickling filters to the primary clarifiers. Similar to the Advantex system, the AQL system uses the trickling filters to remove the organic matter from the wastewater and nitrify the ammonia-nitrogen to nitrate-nitrogen. The treated effluent is then returned to the primary clarifier to denitrify the effluent before discharge or reuse.

The trickling filter is a tank filled with engineered media that provides a substrate for organisms to grow on that treat the wastewater entering the tanks. The organisms are passively aerated and do not require a blower(s). As wastewater is sprayed over the media, the organisms absorb the nutrients in the waste (as food) and grow. Each trickling filter has a clarifier to capture biosolids that slough off the media. Each tank has a solids-return line to allow the solids to be recirculated into the beginning of the treatment system. From the clarifier, the water will either be recirculated through the trickling filter or move through the treatment system to the next stage.

The system would consist of the following components:

- A 20,000 gallon primary clarifier;
- A 3,000 gallon recirculation tank and pump system;
- A two-stage Acqualogic biofilter system (with four biofilters);
- A 3,000 gallon effluent pump tank and pumping system; and
- A duplex manual clean disk filter system.

A process flow schematic is shown in Diagram B.

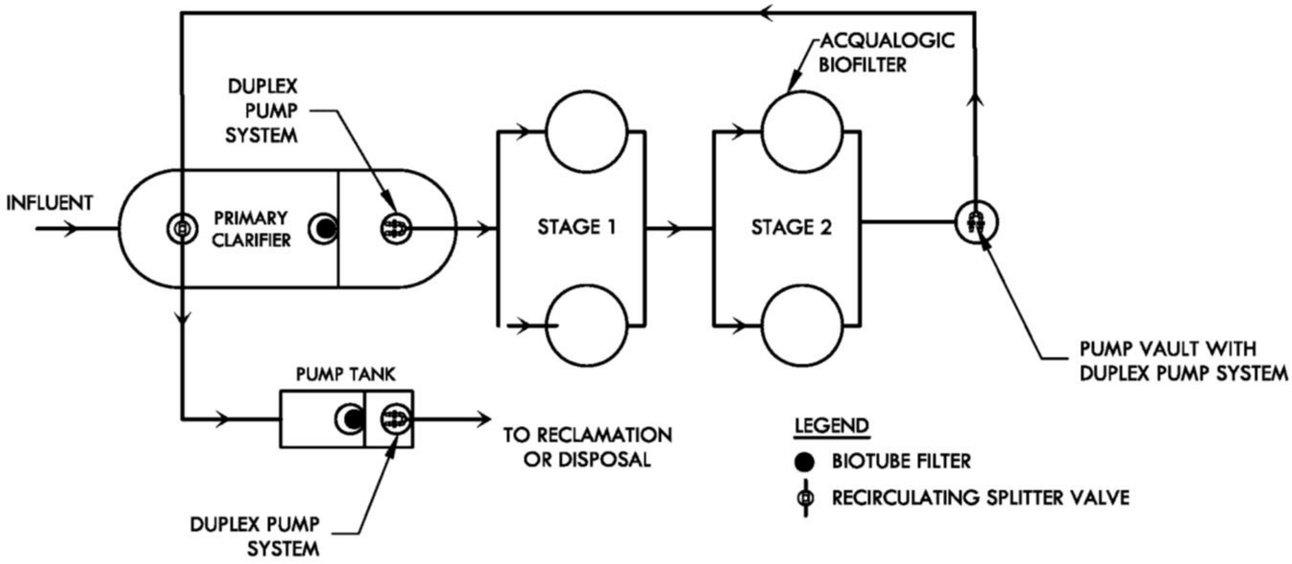

Diagram B. Typical Acqualogic Treatment System Schematic (Not to Scale)

The area required for the Acqualogic system is approximately 1,000 square feet.

Figure 5 shows three sites where this system could potentially be installed on the site.

Alternative #3: Combined Single-Stage Trickling Filter and Natural Wastewater Treatment System

An engineered natural treatment system (ENTS) uses naturally occurring treatment processes with few external inputs (such as energy and chemicals). These systems rely on time and complex natural biochemistry to treat water. The ENTS typically requires more land area to meet detention time requirements. In general, an ENTS will include constructed wetland ponds that use aquatic plants and algae to assist with the treatment process. Constructed wetlands are designed and sized with multiple zones creating both anaerobic and aerobic zones to provide the complex bio-physical treatment system necessary to achieve high levels of treatment.

Treatment wetlands can provide a very high level of treatment or polishing of secondary effluent from a pretreatment system, such as a single-stage trickling filter. It is important to note that constructed wetlands systems should not be used as a primary treatment system. Wetland treatment systems can provide other ancillary benefits that are consistent with the long-term programs at Tolay Lake such as a facility for environmental education about water quality and ecological water treatment, and the creation of additional wildlife habitat.

A combined trickling filter and constructed wetland system is a wastewater treatment system that uses passive aeration, clarifier tanks, and wetlands to provide the aerobic and anaerobic environments for treatment of the wastewater. The proposed ENT system would have a single stage recirculating trickling filter, before the water enters the enhanced treatment wetlands. The trickling filter removes the majority of the Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) to reduce the organic loading to the treatment wetland. The proposed treatment wetland would consist of two three feet deep wetland ponds constructed in series.

Treatment wetlands use plants and other natural organisms to provide treatment and removal of organic matter and nitrogen from the wastewater. The wetlands have shallow and deep zones to provide free water surfaces and habitat for submerged and emergent wetland plants. Provide different zones allows for the ponds to have diverse plant life and ecology that increases the treatment efficiency of the system.

Treatment wetlands in combination with trickling filters provide very good treatment; however they require more area than either Alternatives #1 and #2. Table 8 in Section 7 provides a comparison of the land requirements for each of the alternatives. A constructed wetland that receives treated effluent from the trickling filters can achieve concentrations of 10 mg/L of BOD, 6 mg/L of TSS, and 3 mg/L of Total Nitrogen (TN). The combined treatment system would produce effluent suitable for subsurface irrigation or land disposal.

A process flow schematic for this type of treatment system is presented in Diagram C.

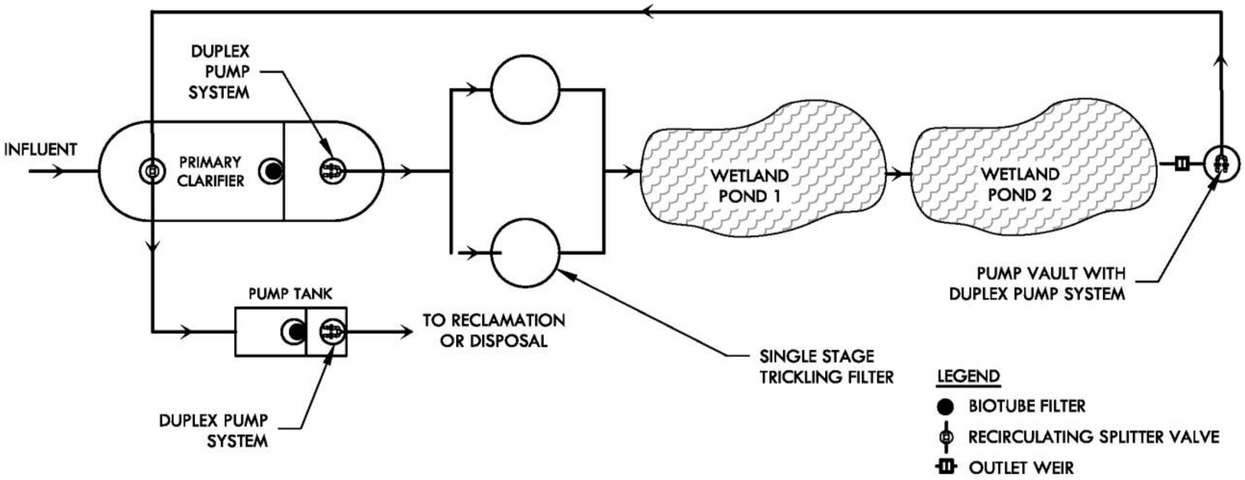

Diagram C. Typical Trickling Filter and Constructed Wetland Treatment System Schematic (Not to Scale)

Two locations have been identified within the park as potential sites to install a treatment wetland system: Duck Pond and an area northwest of the Modern Barn.

Duck Pond is an existing pond within the park that is currently accessed by cattle as a watering hole. Historical grazing activity around the pond has caused some erosion and sedimentation to occur in the pond, which has reduced the pond depth to between one and two feet. A spring on the property flows through Willow Pond to the north before continuing downstream to Duck Pond and eventually flowing into a shallow drainage ditch that connects to Tolay Lake.

If converted to a natural wastewater treatment system as shown in Figure 6, Duck Pond would be divided into two treatment ponds and a third storage pond. The treatment ponds would have both shallow (18 inch deep) and deep zones (5 feet deep) with an average depth of 3 feet. The wetland would be planted with both emergent and submergent wetland vegetation and sized to have a hydraulic residence time of over 13 days within the first two zones, with an additional 34-days of wastewater storage in the third pond area.

Considerations or issues that may constrain conversion of the Duck Pond to a treatment wetland include:

- The Duck Pond may be considered a jurisdictional wetland and if so may not be converted to a treatment wetland;

- The pond likely provides habitat for threatened or endangered species, such as the California Red Legged Frog; converting the pond to a treatment system could require mitigating loss of habitat for this special status species;

- Runoff and spring flows would need to be diverted around the pond if it is converted to a treatment wetland.

- A new wetland might be considered a new utility under the terms of the land conservation easement and if so, then may not be consistent with the existing land use provisions.

Given these issues with the Duck Pond site, it might be easier to install this alternative system in the northwest section of property near the Modern Barn. This location has sufficient area available for the single-stage trickling filter/two-pond treatment, with storage pond system, as proposed at the Duck Pond. Due to the proximity of this site to adjacent properties, additional screening with vegetation may be required to address privacy concerns.

Additional Treatment to Tertiary Treated Wastewater

Fully recycled water use in the park would require additional treatment (filtration and disinfection) in accordance with State Water Recycling Laws (Title 22). Once filtered and disinfected, the water could be available for a wide range of uses, such as irrigation, toilet flushing, fire protection and dust control. To comply with the State's water recycling laws would require additional operation and monitoring requirements that could substantially increase long-term operation and maintenance costs. For example, daily water quality testing for bacteria, which would be required, would increase the monthly service requirements by roughly $3,000 per month.

6. OPTIONS FOR FINAL EFFLUENT DISPOSAL AND REUSE

Based on soil conditions, FCE recommends two alternative wastewater dispersal and disposal systems at the site. The first method is the use of shallow subsurface drip dispersal system to reuse the treated wastewater for irrigation of fruit trees and ornamental landscape, and for habitat restoration projects. The second method is a land disposal system that would include setting up a dedicated spray irrigation field on pasture land that is fenced and not accessible to the public.

Figure 7 shows the proposed layout of the subsurface drip and spray irrigation areas. The subsurface drip dispersal system is shown in areas that will be landscaped and irrigated within standard setback limits from nearby streams and wetlands to assure that the project will not adversely affect surface water or groundwater quality at the site. The proposed spray irrigation system is in areas designated as pasture lands.

Additional site investigations will be required to evaluate on-site groundwater conditions and ensure adequate separation between the shallow drip dispersal system and the highest anticipated groundwater level.

In addition, careful management of the dispersal system will be required before and after rainfall events to prevent overloading or water logging the soils.

FCE has contacted California Regional Water Quality Control Board staff to assess if treated effluent could also be used for irrigation of riparian habitat areas during the spring, summer and fall. The CRWQCB indicated that this could be an appropriate reuse of this water as long as the applied water does not enter any surface water course or impact shallow groundwater resources.

Shallow Drip Dispersal System

The on-site wastewater system plan will reuse treated effluent for landscape irrigation around buildings and roads and within common landscape areas as shown on Figure 7. Based on the clay soil conditions and assuming an application rate of 0.2 gallons per day per square foot, the amount of subsurface drip disposal area required to manage 100% of the treated effluent on the site is approximately 2.23 acres (approximately 97,300 square feet).

Based on the preliminary irrigation plan, treated effluent would be applied to approximately 3 acres of dispersal area using a subsurface drip irrigation system. Table 4 presents the preliminary design calculations for the subsurface drip dispersal system.

The subsurface drip dispersal system will be installed six (6) inches below ground surface, and treated effluent would be applied during dry periods.

Table 4. Subsurface Drip Dispersal Irrigation Design Calculations

Shallow Drip Dispersal Calculations	**Single Zone**	**Multiple Zones**	
Number of Zones	1	5	zone
Quantity of Effluent to be disposed per day	19,460	19,460	gallons
Hydraulic Loading Rate	0.2	0.2	gpd/sf
Disposal Area Required per Zone	97,300	19,460	sf
Spacing between wasteflow lines	1	1	ft
Spacing between wasteflow emitters	1	1	ft
Total Linear Feet of dripline	97,300	19,460	ft

Spray Irrigation

Spray irrigation of treated wastewater is another potential disposal method in areas where public access is prohibited. Based on preliminary calculations, FCE estimates that approximately 2.1 acres is available for spray irrigation of treated wastewater. The spray field would need to be located outside of 100-foot setbacks from adjacent stream and wetland areas.

A spray irrigation system would need to be carefully managed, particularly in relation to forecasted precipitation events. An example operational limitation that could be required is withholding irrigation of the area 24-hours prior to forecast precipitation, (e.g. rainfall exceeding 0.1 inches) with irrigation resuming when soil conditions are sufficiently dry. Additional storage within the wastewater treatment system may be required to store water during prolonged (multi-day) storm events.

7. TECHNICAL EVALUATION OF ALTERNATIVE TREATMENT SCHEMES

A technical evaluation of each treatment system alternative was based on the following criteria:

1. Capital cost;
2. Operation and maintenance requirements; and
3. Land requirements.

<u>Capital Costs for Treatment System Improvements</u>

Capital costs for each alternative treatment system are compared in Table 5 based on the estimated wastewater flows. The reuse and disposal systems are assumed to be identical for each type of treatment system and are not included in this comparison.

Table 5. Capital Costs Comparison for the Treatment System Alternatives

	Alternative #1	**Alternative #2**	**Alternative #3**
Description	**OSI Advantex Packed Bed Treatment System**	**Acqualogic Two-Stage Trickling Filter System**	**Trickling Filter & Wetland**
Pretreatment	$ 44,700	$ 44,700	$ 44,700
Treatment System	$ 261,500	$ 152,200	$ 152,800
Sales Tax	$ 26,000	$ 16,700	$ 16,800
Shipping	$ 15,300	$ 9,800	$ 4,900
Labor	$ 229,700	$ 147,700	$ 148,100
Profit	$ 80,400	$ 51,700	$ 51,800
Engineering and Permitting	$ 82,201	$ 52,852	$ 52,383
Contingency	$ 74,000	$ 47,600	$ 47,100
Total Estimated Cost	**$ 813,801**	**$ 523,252**	**$ 518,583**

The preliminary capital cost analysis indicates that the cost of the Acqualogic two-stage treatment system and the trickling filter-constructed wetland system are very similar. The cost for the OSI Advantex treatment system is substantially higher than these two alternatives. Table 6 presents a preliminary capital cost estimate for an on-site subsurface drip dispersal and spray irrigation system.

Table 6. Preliminary Cost Estimate for On-Site Subsurface Dispersal and Spray Irrigation Systems

Reuse System	**Total Cost**
Subsurface Drip Irrigation	$ 211,900
Spray Irrigation	$ 66,182

Operation and Maintenance Requirements

Operation and maintenance (O&M) requirements are estimated by the amount of hours the operator must clean, monitor, and maintain the system on a weekly basis. All systems will have a Supervisory Control and Data Acquisition (SCADA) system that will allow the system operator to monitor the system remotely and thereby reduce the number of trips to the site. Table 7 provides a comparison of the estimated monthly and annual O&M costs for each alternative.

Table 7. Estimated Operation and Maintenance Costs

	Alternative #1	**Alternative #2**	**Alternative #2**
	OSI Advantex Packed Bed Treatment System	**Acqualogic Two-Stage Trickling Filter System**	**Trickling Filter & Wetland**
Monthly O&M Cost	$ 2,000	$ 2,000	$ 750
Annual O&M Cost	$ 24,000	$ 24,000	$ 9,000

This comparison indicates that the combined trickling filter and wetland system would require the least amount of maintenance compared to the OSI and AQL systems, which have similar O&M requirements.

Land Requirements

Table 8 presents the estimated amount of land required for each wastewater treatment system. Package plants[8] have relatively small footprints compared to the combined trickling filter and wetland treatment system.

Table 8. Land Area Requirements for Alternative Wastewater Treatment Systems

	Alternative #1	**Alternative #2**	**Alternative #3**
Land Use Requirements	**OSI Advantex Packed Bed Treatment System**	**Acqualogic Two-Stage Trickling Filter System**	**Trickling Filter & Wetland**
Square Feet	2,000	1,000	40,820
Acre	0.046	0.023	0.94

The combined trickling filter and wetland treatment system would require more land than either of the two package plants. However, the Duck Pond and the area behind the Modern Barn would be available to install this system.

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[8] Package plants are defined by the Sonoma County PRMD in Policy No. 1-4-3 as a method of sewage treatment that uses energy and mechanical, biological, chemical or physical treatment of wastewater to reduce BOD, suspended solids, nitrogen and bacteria with a degree of complexity that requires a certified operator. Package plants also refer to any treatment unit other than a septic tank that processes more than 1,500 gallons of wastewater per day.

Energy, Operator Skill, and System Reliability

OSI and AQL treatment systems have a similar moderate energy use, whereas the treatment wetland alternative has a low energy use. All three alternatives require a relatively low level of operator skill and are reliable treatment systems.

8. REQUIREMENTS

The County of Sonoma and the California Regional Water Quality Control Board (RWQCB) have adopted standards for on-site wastewater systems. The following sections identify pertinent standards that apply to the siting, design, and operation of an upgraded on-site wastewater system on the property.

Sonoma County Requirements

Sonoma County Code, Chapter 7 and 24: Regulations for Design, Construction, Repair and Operation of Non-Standard Sewage Disposal Systems (policy number 9-2-8)

These regulations establish the rules governing non-standard sewage disposal system programs in Sonoma County. The regulations cover two basic types of non-standard systems, experimental systems and alternative systems. An experimental system is a technology that has not been used within the county but has sufficient design information and monitoring data to substantiate the design, applicability and use at the site. An alternative system is an experimental system that has been used successfully in Sonoma County.

The standards prescribe setbacks from man-made and natural features, groundwater and surface water resources, reserve area requirements, site criteria to determine the suitability of site conditions for installing a disposal system(s), and design criteria for non-standard systems.

Sonoma County Permit and Resource Management Department Package Treatment Plant Policy and Procedure (policy number 1-4-3)

This policy is intended to provide guidance to county staff when an application is submitted for a commercial, agricultural or industrial use that proposes use of a package sewage treatment plant for domestic sewage disposal in cases where such plants are consistent with the General Plan and is also intended to guide the environmental (CEQA) and technical review of projects.

The policy outlines the submittal requirements for a permit application (in conjunction with a discretionary permit application). The submittal must be prepared by a Registered Civil Engineer with a minimum of 5 years of experience in sewage treatment plant design. The submittal shall include a full description of the collection, treatment and disposal systems, including an evaluation of soil and groundwater conditions as well as a site-specific water balance discussion. The submittal shall include an environmental review of the package plant for CEQA compliance that assesses the potential impacts and measures required to mitigate impacts related to noise, odors, vectors, visual impacts, soil erosion, geologic hazards, potential health effects, and groundwater impacts, along with an assessment of alternative treatment schemes, size of the proposed treatment plant, aerosols, hazardous materials, sludge disposal, cumulative impacts, impacts on flood plains, biological impacts and other potential environmental factors.

Sonoma County Site Evaluation and Percolation Test Methods (policy number 9-2-17)

The Sonoma County PRMD has adopted procedures to provide uniform standards for review of site and soil conditions, and performing percolation testing.

California Regional Water Quality Control Board Requirements

Water Quality Control Plan for the North Coast Region

Primary responsibility for the protection and enhancement of water quality in California has been assigned to the State Water Resources Control Board (State Water Board) by the California legislature. The State Water Board provides state-level coordination of the water quality control program by establishing statewide policies and plans for the implementation of state and federal laws and regulations. Nine regional water quality control boards (regional water boards) adopt and implement water quality control plans (basin plans) that recognize the unique characteristics of each region with regard to natural water quality, actual and potential beneficial uses, and water quality problems.

Waste Discharge Requirements

The property will be regulated by the San Francisco Bay (Region 2) Regional Water Quality Control Board (Regional Board) through their Waste Discharge to Land program. The project would be regulated under Waste Discharge Requirements and a Monitoring and Reporting Program adopted and issued by the Regional Board. The County would be required to submit a Report of Waste Discharge (RWD) for the project that provides a full description of the project, engineering calculations, design and construction plans, an operation and maintenance plan, and a copy of an approved CEQA document for the project. Once the RWD has been deemed complete by the Regional Board, Waste Discharge Requirements would be issued or the County could be allowed to operate under the recommendations of the RWD.

9. CONCLUSIONS

1. The future estimated number of visitors to the park represents a significant increase above existing conditions. An enhanced wastewater treatment and disposal system will be required to effectively manage this anticipated use and corresponding projected wastewater flows. The number of visitors projected to use the park would be expected to generate an average wastewater flow of 13,350 gallons per day with peak daily flows around 19,460 gallons per day.

2. Based on this preliminary analysis, FCE recommends installation of a single stage trickling filter and wetland treatment system. The system would treat and reuse wastewater via a subsurface drip irrigation dispersal and spray field irrigation system. A constructed wetland system would have the lowest capital and operation and maintenance costs compared to the other alternatives considered. A constructed wetland system would also provide benefits including additional wildlife habitat and environmental education opportunities for the park. Two potential locations for the treatment wetland have been identified: at Duck Pond and behind the Modern Barn. The Modern Barn location is currently the preferred location because of potential regulatory complications associated with the reuse of an existing water feature such as Duck Pond. For each of the three proposed treatment alternatives there is adequate space within the Park Center to accommodate the required 100 foot setback requirement from water features and wetlands.

3. During peak use the wastewater treatment system can be expected to generate low to moderate odors. Proximity to odors should be considered during the selection of a treatment location. Placement at either Duck Pond or near the Modern Barn has the benefit of being away from the main visitor area, and selection of either these locations should mitigate any potential odor issues from the treatment system.

4. Soil investigations did not find areas suitable for a conventional subsurface disposal system, such as a leachfield, although a leachfield system is currently used on-site. Additional soil testing is advised to determine if a backup leachfield system could be installed to periodic use during wet weather periods when wastewater flows are likely low but surface soils may be saturated. Further percolation tests and groundwater investigations would be needed to identify potential locations suitable for a leachfield system.

5. There is on-site area available to install shallow subsurface drip disposal systems capable of accepting up to 19,460 gpd of treated wastewater. Proposed gully restoration areas can also be served by subsurface drip disposal to assist with establishing new vegetation. Storage of treated effluent within an on-site pond would provide operational flexibility and could potentially reduce the size of the drip and spray dispersal areas by 30% to 40%, if these systems were sized for average daily flows instead of peak daily flows. It is also anticipated that wastewater production rates will be at their lowest during the

winter months when the reuse of treated effluent will need to be carefully managed with precipitation events and soil saturation.

6. The preliminary wastewater system plan assumes that large annual events, such as the Fall Festival, would be served by portable toilet facilities, not the proposed wastewater treatment system.

7. Recycled water that meets Title 22 standards is currently not considered a cost effective option at the site. However, if water supply constraints are encountered to meet anticipated future demands, recycled water could be used to offset potable water uses, such as for toilet flushing.

This concludes the evaluation of wastewater alternatives for the Tolay Lake Regional Park Master Plan. Thank you for the opportunity to assist you with this project. If you have any questions or require any additional information, please do not hesitate to contact me at (831) 426-9054.

Sincerely,

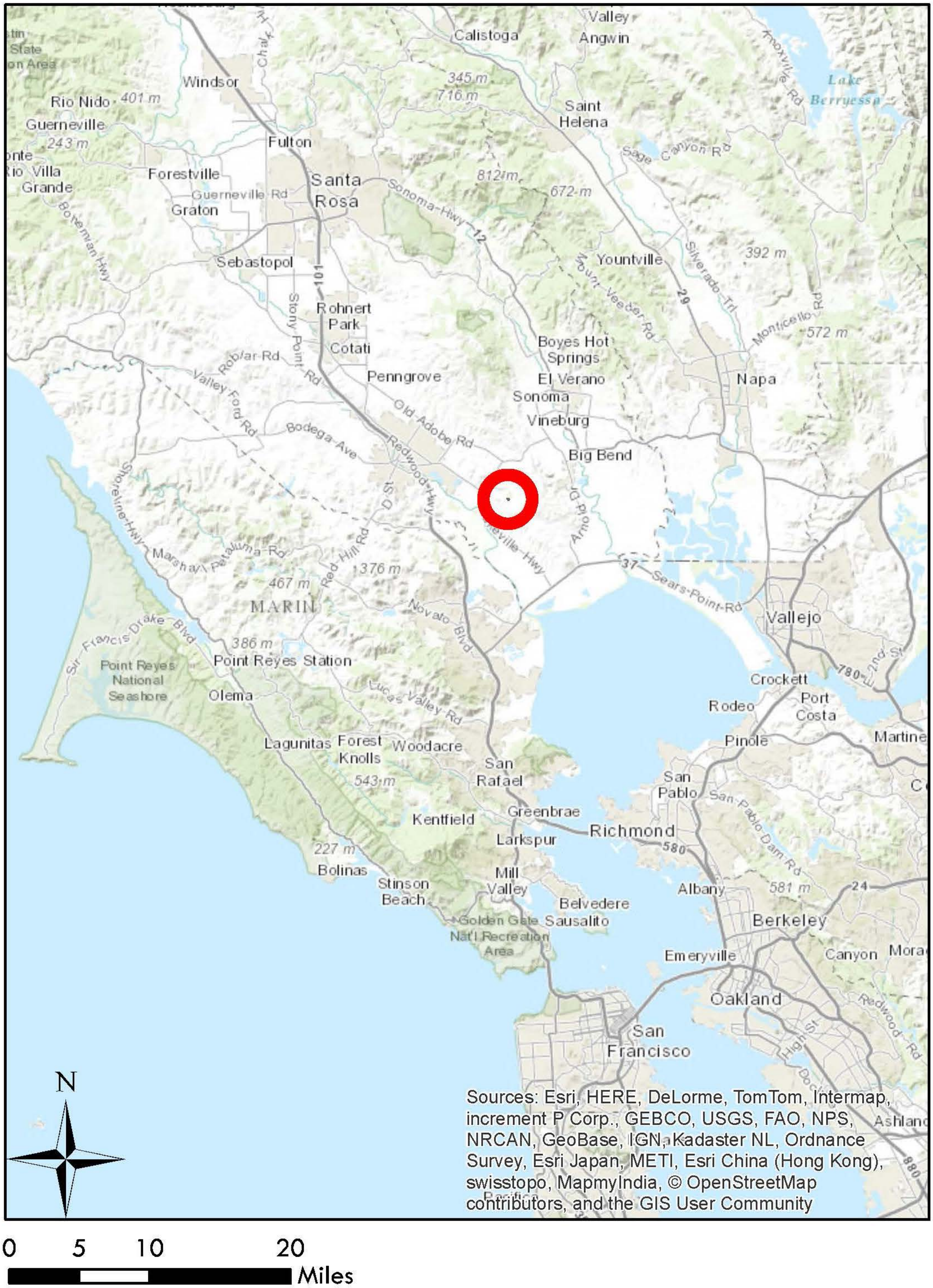
EMILY CORWIN, M.S., P.E.
Senior Associate Engineer

PETER HAASE, M.S., P.E
Principal Engineer

.

