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MEMORANDUM

To: Kathryn Lobato
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SUBJECT: Independent Review of Southern Humboldt Community Park Water Supply and Demand Analysis, and Potential Impacts on Surface Water and Aquatic Habitat

1. PROJECT SCOPE

Pacific Watershed Associates has been retained by the Southern Humboldt Community Park (The Park) to perform the following tasks:

- Review the Southern Humboldt Community Park Water Supply and Demand Analysis Memorandum dated September 2, 2014, prepared by GHD (GHD, 2014).
- Update the water demand analysis based on publicly available water application rates by similar users in the vicinity and turf-grass specific guidance established by non-profit organizations, researchers, and government agencies.
- Perform a field investigation to characterize existing hydrological and aquatic habitat conditions, consider the potential for creating fish barriers and adverse water quality conditions as a result of the Park's future water demands.
- Determine whether there are any significant adverse impacts on aquatic habitat of on-site drainages and the South Fork Eel River, as a result of anticipated Park demands.
- Make recommendations for adaptive management strategies to reduce water use and the adverse effects of the Park's future water demand.
- Identify modifications to the California Department of Fish and Wildlife (CDFW) Lake and Streambed Alteration Agreement (LSAA), including adaptive management measures that will conserve water to sustain the health of fish and other aquatic organisms and avoid adversely affecting downstream water rights holders.

2. BACKGROUND

2.1. Watershed setting

The Park project site is located along the mainstem South Fork Eel River (SF Eel River) with an upstream river basin catchment of 500 square miles (USGS, 2016). The Park is divided into seven distinct units: Tooby Memorial Park, Park Headquarters, Main Agricultural Area, Community Commons, Community Facilities, Riverfront, and Forestland (see Figure 1 – Site Plan). The Park is located immediately west of Garberville on the right bank of the SF Eel River. The area has a Mediterranean climate with typically long, dry summers. For this reason, even though the watershed receives abundant precipitation during the wet season, water scarcity has and will almost certainly continue to be a driving concern affecting both park management as well as anthropogenic and in-stream beneficial water uses in the future. The Park has two sources of water, an infiltration gallery located on the right bank of the Eel River and a developed spring that contributes to a Class III stream that runs through the Park.

2.2. Common runoff and erosion issues in the Eel River Watershed

The vast majority of the anthropogenic changes that have occurred in the Eel River watershed over the last 150 years have served to reduce infiltration and expedite the flow of precipitation out of the basin. Watershed impacts associated with road building, logging, ranching, farming, road construction, and rural/urban development have modified the landscape in ways that have altered runoff patterns and groundwater conditions, resulting in a decreased hydraulic residence time for the average raindrop falling within the basin (USEPA, 1999).

Ranching and intensive agriculture have had significant hydrologic effects in the basin (USEPA, 1999; CDFW, 2014). In many locations, land management practices have tended to compact surface soils, thereby decreasing infiltration of precipitation and recharge of groundwater. In addition, tilling and disturbance of topsoil usually leads to oxidation of soil organic carbon, which further reduces infiltration rates. Decreased infiltration associated with agriculture, road building and timber harvest activities results in increased runoff, which can then exacerbate down slope gully erosion (Weaver et al., 1995; Weaver et al., 2015). Poorly designed and constructed roads tend to simplify stream networks by capturing drainages and emergent subsurface flows, and converting naturally occurring dendritic flow patterns into linear features with significantly shorter channel lengths, higher flow velocities, and lower hydraulic residence times.

Grading and sheet erosion resulting from land disturbance, including ubiquitous historic timber harvesting and tractor logging in our coastal watersheds and river basins, has reduced the thickness and tilth of soil and thereby reduced the volume of water the soil profile can retain. Erosion resulting from over-grazing and soil tilling also tended to result in loss or degradation of topsoil, which contains most of the soil organic carbon. Undisturbed top soils are more able to absorb precipitation and retain nutrients than the typically clayey silt subsoils that are exposed by management activities. Once compacted or depleted of organic carbon, soils likely take many decades or centuries to recover their native permeability (NRC, 1993).