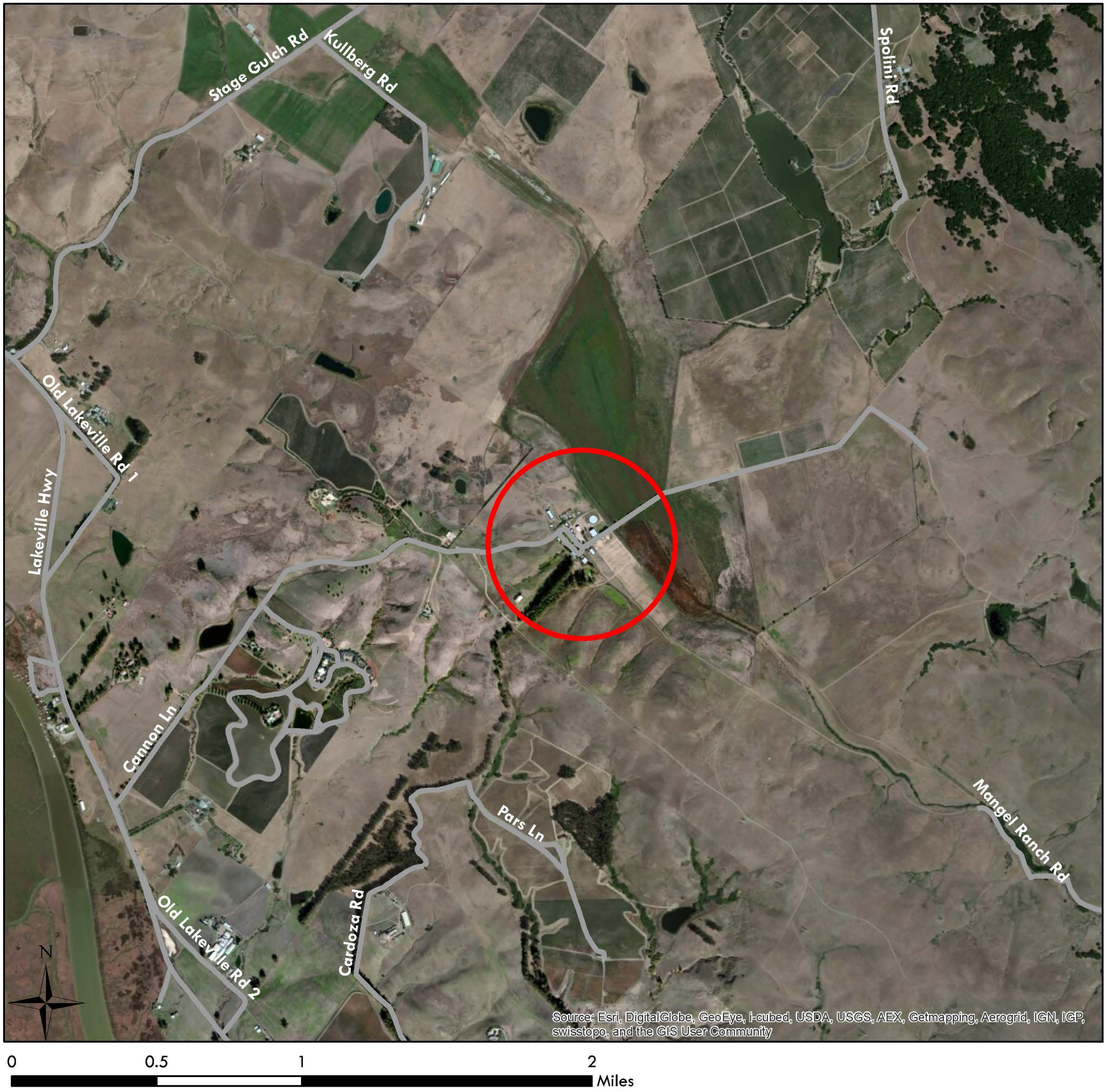
FIGURES

ATTACHMENTS



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 1. Tolay Lake Regional Park Site Vicinity Map



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 2. Tolay Lake Regional Park Site Location Map

Figure 3
Tolay Lake Regional Park
Hand Auger
Soil Boring
Locations

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

FALL CREEK ENGINEERING

Date: 6/17/2014

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 4
Tolay Lake Regional Park
Wastewater Treatment System
Collection System Location

- ◄ Wastewater Collection System
- ⬚ Required Setback from Environmental Resource

Wastewater Treatment Facility

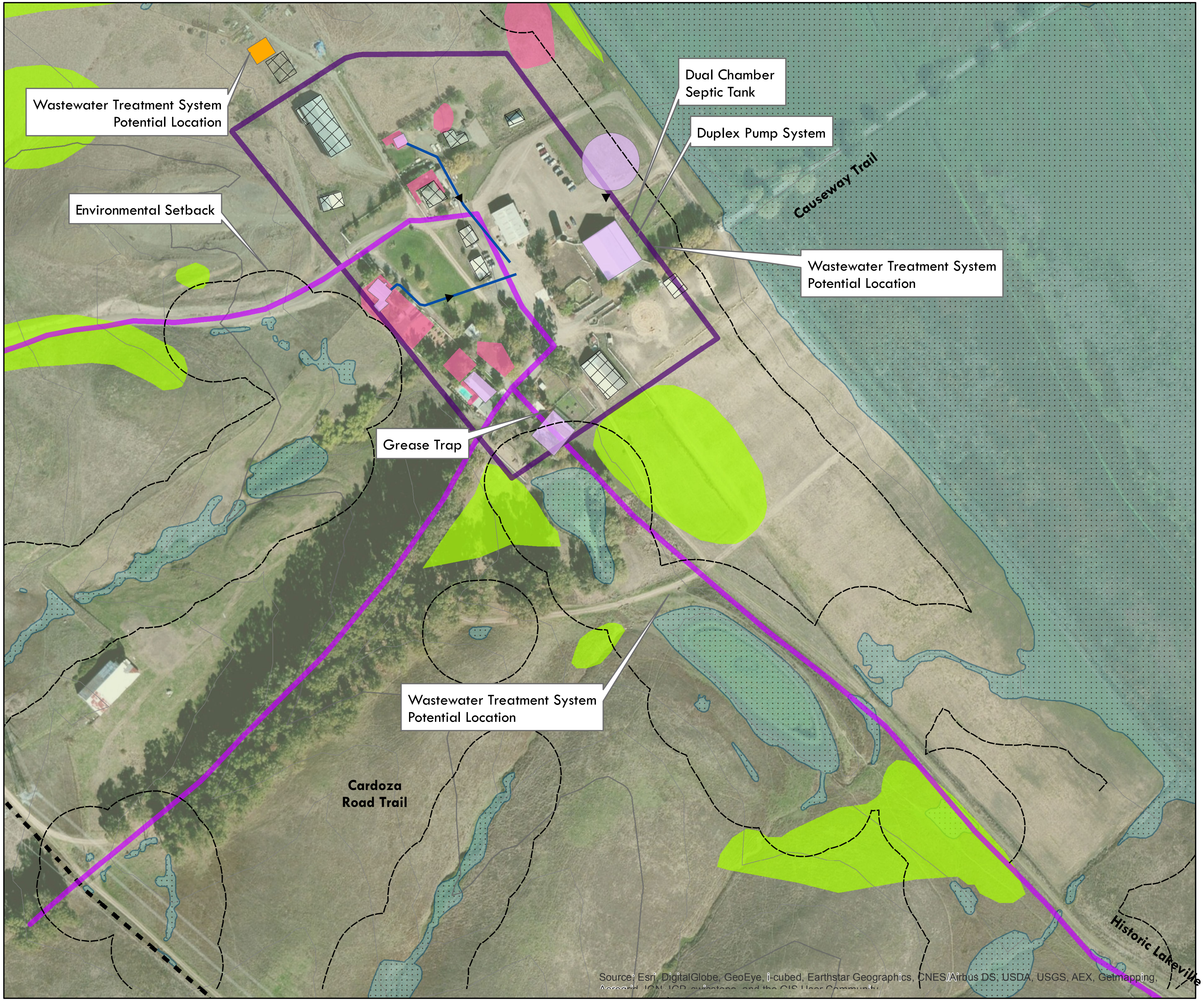
- 🟨 Dual Chamber Septic Tank (Pretreatment)
- 🟩 Duplex Pump System
- 🟥 Grease Trap
- ▨ Building
- ▢ Building Connected to Wastewater System
- **Project Site**
- **Water Feature and Wetlands**
- **Grasslands & Wildflower Fields**
- **Historic Cultural Resource**
- **20' contour**
- **100' contour**

0 200 400 Feet

1 inch = 200 feet

FALL CREEK ENGINEERING
Date: 7/28/2014

Figure 5
Tolay Lake Regional Park Wastewater Treatment System Treatment Alternatives #1 and #2 Package Plant Treatment System with Collection System Location



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- ◀ Wastewater Collection System
- ⬚ Required Setback from Environmental Resource

Wastewater Treatment Facility

- 🟨 Dual Chamber Septic Tank (Pretreatment)
- 🟩 Duplex Pump System
- 🟥 Grease Trap
- 🟧 Acqualogic or Advantex System

Master Plan Facilities

- ▨ Building
- ◻ Building Connected to Wastewater System
- ⬚ **Project Site**
- ▨ **Water Feature and Wetlands**
- 🟩 **Grasslands & Wildflower Fields**
- 🟪 **Historic Cultural Resource**
- — **20' contour**
- — **100' contour**

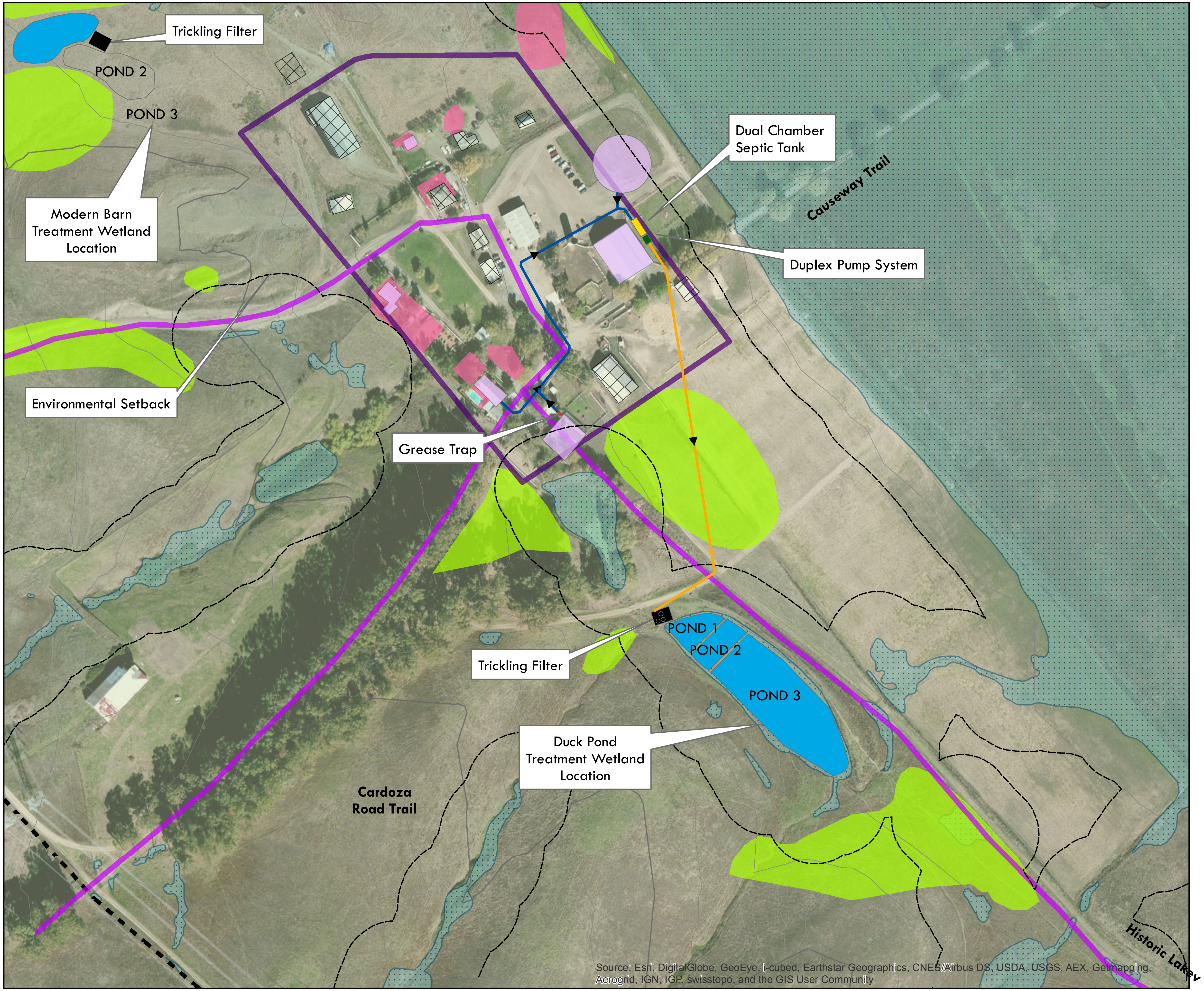
N

0 200 400 Feet

1 inch = 202 feet

FALL CREEK ENGINEERING

Date: 6/25/2014



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 6
Tolay Lake Regional Park Wastewater Treatment System Treatment Alternative #3 Combined Trickling Filter and Natural Wastewater Treatment System with Collection System Location

- ◄ Wastewater Collection System
- ◄ Pipeline to Wastewater Treatment System
- ⬚ Required Setback from Environmental Resource

Wastewater Treatment Facility

- 🟨 Dual Chamber Septic Tank (Pretreatment)
- 🟩 Duplex Pump System
- 🟥 Grease Trap
- 🟦 Treatment Wetland
- ⬛ Trickling Filter

Master Plan Facilities

- ▨ Building
- ▢ Building Connected to Wastewater System
- ⬚ **Project Site**
- ▢ **Water Feature and Wetlands**
- 🟩 **Grasslands & Wildflower Fields**
- 🟪 **Historic Cultural Resource**
- — **20' contour**
- — **100' contour**

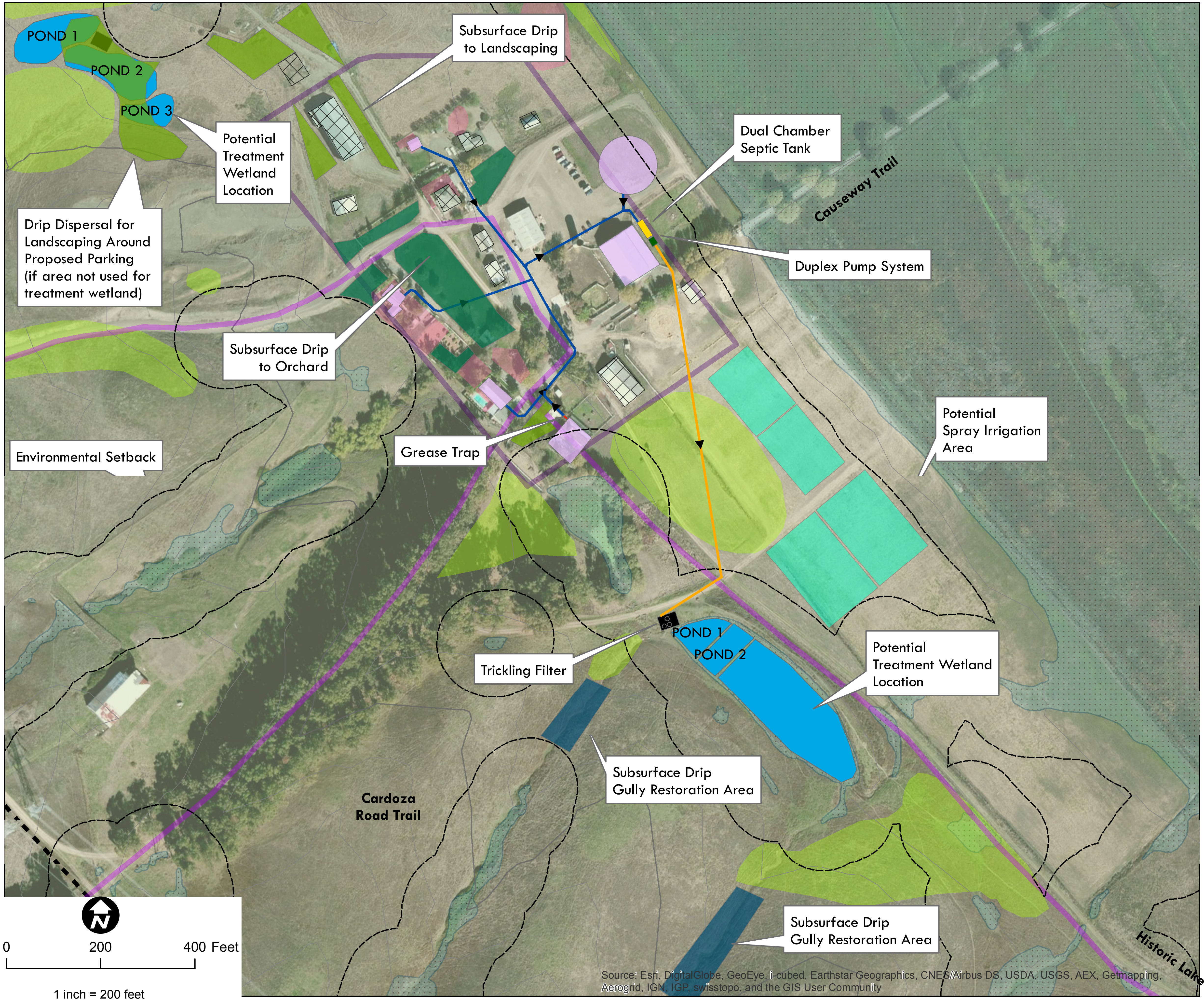
N

0 200 400 Feet

1 inch = 200 feet

FALL CREEK ENGINEERING

Date: 7/28/2014



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 7
Tolay Lake Regional Park
Wastewater Improvement Plan

Combined Trickling Filter and Natural Wastewater Treatment System with Collection and Disposal System Locations

- Wastewater Collection System
- Pipeline to Wastewater Treatment System

Wastewater Treatment Facility

- 🟨 Dual Chamber Septic Tank (Pretreatment)
- 🟩 Duplex Pump System
- 🟥 Grease Trap
- 🟦 Treatment Wetland
- ⬛ Trickling Filter

Subsurface Drip Disposal Location

- 🟩 Landscaping
- 🟩 Orchard
- 🟦 Restoration Area
- 🟦 Potential Spray Irrigation

Master Plan Facilities

- ▨ Building
- 🟪 Building Connected to Wastewater System
- ☐ Required Setback from Environmental Resource
- **Project Site**
- **Water Feature and Wetlands**
- 🟨 **Grasslands & Wildflower Fields**
- 🟪 **Historic Cultural Resource**
- **20' contour**
- **100' contour**

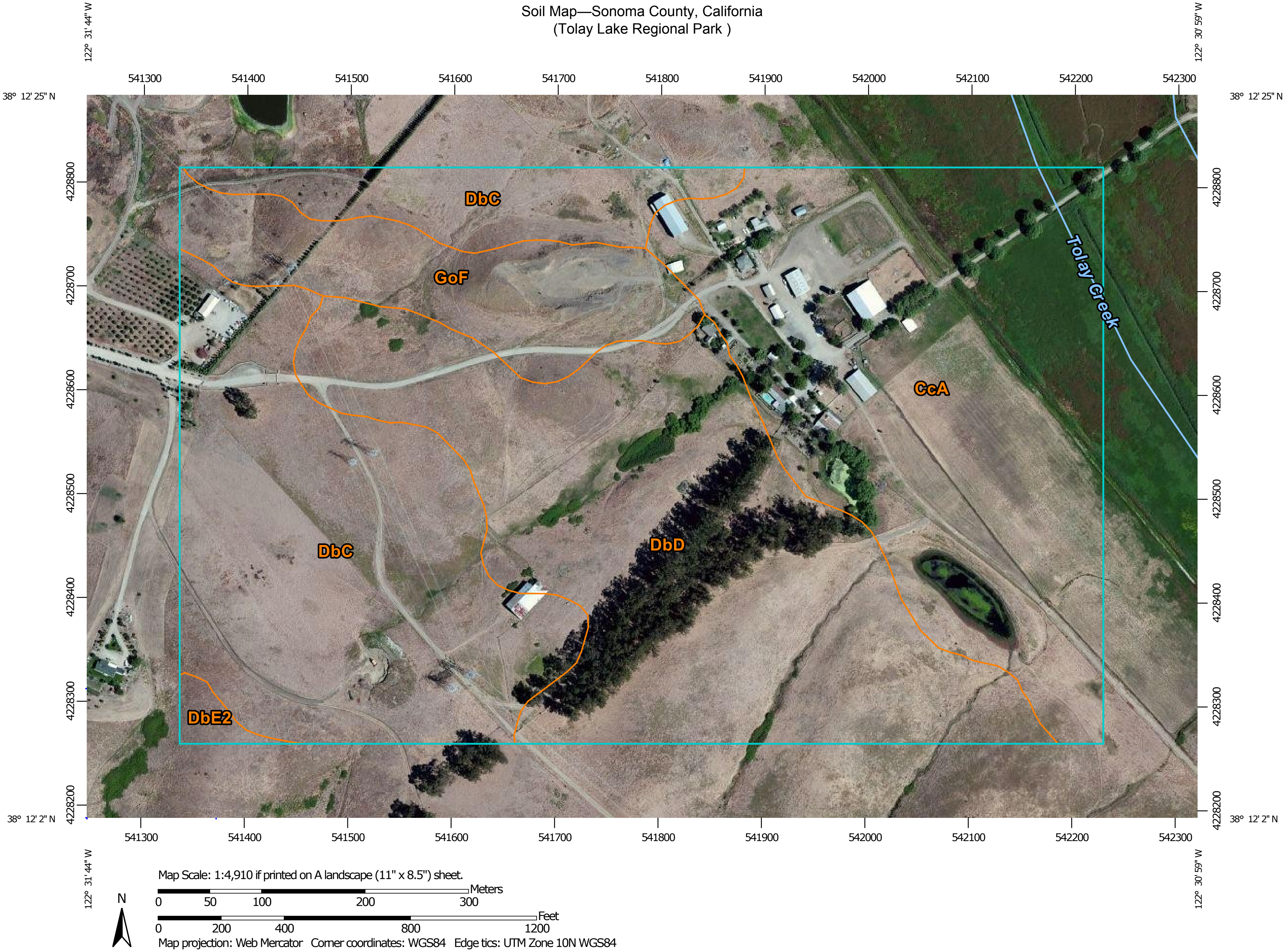
FALL CREEK ENGINEERING

Date: 7/28/2014

ATTACHMENT A

Natural Resources Conservation Service (NRCS) Soil Survey Map
at Tolay Lake Regional Park Master Plan Area

Soil Map—Sonoma County, California
(Tolay Lake Regional Park)



MAP LEGEND

Area of Interest (AOI)

- ▭ Area of Interest (AOI)

Soils

- ▭ Soil Map Unit Polygons
- 〰 Soil Map Unit Lines
- ■ Soil Map Unit Points

Special Point Features

- ◉ Blowout
- ⊠ Borrow Pit
- ✱ Clay Spot
- ◇ Closed Depression
- ✕ Gravel Pit
- ∴ Gravelly Spot
- ⊗ Landfill
- ⋀ Lava Flow
- ⊥ Marsh or swamp
- ⚒ Mine or Quarry
- ◎ Miscellaneous Water
- ○ Perennial Water
- ∨ Rock Outcrop
- + Saline Spot
- ∷ Sandy Spot
- ⊖ Severely Eroded Spot
- ◇ Sinkhole
- ≫ Slide or Slip
- ∅ Sodic Spot
- ≡ Spoil Area
- ◌ Stony Spot
- ∞ Very Stony Spot
- ♆ Wet Spot
- △ Other
- ╌ Special Line Features

Water Features

- ∼ Streams and Canals

Transportation

- ┿ Rails
- 〰 Interstate Highways
- 〰 US Routes
- 〰 Major Roads
- 〰 Local Roads

Background

- ▩ Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Sonoma County, California
Survey Area Data: Version 6, Nov 27, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 2, 2010—Feb 17, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Sonoma County, California (CA097)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
CcA	Clear Lake clay loam, 0 to 2 percent slopes	38.3	31.2%
DbC	Diablo clay, 2 to 9 percent slopes	35.2	28.7%
DbD	Diablo clay, 9 to 15 percent slopes	37.5	30.5%
DbE2	Diablo clay, 15 to 30 percent slopes, eroded	0.8	0.7%
GoF	Goulding-Toomes complex, 9 to 50 percent slopes	11.1	9.0%
Totals for Area of Interest		**123.0**	**100.0%**

ATTACHMENT B

FCE Soil Logs

PROJECT: **BORING LOG**

BORING NO. 1	**PROJECT NO.** 21228	**LOCATION** Tolay Lake	**SHEET** 1 **OF** 1
TIME START 10:40	DRILLING CONTRACTOR FCE	DRILLING EQUIPMENT shovel/2" augur	DATE 5/8/14
TIME STOP 11:15	DRILLING CREW BEE	DRILLING METHOD	SAMPLING METHOD
TOTAL DEPTH 6'4"	BACKFILL MATERIAL Native Material	WATER FIRST ENCOUNTERD NA	FINAL DEPTH TO WATER NA

DEPTH BELOW SURFACE	SAMPLER TYPE	SAMPLE NO.	INCHES DRIVEN/ RECOVERED	BLOWS PER 6 IN.	USCS	LOG OF MATERIAL

Shovel

2" Augur

CL SILTY CLAY: very dark grey(Gley 2 3/5 PB), medium dense, moist

increasing sand content

SC CLAYEY SAND: greenish grey (10YR 5/2), loose, moist

END

Depth scale: 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9

LOGGED BY: Emily Corwin OFFICE: FCE DATE: 6/2/14

PROJECT:

BORING LOG

BORING NO. 2

PROJECT NO. 21228

LOCATION Tolay Lake

SHEET 1 **OF** 1

TIME START 10:10

DRILLING CONTRACTOR FCE

DRILLING EQUIPMENT shovel/2" augur

DATE 5/8/14

TIME STOP 10:40

DRILLING CREW BEE

DRILLING METHOD

SAMPLING METHOD

TOTAL DEPTH 6'0"

BACKFILL MATERIAL Native Material

WATER FIRST ENCOUNTERD NA

FINAL DEPTH TO WATER NA

DEPTH BELOW SURFACE	SAMPLER TYPE	SAMPLE NO.	INCHES DRIVEN/ RECOVERED	BLOWS PER 6 IN.	USCS	LOG OF MATERIAL
	Shovel				CH	CLAY LOAM: dark grey (10YR 3/1), medium
						dense, moist
1	2" Augur					
2						
3						increasing density
4						
5						
6						END
7						
8						
9						
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						

LOGGED BY: Emily Corwin OFFICE: FCE DATE: 6/2/14

3 21228 Tolay Lake 1 1

10:00 FCE shovel/2" augur 5/8/14

10:55 EMC

5'1" Native Material NA NA

Shovel SC CLAYEY SAND: dark brown (4/3 7.5YR), loose, dry

2" Augur

increasing density and moisture w/iron mottling

CL SILTY CLAY: grayish brown (5/4 10YR), moist, some iron deposit and gleying.

increasing sand content, some rounded gravel

SC END

Emily Corwin FCE 6/2/14

PROJECT: **BORING LOG**

BORING NO.	**PROJECT NO.**	**LOCATION**	**SHEET OF**
TIME START	DRILLING CONTRACTOR	DRILLING EQUIPMENT	DATE
TIME STOP	DRILLING CREW	DRILLING METHOD	SAMPLING METHOD
TOTAL DEPTH	BACKFILL MATERIAL	WATER FIRST ENCOUNTERD	FINAL DEPTH TO WATER

DEPTH BELOW SURFACE	SAMPLER TYPE	SAMPLE NO.	INCHES DRIVEN/ RECOVERED	BLOWS PER 6 IN.	USCS	LOG OF MATERIAL
1						
2						
3						
4						
5						
6						
7						
8						
9						
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						

LOGGED BY: ______ OFFICE: ______ DATE: ______

4 21228 Tolay Lake 1 1

9:15 FCE shovel/2" augur 5/8/14

10:00 EMC

6'8" Native Material NA NA

Shovel CL SILTY CLAY: dark gray (2.5 10Y), moist, some sand, high plasticity, some sand

2" Augur

SC CLAYEY SAND: yellow orange (5/3 10YR), fine sand, dry, loose

loose, color lightening (4/4 5Y), some angular gravel

END

Emily Corwin FCE 6/2/14

PROJECT: **BORING LOG**

BORING NO. 5	**PROJECT NO.** 21228	**LOCATION** Tolay Lake	**SHEET** 1 **OF** 1
TIME START 12:55	DRILLING CONTRACTOR FCE	DRILLING EQUIPMENT shovel/2" augur	DATE 5/8/14
TIME STOP 1:25	DRILLING CREW BEE	DRILLING METHOD	SAMPLING METHOD Shovel 2" Augur
TOTAL DEPTH 4'0"	BACKFILL MATERIAL Native Material	WATER FIRST ENCOUNTERD NA	FINAL DEPTH TO WATER NA

DEPTH BELOW SURFACE	SAMPLER TYPE	SAMPLE NO.	INCHES DRIVEN/ RECOVERED	BLOWS PER 6 IN.	USCS	LOG OF MATERIAL
					CH	CLAY LOAM: dark grey (10YR 4/2), dense, moist
						lighter grey color (10YR 5/1)
						increasing gravel
1						
2						
3						
4						
5						
6						
7						
8						
9						
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						

LOGGED BY: Emily Corwin OFFICE: FCE DATE: 6/2/14

6 21228 Tolay Lake 1 1

12:50 FCE shovel/2" augur 5/8/14

1:35 EMC

5'0" Native Material NA NA

Shovel CL SILTY CLAY: dark gray (Gley 1 2.5/5G), medium dense, moist with trace angular gravel

2" Augur

fine sand increasing, trace subrounded gravel

CH CLAY LOAM: greenish gray (Gley 1, 5/5GY) soft, moist, trace sand, some mottling.

END

PROJECT: 6/2/14 FCE Emily Corwin **BORING LOG**

BORING NO.	**PROJECT NO.**	**LOCATION**	**SHEET OF**
TIME START	DRILLING CONTRACTOR	DRILLING EQUIPMENT	DATE
TIME STOP	DRILLING CREW	DRILLING METHOD	SAMPLING METHOD
TOTAL DEPTH	BACKFILL MATERIAL	WATER FIRST ENCOUNTERD	FINAL DEPTH TO WATER

DEPTH BELOW SURFACE	SAMPLER TYPE	SAMPLE NO.	INCHES DRIVEN/ RECOVERED	BLOWS PER 6 IN.	USCS	LOG OF MATERIAL
1						
2						
3						
4						
5						
6						
7						
8						
9						
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						

LOGGED BY: ______ OFFICE: ______ DATE: ______

PROJECT: FCE **BORING LOG**

Emily Corwin 6/2/14

BORING NO. 7

PROJECT NO. 21228

LOCATION Tolay Lake

SHEET 1 OF 1

TIME START 11:10

DRILLING CONTRACTOR FCE

DRILLING EQUIPMENT shovel/2" augur

DATE 5/8/14

TIME STOP 11:50

DRILLING CREW EMC

DRILLING METHOD

SAMPLING METHOD

TOTAL DEPTH 4'3"

BACKFILL MATERIAL Native Material

WATER FIRST ENCOUNTERD NA

FINAL DEPTH TO WATER NA

DEPTH BELOW SURFACE	SAMPLER TYPE	SAMPLE NO.	INCHES DRIVEN/ RECOVERED	BLOWS PER 6 IN.	USCS	LOG OF MATERIAL
	Shovel				CL	SILTY CLAY: dark gray (Gley 1 2.5/10Y), dense, moist
	2" Augur					
					CH	CLAY LOAM: dark gray (Gley 2 3/5PB)
						END

LOGGED BY: Emily Corwin OFFICE: FCE DATE: 6/2/14

PROJECT:

BORING LOG

BORING NO. 8	PROJECT NO. 21228	LOCATION Tolay Lake	SHEET 1 OF 1
TIME START 11:30	DRILLING CONTRACTOR FCE	DRILLING EQUIPMENT shovel/2"augur	DATE 5/8/14
TIME STOP 12:15	DRILLING CREW BEE	DRILLING METHOD	SAMPLING METHOD
TOTAL DEPTH 6-ft	BACKFILL MATERIAL Native Material	WATER FIRST ENCOUNTERD NA	FINAL DEPTH TO WATER NA

DEPTH BELOW SURFACE	SAMPLER TYPE	SAMPLE NO.	INCHES DRIVEN/ RECOVERED	BLOWS PER 6 IN.	USCS	LOG OF MATERIAL
	Shovel				CH	CLAY LOAM: dark grey (Gley2, 3/5PB), moist, dense
	2"Augur					
						Grey mottling
					CL	SILTY CLAY: Gley 2 3/5 PB, moist, dense

LOGGED BY: Emily Corwin OFFICE: FCE DATE: 6/2/2014

appendix f

Analysis of Allowable Park Uses

Due to the nature and length of this appendix, this document is not available as an accessible document. If you need assistance accessing the contents of this document, please contact Victoria Willard, ADA Coordinator for Sonoma County, at (707) 565-2331, or through the California Relay Service by dialing 711. For an explanation of the contents of this document, please direct inquiries to Karen Davis-Brown, Park Planner II, Sonoma County Regional Parks Department at (707) 565-2041.

TOLAY LAKE
REGIONAL PARK
Master Plan Project

Tolay Recreation Activity Analysis Whitepaper

Activity	**Allowed Use?**[1]	**Compatibility with Park Vision**	**Level of Public Support**	**Neighbor concerns**	**Environmental impacts**	**Health and Safety concerns**
Hang glide	No	No	Low (46)	Yes	Yes	Yes
Disc golf	Yes	No	Low (23)	Yes	Yes	Yes
Dogs on leash	Yes	No	High (194)	Yes	Yes	Yes
Dog park	No	No	Low (0)	Yes	Yes	Yes
Hunting	n/a- regulated by CDFW	No	Low (0)	No	Yes	Yes
Archery area	Yes- with Use permit	Yes	Low (4)	No	Yes	No
Paintball area	No	No	Low (0)	Yes	Yes	Yes

[1] *under existing Sonoma County Code, Plans, or other regulations*

Hang gliding

Background

Hang gliding occurs in multiple locations in the San Francisco Bay area. It requires takeoff and landing areas, as well as staging areas. Hang gliders typically take a course and must be certified to participate in this activity. Park policies about hanggliding vary. Marin County Parks and Open Space do not allow hang gliding as per policies in their Countywide Plan. In contrast, California State Parks allows hang gliders to take off from Mount Tamalpais.

Consistency with County Code, Plans, and Regulations

Sonoma County Code appears to prohibit hang gliding. County Code chapter 20 (Parks and Recreation) Article V (Vehicles), section 20-30: "No person shall land any aircraft on or take any aircraft off any body of water or any land area in the park." An "aircraft" is defined in Article II, section 20-2(g) as any device that is used to carry a person or persons in the air.

County Code chapter 15 (Highways, Roads and Bridges) Article IV (Bridges, Dams and Other Facilities), section 15-20(b) refers specifically to hang gliding: "Except as provided herein, it shall be unlawful for any person to jump, dive or glide from a bridge or other manmade structure, including jumping, diving, and gliding using parachutes, parafoils, hang gliders or elastic cords of any type."

Compatibility with Park Vision

Hang gliding is not consistent with the vision for Tolay Lake Regional Park. The preliminary vision for the park includes balancing cultural resource legacies with recreational uses, establishing a cutting edge interpretation oriented park and developing a thriving, ecologically functioning landscape.

Hang gliding has relatively low levels of public support. More than 500 respondents completed the Tolay online survey or a hard copy version at the 2012 Fall Festival. However, just 46 respondents expressed an interest in hang gliding, and 1respondent expressed opposition to hang gliding.

Environmental Impacts

Environmental impacts associated with hang gliding would include impacts related to its potential effects on sensitive wildlife in the area, including raptors. Hang gliding can induce a short term behavioral response from raptors, such as increased vocalization, escape flight (flushing), aggressive flight displays, or defense of their territory.

The addition of hang gliding to the park would require development of a launch site and landing area. The obvious area for a launch site would be located on the west side of the park where elevations are the highest. However, little to no vehicle access presently exists in this area. The addition of vehicular access for a launch site would be inconsistent with the existing natural drainages and landscapes. Construction impacts associated with an access road for hang gliding would result in noise and air quality (fugitive dust) impacts from road construction.

Health and Safety Concerns

Hang gliding is considered a moderately dangerous activity. Should hang gliding be allowed at the Park, appropriate safety plans would need to be developed and implemented, including emergency response access to the landing area, development of an alternate landing area for emergencies, and separation of hang gliders from passive recreation users.

Conclusion

Hang gliding is not consistent with the evaluation criteria discussed above. Hang gliding does not appear to be allowed under Sonoma County Code, and is not compatible with stakeholders' vision for the Park as a peaceful setting that emphasizes passive non-motorized recreation use, environmental education, and wildlife viewing. Moreover, the level of public support for hang gliding is relatively low. Neighbors concerns are also an issue. During the scoping process several neighbors expressed concern for the potential for visitor trespass and possible damage to their private properties.

Disc Golf

Background

Disc golf is a flying disc game, as well as a precision and accuracy sport, in which individual players throw a flying disc at a target. According to the Professional Disc Golf Association, "The object of the game is to traverse a course from beginning to end in the fewest number of throws of the disc. Making disc golf unique is the utilization of natural elements, using trees and shrubs as obstacles and elevation changes to make the course challenging

Consistency with County Code, Plans, and Regulations

Sonoma County Code does not specifically prohibit disc golf. However, County Code chapter 20 (Parks and Recreation) Article IV (Use of Facilities), section 20-19 states: "No person shall drive, putt or in any other fashion, play or practice golf or use golf balls, or fly model airplanes on or over land, or operate model boats or model automobiles, or model craft of any kind or description, or other activities that endanger or disturb persons, in the park, except in areas set aside for these specific activities in accordance with rules and regulations prescribed by the park authority."

Compatibility with Park Vision

Disc golf is not consistent with the vision for Tolay Lake Regional Park. The preliminary vision for the park includes balancing cultural resource legacies with recreational uses, encouraging community visits and interactions in a way that heals the land, and integrating agriculture, American Indian presence, and ecological aspects.

Disc golf has relatively low levels of public support. More than 500 respondents completed the Tolay online survey or a hard copy version at the 2012 Fall Festival. However, just 35 respondents expressed an interest in disc golf, and 13 respondents expressed opposition to disc golf at the Park.

Environmental Impacts

Environmental impacts related to disc golf at the Park would be centered on biological resources. Increased foot traffic would impact existing groundcover, leaving bare ground. Depending on the layout of the course, trees and shrubs in the area of the course could possibly be damaged from multiple disc hits, which can be especially harmful to younger trees. Additionally, gouges to bark from the discs may increase the susceptibility of trees to various insect pests and in some cases can cause death of young trees.

Health and Safety Concerns

Major health and safety concerns related to disc golf in the park are related to the intermingling of passive recreations users (hikers, bird watching, etc.) with the active disc golf users. Disc speeds can range between 50 mph and 70 mph with distances ranging from 300 to 400 feet or more. Most disc golf courses are located within public parks and as a result, non-players are routinely found in the course environment. Serious injury could occur if non-players unknowingly cross into the path of a fast traveling disc. The presence of disc golf would require a strong presence by Park staff to ensure players were abiding by pre-established rules to protect public safety.

Conclusion

Disc golf would not be consistent with the evaluation criteria discussed above. While the activity is not expressly prohibited under Sonoma County Code, disc golf would not be compatible with stakeholders' vision for the Park as a peaceful setting that emphasizes passive non-motorized recreation use, environmental education, and wildlife viewing. Additionally, disc golf courses require an expansive area for play (75-100-foot width fairways) and stray discs could damage valuable cultural and biological resources, as well as provide safety concerns. Moreover, the level of public support for disc golf is relatively low.

Dogs on Leash

Background

Dog walking is both a pastime and a profession involving the act of a person walking with a dog, typically from the dog's residence and then returning. This constitutes part of the daily exercise regime needed to keep a dog healthy but also provides exercise and companionship for the dog owner.

Consistency with County Code, Plans, and Regulations

Sonoma County Code contains numerous ordinances related to dogs and their presence in county parks. The following sections are from County Code, Chapter 20 (Parks and Recreation), Article III (Personal Conduct):

Section 20-8 "Animals"—states "No person shall be permitted to bring, carry, entice or transport a dog, cat or other animal into the park unless such dog, cat or other animal is securely leashed on a maximum six (6) foot leash and in immediate control of a person at all times…. Dogs may be permitted to run free in areas which, from time to time, may be set aside by the park authority for the specific purpose of exercising a dog, provided, however, that the owner or keeper of the dog keeps it under control at all times and does not allow the dog to be beyond the boundaries of the area set aside.

Section 20-8 (b) states: “No person shall keep a noisy, vicious or dangerous dog or animal or one which is disturbing the other persons in the park and remain therein after the owners have been asked by the park authority to leave.”

Chapter 5 of the Sonoma County Code (Animal Regulation), Section 5-40 (a) states: Every owner of a dog over four (4) months of age shall cause such dog to be vaccinated with an approved rabies vaccine unless a veterinarian certifies that such dog should not be vaccinated for health reasons. Revaccination shall be made at such intervals of time as may be prescribed by the State Department of Health.”

Compatibility with Park Vision

Dog walking on leash would not be consistent with the existing Park vision. The preliminary vision for the park includes balancing cultural resource legacies with recreational uses, establishing a cutting edge interpretation oriented park and developing a thriving, ecologically functioning landscape.

Dog walking has a relatively high level of public support. More than 500 respondents completed the Tolay online survey or a hard copy version at the 2012 Fall Festival. In all, 194 respondents expressed an interest in dog walking and 33 expressed opposition to the presence of dogs, with some opposing them all together and others opposed to off leash activity.

Environmental Impacts

Environmental impacts associated with the presence of dogs at the Park would be varied. The protection of native wildlife and their habitat (including sensitive species and their habitat, and federally or state listed, unique, or rare species) from detrimental effects of dog use, including harassment or disturbance by dogs would be important at Tolay Park. Specific environmental issues resulting from the introduction of dogs at the Park are described below.

Wildlife. Intensive dog use at the Park could disrupt its use by wildlife or degrade the habitat, resulting in a multitude of possible negative consequences for wildlife. Reed and Merenlender (2011) found that presence of dogs, regardless on being on or off leash, was negatively related to several canine species (bobcat, coyote and mountain lion) population indicators in a study of park and recreation areas in the SF Bay Area. Adverse effects of intensive dog use, such as chasing and flushing wildlife or disrupting nesting and foraging sites, can range from direct to less direct disturbance from physical effects such as trampling of habitat, the temporary or permanent loss of preferred habitat, and scent intrusion into predator territory. As a result of repeated disturbance, wildlife may relocate from preferred habitat to other areas to avoid harassment. Dogs or dog waste can infect wildlife and vice versa. Domestic dogs that are not vaccinated can potentially introduce diseases (distemper, parvovirus, and rabies) and transport parasites from, or transmit diseases to, wild animals or wildlife habitats.

Vegetation and Soils. Dogs, particularly those off leash and without adequate voice control, can affect vegetation and soils. As a result of recreational activities, vegetation can be affected by trampling indirectly through the consolidation of the soil and directly by treading upon the plants themselves. Dog waste contains nutrients and can increase the amount of nitrogen and phosphorus in the soil. Soils and vegetation can be affected by dogs through defecation and urination. The act of “marking” (scent marking with urine) could also affect vegetation by concentrating nutrients in particular areas.

Cultural Resources. Dogs may affect cultural resources by dog-related ground disturbance such as digging and/or trampling, which would be a contributing element to natural erosion processes on or around sensitive cultural resources. Dog urination/defecation may affect cultural resources by affecting vegetation associated with historic properties.

Land Use. Dog use can damage resources that cannot be easily restored. Overuse by dogs can change the character of soils, vegetation, wildlife habitat, and the species of wildlife themselves. If these resource areas are affected by intense use over a long period of time, or if natural resources are particularly vulnerable to change or damage, the impacts caused by dogs can pose challenges to restoration.

Health and Safety Concerns

Issues related to health and safety at the Park with the inclusion of dogs would be related to encounters between visitors and park employees with unruly or aggressive dogs. Incidents can include being knocked down, intimidated, and bitten by dogs. Additionally, dog-on-dog bites and dog-on horse bites often involve visitors who could be injured during these conflicts (e.g., attempts to separate dogs, horses bolting).

Conclusion

Dog walking is consistent with the existing preliminary vision for the Park. Dog walking is allowed under Sonoma County Code. Allowing dogs at the Park would be consistent with many of the stakeholder's vision for the Park including environmental education, cutting edge interpretation oriented park, encouraging community visits, and interactions in a way that heals the land. The level of public support for dog walking is relatively high. In order to minimize negative environmental impacts while maximizing positive visitor experience for everybody at the Park, dog walking will be permitted with the following caveats: dogs must be secured to a six-foot leash (maximum length); dog must be under owner's control at all times; dogs are only permitted on multi-use trails; dogs must be vaccinated; dog owners must pick up dog waste and dispose the waste in the proper waste bin. Depending on certain sensitive species' breeding or nesting patterns, the multi-use trail may be subject to seasonal closures for dogs.

Dog Park

Background

Dog parks are designed for dogs to exercise and play off-leash in a controlled environment under the supervision of their owners. Dog parks can have a number of different features, depending in part of their location, including fences, adequate drainage, benches for humans, shade for hot days, parking close to the site, water, tools to pick up and dispose of animal waste in covered trash cans, and regular maintenance and cleaning of the grounds.

Consistency with County Code, Plans, and Regulations

The Sonoma County Code does permit dog parks in the county. Additionally, there are two dog parks located within Sonoma County parks, including Ernie Smith Community Park in El Verano and Sonoma Valley Regional Park in Glen Ellen.

Compatibility with Park Vision

The addition of a dog park would not be compatible with the preliminary vision for the Park including the development of a thriving, ecologically functioning landscape, encouraging community visits and interactions in a way that heals the land, and development of a tribal connection to the landscape and the sacredness of the area.

The addition of a dog park has a low level of public support. More than 500 respondents completed the Tolay online survey or a hard copy version at the 2012 Fall Festival. None of the respondents expressed specific interest in a dog park, while one respondent expressed opposition to a dog park.

Environmental Impacts

Environmental concerns would be similar to those described above for dog walking. While impacts would be more localized than those associated with dog walking, impacts could be intensified due to the concentration of dogs into one area of the Park.

Health and Safety Concerns

With the inclusion of a dog park, it is assumed that dogs would be limited to a specific area of the Park. A dog park would include perimeter fencing, which would reduce interaction between humans (visitors and park staff) and dogs as well as between horses and dogs. However, dog-on-dog bites and dog-on human bites could be possible in the area around the dog park location.

Conclusion

Inclusion of a dog park within a county park is not consistent with the existing preliminary vision for the Park. Dog parks do appear to be allowed under Sonoma County Code, and have been included at least one other regional park (Sonoma Valley Regional Park). Construction of a dog park would not be consistent with many of the stakeholder’s vision for the Park including environmental education, cutting edge interpretation oriented park, encouraging community visits and interactions in a way that heals the land. While the level of public support for dog walking is relatively high, there was little support for a dog park. Neighbors concerns are also and issue. A dog park is located on W. Casa Grande Road (Rocky Memorial Dog Park), southwest of Lakeville Highway.

Hunting

Background

Hunting is typically regulated by game, category, and area within the state, and time period. Regulations for hunting often specify a minimum caliber or muzzle energy for firearms. The use of rifles is often banned for safety reasons in areas with high population densities or limited topographic relief. Regulations may also limit or ban the use of lead in ammunition because of environmental concerns. Specific seasons for bow hunting or muzzle-loading black-powder guns are often established to limit competition with hunters using more effective weapons.

Consistency with County Code, Plans, and Regulations

The Sonoma County Code does not permit hunting in parks. Section 20-9, Parks and Recreation, Hunting and Fishing, states:

"No person shall hunt or trap in the park. Fishing shall be confined to those water areas specifically designated by the park authority. A valid state of California fishing license shall be required and all state fish and game laws and regulations which are applicable shall apply.

(a) In the taking of invertebrates, all persons shall abide by the California sport fishing regulations according to Chapter 4, Section 27.15a and with permission of the park authority.

(b) No person shall clean fish in the park except in areas designated by the park authority.

Sec. 20-11, Parks and Recreation, Firearms, states: "No person shall carry or possess a firearm with a cartridge in any portion of the mechanism (except any federal, state, county, or municipal officer in the performance of his official duties), nor shall any person discharge across, in, or into, any portion of the park, a firearm, bow and arrow, or air or gas weapon, or any device capable of injuring or killing any person or animal, or damaging or destroying any public or private property."

Hunting seasons in California are regulated by the California Department of Fish and Wildlife. In California, there are three main categories for hunting of wildlife: Big Game: Deer, Elk, Pronghorn, and Bear, Wild Pig, Bighorn Sheep; Waterfowl: Goose, Duck, Coot, Moorhen, and Black Brant; and Upland / Small Game; Pheasant, Quail, Wild Turkey, Dove, Squirrel, and Rabbit. A valid California State Hunting License is required for hunters at all times.

The California Code of Regulations Section 4305-Animals states: "No person shall molest, hunt, disturb, injure, trap, take, net, poison, harm, or kill any kind of animal or fish, or so attempt, except that fish may be taken other than for commercial purposes in accordance with the state fishing laws and regulations, provided, however, that no person shall use or discharge a spear or bow and arrow in the state park system (except in underwater parks or on designated archery ranges). Where hunting in a state recreation area or portion thereof is permitted by regulations herein, so much of this section as is inconsistent therewith shall be deemed inapplicable, provided hunting is conducted in the manner specified."

Compatibility with Park Vision

Hunting could be considered consistent with the vision for Tolay Lake Regional Park in that the preliminary vision for the park includes balancing cultural resource legacies with recreational uses and integrating agriculture, American Indian presence, and ecological aspects. Hunting is an activity with a long history. Hunting could be included into historical and cultural interpretations for the Park and would have relatively low impacts on the ecological resources within the park. Hunting has a relatively low level of public support. More than 500 respondents completed the Tolay online survey or a hard copy version at the 2012 Fall Festival. However, no respondents expressed an interest in hunting and 13 respondents expressed opposition to hunting.

Environmental Impacts

Environmental impacts associated with hunting at the Park would be low. Potential impacts would originate from hunters accidently trampling sensitive plant species in their pursuit of animal targets. Noise generated from gunfire may cause impacts to residences located in proximity to the Park.

Health and Safety Concerns

Health and safety concerns for hunting at the Park include the safety of passive park users (hiking, walking, etc.) when hunters are present. Planning would be required to ensure separation of hunters from the general recreation public.

Hunters would be expected to follow widely adopted safety precautions that include making themselves visible to other hunters by wearing the legal amount of fluorescent orange clothing, preventing falls by wearing skid-resistant boots, and not hunting alone.

It is estimated that California issues approximately 300,000 hunting licenses per year. Yet the state averages only about 16 hunting (firearm-related) injuries per year, with two or fewer resulting in death. In these cases, the injured person is typically a member of the shooter's hunting party.

Conclusion

Hunting is not consistent with the existing preliminary vision for the Park. Allowing hunting within the Park would not be consistent with many of the stakeholder's vision for the Park including environmental education, cutting edge interpretation oriented park, encouraging community visits and interactions in a way that heals the land. There would be serious health and safety issues that would need to be addressed if hunting was permitted at the Park. The level of public support for hunting is low. None of the respondents expressed interest in hunting, while a number of respondents opposed hunting.

Archery Area

Background

Historically, archery has been used for hunting and combat, while in modern times its main use is that of a recreational activity. Competitive archery (also called target archery) involves shooting arrows at a target for accuracy from a set distance or distances. This is the most popular form of competitive archery.

Consistency with County Code, Plans, and Regulations

Sonoma County Code does not appear to prohibit archery. Article 42 of the Sonoma County Code, K Recreation and Visitor-Serving Commercial District, Section 26-42-020 states that "Shooting and archery ranges" are permitted but require a use permit.

Compatibility with Park Vision

Archery could be considered consistent with the vision for Tolay Lake Regional Park in that the preliminary vision for the park includes balancing cultural resource legacies with recreational uses and integrating agriculture, American Indian presence, and ecological aspects. Archery is a sport with a long history and strong cultural values. If archery were developed for children, this activity could be instructional and would have relatively low impacts on the ecological resources of the park as opposed to a more competitive archery range which would likely have more users. However, archery has relatively low levels of public support. More than 500 respondents completed the Tolay online survey or a hard copy version at the 2012 Fall Festival. However, just 4 respondents expressed an interest in archery and 2 respondents expressed opposition to archery.

Environmental Impacts

Environmental impacts from archery at the Park would be minimal. The activity does not require a large amount of space and would be located in a flat area of the Park. There would be little construction activity associated with development of the course. Any potential environmental damage would be from participants accidently trampling sensitive plant species.

Health and Safety Concerns

Organized archery is considered fairly safe and as a result there would be few health or safety concerns associated with its addition to the Park. Most injuries occur to players themselves because of faulty or damaged equipment. Most archery courses enforce rules related to the handling of bows and arrow including never pointing them at other people, never shooting at an unidentified target, and never shooting an arrow straight up into the air. Most archers wear a bracer (also known as an arm-guard) to protect the inside of the bow arm from being hit by the string and prevent clothing from catching the bow string.

Conclusion

Archery would be consistent with the evaluation criteria discussed above. Archery is an approved activity under the Sonoma County Code provided a use permit is obtained. The presence of an archery area would be compatible with stakeholders' vision for the Park as a peaceful setting that emphasizes passive non-motorized recreation use and balance cultural resource legacies with recreational uses. However, the addition of an archery area would not support the Park's vision of an ecologically thriving landscape. During the scoping process, there were no comments received opposed to an archery area.

Paint Ball Area

(not listed in the survey responses)

Background

Paintball is a sport in which players compete; in teams or individually, to eliminate opponents by tagging them with capsules containing water soluble dye and gelatin shell outside (referred to as paintballs) propelled from a device called a paintball marker (commonly referred to as a paintball gun). Paintballs are composed of a non-toxic, biodegradable, water soluble polymer.

Games can be played on very hard floors in indoor fields, or outdoor fields of varying sizes. A game field is scattered with natural or artificial terrain, which players use for tactical cover. Game types in paintball vary, but can include capture the flag, elimination, ammunition limits, defending or attacking a particular point or area, or capturing objects of interest hidden in the playing area. Depending on the variant played, games can last from seconds to hours, or even days in scenario play.

Consistency with County Code, Plans, and Regulations

Sonoma County Code does not appear to prohibit paintball. Article 42 of the Sonoma County Code, K Recreation and Visitor-Serving Commercial District, Section 26-42-020 states that “Shooting and archery ranges” are permitted but require a use permit. It is unclear whether this would include paintball facilities.

Compatibility with Park Vision

Paintball would not be consistent with the vision for Tolay Lake Regional Park in that the preliminary vision for the park includes balancing cultural resource legacies with recreational uses and supporting a “cutting edge” interpretation oriented park. Paintball has relatively low levels of public support. More than 500 respondents completed the Tolay online survey or a hard copy version at the 2012 Fall Festival. However, no respondents expressed an interest in paintball and 1 respondent was in opposition to paintball at the Park.

Environmental Impacts

Environmental impacts associated with the addition of a paintball park would be related to the noise generated from the use of air-powered rifles. Noise generated from paintball would impact park visitors in the general vicinity of paintball play. The air-powered riffles could also contribute to noise impacts on nearby wildlife resulting in flushing of nests from nesting birds. Impacts to sensitive plant species could occur from participants accidently trampling them during play.

Health and Safety Concerns

Health and safety concerns related to paintball in the park would be related to the intermingling of passive recreations users (hikers, bird watching, etc.) with the more active paintball participants. Many outdoor paintball courses are located within public parks and as a result, non-players can easily wander into the paintball the course environment. Injury could occur if non-players unknowingly cross into the path of an air fired paintball. The presence of paintball would require a strong presence by Park staff to ensure players were abiding by pre-established rules to protect public safety.

Conclusion

Paintball would not be consistent with the evaluation criteria discussed above. Paintball is an aggressive team sport that would not be conducive to the peaceful setting discussed in the preliminary vision statement for the Park. There could be serious health and safety issues associated with paintball participants coming into contact with other park users. The level of public support for paint ball is low, for none of the respondents expressed interest in paintball, while one respondent opposed paintball at the Park.

Policy information relative to Dogs

There are two sections of the County Code in chapter 20 (Parks and Recreation) under Article III (Personal Conduct) that pertain to dogs.

Section 20-8 "Animals"--

No person shall be permitted to bring, carry, entice or transport a dog, cat or other animal into the park unless such dog, cat or other animal is securely leashed on a maximum six (6) foot leash and in immediate control of a person at all times…. Dogs may be permitted to run free in areas which, from time to time, may be set aside by the park authority for the specific purpose of exercising a dog, provided, however, that the owner or keeper of the dog keeps it under control at all times and does not allow the dog to be beyond the boundaries of the area set aside.

(a) No person shall permit a dog, cat or other pet to remain outside a tent, camper or enclosed vehicle during the night.

(b) No person shall keep a noisy, vicious or dangerous dog or animal or one which is disturbing the other persons in the park and remain therein after the owners have been asked by the park authority to leave. …

[remaining provisions deal with leaving animals in the park, having valid inoculation information, and animal feeding restrictions]

Section 20-8.5 "Dogs in parks located within the coastal zone"--

(a) There are within the county of Sonoma numerous parks, campgrounds and other recreational sites located within the county's coastal zone, as that area is defined in the Sonoma County coastal plan certified by the State Coastal Commission in December, 1980. … Recommendation 22 of this coastal plan provides that if dog predation of coastal livestock cannot be effectively controlled, dogs may be prohibited from areas directly adjacent to vulnerable grazing lands.

(b) Dogs shall be prohibited from parks, campgrounds and other recreational sites located within the coastal zone of Sonoma County whenever the decision-making body makes a finding and imposes a condition on the coastal development permit that such areas are adjacent to vulnerable grazing lands and dog predation cannot be effectively controlled, pursuant to the coastal plan of Sonoma County. This section shall not apply to seeing eye dogs used to guide a blind person, provided that such dogs shall remain under the immediate control of such blind persons.

Also, there are some individual park restrictions:

- Annadel State Park: "Dogs are not allowed on trails. Dogs are permitted on Channel Drive (a paved road) within the park. They must be on a leash no longer than 6' in length."
- Ernie Smith Community Park: "Permitted on leash no longer than 6' in length….No leash required in the dog park."
- Healdsburg Veterans Memorial Beach: "Permitted on leash no longer than 6' in length….Note: Dogs are not allowed on the beach or in the river at the park."

- Hood Mountain Regional Park & Open Space Preserve: "Please keep in mind that although leashed dogs are welcome in Regional Parks, they are not allowed on trails within Sugarloaf Ridge State Park. … Dogs are not allowed [in Hood Mountain campsites]."
- Laguna de Santa Rosa Trail: "Permitted on the multi-use trail segment on leash no longer than 6' in length."
- Ragle Ranch Regional Park: "Permitted on leash no longer than 6' in length….No leash required at the Animal Care Center Dog Park."
- Shiloh Ranch Regional Park: "No dogs allowed beyond the picnic area. Dogs in the picnic area must be kept on a 6 foot leash at all times. … Shiloh is the only Regional Park that does not allow dogs on trails, although they are welcome in the group picnic area."
- Spring Lake Regional Park: "Permitted on leash no longer than 6' in length….Dogs are allowed on the lawn around the swimming lagoon but not on the sand/beach. … Please note that leashed dogs are welcome in both Howarth and Spring Lake parks, but are not permitted in Annadel State Park."
- Taylor Mountain Regional Park and Open Space Preserve (cattle grazing area): "Dogs are perceived as predators. Cows cannot always distinguish the difference between a coyote and a dog and may become aggravated by an approaching dog off leash."

appendix g

Technical Memorandum - Water Budget Analysis

Due to the nature and length of this appendix, this document is not available as an accessible document. If you need assistance accessing the contents of this document, please contact Victoria Willard, ADA Coordinator for Sonoma County, at (707) 565-2331, or through the California Relay Service by dialing 711. For an explanation of the contents of this document, please direct inquiries to Karen Davis-Brown, Park Planner II, Sonoma County Regional Parks Department at (707) 565-2041.