2.3. Public water supply systems in the vicinity of the SHCP

There are two main public water systems near the Park, operated by the Garberville Sanitation District and the Redway Community Services District, that draw water from the SF Eel River, as well as other groundwater and surface water sources. The Garberville Sanitary District (GSD) water system is a state-regulated public water supply (PWS) that was purchased from private owners. It consists of two water sources, a treatment plant, four water tanks, three booster stations, and a water distribution network that currently serves about 180 connections. The water sources include an infiltration gallery that withdraws surface water from the SF Eel River and one shallow well in downtown Garberville. The water treatment facility produces water that meets or exceeds State regulations for drinking water quality (Winzler and Kelly, 2007).

GSD's infiltration gallery[1] in the SF Eel River is located approximately 2,000 feet downstream of the Park's infiltration gallery and is their main water source. GSD produces about 80 million gallons of water per year. GSD holds a current water diversion permit from the State Water Resources Control Board to appropriate water from the SF Eel River at a maximum rate of 0.595 cubic feet per second or 10% of the stream flow, whichever is less. According to Mr. Emerson, the GSD manager, an 8" diameter potable water supply line runs along Camp Kimtu Road.

The Redway Community Services District (RCSD) also maintains and operates a public water supply, which lies about four river-miles downstream of GSD's intake. RCSD's potable water system consists of two water sources, a conventional drinking water treatment plant, three storage facilities, two pressure reduction vaults, and one booster pump station, as well as the transmission and distribution lines. In 1999, there were about 600 service connections (Winzler and Kelly, 2007). RCSD water sources include the SF Eel River and an unnamed spring. The water treatment plant design capacity is approximately 460,000 gallons per day. The water permit allows for a withdrawal of 1.05 cubic feet per second (cfs) from the SF Eel River and no more than 0.123 cfs and 52 acre-feet[2] per year from the spring. The maximum yield from the spring is 46,000 gallons per day, but according to Mr. John Rogers, the RCSD Manager, the spring has not been as productive during drought years.

3. REVIEW OF THE SOUTHERN HUMBOLDT COMMUNITY PARK WATER SUPPLY AND DEMAND ANALYSIS MEMORANDUM PREPARED BY GHD, INC.

In order to simplify analysis, hydrologists often segregate water resources into environmental compartments such as surface water, groundwater, precipitation, soil moisture, and biomass. Options for protecting water resources can then be evaluated in relation to altering the distribution of water between those environmental compartments. While this paradigm is very useful, one must recognize that environmental compartments are human constructs and water in the environment exists in a continuum from rain drop to groundwater to plant moisture, and finally, as water vapor evapotranspired by a forest that is blown eastward by the prevailing wind. Every watershed is subject to a variety of natural and anthropogenic environmental conditions that shape its hydrology. Though some factors affecting watershed hydrology are immutable (e.g., geology, tectonics), some are variable (e.g., climate changes, forest fire, timber harvest cycles, and road building). The environmental conditions determine the route that each water molecule ultimately takes on its journey out of the watershed.

PWA analyzed the Park's Water Supply and Demand Analysis Memorandum dated September 2, 2014, prepared by GHD, Inc. (the Memorandum). The Memorandum estimates future water

[1] An infiltration gallery is a sub-surface ground water collection system typically installed near rivers, streams, or ponds. It is comprised of horizontal open-jointed or perforated pipes, block drains, or gravel-filled trenches installed below the water table. Groundwater is collected and discharged to a sump or collection well, and then pumped to a storage tank.
[2] One gallon = 3.07×10^{-6} acre-feet; 1 acre-foot = 325,851 gallons.

demand for seven areas: Tooby Memorial Park, Park Headquarters, Main Agricultural Area, Community Commons, Community Facilities, Riverfront, and Forestland. In our opinion, the water demands identified by GHD are upper-bound estimates and do not reflect water conservation measures that have been mandated by the State in lieu of the declared drought emergency. Although GHD likely overestimated current demand, in general we concur with GHD's water demand estimates for the Park, with the exception of the Main Agricultural and the Community Facilities areas.

While the GHD water demand analysis is thorough, it is our opinion that some of the irrigation demand assumptions overstate the probable demand and do not consider the overall potential beneficial effects of the Park on the both the local and watershed scale water balance. The USDA water demand model used by GHD is based on the Blaney-Criddle equation and is not necessarily the best or most suitable approximation for sports turf. According to the United Nations Food and Agriculture Organization, the Blaney-Criddle method is "not very accurate; it provides a rough estimate or 'order of magnitude' only" (FAO, 2015). While this approach is technically acceptable, it overstates the projected irrigation water demand, especially for the sports field if adaptive management measures are incorporated. The GHD model estimates the amount of water needed to maximize biomass (grass) regardless of climate conditions. Their model assumes a near infinite supply of water is available for the turf grass to evapotranspire, which is significantly greater than the water needed to keep the grass alive during a drought period (Karlin, 2015).

A detailed analysis GHD's assumptions and methods used to calculate the effective irrigation demand calculations was conducted to determine potential factors that would contribute to an overestimation of water demand. The spreadsheet "Effective Irrigation Demand Calculations" (see Appendix 1), provides the assumptions, factor values, and Blaney-Criddle calculations used to determine the effective irrigation demand for the proposed (10 acres) and minimum (5.5 acres) areas of the Sports Field. The majority of factors and assumptions seem accurate for the SHCP location, with the exception of the crop coefficient, $k_{c,}$ used to calculate the climatic coefficient, k. The climatic coefficient, k, and the monthly consumptive use factor, f, are multiplied to give monthly consumptive use, U. Consumptive use is the water loss from an area of land by evapotranspiration. The crop coefficient, k_c, is a dimensionless number that reflects the percentage of potential evapotranspiration (ETo) needed to satisfy water needs of a specific crop or plant (Harivandi, et al., 2009).

The GHD analysis used relatively high crop coefficient values of 0.85, 0.9, 0.92, 0.92, 0.91, 0.87, and 0.79 for the months of April through October, respectively. According to Harivandi et al. (2009), crop coefficient, k_c, values may vary for California turfgrasses to meet restricted irrigation demands (Table 1).

Suggested crop coefficient values are provided for cool-season and warm-season turfgrasses. Turfgrasses in the SHCP would be classified as warm-season due to the hot and dry summer climate. The crop coefficient values for warm-season turfgrasses range from 0.60 for optimum performance to 0.20 for the driest conditions that allow crop survival. GHD's crop coefficient values are 1.3 to 1.5 times greater than the crop coefficient values suggested for warm-season turfgrasses. If the optimum crop coefficient value of 0.60 was used instead of the high values used by GHD, the average and drought effective irrigation values would decrease by 32% to 48% (Table 2).

Table 1. Suggested K_c values (% ETo) for irrigation strategies resulting in optimum, deficit, and survival performance levels for selected turfgrasses grown in California[1]

Turfgrass performance level	Cool-season turfgrass	Warm-season turfgrass
	Kc[2]	Kc
Optimum	0.80	0.60
Deficit	0.60	0.40
Survival	0.40	0.20

[1]From Harivandi et al., 2009; [2] Kc (crop coefficient) is a dimensionless number that is multiplied by the ETo value to arrive at an estimate of crop ET, or water requirement (ET = Kc x ETo).

Table 2. Comparison between Average and Drought Effective Irrigation Demand calculated using GHD and the optimum crop coefficient for warm-season turfgrass.[1]

Month	Average Effective Irrigation Demand (in/mo)			Drought Effective Irrigation Demand (in/mo)		
	GHD k_c values	Optimum k_c value for warm-season turfgrass	Percent less than GHD estimate (%)	GHD k_c values	Optimum k_c value for warm-season turfgrass	Percent less than GHD estimate (%)
January	-	-	-	-	-	-
February	-	-	-	-	-	-
March	-	-	-	-	-	-
April	0.325	-0.454	39%	1.736	0.903	48%
May	3.468	2.009	42%	4.118	2.616	36%
June	5.574	3.561	36%	5.796	3.764	35%
July	7.402	4.856	34%	7.439	4.890	34%
August	6.368	4.106	36%	6.648	4.358	34%
September	4.357	2.845	35%	4.770	3.231	32%
October	0.410	-0.228	32%	1.771	1.090	38%
November	-	-	-	-	-	-
December	-	-	-	-	-	-

[1] GHD k_c values = 0.85, 0.9, 0.92, 0.92, 0.91, 0.87, and 0.79 between the months of April and October, respectively. Optimum k_c value for warm-season turfgrass = 0.60 (Harivandi et al., 2009).

3.1. Updated Water Supply and Demand Analysis Using Site-Appropriate Water Application Rates.

While parks and outdoor recreation opportunities are important components of a healthy and vibrant community, parkland irrigation demands must be considered secondary to the obligation to maintain stream flows to support downstream ecological and human consumption needs. To maximize the beneficial use of water, we recommend a water allowance that is based on antecedent precipitation conditions. In wet years, the Park should be able to irrigate more and in drought years it will likely be necessary to irrigate less.