TOLAY LAKE
REGIONAL PARK
Master Plan Project

Technical Memorandum - Water Budget Analysis

Tolay Lake Restoration Alternatives

Sonoma County, California

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TABLE OF CONTENTS

1.0 INTRODUCTION

This Technical Memorandum serves to provide the results of a water budget analysis performed to evaluate three restoration alternatives for Tolay Lake. This memorandum provides supplemental analysis to the Tolay Lake Restoration Alternatives Memorandum by WRA dated February 3, 2014.

The primary goal of the restoration is to restore, enhance, and expand the lake at depths that are ideal for dabbling migratory birds. This includes habitat with water depths from 0" to 18" and corresponds to the shallow seasonal wetland and deeper seasonal wetland habitats used in this evaluation.

The hydrology of the system is dynamic with variables affecting the water level on any given day including topography, rainfall, upstream water use, evaporation rates, infiltration into the soil, groundwater flows, and downstream constrictions to outflow. Only some of these variables can be controlled such as topography and the rate of outflow. All restoration alternatives should consider the variability of the weather expected in Sonoma County. The water budget analysis is a tool that can translate these variables into predicted lake water levels over long periods of time. Through the evaluation of the water budget results, we can estimate the health and viability of target ecosystem habitats including shallow seasonal wetlands, deeper seasonal wetlands, seasonal emergent wetlands, and open water.

Five restoration alternatives were proposed for the project including the following:

- Alternative 1 – Lake Outlet at Elevation 215';
- Alternative 2 – Lake Outlet at Elevation 218' without a Back-berm;
- Alternative 3 - Lake Outlet at Elevation 218' with a Back-berm;
- Alternative 4 - Mid-berm Alternative;
- Alternative 5 – Lake Outlet at Elevation 215' with Enhanced Southeast Basin.

We estimated the lake size and storage volume for each of the alternatives (Table 1).

Table 1 Size and storage volume for each of the restoration alternatives.

Alternative	Size (acres)	Storage Volume (acre-feet)
Alternative 1	71.1	97.7
Alternative 2	171	439
Alternative 3	150[1]	350[1]
Alternative 4	93.3[1]	115.5[1]
Alternative 5	93.3	115.5
[1] approximate measurement		

WRA previously evaluated the first four alternatives in the *Memorandum – Tolay Lake Restoration Alternative*. In this memorandum WRA concluded that Alternatives 3 and 5 were not feasible for several reasons including the need for complex water control structures. The County selected Alternatives 1 and 2 for evaluation using the water budget in response to this information.

In the early planning stages of the project WRA developed Alternative 5 because it provided an opportunity to enhance the hydrology of the seasonal wetlands in the southeastern portion of the lake without using too much additional water. Initially this alternative was dismissed by the County because it involved grading within that Lake in an area were there may be significant archeological artifacts, and the County made a strong commitment to the Tribes to protect this resource. Since then the Tribes have indicated that they may not object to grading within the Lake if it can be shown that the area does not contain archeological artifacts. At the time that this memorandum was prepared there was an ongoing study being performed to determine if there are artifacts in this area. In response to this potential opportunity we also evaluated Alternative #5 using the water budget.

2.0 BACKGROUND INFORMATION

2.1 Effects of Water Depth and Hydrology on Wetland Habitat

The following observations and generalizations were made by WRA staff during more than twenty years designing, constructing, and monitoring the hydrology and revegetation of seasonal wetlands and emergent marshes. These observations can provide insights into the role that depth of water and frequency of inundation play in the species composition and quality of seasonal wetlands and emergent marshes. These observations can also provide criteria for evaluating alternative designs for the restoration of these types of habitats. The following describes how most wetland plant species occur within specific elevation ranges relative to the elevation of the outlet of a lake or wetland, and that wetland plant species cannot survive if they are flooded beyond a maximum depth for relatively short periods of time. In addition, species diversity and distribution is also dependent on the frequency of inundation. Inadequate inundation within seasonal wetlands can result in fewer wetland species and dominance by upland species. In addition, infrequent inundation or highly fluctuating water levels within lakes and ponds can severely limit the species that can adapt to these changing conditions. It should be noted that we are trying to describe common trends for use in developing design strategies for restoring these types of habitat and that exceptions can be found for each of the generalizations made above.

2.1.1 Adverse Effects of Excess Water Depth on Wetland Habitat

Most wetland plant species grow within a specific and limited range of water depths. A typical seasonal wetland species such as *Eleocharis macrostachya*, when grown under seasonal wetland conditions, thrives in water depths between 0.0’ and 0.5’, but is often absent from areas with depths greater than 1.0’. Along the perimeter of perennial ponds and lakes, this same species seems to be able to extend its range to water depths between 0.0’ and 1.5’, but is often absent from water depths greater than 2.0’. A typical emergent wetland species such as *Schoenoplectus californicus*, when grown in a perennial freshwater marsh hydrological regime typically inhabits depths between 0.0’ and 3.0’. Although it can occur at depths up to 6.0’, it typically has difficultly becoming established in areas were the water depth is greater than 3.0’. Often the spatial distribution of these wetland plant species is limited in areas within seasonal and emergent wetlands if the water is too deep. In general terms, species such as this can drown if they are covered with deep water for a relatively short period of time. For example, periods of deep inundation for 4 or more weeks is often enough to preclude certain species or disrupt the normal diversity and distribution of wetland species.

As we consider whether to increase the size of the lake it is important to evaluate the effect on existing wetland habitat and whether or not the increased size will create an opportunity to maintain or improve the quality of the wetlands. For example, raising the elevation of the lake outlet by more than 2 feet would drown the existing seasonal wetlands within the lake, and raising the elevation of the lake outlet more than 4 or 5 feet would drown the existing emergent wetlands within the lake. Depending on the topography of the adjacent uplands, raising the elevation of the outlet could create an opportunity to create more areas of seasonal wetlands and/or emergent wetlands but only if there is enough water to keep these new fringes wet. If there is an abundance of water than there is good chance that making the lake larger could create a larger area for quality wetlands. On the other hand, if there is a limited amount of water than making the lake large could both destroy existing wetland habitat and provide inadequate hydrology for the new wetland areas.

2.1.2 Adverse Effects of Insufficient Hydrology on Wetland Habitat

Wetland hydrological regimes can be categorized as seasonal or perennial. Seasonal hydrology involves extended periods of time during the rainy season when the wetland is inundated or the soils within the wetland are saturated. The duration of inundation and soil saturation is long enough to support wetland plant species and exclude upland plant species. The quality of a seasonal wetland, in terms of wetland vegetation coverage, native plant species diversity, and absence of upland plant species, is often dependent on the frequency and duration of inundation/saturation periods. Insufficient frequency and duration often results in a decrease in the abundance and diversity of wetland plant species and an increase in the presence of upland plant species.

Perennial wetlands such as freshwater marshes can also be adversely affected by annual and seasonal fluctuations in water levels and infrequent inundation. Ponds and lakes that have fluctuating water levels from year to year usually do not have a well-developed wetland fringe. These habitats types are limited by years when these bodies of water do not fill. Wetland species can become established at a lower elevation relative to the elevation of the outlet but these plants often drown in subsequent years when the lake fills to capacity and they are covered with water depths they cannot survive.

2.1.3 Analysis Based on the Elevation of the Lake or Wetland Outlet

In this context we found it useful to evaluate and design wetland habitat relative to the elevation of the lake or wetland outlet. Water depths are calculated downward from elevation of the outlet as opposed to the being calculated upward from the lowest point. This type of analysis allowed us to focus on the frequency and duration of inundation in the top margins of the lake where the wetland habitat occurs. Analysis of this type was used to evaluate if there was an adequate hydro-period within the elevation ranges where seasonal and emergent wetland species are most likely to occur.

For this type of analysis the wetland habitats were mapped in accordance with depth relative to the elevation of the lake outlet. Predictions of the amount (acreage) of wetland habitat were made based on the topography of the site and the elevation ranges for each habitat type. However, sustainable wetland habitat will only occur if there is sufficient hydrology within these designated elevation ranges. In cases where there is insufficient hydrology the areas were these habitat types should occur are likely to be predominated by upland species and not develop in to high quality wetlands.

2.2 Wetland Habitat Types and Corresponding Water Depths

For this project we identified 4 types of wetland habitat for consideration as target types and hydrological evaluation. The four types included shallow seasonal, deeper seasonal, emergent marsh, and open water. The following table lists the four types and their corresponding target hydrology and depth range (Table 2). The following subsections provide a description of each the deepest point in the water feature.

Table 2. Wetland types used in this analysis including the corresponding target hydrology and depth range.

Wetland Type	Target Hydrology	Depth Range (feet)
Shallow Seasonal	seasonal	0.0 to 0.5
Deeper Seasonal	seasonal	0.5 to 1.5
Emergent Marsh	perennial	1.5 to 3.0
Open Water	perennial	>3.0

We selected these wetland habitats to evaluate based on the primary restoration goal of the project. As stated earlier in this memorandum and discussed in more detail later in this memorandum, the primary restoration goal of the project is to increase habitat for dabbling ducks. This corresponds to the shallow seasonal and deeper seasonal wetland habitats. We subdivided this range into shallow and deeper because we were not sure that there would be enough water to support deeper seasonal wetlands. We included emergent marsh habitat because this type of habitat exists, and we wanted to maintain it to some degree, and evaluate the feasibility of expanding it. We included open water habitat because this also exists to a limited extent, and we wanted find out if it would be practical to expand it.

2.2.1 Shallow Seasonal Wetlands

Shallow seasonal wetlands are located in areas at the fringes of Tolay Lake. They are characterized by a maximum depth of six inches of water, and they support perennial and annual grasses such as creeping spike rush (*Eleocharis macrostachya*), iris leaved rush (*Juncus xiphoides*), and wire rush (*Juncus balticus*). These species typically thrive with a relatively short period of inundation and saturated soils that occur in most years. They go dormant in the summer and they can also tolerate some short duration flooding (a few weeks) beyond a depth of 0.5’. While they can survive the occasional year without inundation, they tend to be invaded by upland weeds when the period of inundation is less than a month or only in occasional years. We recommend that the water budget should show at least 60% of years with a minimum of 4 to 6 weeks of inundation in this zone to support seasonal wetland vegetation and wildlife. The healthiest shallow seasonal wetlands that have vigorous native wetland vegetation have consistent inundation year after year, except in the severest of droughts.

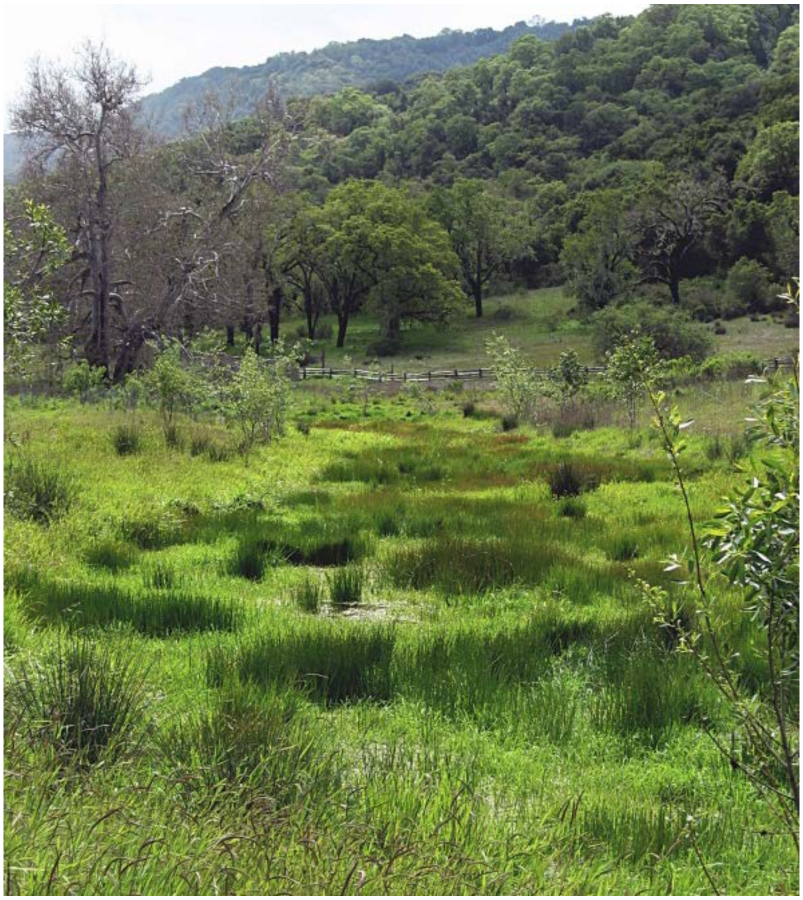

Figure 1. Photograph of shallow seasonal wetland habitat.
Typical depths are less than 0.5’ relative to the lake/wetland outlet.

2.2.2 Deeper Seasonal Wetlands

Deeper seasonal wetlands are also located in areas at the fringes of Tolay Lake but have slightly deeper maximum water depths and thus support a different plant palette. They are characterized by a maximum depth of 18 inches of water and support some of the perennial wetland species found in the shallow seasonal wetlands as well as hardstem bulrush (*Schoenoplectus acutus*) and alkali bulrush (*Bolboschoenus maritmus*). These species and others typical of deeper seasonal wetlands typically thrive with a seasonal period of inundation and saturated soils of at least six weeks in most years. They can go dormant in the summer and they can also tolerate some short duration (a few weeks) flooding beyond a depth of 18 inches. While they can survive the occasional year without inundation, they tend to be invaded by upland weeds when the period of inundation is less than a month or only in occasional years. We recommend that the water budget should show at least 60% of years with 8 to 12 weeks of inundation in this zone to support wetland vegetation and wildlife. The healthiest deeper seasonal wetlands that have vigorous native wetland vegetation have consistent inundation year after year, except in the severest of droughts.

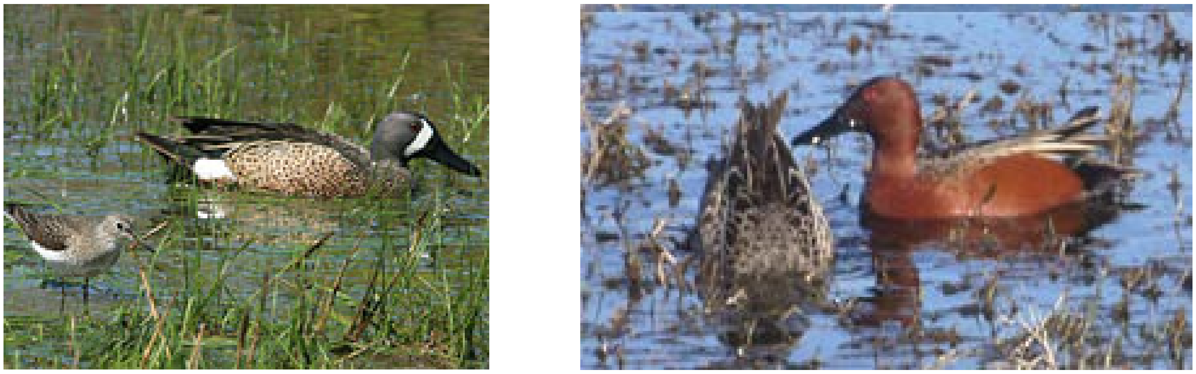

Figure 2. Photograph of deeper seasonal wetland habitat.
Typical depths range from 0.5’ to 1.5’ relative to the lake/wetland outlet.

2.2.3 Emergent Wetlands

Emergent wetlands comprise the deepest vegetated areas of Tolay Lake with maximum water depths of up to 3 feet. These areas support some of the perennial wetland species found in the shallow and deeper seasonal wetlands as well as chairmaker’s bulrush (*Schoenoplectus americanus*), California bulrush (*Schoenoplectus americana*) and cattail (*Typha spp*). The hydrology associated with emergent wetlands can be either perennial or seasonal. When the hydrology is perennial the plants will grow to their maximum height and grow throughout the summer season. These species and others typical of emergent wetlands typically thrive with perennial inundation or a short (2 months or less) dry period with saturated soils in most years.

When the hydrology is seasonal the marsh will dry out in the summer and plants will stop growing and become dormant. When the hydrology is insufficient - dry periods extend beyond a few months each year - this species will often exhibit stunted growth.

For perennial hydrology we recommend that the water budget should show at least 80% of years with a minimum of 10-12 months of inundation in this zone to support emergent wetland vegetation and wildlife. For seasonal hydrology, we recommend that the water budget should show at least 60% of years with a minimum of 4 months of inundation in this zone. The healthiest emergent wetlands that have vigorous native wetland vegetation have consistent inundation

2.2.4 Open Water Habitat

Open water is found in areas that are too deep to support vegetation. Typically vegetation is not capable of surviving in areas that are inundated with 3 or 4 feet of water or more. Currently, only the deepest areas of Tolay Lake, within channels, are of a depth great enough to exclude all vegetation. These areas can be perennial or seasonal. A long duration of inundation during the rainy season would provide refuge for migratory birds. A summer drawdown would provide mudflats, which would potentially provide foraging habitat for resident shorebirds. We recommend that the water budget should show at least 80% of years with a minimum of 4 months of inundation in this zone to be beneficial for wildlife. This corresponds to seasonal hydrology.

Figure 3 Photograph of typical emergent marsh habitat. Water depths typically range from 1.5’to 3.0’ relative to the lake/wetland outlet.

Figure 4. Photograph of typical open water habitat within a freshwater marsh. Typical depths are greater than 3’.

2.3 Restoration Goals

We collaborated with the County and developed restoration goals for the project   The main goal of the restoration is to restore, enhance, and increase seasonal wetland habitat and habitat for shorebirds and waterfowl, with an emphasis on dabbling ducks. This main goal was based on the following biological goals that were previously developed for the project (Technical Memorandum, Tolay Lake Restoration Alternatives, WRA, Inc., Revised September, 2014).

> *The main goal of the restoration is to restore, enhance, and increase seasonal wetland habitat and habitat for shorebirds, dabbling ducks, and waterfowl. This includes water deeps that range from 0.0' to 1.5' feet (shallow and deeper seasonal wetlands), which would provide foraging habitat for dappling ducks during annual migrations.*
>
> *Goal #B1 – Enhance the frequency and duration of inundation*
>
> - Maintain or enhance seasonal wetland hydrology within the lake
> - Evaluate the feasibility of creating some perennially inundated areas within the lake
>
> *Goal #B2 – Enhance the physical parameters of the lake if feasible and consistent with #B1.*
>
> - Increase the frequency and duration of inundation
> - Increase the area of the lake if feasible
> - Increase the depth of the lake if feasible
>
> *Goal #B5 – Enhance the habitat for migratory water fowl if feasible.*
>
> - Shorebirds and wading birds: shallow shorelines
> - Dabbling ducks: < 8" water depth; large area; diverse topography
> - Waterfowl: 12"-18" water depth, large area, diverse topography

2.4 Previous Hydrology Feasibility Studies

2.4.1 Kamman Feasibility Study

A hydrology feasibility study was performed by Kamman Hydrology in 2004 (*Hydrologic Feasibility Analysis for the Tolay Lake Ranch Property, Sonoma County, California, Sonoma County Agricultural Preservation & Open Space District, Final Report, Kamman Hydrology, December, 2003*). This study used a water budget to evaluate the seasonal and annual fluctuations in water levels and storage volumes for proposed lake restoration scenarios that varied in size and storage capacity.

The study evaluated three scenarios with corresponding storage capacity of 136 acre-feet, 1100 acre-feet, and 2550 acre-feet. The 136 acre-feet scenario was assumed to represent the area of sustained ponding under existing site conditions. The 2550 acre-feet scenario represented the maximum size based downstream topography and the potential to raise the outlet elevation significantly. The 1100 acre-feet scenario represented an intermediate storage volume equal to the existing Cardoza water right application volume.

The following is a summary of the results of this study:

- there was insufficient water available to substantially increase the size of the lake;
- it is not feasible to create a significant amount of area with perennial hydrology;
- the target hydrology should be seasonal wetland.

2.4.2 WRA Supplemental Evaluation of the Kamman Dataset

WRA re-evaluated the Kamman dataset to get a better understanding of how the limitation of water would affect year-to-year changes in the lake size and how the limitations would affect the hydrology of wetland habitat. We re-evaluated data from the 136 acre-feet and 1100 acre-feet scenarios. Our concern was that increasing the lake size significantly would worsen the hydrology of the wetlands. We did not evaluate the 2550 acre-feet scenario because we were fairly confident, based some preliminary analysis, that we would show that the 1100 acre-feet alternative would worsen the hydrology.

We found that there is not enough water to effectively enlarge the lake and that in most years a large portion of the lake storage capacity would be underutilized. We also found that making the lake larger would have an adverse effect on the hydrology of the seasonal wetland habitat. The overall area of seasonal wetlands would not increase and, on an annual basis, the percentage of time that the wetlands would be wet would decrease. The expected effect of this change in hydrology would likely be a decrease in the coverage by wetland species, a decrease in wetland species diversity, and an increase in abundance of unwanted upland species.

Effects of Limited Water on the Size of the Lake

- On an annual basis, the lake will fill to capacity only 47% of the time. At capacity the lake would have a water surface area of 327 acres and a storage capacity of 1100 acre-feet
- On an annual basis, 37% of the time, the lake will be filled to less than 75% of its total area. During these years the lake area will be limited to 245 acres instead of 327 acres.
- On an annual basis, 18% of the time, the lake will be filled to less than 50% of its total area. During these years the lake area will be limited to 164 acres instead of 327 acres.
- On an annual basis, 14% of the time, the lake will be filled to less than 25% of its total area. During these years the lake area will be limited to 82 acres instead of 327 acres.

- On an annual basis, 41% of the time, the lake will be filled to less than 75% of its total storage volume. During these years the lake area will store 759 acre-feet instead of 1100 acre-feet.

- On an annual basis, 37% of the time, the lake will be filled to less than 50% of its total storage volume. During these years the lake area will store 506 acre-feet instead of 1100 acre-feet.

- On an annual basis, 24% of the time, the lake will be filled to less than 25% of its total storage volume. During these years the lake area will be limited to 253 acre-feet instead of 1100 acre-feet.

Hydrology of the Wetland Habitat for the 136 acre-foot lake

- The existing seasonal wetlands may have marginal hydrology. On an annual basis, the shallow seasonal wetlands are wet 67% of the time, the deeper seasonal wetlands areas are wet 69% of the time, and the emergent marsh areas are wet 71% of the time.

E*ffects of Limited Water on the Wetland Habitat for the proposed larger 1100 acre-foot lake*

- The hydrology of the seasonal wetlands would worsen if the lake was enlarged from 136 acre-feet to 1100 acre-feet.

- Over a 50-year time frame, the percentage of years when the lake would fill enough to inundate the shallow seasonal wetland habitat would drop from 67% to 47%.

- Over a 50-year time frame, the percentage of years when the lake would fill enough to inundate the deeper seasonal wetland habitat would drop from 69% to 53%.

- Over a 50-year time frame, the percentage of years when the lake would fill enough to inundate the emergent marsh habitat would drop from 71% to 61%.

- If the lake was enlarged from 136 acre-feet to 1100 acre-feet than the size of the overall area of seasonal wetlands remain at about 95 acres, although the composition would shift significantly: shallow seasonal wetlands would decrease from 55 acres to 10 acres; deeper seasonal wetlands would increase from slightly from 30 to 35 acres; emergent marsh would increase from 20 to 50 acres.

2.5 Restoration Alternatives

2.5.1 Preliminary Restoration Alternatives

As mentioned earlier in the memorandum, WRA in collaboration with the County developed 4 preliminary restoration alternatives (Technical Memorandum, Tolay Lake Restoration Alternatives, WRA, Inc., Revised September, 2014) which are listed by name below. These were described and analyzed in detail in the technical memorandum referenced above.

- Alternative 1 – Lake Outlet at Elevation 215’
- Alternative 2 – Lake Outlet at Elevation 218’ without a Back-berm
- Alternative 3 - Lake Outlet at Elevation 218’ with a Back-berm
- Alternative 4 - Lake Outlet at Elevation 215’ with a Mid-berm

2.5.2 Alternatives Selected for Evaluation Using a Water Budget

For this study WRA, in collaboration with the County, selected 3 restoration alternatives to evaluate using a water budget:

- Alternative 1 – Lake Outlet at Elevation 215’
- Alternative 2 – Lake Outlet at Elevation 218’ without a Back-berm
- Alternative 5 – Lake Outlet at Elevation 215’ with Enhanced Southeast Basin

Alternative 1 was selected because previous analysis indicated that this size wetland is in balance with the available water from the watershed and this alternative would not increase flooding on the adjacent upstream properties.

Alternative 2 was selected to find out if the watershed can support a wetland of this size and storage capacity. This alternative is likely not to be feasible because it would cause increased flooding on the adjacent upstream properties.

Alternative 5 was selected because it represents an opportunity to restored and enhance the wetlands in the southern portion of the lake without increased flooding on the adjacent upstream properties. This alternative would not increase the amount of storage water significantly and has the potential to be feasible given the limited amount of water available from the watershed. This alternative does include grading with the southern portion of Tolay Lake, which may not be desirable if there are a significant amount of archeological resources in the area.

2.5.3 Alternative 1 – Lake Outlet at Elevation 215’

This alternative would maintain the elevation of the lake outlet at 215’ for both the northwestern and southeastern segments of the lake (see Figure 5). It would include reducing the frequency and duration of flooding by increasing the flow capacity of the causeway culvert, eliminating the horseshoe culvert, and increasing the cross sectional area at the farm bridge. This alternative would establish a stable water elevation and reduce flooding. This alternative would have a maximum lake size and storage volume of 71.1 acres and 97.7 acre-feet respectively.

2.5.4 Alternative 2 – Lake Outlet at Elevation 218’ without a Back-berm

This alternative would raise the elevation of the lake outlet from 215’ to 218’ in order to increase the potential depth and size of the lake (see Figure 6). The lake, when full, would extend onto the upstream adjacent properties. The County would have to negotiate an agreement with the adjacent property owners and gain permission to increase flooding on their property. This alternative would have a maximum lake size and storage volume of 171.53 acres and 439 acre-feet respectively.

2.5.5 Alternative 5 – Lake Outlet at Elevation 215’ with Enhanced Southeast Basin

This alternative would maintain the elevation of the lake outlet at 215’ for both the northwestern and southeastern segments of the lake. It is similar to the Alternative 1 but also includes increasing the size of the lake and enhancing the hydrology of the southeastern segment of the lake by lowering the bottom elevations in this area from 216’-217’ to 214.5’ (see Figure 7). This alternative would result in the establishment of a stable water elevation and high quality wetland habitat on both sides of the causeway. The southeastern segment of the lake may contain buried archaeological artifacts, which may make grading in this area undesirable. This alternative would have a maximum lake size and storage volume of 93.3 acres and 115.5 acre-feet respectively.

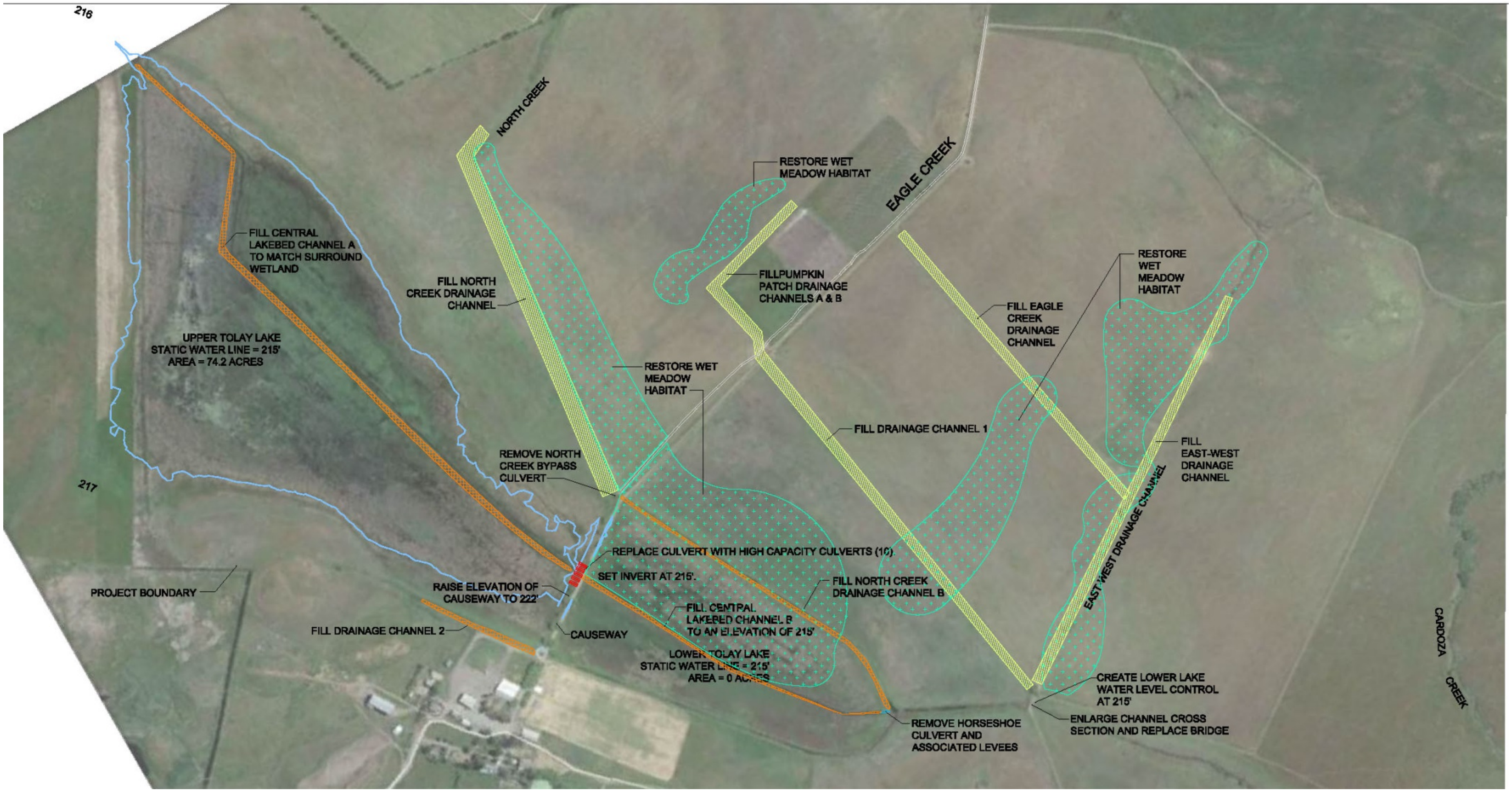

Figure 5. Conceptual design for lake restoration Alternative 1 – Lake Outlet Elevation at 215'.

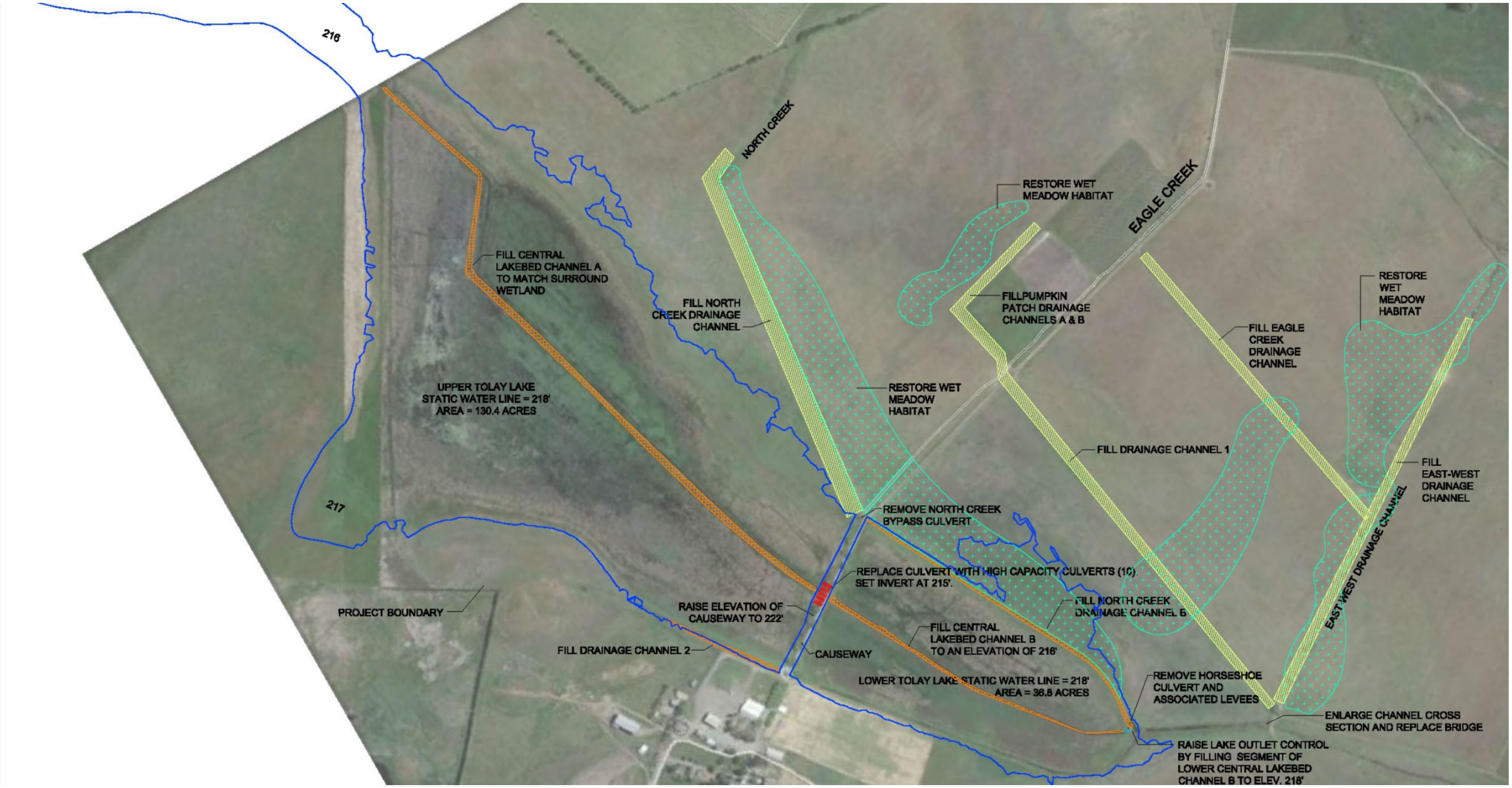

Figure 6. Conceptual design for lake restoration Alternative 2 – Lake Outlet Elevation at 218” without a Back-berm.

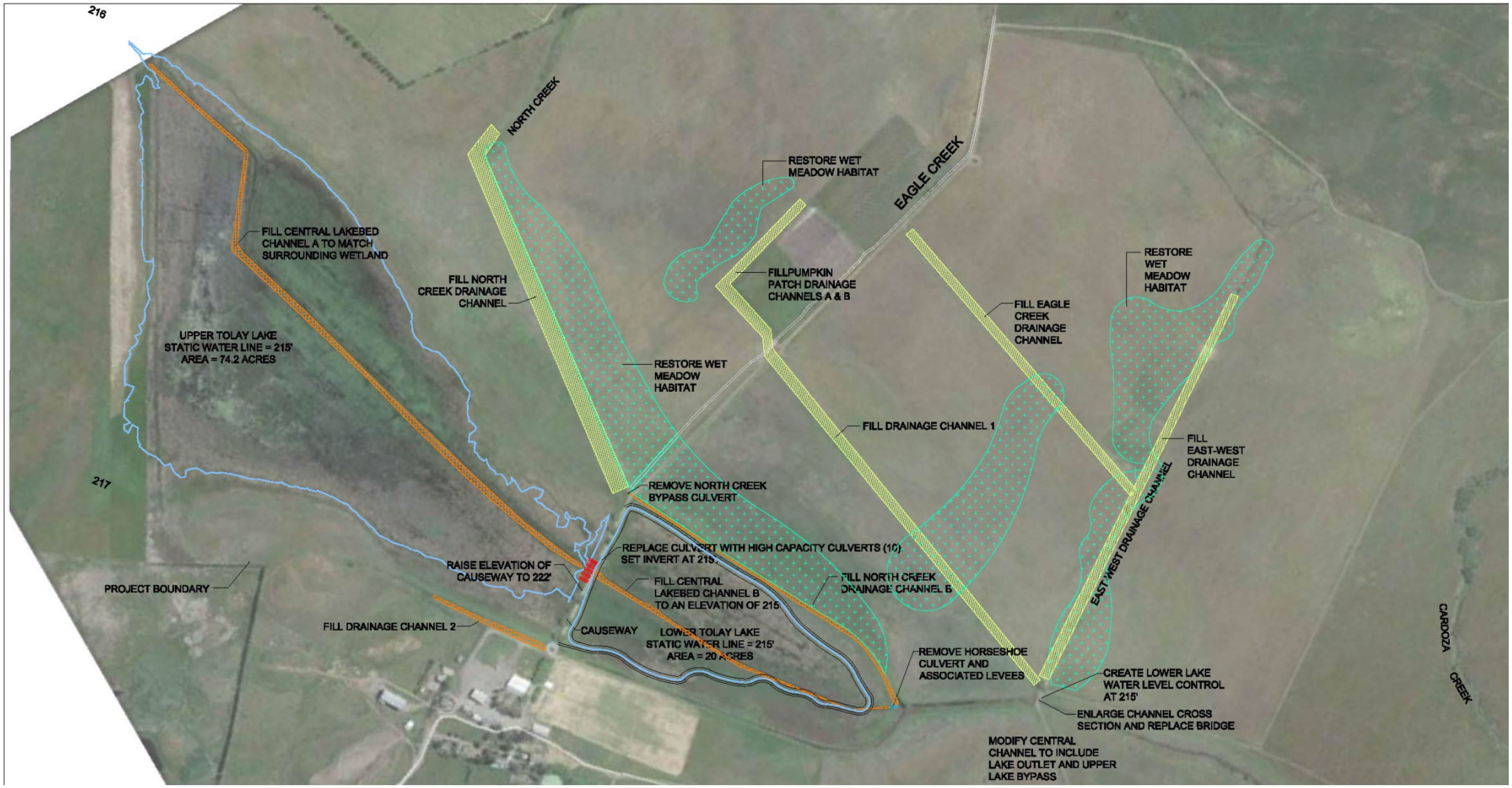

Figure 7. Conceptual design for lake restoration Alternative 5 – Lake Outlet at Elevation 215’ with Enhanced Southeast Basin.

3.0 WATER BUDGET METHODS

WRA developed a water budget model to evaluate the hydrology of the proposed restoration alternatives. The goal was to understand how the proposed restoration alternatives would affect the desired habitat types. This analysis included soils data collection, historic weather data collection, and water budget modelling. The following discussion provides an overview of the methods used for this analysis.

The water budget generated a daily estimate of the amount of water likely to inundate the proposed wetland with inputs of precipitation and surface inflow and outputs of outflow, infiltration, and evaporation. We based the water budget calculations on the hydrology of a wetland, which can be estimated using the following equation (Mitsch and Gosselink 1993):

Change in volume of water storage in wetland per unit time =

(Precipitation + Surface Inflow + Groundwater Inflow) –

(Surface Outflow + Groundwater Outflow + Evapotranspiration)

In preparing the water budget, we modified this equation by converting volume of water storage to depth of water by analyzing the available topographic data for the site. For the unit of time, we used a daily hydro-period. Thus, the model predicts the approximate duration of inundation in the Lake. We collected the information needed for the water budget as described below.

3.1 Topography

We used the topographic data set provided by the County that was generated using LiDAR. The dataset included contour lines at a 1-foot interval. The data was prepared at a time when the vegetation was low and when there was not water in the Lake. For each restoration alternative we generated a volume-to-depth dataset from the topographic data for use in the water budget.

3.2 Soils

Basic soil data was collected from the National Cooperative Soil Survey (NCSS 2013). According to NCSS, sixteen soil units have been mapped within the Tolay Lake watershed. Within Tolay Lake, one soil type is represented, - Clear Lake Clay Loam, 0 to 2 percent slopes. These soils consist of very deep, poorly drained soils that formed in the fine textured alluvium derived from sandstone and shale. They are extremely hard clays overlain by a clay loam surface 10 to 15 inches thick. The most limiting layer to transmit water (Ksat) is described as very low (1.29×10^{-4} cm/sec).

3.3 Precipitation and Surface Inflow

For the water inputs, daily rainfall data was taken from the nearest weather station in the county, for a twelve year period to capture variability in annual weather. The long-term annual average precipitation rate is 30.69 inches in Sonoma, California (WETS Station: Sonoma, CA8351).

Daily precipitation rates recorded at the East Petaluma, California station (CIMIS Station#144 Petaluma East) for 2002 – 2013 were collected and entered into the water budget model. Years 2005, 2006, 2010, and 2012 received average precipitation, while 2002 and 2003 were wet years (30% or more above normal), and 2003, 2004, 2007, 2008, 2009, 2011, and 2013 were dry (30% or more below normal). Variability in rainfall patterns from year to year, such as large single storms or small back-to-back storms, may produce more or less runoff in any given year. Results from the model for twelve years with different levels of rainfall are provided to show this variability. Surface runoff was determined using the Soil Conservation Service Runoff Curve Number Method (USDA 1986).

3.4 Evapotranspiration, Infiltration, and Outflows

For the outputs of water, daily evapotranspiration rates were also taken from the weather station for the same years as the precipitation rates. Daily evaporation rate data were taken from the East Petaluma, California station (CIMIS Station#144 Petaluma East) for 2002 – 2013 managed by the California Irrigation Management Information System, the closest station to the Project Area with evaporation data.

The infiltration rate is a value that is site specific to the Lake indicating the rate at which water is absorbed into the soil. In the previous water budget prepared by Kamman Hydrology, they used 0.0 cm/sec for the infiltration rate, surmising that the input of groundwater was equal to the output of water via infiltration. For this water budget model, we took the rate published by NCSS and reduced some inputs from groundwater. This infiltration rate is comparable to the measured in-situ infiltration rates observed within wetlands and lake habitats on similar clay soils.

Surface outflow occurs when the Lake is completely full and water flows out of the Lake via Tolay Creek. It was previously determined that there were several locations where flow within the lake drainage was constricted by undersized pipes, severely clogged pipes, or undersized channel cross sections. The project plans on retrofitting these project elements, in all of the alternatives, to reduce the frequency, duration, and magnitude of flooding of the adjacent up-stream properties. As part of this analysis we determined that the rate of outflow for the restored lake would be controlled by the outflow rate at the retrofitted channel at the farm bridge.

3.5 Annual Frequency of Inundation for Wetland Habitat Types

Annual frequency of inundation is the number of years that the target habitat type received adequate inundation over the study period, expressed as a percentage. We used the water budget to calculate the daily water depth for a 12-year time period for each of the restoration alternatives. As previously discussed, the water depth was measured relative to the elevation of the lake outlet. This allowed us to calculate the annual frequency of inundation for each of the target wetland habitat types: shallow seasonal wetland, deeper seasonal wetland, emergent marsh, and open water.

3.6 Daily Time Interval for Analysis

We evaluated the water budget on a daily time interval instead of a monthly time interval. This allowed us to make more accurate predictions of surface in-flow based on rainfall because the relationship between rainfall and surface in-flow is non-linear. Predictions of surface in-flow based on aggregated rainfall measurements, such as monthly rainfall totals, overestimate the resulting surface in-flow. Daily precipitation data was only available for the past 12 years and therefore, we had to limit our analysis to this time period. Other studies, such as Kamman's, used monthly rainfall data and evaluated the water budget over a longer period of time (50 years). We felt that the improvement of accuracy out-weighed the limitation of only 12 years of data.

3.7 Water Rights

The water budget included the upstream water rights in the watershed. We utilized the State database to identify the upstream water rights. Table 3 lists the water rights that were used in the water budget. For the water budget analysis, we deducted the total upstream water rights from the estimated surface inflow prior to conveying any water to the Lake. This water budget analysis did not evaluate downstream water rights.

Table 3. Water Rights Used in the Water Budget Evaluation.

Owner	**Application Number**	**Application Status**	**Permit ID**	**Volume**	**Used In Water Budget**
Kullberg	A030592	Pending	na	35	no
Kullberg	A029402	Permitted	20393	12	yes
Kullberg	A029678	Permitted	20561	37	yes
Martinelli	A016625	Licensed	10471	9	yes
Martinelli	A031022	Pending	na	200	no
Universal Portfolio, ltd	S019753	Claimed	na	0	yes
Universal Portfolio, ltd	A031818	Pending	na	124	no
Oxfoot	A029166	Permitted	20330	245	yes

Permitted – Authorization to develop a water diversion and use project. The right to use water is obtained through actual use of water within the limits described in the permit.

Licensed – After you have received a water right permit, constructed your project, and used water, we will inspect your project. If you have used water beneficially and if you comply with all of the conditions in your permit, you will be offered a water right license. The water right license is a vested right that confirms your actual use. If you have not used all the water allowed by your permit, or if you have used water unreasonably, you will receive a license for less water than your permit allowed. You will receive a license for only that water that has been reasonably and beneficially used.

State Div. of Land Use - Pre-1914 appropriative water right that is undecided by the courts.

Claimed - Describes pre-1914 water right.

4.0 WATER BUDGET RESULTS

We evaluated the three restoration alternatives using the water budget that was described above. The follow section contains the results for each of the alternatives and a summary and conclusion.

4.1 Water Budget Results for Alternative 1 – Outlet Elevation at 215’

The results showed that this alternative supports the shallow seasonal wetland, the deeper seasonal wetland, and the emergent marsh habitat types, but has limited to no open water habitat. Figure 8 illustrates the daily surface water elevation over the 12 year analysis period and shows each target habitat elevation range. From this figure we can see that:

- Shallow seasonal wetland habitat would be inundated in only 42% of the years;
- Deeper seasonal wetland habitat would be inundated all years;
- Emergent marsh habitat would be sufficiently inundated in all years;
- There would be no open water habitat because the lake is too shallow.

We can expect that the upper margins of the shallow seasonal wetland habitat may be invaded with upland plants in times of prolonged drought but that all three of the target habitats (shallow seasonal wetland, deeper seasonal wetland, and emergent marsh) will be present and relatively well supported by the expected hydrology.

Another consideration when comparing the alternatives is the amount of habitat that can be supported in each scenario. Figure 11 below illustrates the habitat area that will be present under Alternative 1. This shows that there will be:

- 11.29 acres of shallow seasonal wetland;
- 29.77 acres of deeper seasonal wetland;
- 34.04 acres of emergent marsh;
- There is no open water habitat because the lake is too shallow;
- Total area of viable wetlands is 75.1 acres.

4.2 Water Budget Results for Alternative 2 – Outlet Elevation at 218’ without a Back-berm

The results showed that this alternative would have less stable hydrology with reductions in the annual inundation frequencies in the shallow seasonal wetland, deeper seasonal wetland, and emergent marsh habitat types. We predicted that this would result in lower quality wetland habitat with a higher percentage of weeds. Figure 9 below illustrates the daily surface water elevation over the 12 year analysis period and shows each target habitat elevation range. From this figure we can see that:

- Shallow seasonal wetland habitat would be inundated in only 27% of the years;
- Deeper seasonal wetland habitat would be inundated in only 29% of the years;
- Emergent marsh habitat would be inundated in 83% of the years;
- Open water habitat would be inundated in all years;
- Bare ground will be exposed in 66% of years as Tolay Lake dries down in late summer.

It is possible that the seasonal wetland habitat could shift downward; however, we feel this is unlikely because when the lake fills in 27% of years, the wetland plants would most likely be drowned in the deeper water. This scenario is most likely to result in low quality seasonal wetlands with a high percentage of non-native weeds. Open water would be present and relatively well supported by the expected hydrology; however, more bare ground will be present in most years at the end of the summer.

Figure 12 below illustrates the habitat area that would be present under Alternative 2. This shows that this scenario has the potential to have:

- 26.7 acres of shallow seasonal wetland habitat (although the hydrology does not support it);
- 32.4 acres of deeper seasonal wetland habitat (although the hydrology does not support it);
- 48.62 acres of emergent marsh;
- 63.81 acres of open water habitat (or bare ground in some summers);
- Total area of viable wetlands is 112.43 acres;

4.3 Water Budget Results – Alternative 5, Outlet at 215' with Enhanced South Basin

The results showed that this alternative has almost exactly the same water surface elevation as the existing conditions; however, this alternative substantially increases the acreage of the deeper seasonal wetland by approximately 17 acres. In addition, there would be sufficient hydrology to support shallow seasonal wetland, deeper seasonal wetland, and emergent marsh habitats. Figure 10 below illustrates the daily surface water elevation over the 12 year analysis period and shows each target habitat elevation range. From this figure we can see that:

- Shallow seasonal wetland habitat would be inundated 42% of the years;
- Deeper seasonal wetland habitat would be inundated all years;

- Emergent marsh habitat would be sufficiently inundated in all years;
- There would be no open water habitat because the lake is too shallow.

We can expect that the upper margins of the seasonal shallow zone may be invaded with upland plants in times of drought but that all three of the target habitats wouldl be present and relatively well supported by the expected hydrology of Tolay Lake with a static water line at elevation 215.

Another consideration when comparing the alternatives is the amount of habitat that can be supported in each scenario. Figure 13 below illustrates the habitat area that would be present under Alternative 5. Alternative 5, while it has nearly the same hydrology as Alternative 1, supports more area of seasonal wetland habitat. Alternative 5 would have the following acres of habitat:

- 11.86 acres of shallow seasonal wetland;
- 47.4 acres of deeper seasonal wetland;
- 34.03 acres of emergent marsh;
- There is no open water habitat because the lake is too shallow;
- Total area of viable wetlands is 93.29 acres

4.4 Summary and Conclusions

We compared the restoration alternatives based on the results of the water budget (Table 4). For each restoration alternative we provided the maximum acreage and maximum storage volume. We also provided an estimate of the annual frequency of inundation for each of the target habitat types: shallow seasonal, deeper seasonal; emergent marsh; open water.

It should be noted that all of the alternatives included that same improvements to the water control features of the site. In a previous study we determined that several of these were too small, clogged, or no longer functioning. Improving these water control features would reduce the duration, magnitude and frequency of flooding of the upstream properties without significantly changing the size or storage volume of the lake.

Alternative 1 represents current size and storage capacity of the lake. The hydrology for the shallow seasonal wetland was predicted to be marginal (annual frequency of inundation of 42%) and our field survey indicated that the shallow wetland fringes include non-native wetland species and a larger then desirable amount of upland species. These results indicated that the hydrology of the lake would likely remain predominantly seasonal and that there is not really any opportunity to make a perennial lake.

Alternative 2 allowed us to evaluate if there is enough water to substantial increase the size and storage volume of the lake. The results indicated that increasing the size and storage volume of the lake would likely decrease the annual inundation frequency in the shallow seasonal wetland, deeper seasonal wetland, and emergent wetland habitat types. This would likely decrease the abundance and diversity of wetland plant species and increase the abundance of non-native wetland plant species and upland plant species in these areas. When full this lake would extend onto the upstream neighbor’s property and the County does not currently have permission from these landowners to increase flooding. These results are consistent with the results from evaluating the Kamman dataset.

Alternative 5 allowed us to explore enlarging the seasonal wetlands and enhancing the hydrology of the southeast section of the lake without substantially increasing the amount of required water. This would create the opportunity to enhance the wetland habitat and maintaining sufficient hydrology. In addition, the storage volume only increases from 97.7 to 115.5 acre feet. The County may be able to enhance the wetlands without needing to increase their water rights by a significant amount.

We recommend that the County consider Alternative 5 because it provides an opportunity to increase the size of the lake slightly and enhance the hydrology of the southeast portion of the lake. This alternative involves excavating the southeast portion of the lake by approximately 1 to 2 feet. There is a potential that this area contains archeology resources, and the County should work with the Tribes to determine if these resource as present and make sure that this level of ground disturbance is acceptable to the Tribes.

There are limitations to using a water budget to evaluate the restoration alternatives. The water budget does not predict dynamic flood levels under different storm scenarios. It also should not be used to design the size of water control features such as the size of culverts or cross sectional requirements for open channel conveyances. In addition the water budget is limited by the quality of data input and assumptions. It should be noted that the water budget analysis is sensitive to the soil infiltration rate. We were careful to select a soil infiltration rate that represents site conditions. In this context the water budget should be used to guide the selection of project alternatives based on the project goals and results.

We have not yet evaluated potential effects that modifying the lake may have on downstream habitat or downstream water rights.

Table 4. Results of the Water Budget Evaluation for Three Restoration Alternatives.

Restoration Alternative	**Storage Volume (acre-feet)**	**Area (acres)**	**Percent Year with Inundation (%)**	**Potential Adverse Impact on Existing Habitat**	**Potential Insufficient Hydrology on Proposed New Habitat**
Lake Outlet at Elevation 215'	**97.7**	**71.1**			
Shallow Seasonal Wetland		11.3	42%	none	none
Deeper Seasonal Wetland		29.8	100%	none	none
Emergent marsh		34.0	100%	none	none
Open Water		none	Not applicable	Not applicable	Not applicable
Lake Outlet at Elevation at 218'	**439**	**171.5**			
Shallow Seasonal Wetland		26.7	27%	yes-relocated	yes
Deeper Seasonal Wetland		32.40	29%	yes-relocated	yes
Emergent marsh		48.62	82%	yes-relocated	yes
Open Water		63.81	100%	no	no
Lake Outlet at Elevation 215' with Enhanced South Basin	**115.5**	**93.3**			
Shallow Seasonal Wetland		11.9	42%	none	none
Deeper Seasonal Wetland		47.4	100%	none	none
Emergent marsh		34.0	100%	none	none
Open Water		none	Not applicable	Not applicable	Not applicable

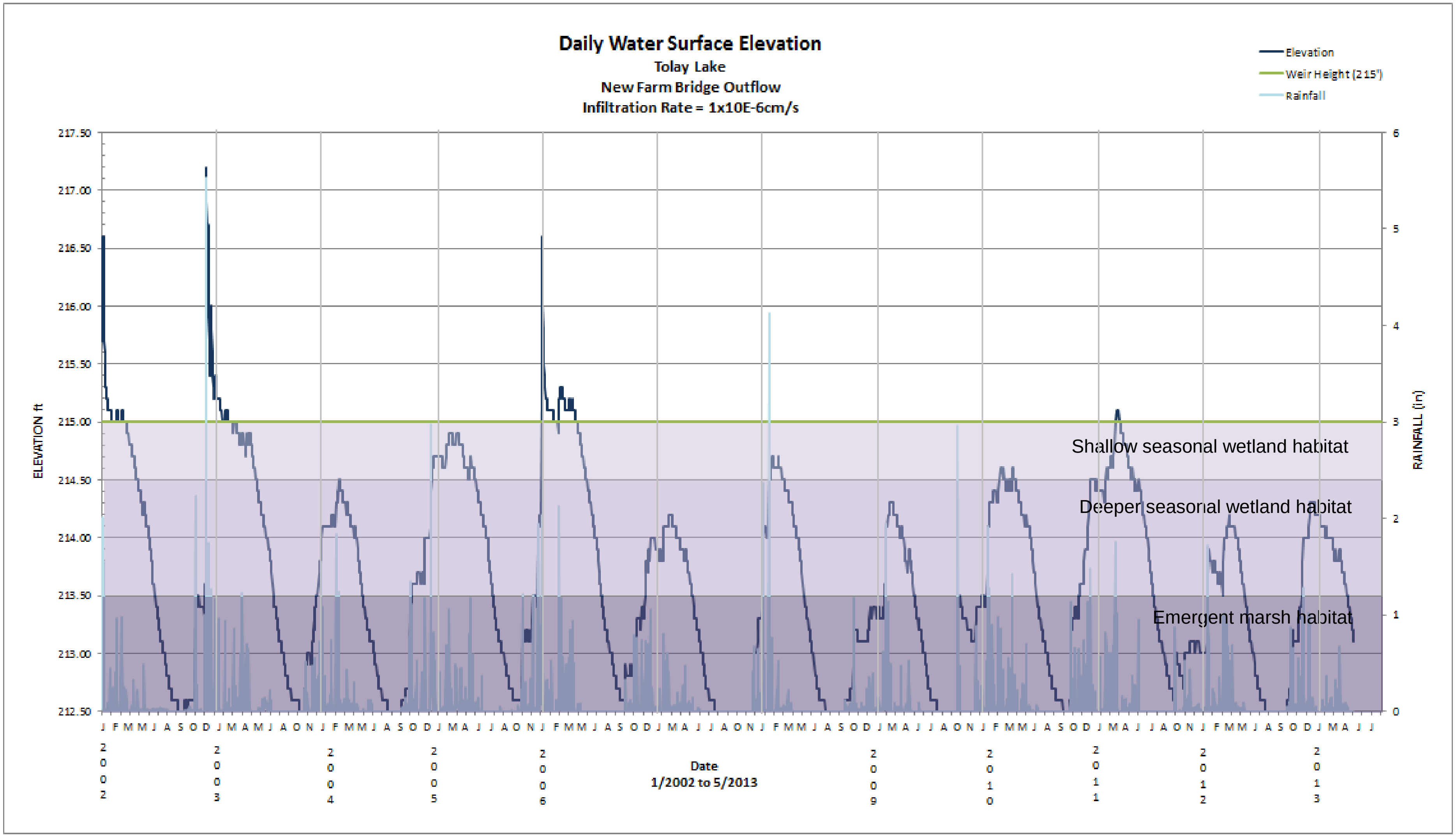

Figure 8. Daily Water Surface Elevation and Habitat for Restoration Alternative 1 – Lake Outlet at Elevation 215'.

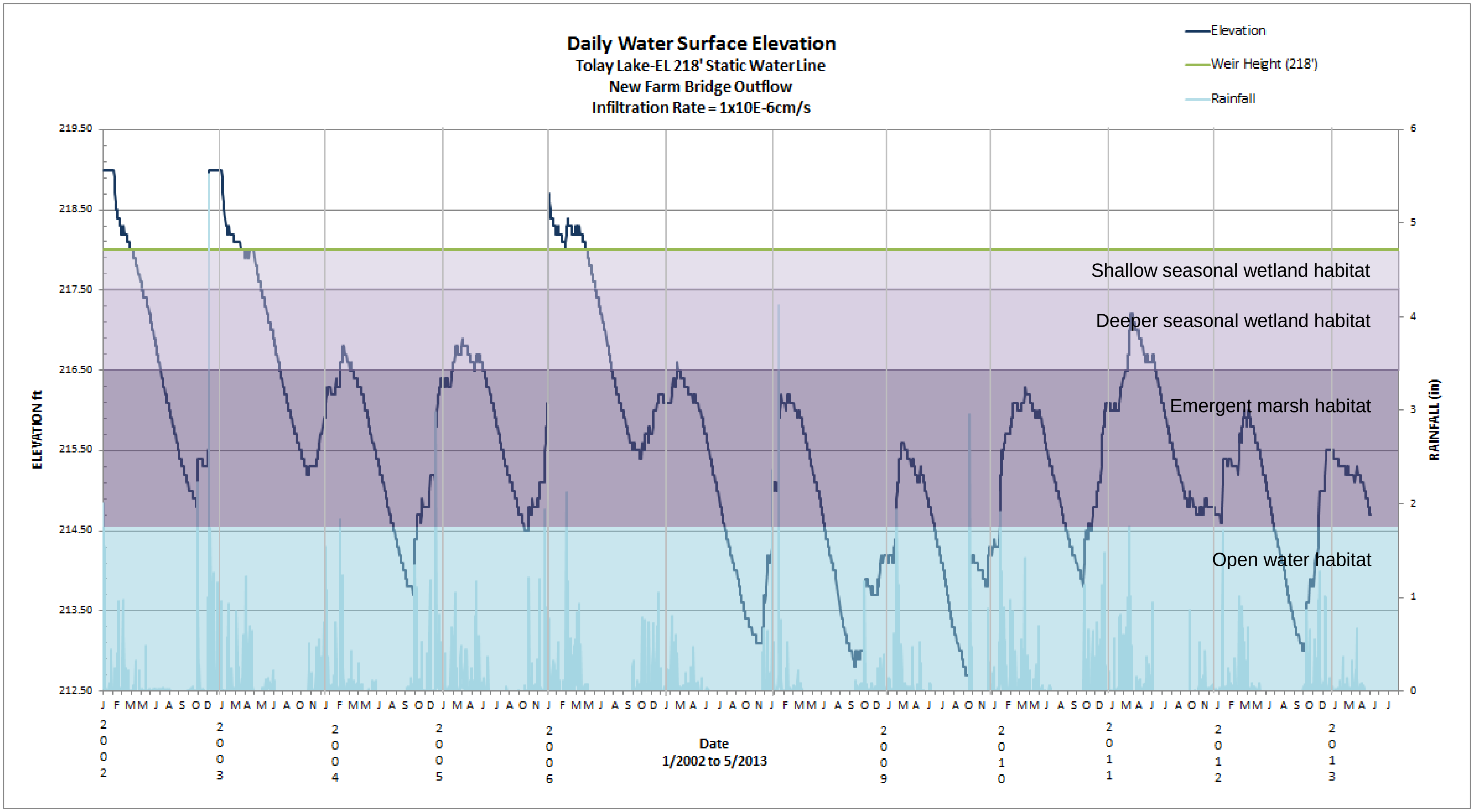

Figure 9. 12-year Daily Water Surface Elevation and Habitat for Restoration Alternative 2 – Lake Outlet at Elevation 218’

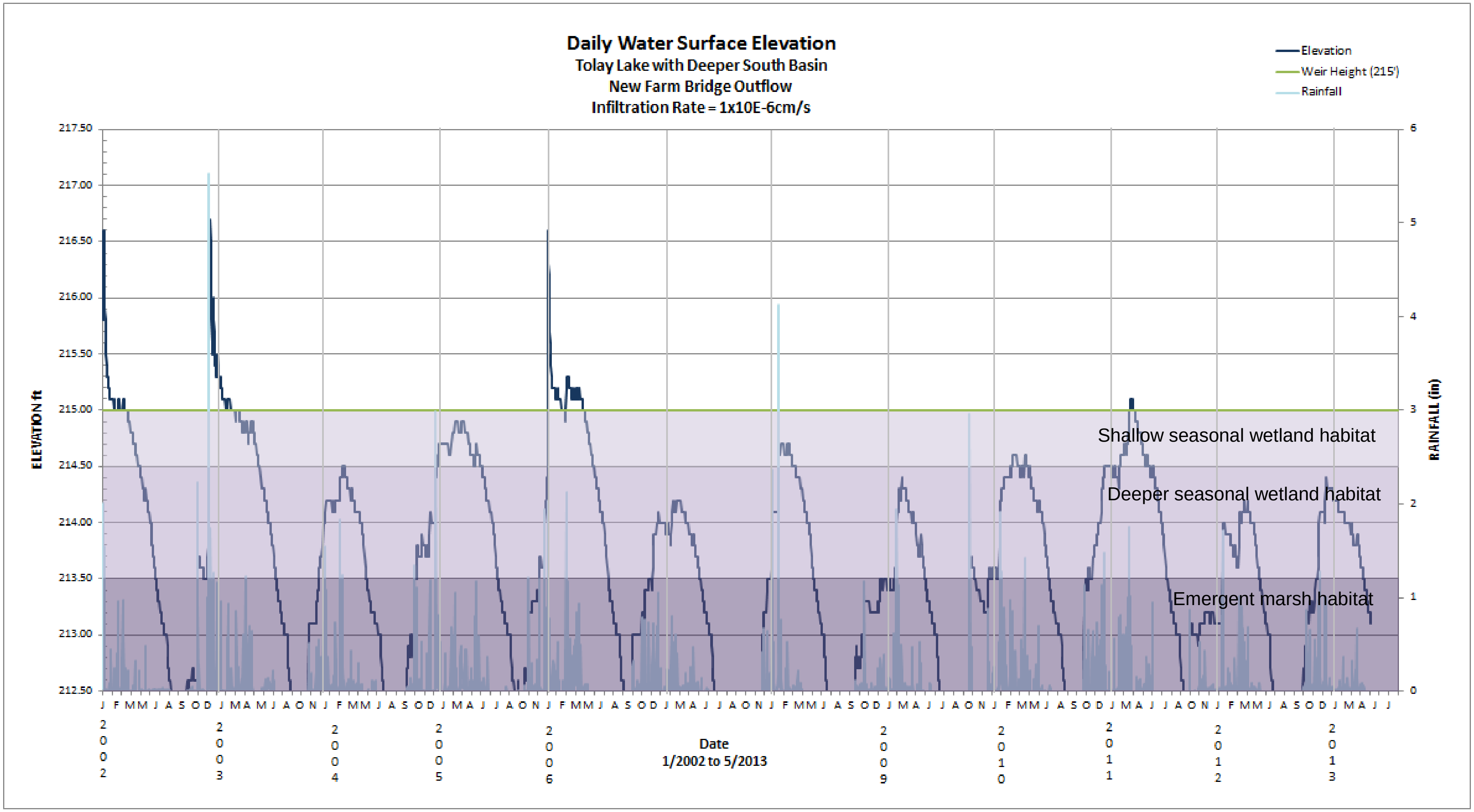

Figure 10. 12-year Daily Water Surface Elevation and Habitat for Restoration Alternative 5 – Lake Outlet Elevation at 215’ with Enhancement of the South Basin

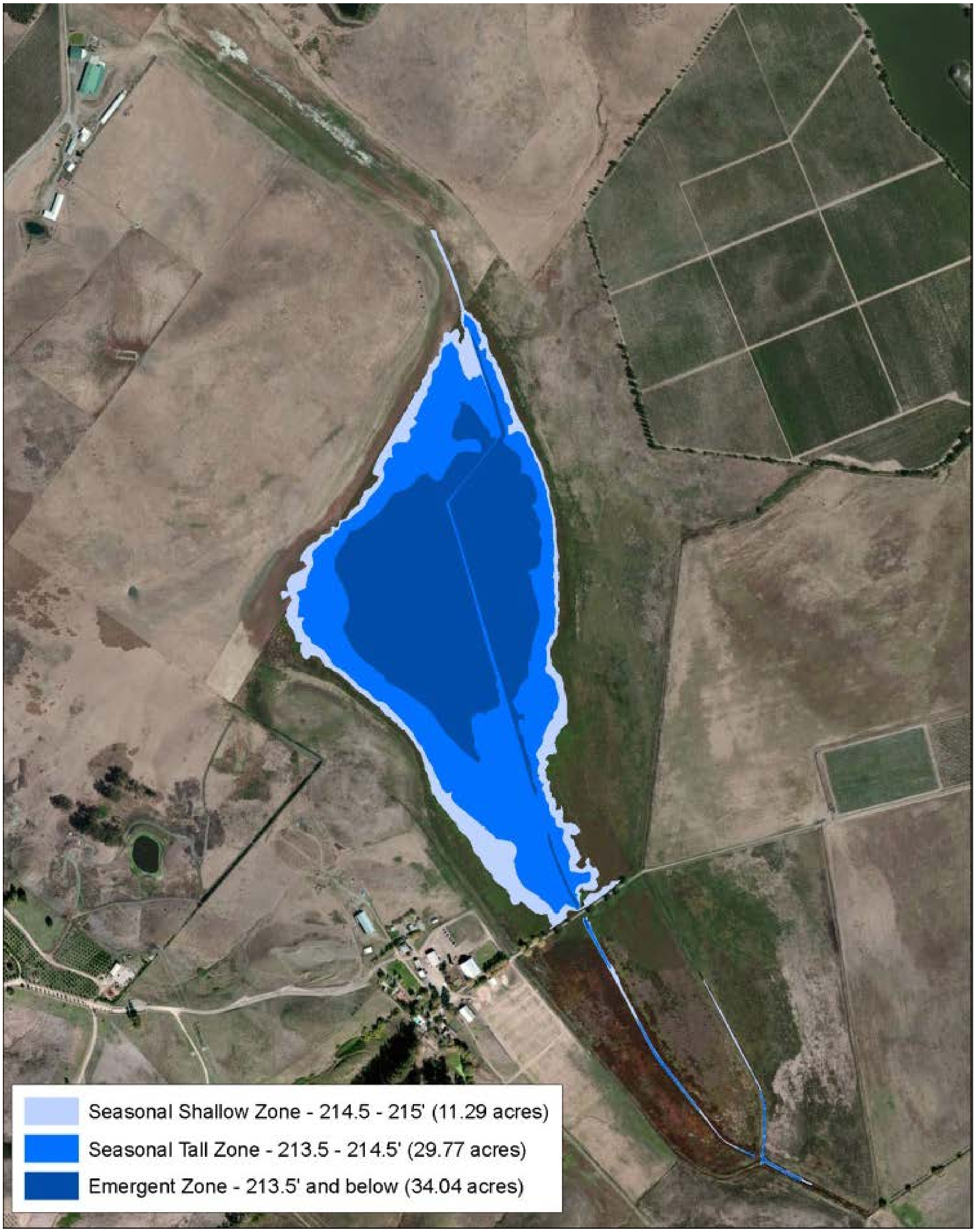

Figure 11. Areas of Inundation for Target Habitats for Restoration Alternative 1 – Lake Outlet Elevation at 215’

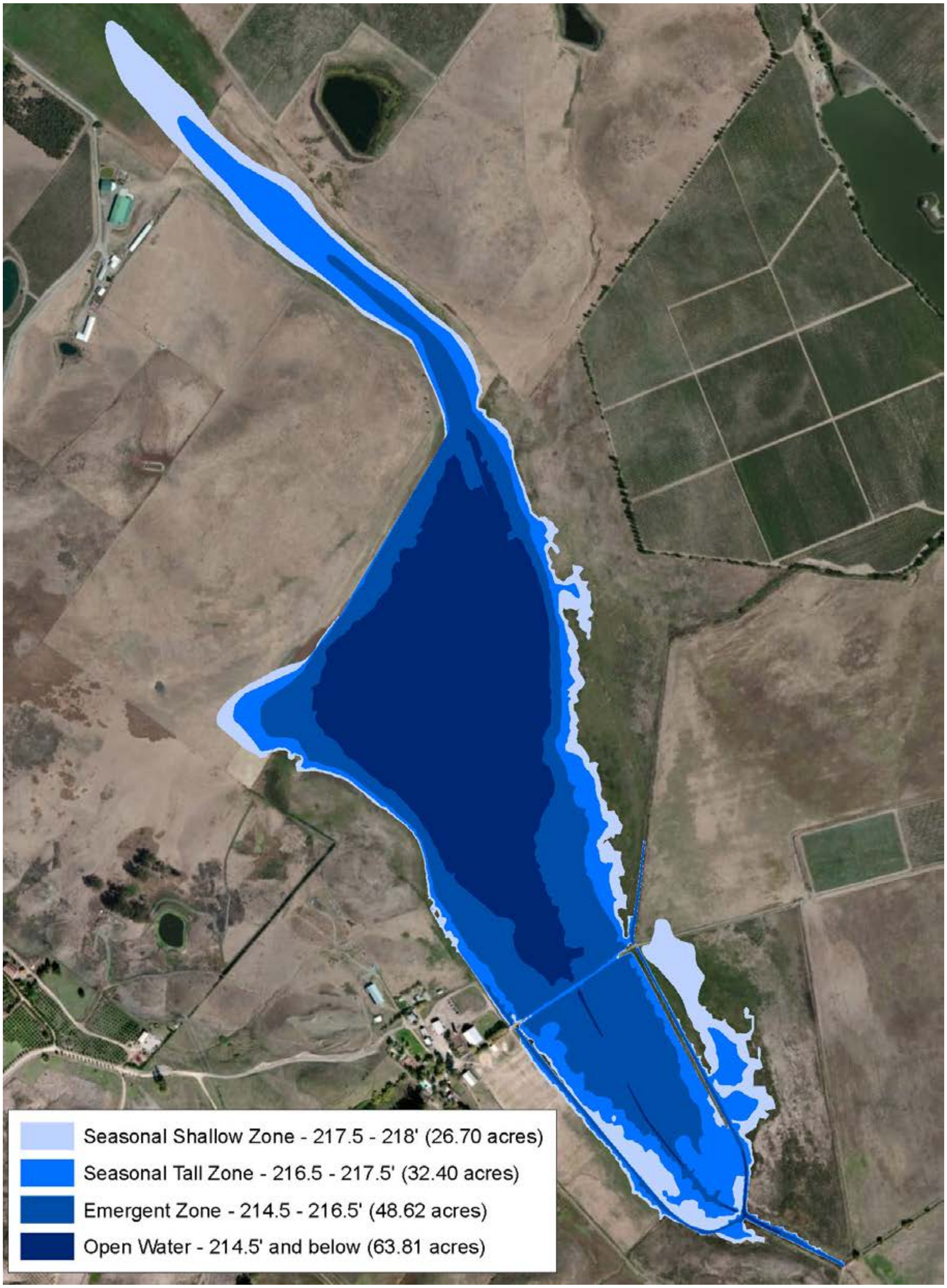

Figure 12. Areas of Inundation for Target Habitats for Restoration Alternative 2 – Lake Outlet Elevation at 218’ without a Back-berm.

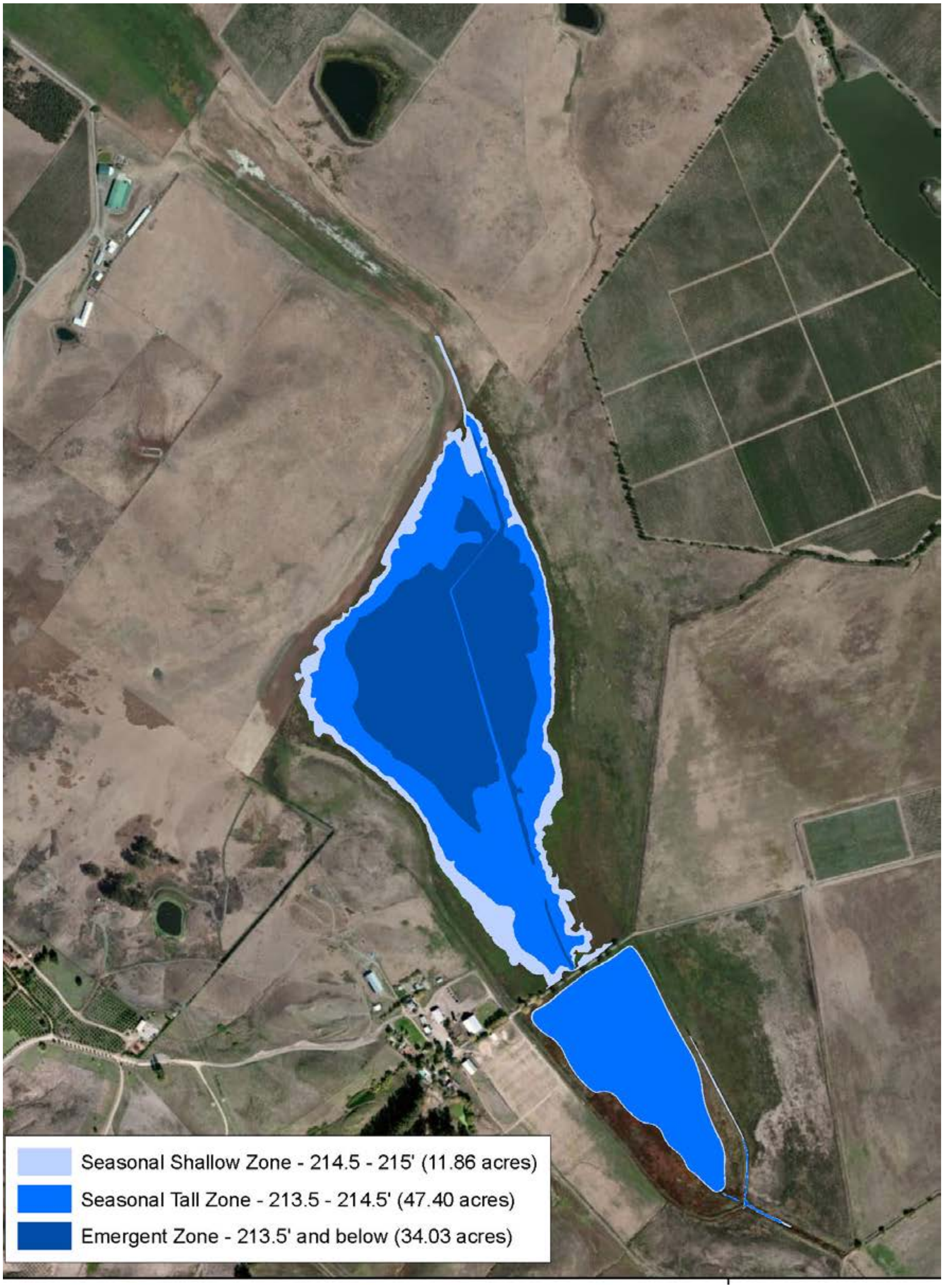

Figure 13. Areas of Inundation for Target Habitats for Restoration Alternative 5 – Lake Outlet Elevation at 215’ with Enhanced Southeast Basin.

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Appendix - Water Budget Analysis Data

Tolay Lake Restoration Alternatives

Sonoma County, California

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ENVIRONMENTAL CONSULTANTS

1.0 INTRODUCTION

This Appendix serves to provide additional input data and results of a water budget analysis performed to evaluate three restoration alternatives for Tolay Lake, as described in the Technical memorandum dated November 11, 2014. Data presented here are a subset of the complete data set which can be provided upon request.

Table 1. Water Rights Used in the Water Budget Evaluation.

Owner	**Application Number**	**Application Status**	**Permit ID**	**Volume**	**Used In Water Budget**
Kullberg	A030592	Pending	na	35	no
Kullberg	A029402	Permitted	20393	12	yes
Kullberg	A029678	Permitted	20561	37	yes
Martinelli	A016625	Licensed	10471	9	yes
Martinelli	A031022	Pending	na	200	no
Universal Portfolio, ltd	S019753	Claimed	na	0	yes
Universal Portfolio, ltd	A031818	Pending	na	124	no
Oxfoot	A029166	Permitted	20330	245	yes

Permitted – Authorization to develop a water diversion and use project. The right to use water is obtained through actual use of water within the limits described in the permit.

Licensed – After you have received a water right permit, constructed your project, and used water, we will inspect your project. If you have used water beneficially and if you comply with all of the conditions in your permit, you will be offered a water right license. The water right license is a vested right that confirms your actual use. If you have not used all the water allowed by your permit, or if you have used water unreasonably, you will receive a license for less water than your permit allowed. You will receive a license for only that water that has been reasonably and beneficially used.

State Div. of Land Use - Pre-1914 appropriative water right that is undecided by the courts.

Claimed - Describes pre-1914 water right.

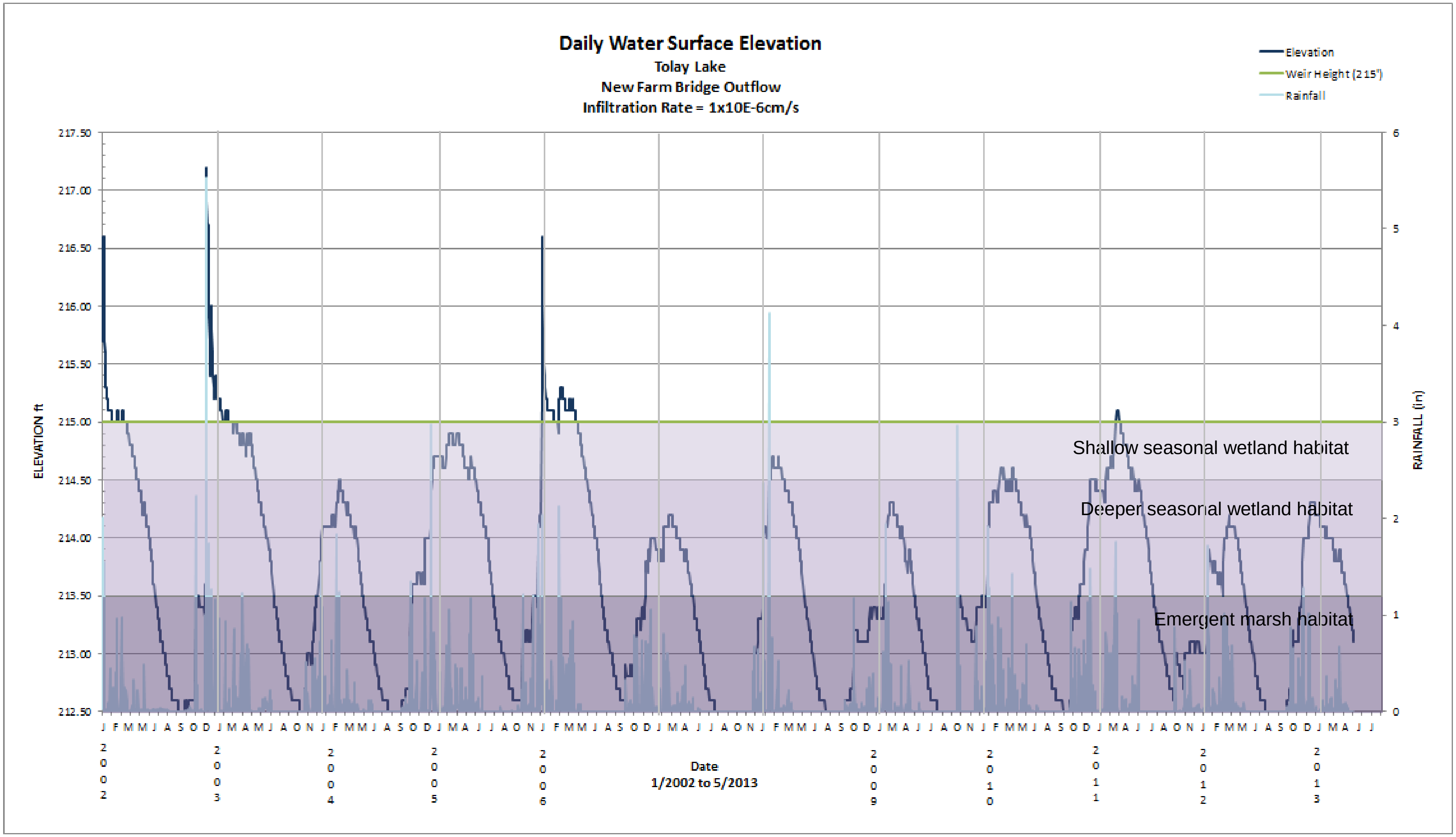

Figure 1. Daily Water Surface Elevation and Habitat for Restoration Alternative 1 – Lake Outlet at Elevation 215’.

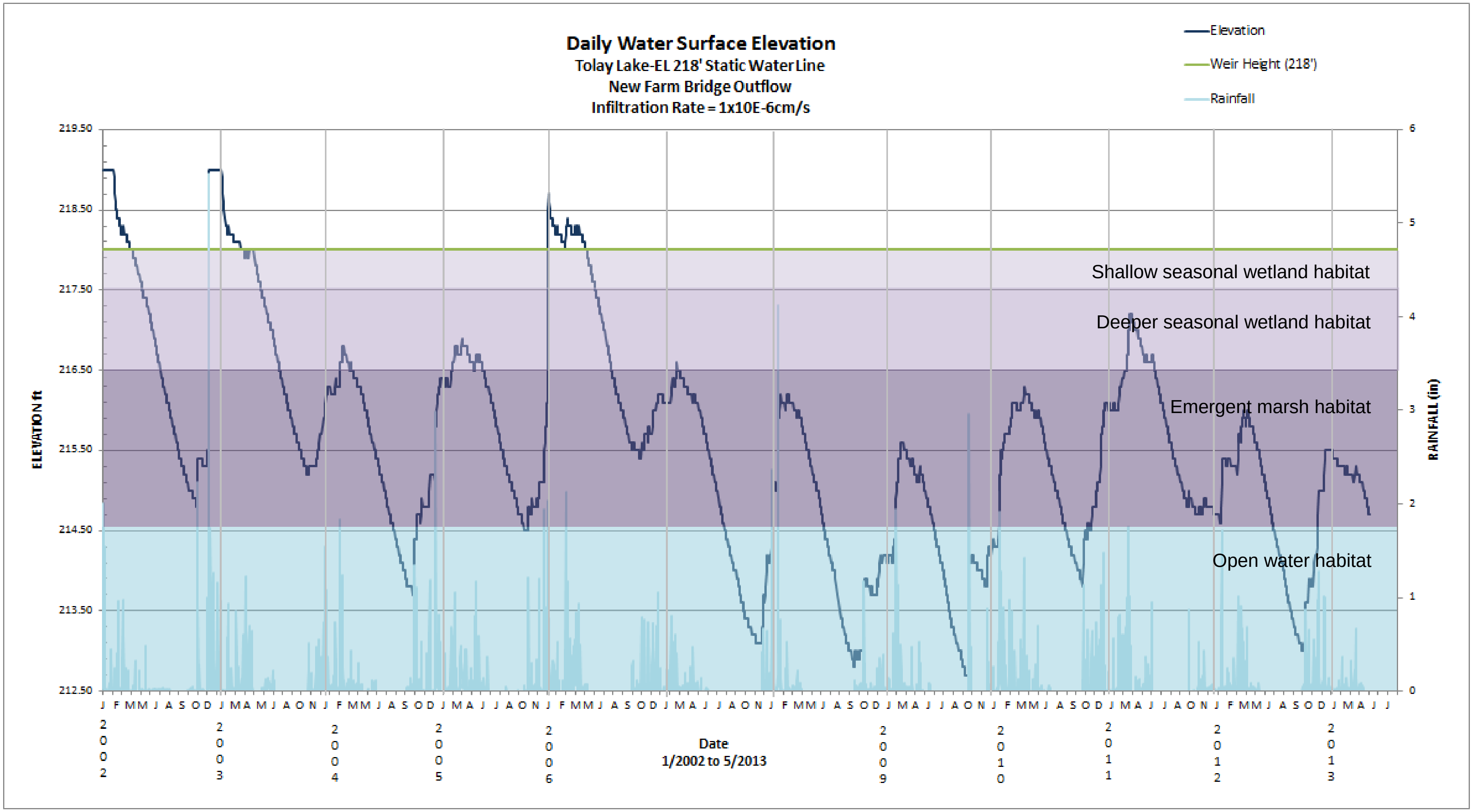

Figure 2. 12-year Daily Water Surface Elevation and Habitat for Restoration Alternative 2 – Lake Outlet at Elevation 218’

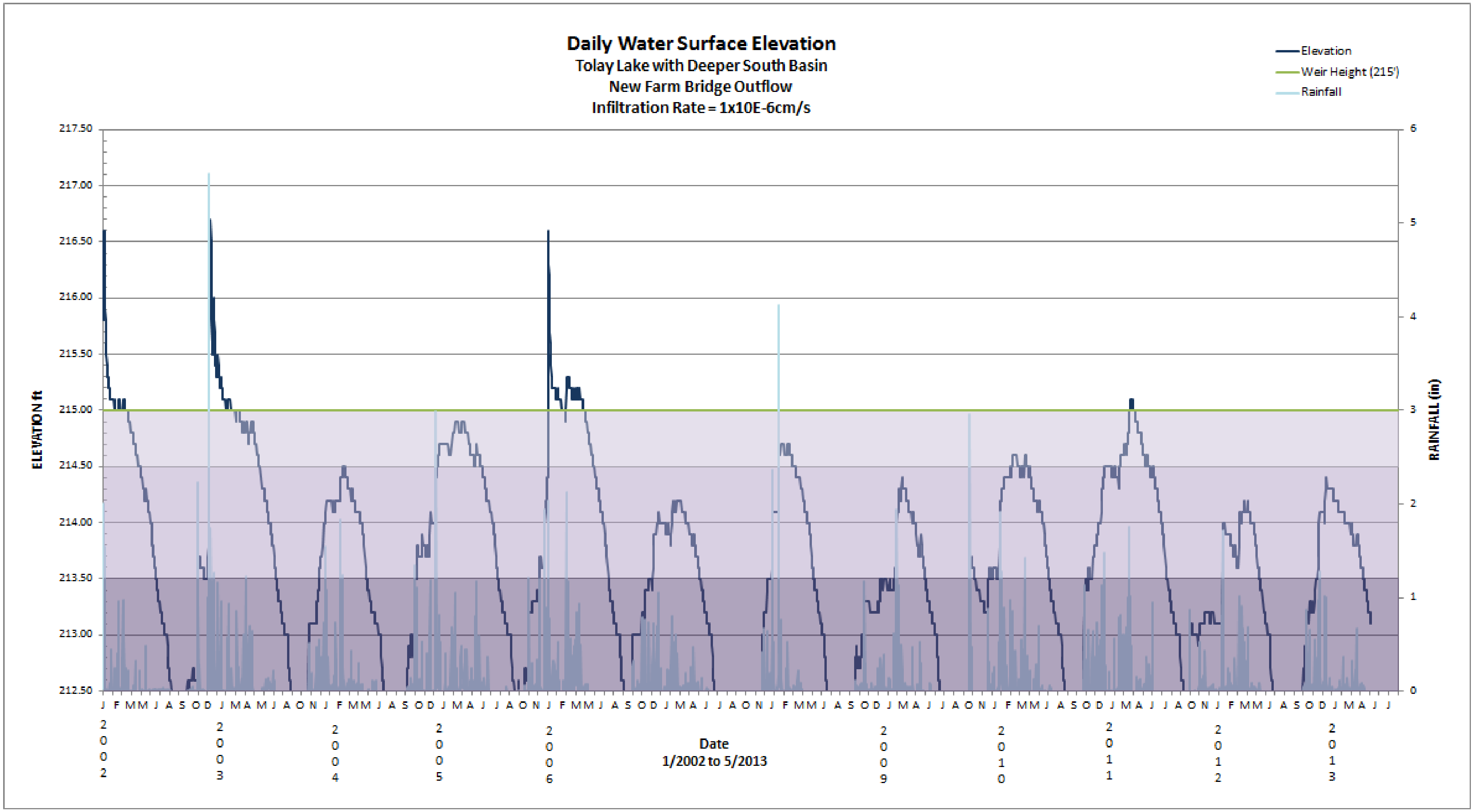

Figure 3. 12-year Daily Water Surface Elevation and Habitat for Restoration Alternative 5 – Lake Outlet Elevation at 215' with Enhancement of the South Basin

appendix h

Tolay Lake Conceptual Ecological Model for Restoration goals

Due to the nature and length of this appendix, this document is not available as an accessible document. If you need assistance accessing the contents of this document, please contact Victoria Willard, ADA Coordinator for Sonoma County, at (707) 565-2331, or through the California Relay Service by dialing 711. For an explanation of the contents of this document, please direct inquiries to Karen Davis-Brown, Park Planner II, Sonoma County Regional Parks Department at (707) 565-2041.

TOLAY LAKE
REGIONAL PARK
Master Plan Project

Lake Restoration Alternatives

ALTERNATIVE 1 – LAKE OUTLET AT ELEVATION 215 FEET.

Alternative 1 was evaluated because previous analysis indicated that this wetland size is in balance with the available water from the watershed and this alternative would not increase flooding on the adjacent upstream properties.

This alternative would maintain the elevation of the lake outlet at 215 feet for both the northwestern and southeastern segments of the lake. It would include reducing the frequency and duration of flooding by increasing the flow capacity of the causeway culvert, eliminating the horseshoe culvert, and increasing the cross-sectional area at the farm bridge. This alternative would establish a stable water elevation and reduce flooding. This alternative would have a maximum lake size and storage volume of 71.1 acres and 97.7 acre-feet, respectively.

ALTERNATIVE 2 – LAKE OUTLET AT ELEVATION 218 FEET WITHOUT A BACK-BERM.

Alternative 2 was evaluated to find out if the watershed can support a wetland of this size and storage capacity. This alternative is likely not to be feasible because it would cause increased flooding on the adjacent upstream properties.

This alternative would raise the elevation of the lake outlet from 215 feet to 218 feet to increase the potential depth and size of the lake. The lake, when full, would extend onto the upstream adjacent properties. The County would have to negotiate an agreement with the adjacent property owners and gain permission to increase flooding on their property. This alternative would have a maximum lake size and storage volume of 171.53 acres and 439 acre-feet respectively.

ALTERNATIVE 5 – LAKE OUTLET AT ELEVATION 215 FEET WITH ENHANCED SOUTHEAST BASIN.

Alternative 5 was evaluated because it represents an opportunity to restore and enhance the wetlands in the southern portion of the lake without increased flooding on the adjacent upstream properties. This alternative would not increase the amount of storage water significantly and has the potential to be feasible given the limited amount of water available from the watershed. This alternative does include grading within the southern portion of Tolay Lake, which may not be desirable if there are a significant amount of archeological resources in the area.

This alternative would maintain the elevation of the lake outlet at 215 feet for both the northwestern and southeastern segments of the lake. It is like Alternative 1 but includes increasing the size of the lake and enhancing the hydrology of the southeastern segment of the lake by lowering the bottom elevations in this area from 216 feet-217 feet to 214.5 feet. This alternative would result in the establishment of a stable water elevation and high quality wetland habitat on both sides of the causeway. The southeastern segment of the lake may contain buried archaeological artifacts, which may make grading in this area undesirable. This alternative would have a maximum lake size and storage volume of 93.3 acres and 115.5 acre-feet respectively.

Water Budget Analysis

The *Water Budget Analysis* incorporated site specific information regarding water rights, topography, soils, precipitation, inflow, outflow, and evapotranspiration (WRA 2014). In addition, the report calculated the resulting size and annual frequency of inundation (the percentage of years with adequate inundation) of each of the target wetland habitat types (shallow seasonal wetland, deeper seasonal wetland, emergent marsh, and open water) for each restoration alternative. See Table 5-5 for a comparison of terms used throughout this chapter.

The following table compares the nomenclature used to classify the historic and target wetland habitat types within these documents to the standard *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al., December 1979). The nomenclature is ordered from the outer lake fringe to the inner lake bed.

Table 1 Comparison of Wetland Habitat Nomenclature

Baye Habitat Nomenclature	WRA Habitat Nomenclature	Cowardin Habitat Nomenclature
Vernal pool	N/A	Palustrine Emergent Persistent Temporarily Flooded (PEM1A)
Vernal (Seasonal) marsh wetlands	Shallow Seasonal Wetlands, Deeper Seasonal Wetlands	Palustrine Emergent Persistent Seasonally Flooded, Seasonally Flooded / Saturated (PEM1C, PEM1E)
Perennial emergent freshwater marsh	Emergent Marsh	Palustrine Emergent Persistent Semi-permanently Flooded (PEM1F)
Submerged aquatic vegetation beds (SAV), Floating aquatic vegetation (FAV)	Open Water	Aquatic Bed Rooted Vascular/Floating Vascular/Palustrine Emergent Persistent Permanently Flooded (AB3,4/PEM1H)

WATER BUDGET RESULTS FOR ALTERNATIVE 1 – OUTLET ELEVATION AT 215 FEET

The analysis showed that this alternative could support shallow seasonal wetland, deeper seasonal wetland, and emergent marsh habitat types, but would have limited to no open water habitat. Results of this evaluation, based on 50 years of water records, are summarized in Table 5-6 (which includes all three lake restoration alternatives). For daily water surface elevation data, see Appendix F, “Technical Memorandum – Water Budget Analysis, Tolay Lake Restoration Alternatives”; WRA, November 11, 2014. Table 5-6 indicates that:

- Shallow seasonal wetland habitat would be inundated in 42% of the years;
- Deeper seasonal wetland habitat would be inundated all years;
- Emergent marsh habitat would be sufficiently inundated in all years;
- There would be no open water habitat because the lake is too shallow.

The upper margins of the shallow seasonal wetland habitat may be invaded with upland plants in times of prolonged drought but that all three of the target habitats (shallow seasonal wetland, deeper seasonal wetland, and emergent marsh) will be present and relatively well supported by the expected hydrology.

Another consideration when comparing the alternatives is the amount of habitat that can be supported in each scenario. Figure 5-13 illustrates the habitat area that will be present under Alternative 1. This shows that there will be:

- 11.29 acres of shallow seasonal wetland;
- 29.77 acres of deeper seasonal wetland;
- 34.04 acres of emergent marsh;
- There is no open water habitat because the lake is too shallow;
- Total area of viable wetlands is 75.1 acres.

WATER BUDGET RESULTS FOR ALTERNATIVE 2 – OUTLET ELEVATION AT 218 FEET WITHOUT A BACK-BERM

The analysis showed that this alternative would have less stable hydrology with reductions in the annual inundation frequencies in the shallow seasonal wetland, deeper seasonal wetland, and emergent marsh habitat types, which could result in lower quality wetland habitat and a higher percentage of weeds. Table 5-6 indicates that:

Shallow seasonal wetland habitat would be inundated in 27% of the years;

- Deeper seasonal wetland habitat would be inundated in 29% of the years;
- Emergent marsh habitat would be inundated in 83% of the years;
- Open water habitat would be inundated in all years;
- Bare ground will be exposed in 66% of years as Tolay Lake dries down in late summer.

It is possible that the seasonal wetland habitat could shift downward; however, this is unlikely because when the lake fills in 27% of years, the wetland plants would most likely be drowned in the deeper water. This scenario is most likely to result in low quality seasonal wetlands with a high percentage of non-native weeds. Open water would be present and relatively well supported by the expected hydrology; however, more bare ground will be present in most years at the end of the summer.

Figure 5-14 illustrates the habitat area that would be present under Alternative 2. This shows that this scenario has the potential to have:

- 26.7 acres of shallow seasonal wetland habitat (although the hydrology does not support it);
- 32.4 acres of deeper seasonal wetland habitat (although the hydrology does not support it);
- 48.62 acres of emergent marsh;
- 63.81 acres of open water habitat (or bare ground in some summers);
- Total area of viable wetlands is 112.43 acres;

WATER BUDGET RESULTS FOR ALTERNATIVE 5 – OUTLET ELEVATION AT 215 FEET WITH ENHANCED SOUTH BASIN

The analysis showed that this alternative has almost the same water surface elevation as the existing conditions; however, this alternative substantially increases the acreage of the deeper seasonal wetland by approximately 17 acres. In addition, there would be sufficient hydrology to support shallow seasonal wetland, deeper seasonal wetland, and emergent marsh habitats. Table 5-6 indicates that:

- Shallow seasonal wetland habitat would be inundated 42% of the years;
- Deeper seasonal wetland habitat would be inundated all years;
- Emergent marsh habitat would be sufficiently inundated in all years;

- There would be no open water habitat because the lake is too shallow.

The upper margins of the seasonal shallow zone may be invaded with upland plants in times of drought but that all three of the target habitats would be present and relatively well supported by the expected hydrology of Tolay Lake with a static water line at an elevation of 215 feet.

Another consideration when comparing the alternatives is the amount of habitat that can be supported in each scenario. Figure 5-15 illustrates the habitat area that would be present under Alternative 5. Alternative 5, while it has nearly the same hydrology as Alternative 1, supports more area of seasonal wetland habitat. Habitat acreages would be the following:

- 11.86 acres of shallow seasonal wetland;
- 47.4 acres of deeper seasonal wetland;
- 34.03 acres of emergent marsh;
- There is no open water habitat because the lake is too shallow;
- Total area of viable wetlands is 93.29 acres

Table 2 Results of the Water Budget Evaluation for Three Restoration Alternatives

Restoration Alternative	Storage Volume (acre-feet)	Area (acres)	Percent Year with Inundation (%)	Potential Adverse Impact on Existing Habitat	Potential Insufficient Hydrology on Proposed New Habitat
Lake Outlet at Elevation 215’	97.7	71.1			
Shallow Seasonal Wetland		11.3	42%	None	None
Deeper Seasonal Wetland		29.8	100%	None	None
Emergent marsh		34.0	100%	None	None
Open Water		None	N/A	N/A	N/A
Lake Outlet at Elevation 218’	439	171.5			
Shallow Seasonal Wetland		26.7	27%	Yes - relocated	Yes
Deeper Seasonal Wetland		32.40	29%	Yes - relocated	Yes
Emergent marsh		48.62	82%	Yes - relocated	Yes
Open Water		63.81	100%	No	No
Lake Outlet at Elevation 215’ w/ Enhanced South Basin	115.5	93.3			
Shallow Seasonal Wetland		11.9	42%	None	None
Deeper Seasonal Wetland		47.4	100%	None	None
Emergent marsh		34.0	100%	None	None
Open Water		None	N/A	N/A	N/A

Figure 5-13
Target Habitats - Restoration Alternative 1

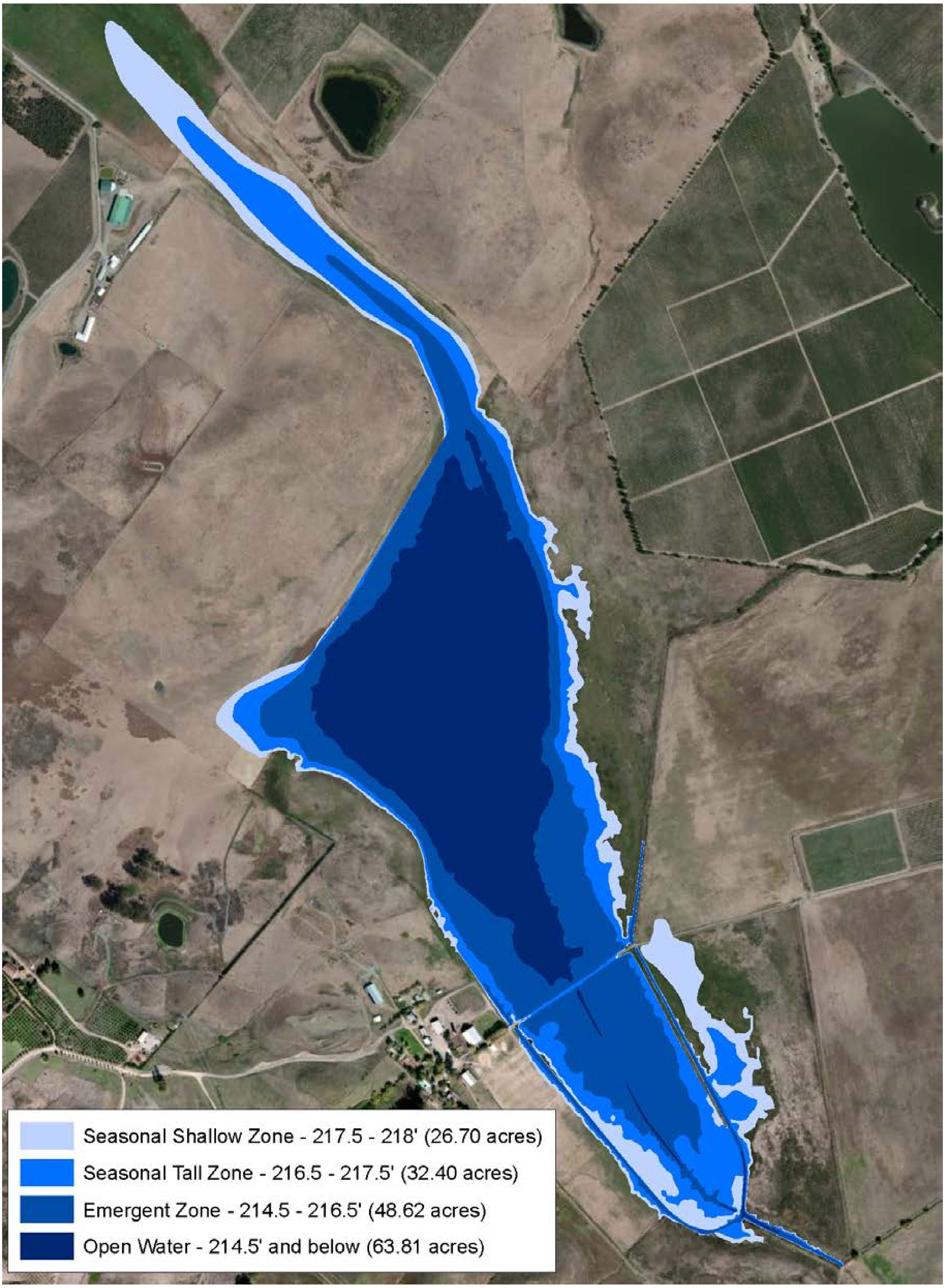

Figure 5-14
Target Habitats - Restoration Alternative 2

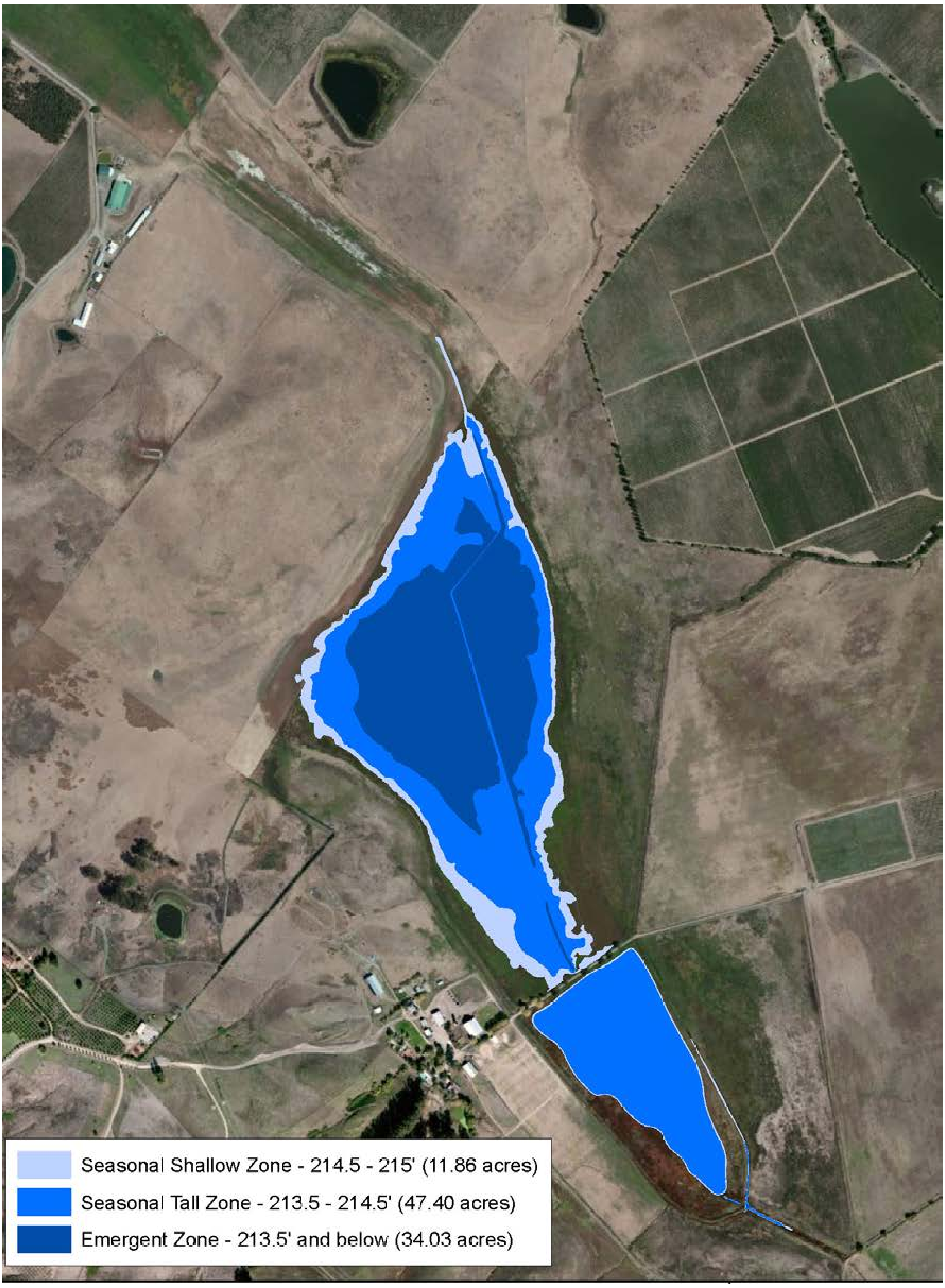

Figure 5-15
Target Habitats - Restoration Alternative 5

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Draft final MEMORANDUM

To: John Baas **MIG, Inc.** Berkeley, California 94710 johnb@migcom.com,
Steve Ehret, Sonoma County Regional Parks Steve.Ehret@sonoma-county.org

Date: July 28, 2014

SUBJECT: Tolay Lake conceptual ecological model for restoration goals; synthesis of regional reference systems, hydrology, vegetation, ecosystem processes.

John, Steve:

This memorandum responds to your request for a supplementary conceptual ecosystem model for a pre-agricultural (late Holocene, Coast Miwok influenced) Tolay Lake. The scope of the memorandum includes, as discussed in our July 2 phone meeting:

- Ecosystem conceptual model – system potential & restoration goals based on regional analog reference systems
- Habitat relative values – goals
- Biological benefits, impacts, risks, opportunities
- Design alternatives – recommendations for water budget model and analysis

1. Wetland and seasonal lake typology: hydrology, vegetation, and terminology

The first step in establishing a valid conceptual ecosystem model for Tolay Lake is to classify it correctly within a spectrum of California wetland and aquatic ecosystem types, and distinguish it from largely artificial permanent lakes and reservoirs (impoundments mostly stocked with fish) in the region. Otherwise, unconscious concepts and goals based on basically dissimilar permanent lake ecosystems may inappropriately influence restoration goal-setting for Tolay Lake.

Tolay Lake is inherently an intermittent perennial to seasonal lake, subject to recurrent, extensive lakebed emergence (drawdown) during prolonged or severe droughts. Droughts in the Bay Area during the late Holocene lasted from decades to centuries, punctuated by extreme floods and relatively benign, moderate climates relative to the historical period (Malamud-Roam et al. 2007). Tolay Lake was very likely a naturally fishless lake because of hydrologic isolation from fish dispersal corridors and episodic drawdown to emergent marsh during droughts. This condition would promote an amphibian and invertebrate-dominated aquatic trophic structure. The aquatic and wetland habitat/vegetation types within Tolay Lake were likely highly variable over climate cycles, including a gradient with vernal pool and vernal (seasonal) marsh wetlands, perennial emergent freshwater marsh, and submerged aquatic vegetation beds (SAV). It may have also included, at least intermittently, some floating aquatic vegetation (FAV). The nature of these aquatic ecosystems is highly fluctuating, with episodic, recurrent extremes of wetness (deeper lakes with consecutive years of wet, flooded conditions) and dryness (emergent seasonal wetlands prevalent, short-hydroperiod, shallow flooding). Hydrological extremes, and their ecological consequences (strong fluctuations in populations, community composition) are natural, and inherent features of the ecosystem, and not "pathological" or adverse conditions to mitigate with "restoration" designs for artificially enhanced stability.

The lake's shallow margins on Clear Lake clay loam flats probably included extensive vernal pool habitats. Indeed, the intermittent perennial/seasonal lake overall may be viewed in the long term as an extremely large and deep vernal pool (vernal lake) grading into to perennial lake and SAV habitat during its wettest phases -- rather than as a small or impaired permanent lake. Vernal lake habitats (Helm 1998) are similar to vernal pools, but occur in larger (>8 acre) deeper basins flooded by surface inflows in winter-spring, with emergent and dry (desiccated) soils in summer most years. Vernal lakes of the Central Valley supported foraging habitat for large populations of migratory waterfowl (Medeiros 1976). Vernal pools are distinguished by generally impermeable substrates, relatively low nutrient and sediment inflows (due to small watersheds and low gradients), high percentage annual specialist amphibious plant species and invertebrates (Keeley & Zedler 1998). Vernal pool hydrology is distinguished by summer soil desiccation phase, and normally insignificant watershed runoff (primary precipitation-driven hydrology most years. Vernal pools contrast with vernal (to seasonal) marsh, a related (and sometimes intergrading) seasonal wetland type distinguished by later emergence (drawdown) in spring to summer, emergent soils saturated to moist by summer (gradually drying to fall), and larger watersheds with significant runoff inflow. Vernal marsh vegetation consists of high percentage generalist perennial marsh species that undergo summer-dormant dieback.

At the wetter end of the spectrum, freshwater emergent marsh is characterized by permanently flooded to saturated wetlands most years, vegetated by tall emergent grass-like to broadleaf herbaceous plants. Freshwater marsh in California is generally restricted to water depths shallower than approximately 3 ft for most of the growing season. At the wettest end of the spectrum submerged aquatic vegetation (SAV) beds can occupy open water areas of variable depth (depending on water clarity), in the absence of emergent marsh. Similarly floating aquatic vegetation (FAV) can occur in sunlight exposed open freshwater water of nearly any depth, and can colonize relatively ephemeral waterbodies. SAV and FAV habitats may be permanent deepwater features, or intermittent, recolonizing during wet climate cycles after droughts have reduced freshwater marsh, or when freshwater marsh becomes excessively submerged.

2. **Recent descriptive accounts of fluctuating hydrology of intermittent/seasonal lakes in Sonoma County: physical drivers of aquatic ecosystems**

Rubtzoff (1976) plainly described the seasonal (winter-spring) lake hydrology of two intermittent lakes in Sonoma County in relation to their wetland vegetation in the 1970s, both within historical or active agricultural settins (ranching and farming), like Tolay Lake: "Bennett Mountain Lake" (now Ledson Marsh, Annadel State Park) and Laguna Lake of Chileno Valley (Sonoma-Marin border). These are among the few semi-natural analogs of Tolay Lake, which may be used as partial reference lake ecosystems. Rubtzoff's (1976) accounts of intermittent southern Sonoma County lakes describe extensive wetland lake beds that grade from vernal pool-like summer-desiccated flats, to later-emerging, moister seasonal marsh, and core areas of perennial saturated or flooded freshwater marsh:

> Like Boggs Lake [Lake County], the entire area [of Ledson Marsh] is normally flooded in winter, but in the summer only central parts contain water, being surrounded by extensive marshy ground. Peripheral areas dry up completely, and they are the ones that exhibit a rich vernal pool flora. In some summers the entire lake dries up, but…[1974-1975].it still had much water even in late summer.

Laguna Lake's seasonal hydrology was described by Rubtzoff (1976) when it was still being drained for corn farming, which ceased in 1991 (RWQCB 2001):

> Most of the area is a winter lake over 1 mile long and ½ mile wide. In the course of the summer it dries up, exposing extensive muddy flats, but usually does not dry up completely until late summer, leaving just a strip of moist mud with a stand of tules in the middle. A more permanent lake in the southern part of the area, in Marin County, may be partly artificial. The area is under heavy agricultural use, being plowed regularly as water recedes and the exposed mud dries. Nevertheless, a vernal pool flora has time to develop before plowing….

In addition, Rubtzoff (1976) described a seasonal pond near the mouth of Tolay Creek on Yenni Ranch, on the east side of Highway 121, also supporting a zoned wetland of vernal pool vegetation grading to freshwater perennial marsh (tule, cattail, water-potato/arrowhead species).

Rubtzoff's descriptive accounts of intermittent lakes and seasonal ponds in southern Sonoma County are consistent with Kamman's (2003) characterization of the pre-agricultural hydrology of Tolay Lake. Kamman determined that the original natural sill spillway (natural dam outlet at the downstream end) of the lake, probably a bedrock feature at least in part, was 14 ft above the lowest lakebed elevation (flat fields), indicating the maximum potential depth of lake flooding in wet years prior to dam breaching for agricultural drainage in the late 19th century (Florsheim 2009).

The episodic emergence of the lakebed during droughts, and the natural disconnection of the lake from potential fish dispersal habitat, indicates that the lake was normally fishless, which indicates that the trophic structure of the lake was essentially like a large vernal pool. A large algal and detrital invertebrate grazer community (crustaceans [ostracods, copepods, cladercerans, large branchiopods], and insects, with higher species richness than permanent lakes; Simovich 1998, Helm 1998). The invertebrate-dominated lake, free from perennial poulations of aquatic predators, would likely support abundant amphibians (frogs, salamanders, newts), wading bird predators of amphibians, and waterfowl grazers of seed, submerged aquatic vegetation, and insect larvae. This inference is consistent with local vernal pool fauna observations: in the adjacent Sears Point watershed south of Tolay Creek, reconnaissance-level aquatic dip-net surveys of adjacent Sears Point sag ponds and swale pools in high rainfall winters of 2005-2006 detected rich vernal pool invertebrate communities, including seed shrimp (Ostracoda), copepods (Copepoda), water fleas (Cladocera), predaceous diving beetles (Dyticidae), water boatmen (Corixidae), chironomid larvae (Chironomidae), snails (Lymnaeidae), flat worms (Microturbellaria), and California clam shrimp (*Cyzicus californicus*) (Wetlands and Water Resources *et al.* 2005). Strong grazer-dominant food chains of seasonal fishless ponds and lakes are associated high water clarity and low abundance of algae. The introduction of fish predators of microzooplankton and invertebrate algal grazers in naturally fishless lakes, in contrast, are associated with high turbidity and abundance of microalgae and cyanobacteria (Eilers *et al.* 2007) – a fundamental principle of lake biomanipulation to improve water quality (Mehner *et al.* 2004, Kasprzak *et al.* 2004)

Kamman's (2003) caveats about the inherently variable intermittent to seasonal lake hydrology under all restoration alternatives deserve emphasis in the conceptual ecological model and restoration goals. Familiar perennial artificial lakes (reservoirs like Lake Sonoma or Lake Mendocino) are not valid models for Tolay Lake ecological goals or restoration designs:

> …a lake whose water level and area of inundation will fluctuate dramatically seasonally and between wet and dry year-types. This will lead to unique challenges in the planning and design of revegetation efforts in and around the lake. These results are also important from the context of educating stakeholders and the public of the highly dynamic lake and wetland conditions that will exist under any restoration alternative. It will be important to emphasize that many recreation activities such as boating and swimming may not be possible (or seasonally limited) due to the limited size and depth of the restored lake (Kamman 2003).

3. Regional Tolay Lake Analogs: Descriptive Accounts of Reference Ecosystems – Intermittent Perennial/Seasonal Lake of Southern Sonoma County

The conceptual model for a natural, restored Tolay Lake is rooted in comparative geography of partially analogous seasonal/intermittent lakes in southern Sonoma County, which have climate, soils, and flora, as well as land use history comparable with Tolay Lake. As an array, they bracket the spectrum of potential lake hydrologic features (depth-duration curves, maximum depths, annual variability). They are reviewed here to flesh out the conceptual model, and illustrate some key ecological attributes that may be instructive for restoration goals and designs.

Chileno Valley Laguna Lake, Sonoma/Marin County

Chileno Valley's Laguna Lake (Marin/Sonoma Counties, south of Petaluma; upper Chileno Creek watershed) is a natural intermittent lake which is now mostly perennial in its lower reaches, following cessation of agricultural drainage for corn farming that was discontinued in 1991 (RWQCB 2001). The lake is privately owned, and largely inaccessible. The deepest, downstream end of the lake (tributary to Chileno Creek) even in the extreme drought of 2014 was predominantly open shallow water and abundant submerged aquatic vegetation (SAV; small pondweed, *Potamogeton pusillus,* dominant), narrowly fringed by freshwater emergent marsh around the ordinary high water shoreline (dominants: bur-reed, *Sparganium eurycarpum*; smartweeds, *Persicaria* spp.; water-parsley, *Oenanthe sarmentosa*; hardstem tule, *Schoenoplectus acutus*). Cattle-grazed hillslope grassland and local, peripheral riparian scrub stands border the lake. The abundant native submerged pondweed vegetation and fringing perennial marsh appear to have developed in the two decades since active drainage and farming of the lakebed ceased just over two decades ago, indicating rapid succession and wetland recovery even in the absence of active restoration.

The water quality of the lower Laguna Lake is noteworthy, given its agricultural history's similarity with Tolay Lake (farmed, drained lake bed, ongoing cattle ranching in uplands). The perennial lower lake has high water clarity and abundant SAV, and absence of abundant algal mats, despite the legacy of fertilizer-intensive (high nitrogen, phosphorus) corn farming, and the continued prevalence of cattle ranching in the entire watershed (manure/urine runoff). This suggests that light and nutrient competition from SAV, denitrification in organic-rich submerged anoxic soils, and aquatic trophic structure (well-developed algal grazer community) has established and maintained relatively high water quality, despite past concerns about potential excessive ammonium (RWQCB 2001).

Wildlife data are not available for the privately owned Laguna Lake, but it evidently supports wetland and waterbird communities (wading birds, dabbling ducks, and swallow foraging above the lake), and frogs (P. Baye, pers. observ. 2014). The lake lies within the Marin core area (Walker Creek hydrologic sub-area) of the California red-legged frog recovery plan (USFWS 2002). Based on roadside shoreline sampling, the extensive small pondweed vegetation of the lower lake appears to be one of the largest, if not largest stand of the species in the Bay region, and covers almost the entire lower lake. Abundant production of small pondweed fruits, and rich aquatic invertebrate communities within submersed pondweed canopies, indicates high potential wildfowl foraging habitat, as well as potential

California red-legged frog breeding and foraging habitat. Relatively deep-water marsh edges with dense smartweed (*Persicaria*) floating mats also indicates extensive potential microhabitats favorable for bullfrogs (Cook and Jennings 2007). No floating aquatic vegetation common to the Point Reyes peninsula (*Hydrocotyle ranuncuoides*, water-pennywort, sometimes superabundant in stock ponds) appears to occur at Laguna Lake (Howell *et al.* 2007, P. Baye pers. observ.). The wetland plant species richness of Laguna Lake and its peripheral Chileno Valley wetlands is high, and includes many regionally uncommon to rare species (Howell *et al.* 2007), including intermediate form of Suisun aster (*Symphyotrichum lentum*), an arrowhead species (*Sagittaria brevirostra*), and burhead (*Echinodorus berteroi*).

Laguna Lake may represent an analog of the wetter end of the spectrum of potential Tolay Creek restoration alternatives, with low frequency of complete lakebed emergence or drying, and high frequency of consecutive years with perennial ponding. It was treated, however, as part of the "vernal pool" spectrum in a statewide classification (Keeler-Wolf et al. 1998:37). The agricultural land use and drainage history appears to be very similar to Tolay Creek, so the two decades of wetland and aquatic community succession following cessation of artificial drainage and farming provide a relevant point of reference for rates of spontaneous lake restoration.

Laguna Lake, Chileno Valley, Marin County (downstream end), July 2014. Small pondweed SAV beds occupy all water surfaces lacking ripples/wind-waves; narrow fringing freshwater marsh is mostly hardstem tule, bur-reed, cattail, water-parsley, and smartweed.

Ledson Marsh – Annadel State Park, Sonoma County

In addition to Rubztoff's (1976) descriptive account of Ledson Marsh with emphasis on wetland vegetation, Cook (1997) investigated habitat structure and California red-legged frog habitat of the artificially impounded seasonal marsh and pond (constructed 1930s) in interior southern Sonoma County. The 27 acre marsh/seasonal pond had a maximum water depth of approximately 1.5 m (approximately 5 ft) in the late 1990s (El Niño phase), a depth within the range of some restoration alternatives for Tolay Lake. Dominant freshwater marsh vegetation includes tule, cattail, and spikerush (*Eleocharis macrostachya*), with water-plantain (*Alisma triviale*), smartweed (*Persicaria* spp.), and Lobb's aquatic buttercup (Cook 1997). Extensive standing litter of spikerush and cattail vegetation (dead, matted shoots), were preferred sites of egg mass deposition by California red-legged frogs. The seasonal hydrology of Ledson Marsh – characterized by late summer drawdown, and only small residual areas of persistent shallow flooding or none – favored California red-legged frog reproduction over invasive non-native predator bullfrogs. This was due to the completion of larval-adult metamorphosis in one season by California red-legged frogs, and the requirement for two consecutive years of flooding for maturation of most bullfrogs larvae to adults (Cook 1997). Recurrent drawdown of the seasonal pond/lake impoundment was an important limiting factor in the size of the bullfrog population and its competitive and predator-prey interactions.

Tolay Creek Delta margin: seasonal ponds of subsided diked nontidal baylands

The aggraded, avulsed delta of Tolay Creek has discharged into diked baylands at the historic transition zone of terrestrial delta lowlands since the El Niño (ENSO; El Niño Southern Oscillation Cycle) event of the late 1990s (P. Baye, pers. observ., unpubl. data). This has resulted in episodic deep (2-3 ft) flooding of freshwater in winter and spring, with variable drawdown to emergent mud from spring to late summer, along elevation gradients from uplands to railroad embankment/dikes. The wetlands of this complex span Clear Lake clay loam (soil series at Tolay Lake) and similar but more brackish drained Reyes series (historical tidal marsh). The wetland vegetation gradient of this Tolay Delta wetland includes alkali grassland and vernal pool flats (on hard-packed Clear Lake clay, upper elevation range with shallow flooding), wet meadow (creeping wildrye, rushes, and basket sedge on silty-clay floodplain deposits, shallow-flooded in winter), and intermittent oligohaline marsh (spikerush-lanceleaf water plantain-hardstem tule, in wet El Nino years; subject to dieback in droughts), as well as diked brackish pickleweed marsh. Rubtzoff (1976) description of seasonal pond near the mouth of Tolay Creek on Yenni Ranch (east side of Highway 121) probably corresponds with this location, or a similar past equivalent. The wetland is owned by California Department of Fish and Wildlife, and developed without active management or restoration, due to channel avulsion and sedimentation in the delta during high discharge ENSO events of 1997-98 and again in 2005-2006. This seasonal pond vegetation represents the wetland seed and propagule rain of the Tolay Creek watershed over a period of decades when seasonal ponding of Clear Lake clay (and similar clays) occurred to a depth of up to several feet. This wetland provides a partial and proximate analog of the shallower spring-summer emergent zones of Tolay Lake's bed. The rapid invasion of the marsh by non-native lanceleaf water-plantain (*Alisma lanceolatum*) during wet ENSO phases is noteworthy.

May 2013 – Infineon overflow parking flats, N of CDFW Tolay entry road, within the Tolay Ck Delta wetland complex. About 2 acres of *Downingia pulchella*, native vernal pool wetland wildflower with amphibious life-cycle. Co-occurs with subdominant native vernal pool associate, *Lasthenia glaberrima*. Flooded about 1 ft deep in winter from rainfall and creek overbank flows.

May 2013. *Lasthenia glaberrima*, a "wetter" species of goldfields, is abundant in seasonally flooded flats and gaps in seasonal marsh of the Tolay Creek delta. Infineon overflow parking flats, N of CDFW Tolay entry road.

May 2013. Infineon overflow parking flats, N of CDFW Tolay entry road, within Tolay delta wetland complex. Spikerush (*Eleocharis macrostachya*) seasonal marsh spreads into algal-matted clay flats during drawdown of seasonal shallow pond, analogous with seasonal lakebed.

May 2013. Young, vigorous spikerush marsh dominates margins of seasonal shallow pond with algal mat bed exposed during drawdown in drought year. Note patchy *Downingia* at edges. Infineon overflow parking flats, west end N of CDFW Tolay entry road, within Tolay delta wetland complex.

May 2013. CDFW Tolay seasonal marsh within delta lobes; east. Mature spikerush meadow transition to wet meadow dominated by native rushes (*Juncus balticus)* and grasses (*Elymus triticoides*) within delta floodplain.

May 2013. CDFW Tolay seasonal marsh within delta lobes; east. Wet meadow composed of native perennial grasses (*Elymus triticoides*, *E.*× *multiflorus*), rushes, and sedges now dominate many silty clay flats along the delta and its margins. They are taller than nonnative invasive ryegrasses (*Festuca perennis*) and are able to outcompete them here. Willows in background mark channel distributaries.

May 2013 – CDFW Tolay/Infineon parking flats. Inconspicuous rare native peppercress, *Lepidium oxycarpum*, in alkali clay flats on Clear Lake clay loam on seasonally desiccated delta margins. Overlooked among the "weeds".

May 2013 – CDFW Tolay seasonal marsh, south. Lemmon's canary-grass (*Phalaris lemmonii*), a regionally rare annual native grass of seasonal wetland meadows, occurs in the Tolay Delta wet meadows; it formerly grew in Sears Point baylands that are being restored to tidal marsh.

April 2005 – CDFW Tolay seasonal marsh, south end of Tolay Delta wetland complex. Wet year forms shallow seasonal lake over spikerush meadow. Note tules in depressions, background. Waterfowl use of the flooded meadow is significant due to invertebrate and seed foraging resources.

Late March, 2006 – Flooded CDFW Tolay seasonal shallow lake flats (later *Downingia* wildflower fields) from avulsed delta flooding.

April 2005. Flooded CDFW Tolay seasonal marsh, local dominance by non-native invasive *Alisma lanceolatum*.

Reference systems considered but rejected

Cunningham Marsh and Pitkin Marsh in southwestern Sonoma County, and portions of the Laguna de Santa Rosa are remotely analogous with Tolay Lake, but have significant ecological differences that make them invalid as ecological models. The Laguna is connected to tributaries of the Russian River, and supports a fish community; it is also strongly perennial and supports riparian woodland and agriculture in a mixed urban/agricultural setting. Cunningham and Pitkin Marshes occur on sandy to sandy clay acidic soils (raised marine terraces with Goldridge and Blucher soils, in a matrix of woodland, forest, and riparian woodland vegetation). They have a distinct postglacial relic wetland flora that is not comparable with southeastern Sonoma County wetland flora. Permanent artificial lakes (reservoirs) stocked with predatory fish, including Lake Sonoma, Lake Mendocino, and the Mt. Tamalpais watershed impoundments, are negative, contrasting examples of lake ecosystems that fundamentally differ from the naturally intermittent to seasonal Tolay Lake ecosystem. Lakes and lagoons managed for artificially stable near-static water levels (whether low or high), such as Mountain Lake, Lake Merced, and Laguna Salada (San Francisco Peninsula) are also negative, examples of lake ecosystems contrasting with inherently dynamic seasonal lakes. The recreational and ecological attributes of these rejected, incompatible reference systems should not be reflected in Tolay Lake ecosystem restoration goals, and clarify by contrast the different ecosystem ecosystem type. This is significant because initial restoration goals for Tolay Lake emphasized larger lake area and volume and more "predictable consistent" hydrological conditions as goals. These "wetter/bigger as better" goals are may be appropriate for some permanent lakes with naturally low variability, but not for ENSO-sensitive seasonal to intermittent fishless lakes.

4. Narrative Conceptual Ecosystem Model of "natural" Late Holocene Tolay Lake.

The following section is an abbreviated, summary ecological conceptual model of a pre-agricultural ("natural" in the popular sense; influenced by Coast Miwok or paleoindian burning and hunting)

Hydrology and Water Quality

- **Alternating, unsteady state lake ecosystem driven by climate cycles and extremes**. Alternating hydrologic states, driven by long-term and short-term climate cycles (rainfall extremes; droughts, mega-floods; Malamud-Roam & *al.* 2007) would shift Tolay Lake between wet phases The lake would lack an "equilibrium", average, or steady-state ecosystem, and its dynamics between unsteady extremes would maintain a normal dynamic, disequilibrium condition of vegetation composition and structure.

- **Wetland/aquatic soil biogeochemical processes.** During wet phases, denitrification (net loss accumulated biologically available nitrogen) and carbon sequestration would be significant in anaerobic SAV bed and freshwater marsh soils. During droughts (increased frequency/duration wetland soil drainage), soil N would be nitrified and released from soil as available, elevated nutrients, and soil carbon would be released by decomposition)

- **Permanent fishless trophic structure: dominance by invertebrates and amphibians; wading birds top predators**. The naturally fishless intermittent lake would be dominated by invertebrates (crustaceans, insects) and microzooplankton grazers of algae. Suppression of algae would maintain high water clarity and water quality, and promote primary productivity through vascular plants (SAV and marsh vegetation). Absence of fish predators would promote high abundance of amphibians that can complete life-cycles in one season.

Vegetation

- **Dynamic aquatic and wetland/aquatic vegetation types, proportions, and internal distribution**. Proportions of vernal pool, seasonal marsh, freshwater marsh, and SAV beds would fluctuate with climate cycles. SAV beds and freshwater marsh would expand rapidly during wet cycles, when perennial shallow water or soil saturation occurs for multiple consecutive years. During extreme or prolonged dry phases, freshwater marsh and SAV would die back and become displaced by seasonal marsh tolerant of summer dry/marginally moist soil, or would become reduced to marginal or core areas (deepest depressions or local seeps, springs) where freshwater marsh may persist during extreme droughts. SAV and freshwater marsh may potentially collapse in extreme droughts, and re-establish rapidly from seed banks or seed rain. The overall plant community diversity of Tolay Lake would depend on high-amplitude fluctuation of dominant vegetation; alternating hydrology states (predominantly perennial-saturated/flooded; predominantly seasonal, summer-dry or desiccated) driven by episodic or cyclic climate extremes would prevent any one wetland plant community from becoming dominated by species most competitive in any one hydrologic regime. Vernal pool flora in particular would depend on shallow marginal lake flats undergoing frequent desiccation in summer. The SAV vegetation would depend on deep water re-occupying lakebed areas affected by drought-dieback zones of tall emergent freshwater marsh.

- **Herbaceous vegetation dominant**. Woody riparian vegetation at lake margins would likely have been limited by frequent (annual) burning during Coast Miwok occupation, as a result of annual post-harvest (pinole) grassland management and hunting drives using fire. Frequent or recurrent burning would likely select for grass-like or forb (herbaceous) vegetation, and limit riparian scrub to small groves, and limit oak woodland to isolated mature trees. Sedge beds would likely occur in seeps of lower hillslopes bordering the lake and along some lake margins.

Wildlife

- **Dynamic waterfowl and wading bird habitat**. During wet phases, SAV habitat would become available for both diving ducks and dabbling ducks in deeper water areas, when SAV canopies reach the water surface and provide foraging habitat (seed, herbage, invertebrates) at all depths; dabbler habitat would not be limited by water depth when SAV canopies are extensive. In dry phases (seasonal marsh), dabblers would be excluded in freshwater tall emergent marsh, and forage primarily in more extensive short wetland vegetation during submergence in winter-spring (seasonal marsh or vernal pool flats). Principal food items for dabbling ducks would shift with climate phases: chironomid midge larvae and seed and broadleaf forbs and spikerush from seasonal marsh [dry climate phase]; pondweed turion, tuber, and seed and smartweed seed [SAV and freshwater marsh, wet climate phase]). Tricolor blackbirds may nest in tall emergent freshwater marsh, or (limited) riparian scrub such as California rose stands. Dabbling ducks may nest in sedge beds and tall continuous canopies of wet meadow fringing the lake; breeding success may be limited by available brood water in summer during dry (extreme drought) phases. Wading birds would forage at shallow submerged margins of freshwater marsh or submerged seasonal marsh, preying on high amphibian populations.

- **Dynamic herpetofauna habitat**. The naturally fishless aquatic ecosystem would support large populations of amphibians with larval stages lasting only one water-year: Pacific chorus (tree) frog and California red-legged frog, California tiger salamander, and other salamander and newt species. Breeding habitat quality and extent would vary with the extent of shallow-submerged marsh. During wet phases with deep perennial water, western pond turtles would likely recolonize the intermittently perennial lake from channel pools in Tolay Creek.

5. Key predictions for Tolay restoration benefits and risks

Restoration of Tolay Lake in the modern setting (anthropogenically altered climate, biological communities, and land uses) cannot fully reassemble the pre-agricultural ecosystem structure, composition and dynamics of Tolay Lake. Restoration actions intended to have beneficial effects with respect to restoration goals may have intended consequences, some of which are foreseeable. A short list of caveats, based on predictions about alternative water management and restoration outcomes, is provided below to distinguish between two major approaches of lake restoration: maximizing the lake depth, hydroperiod to different levels while minimizing or buffering its variability ("predictable, consistent" conditions; WRA 2013); and maximizing the amplitude of natural hydrologic variability driven by climate cycles (alternating extremes of intermittent perennial lake and seasonally flooded emergent/dry lake over consecutive years).

The gist of this assessment is that attempts to manage the system to a set point or "benign" environmental conditions that avoid extremes is likely to cause long-term decline in ecosystem diversity and functions, and make the ecosystem more vulnerable to biological invasions (fish, bullfrogs) that would likely have cascading effects on biological diversity, water quality, trophic structure, vegetation and wildlife habitat quality, and management burdens.

5.1. Long-term marsh succession under relatively stable "predictable, consistent") managed annual flooding regimes.

Shallow (18-24") maximum winter-spring flooding

Lakebed areas subjected to relatively stable ("predictable, consistent") annual winter-spring shallow flooding to a depth of approximately 18" to 24" or more, followed by *prolonged slow emergence (drawdown) to saturated or moist soil during the summer in most years,* will likely result in *extensive dominance by relatively few competitive tall emergent freshwater marsh species such as tules, cattails, or bulrushes*, and *progressive reduction of open water areas* (submerged short wetland vegetation) over a period of 1-2 decades. Natural succession and dominance by tall emergent freshwater marsh would require artificial maintenance of shallow open water surface areas (vegetation removal) during winter-spring peak flood phases.

Lakebed areas subjected to relatively stable ("predictable, consistent") annual winter-spring shallow flooding to a depth of approximately 18" to 24", followed by with *rapid emergence (drawdown) by mid-spring and moist to dry soil conditions in midsummer* most years, will likely result in *extensive dominance by spikerush marsh or alkali-bulrush marsh*, with some marginal seasonal wetland areas dominated by rushes (Baltic rush, soft rush), sedges (basket sedge) or perennial creeping grasses (creeping wildrye). Spikerush marsh shoot canopies are relatively short and prone to matting, and are compatible with shallow open water surface areas during winter-spring flood phases. Alkali-bulrush marsh, in contrast, maintains persistent, tall canopies that may exclude shallow open water areas. The succession of alkali-bulrush marsh and spikerush marsh is influenced by many ecological factors other than average seasonal depth-duration flood curves and the timing of summer soil drying, and cannot be predicted by hydrology alone.

Deeper (24”-48”) maximum winter-spring flooding

Lakebed areas subjected to relatively stable (“predictable, consistent”) flood depths exceeding 2 ft, and less than approximately 3- 4 feet during most of the spring-summer growing season drawdown most years will likely become *progressively dominated by monotypic stands of tule or cattail*, and will permanently lose shallow open water or submersed aquatic vegetation (pondweed) habitat. (Some cattail-like species, such as bur-reed [*Sparganium eurycarpum*] may colonize the tule-cattail marsh zone, but have the same effect of displacing open water or aquatic plant habitat]. Cattail-tule marsh will persist (with declining density and height) during multi-year severe droughts if soil remains saturated to moist (not desiccated) through late summer.

Deepest (>48”) maximum winter-spring flooding

Lakebed areas subjected to relatively stable (“predictable, consistent”) flood depths exceeding 3-4 feet during most of the spring-summer growing season drawdown most years will likely become *progressively dominated by either mixed or monotypic stands of submerged aquatic vegetation (SAV; pondweeds and related aquatic plants) or open water surface area.* SAV will persist through multi-year severe droughts if soil is saturated to moist through late summer, and may even regenerate from seed or turions if desiccation occurs in late summer/fall, provided that emergent marsh vegetation does not displace it.

5.2. Long-term marsh succession under highly fluctuating (unpredictable, high magnitude variability) unmanaged annual flooding regimes: ENSO-driven hydrology and ecology. Freshwater marsh succession (cattail/tule marsh spread) would naturally be limited by both extreme deepwater conditions in wettest ENSO phases (dieback or density decline during submergence deeper than 4 ft for most of the growing season), and summer soil drying in long-term droughts. Encroachment of vernal pool flats by rush or spikerush during wet ENSO phases would also be limited by dieback during long-term droughts. Similarly, overabundance of native floating aquatic mat vegetation (water pennywort, *Hydrocotyle ranunculoides*) is limited by natural drought and marsh desiccation of the lakebed. High-amplitude hydrological variability of the lake ecosystem would maintain higher long-term plant community diversity compared with relatively stable or presumed “benign” moderate sustained near-average hydrological conditions.

5.3. Long-term prevalence of perennial open water and invasion risks. Artificial perennial ponds and lakes with frequent public visitation are subject to unauthorized introduction of fish, including deliberate stocking attempts and disposal of hobby aquarist pets. For example, the recent restoration of Mountain Lake (San Francisco), a naturally nearly fishless lake (but for threespine stickleback), involved removal of decades of accumulated large carp, goldfish, exotic pet fish, and even a 5 ft long sturgeon (Jonathan Young, Presidio Trust, pers. comm. 2014). Converting a naturally intermittent/seasonal lake to a managed, artificially stabilized perennial system facilitates invasion by introduced fish, and colonization and local population growth of bullfrogs dispersing from artificial stock ponds. Both bullfrogs and non-native fish population viability at Tolay Lake would naturally be limited by episodic drawdown and pool emergence during droughts. Introduced fish populations may increase the risk of converting a perennial lake to a eutrophic or hypereutrophic aquatic system with low water quality and nuisance (or toxic) algal/cyanobacterial blooms.

5.4. **Excavation and substrate type at the lake bed; paleoecological data loss; wetland steepened gradient**. Excavation as an alternative approach to achieving deeper water areas would differ from restoration of higher water surface stands:

- Exposure of mineral clay subsoils with low organic content at the lakebed surface would likely alter biogeochemical processes fueled by accumulated soil carbon, until organic detritus accumulates to sufficient amounts through the root zone of new freshwater marsh or SAV. The primary productivity and above-ground biomass of freshwater marsh may be significantly reduced in relatively infertile (low-carbon) excavated clay basins. The natural lakebed of Tolay Lake is composed of the A horizon of Clear Lake clay loam enriched by millennia of stored soil carbon, not B or C horizons with negligible carbon content. The slowest, lagging wetland restoration variable in the oldest known wetland restoration projects (1940s-1960s tidal marsh restoration) has been the recovery of soil carbon. Excavation should not be presumed to be ecologically equivalent to restoration of (intermittent) maximum water depths.
- The deep clay sediments at the downstream end of Tolay Lake probably contain data-rich and regionally unique paleoecological data (pollen, charcoal, phytoliths, isotopic signatures, etc.) that have not been sampled. The number of inland basins preserving long records of Holocene sediments and pollen are few in this region. Tolay Lake may provide a unique and important data set for reconstruction of Holocene vegetation, climate, and human occupation history to compare with estuarine and (rare) inland pond or lake sediment cores. “Restoration” surrogate methods reliant on lakebed excavation prior to sediment core sampling may forfeit a unique and scientifically important sediment core data source.
- The excavation of a deeper pool to “restore” lake depth range without allowing higher water levels would decouple the hydrologic fluctuations of the intact lakebed and the excavated pool. The remaining unexcavated lakebed wetland flats would be

subject to less dynamic hydrology (depth range and decadal variability) than the excavated pool.

6. General recommendations for restoration goals, alternatives, and design elements

Goals

- Restoration goals should be based on ecosystem dynamics and structure of an intermittent perennial/seasonal fishless lake, not a perennial lake, managed perennial pond, or recreational lake/impoundment. The intermittent lake ecosystem is more like a vernal pool-freshwater marsh gradient than a perennial deepwater lake ecosystem.
- Appropriate species-specific goals, consistent with the conceptual ecological model of the intermittent lake wetland complex and its dynamics under restored, managed conditions, could include:
    - Special-status wildlife
        - California red-legged frog (passive predictable colonization from watershed)
        - Western pond turtle (passive predictable intermittent colonization from Tolay Creek; or assisted colonization)
        - California tiger salamander (assisted colonization)
        - Tricolored blackbirds (passive unpredictable colonization)
        - Burrowing owl (passive unpredictable colonization)
    - Special-status plants
        - Baker's blennosperma (*Blennosperma bakeri*; assisted colonization; highly feasible)
        - Burke's goldfields or Contra Costa goldfields (*Lasthenia burkei, L. conjugens*, but not both; assisted colonization highly feasible)
        - Lobb's aquatic buttercup (*Ranunculus lobbii*; assisted colonization if not already present; highly feasible)
        - Sebastopol meadowfoam (*Limnanthes vinculans*; assisted colonization; highly feasible, occurs near Tolay Delta)
        - Saline clover (*Trifolium hydrophilum*; assisted colonization if not already present; highly feasible; occurs in Sears Point and baylands near Tolay Delta)
        - Suisun-Common Aster intermediates (*Symphyotrichum lentum, S. chilense*; assisted colonization highly feasible)
    - Regionally uncommon/limited distribution native wetland plants
        - *Echinodorus berteroi*
        - *Sagittaria* spp (native Marin-Sonoma)
        - *Potamogeton pusillus, P. foliosus, P. nodosus*
        - *Sparganium eurycarpum*

Alternatives and restoration/management design elements

- Alternatives should emphasize restoration of hydrological variability and amplitude (dynamics at seasonal/annual and decadal time-scales), including long-term (decadal) extremes. Alternatives should not simply focus on "static" high water levels or achievement of maximum depth and duration of flooding – goals suited to perennial managed lakes. Alternatives should include all feasible options to allow maximum flooding (greatest water depths, annual hydroperiods, and episodes of consecutive years of perennial water) and extreme dry phases (drawdown, drainage, desiccation) to develop with ENSO climate cycles over the entire lakebed (wetland gradient), to the greatest extent feasible.
- Alternatives that allow greater intermittent (not perennial) maximum water surface elevations (extreme high lake level stands), but also allow for extreme, unmitigated drought-induced ecological extremes, are likely to provide the greatest degree of biological benefits in terms of biological diversity and productivity, and emulation of pre-agricultural Tolay Lake. Public education is likely to be needed to promote popular understanding and support of a highly fluctuating intermittent lake (Kamman 2003).
- Excavation should be considered a last resort as a surrogate for allowing higher maximum water levels to develop over the entire lakebed.
- Ditches should be disconnected and decommissioned (blocked; ceased to function as drainage channels), but the pools provided by disconnected, blocked ditches should be included in some alternatives, to provide small, widely distributed late-season pool or hydration habitats during drought years.
- Recolonization of Tolay Lake by California tiger salamanders, through active reintroduction/translocation, should be considered in some or all alternatives. Colonization of restored Tolay Lake by Tricolored blackbirds should be considered in some restoration alternatives.
- Restoration actions should include low-cost founder population plantings of target plant species, rather than extensive disturbance and planting, in at least some alternatives. This is indicated by the spontaneous "restoration" of Laguna Lake (Chileno Valley) over two decades. Restoration of rhizomatous species that were likely reduced or eliminated by wet-season cattle grazing and trampling, including sedge beds, should be included in some or all alternatives.
- Vegetation management actions supporting restoration may include above-ground biomass and nutrient reduction through haying (mowing + thatch, hay removal), controlled firebreak-contained burns, and dry-season grazing. Pre-restoration timed (pre-fruiting) mowing of potential nuisance species, such as cocklebur (*Xanthium strumarium*), pennyroyal (*Mentha pulegium*), or non-native Ludwigia spp. (if present) should be incorporated in all alternatives that increase water depth or hydroperiods.
- Alternative grazing plans should consider sheep grazing (avoidance of wet clay soil trampling impacts to moist wetland soils) over cattle grazing (concentration of grazing and trampling in wet clay soil). Restoration of rhizomatous sedge, rush, and

spikerush vegetation is likely to be impaired or precluded by moist-soil cattle grazing, due to rhizome and soil shearing caused by cattle trampling of wet clay soil.

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