A holistic approach must be used to develop a water balance for the Park and the affected reach of the SF Eel River. First, it is important to identify consumptive use demands that result in out-of-basin water transport (e.g., ocean outflow, evapotranspiration, interception, and groundwater); and non-consumptive use demands that simply "borrow" water, use it beneficially, and then release that water back into the basin via percolation or direct discharge (e.g., domestic use, over-applied irrigation). When non-consumptive uses are constant over time and deep-rooted vegetation does not evapotranspire this water, the non-consumptive use component of the water budget operates at a near steady state condition, where water withdrawal is about the same as groundwater seepage back into the system. While non-consumptive use is an important element of water demand analysis, it must not be misunderstood; there are undoubtedly drought periods with the characteristic long dry summers when surface water and connected groundwater "loans" cannot be afforded.

We have updated GHD's water demand analysis based on publicly available water application rates by similar users and turf-grass specific guidance established by environmental non-profit organizations, researchers, and local and state agencies. Based on the Turf Grass Water Conservation Alliance (TWCA) guidelines for typical residential lawn water demand, a 0.11 acre lawn can subsist with between 8,000-16,000 gallons per 90 day period, depending on the soil and the grass species of the turf (Karlin, 2015). In terms of water application rates, this equates to 0.2 and 0.5 inches of water per week. In comparison, the GHD water demand estimate ranges from 2x to 4x higher than the high end of the TWCA values. The high values may be in response to heavy use, where playing fields generally require more irrigation water to grow biomass to recover from damage.

Estimates for the Sports Fields irrigation demands were updated using the optimum crop coefficient value of 0.6 for warm-season turfgrasses, as discussed in Section 3. Table 3 provides the updated monthly irrigation demands for the proposed Sports Field area (10 acres) and the minimum Sports Field area (5.5 acres). This analysis uses the same procedures as used by GHD in their report (see Section 2.2.2: Irrigation calculations: Table 4 and Table 5). The updated total irrigation demand for the proposed Sports Field area (10 acres) based on average and drought conditions are 4,718,663 ga and 5,662,079 ga, respectively. These values are 38% and 35% lower, respectively, as compared to the GHD values (Table 3). Updated estimates of total irrigation demand for the minimum Sports Field area (5.5 acres) based on average and drought conditions are 2,613,344 ga and 3,135,838 ga, respectively; which are 38% and 35% lower than the GHD values for the same area (Table 3).

Table 3. Updated proposed and minimum Sports Fields irrigation demands using an optimum crop coefficient value of 0.6 for warm-season turfgrasses.

Month	Proposed Sports Field – 10 acres		Minimum Sports Field – 5.5 acres	
	Average (ga)	Drought (ga)	Average (ga)	Drought (ga)
January	-	-	-	-

February	-	-	-	-
March	-	-	-	-
April	0	245,067	0	135,726
May	545,512	710,335	302,122	393,406
June	966,961	1,022,129	535,534	566,087
July	1,318,687	1,327,751	730,330	735,350
August	1,114,911	1,183,509	617,473	655,465
September	772,592	877,317	427,886	485,886
October	0	295,971	0	163,918
November	-	-	-	-
December	-	-	-	-
Updated Total (ga)	4,718,663	5,662,079	2,613,344	3,135,838
Updated Total (acre-ft)	14.48	17.38	8.02	9.62
GHD Total (ga)	7,576,727	8,764,113	4,196,499	4,853,841
GHD Total (acre-ft)	23.25	26.90	12.88	14.90

4. FIELD INVESTIGATION TO CHARACTERIZE EXISTING HYDROLOGICAL AND AQUATIC HABITAT CONDITIONS

PWA visited the Park on July 17 and July 29, 2015 to inspect the affected section of the SF Eel River and the drainage network within the Park boundary. During the July 29 visit, Brad Job, and Chris Herbst (PWA Civil Engineer Professional Geologist, respectively) discussed site drainage and farm management with Mr. John Finley, current farmer of the Main Agricultural Area. Mr. Finley is very familiar with the environs and the drainage patterns within the Main Agriculture area. He described the general irrigation water system and how the Farm operates.

Mr. Kyle Wear, the wetland biologist that delineated the jurisdictional wetlands on the Park, provided PWA with a map, included as Figure 2 - Jurisdictional Wetland Map, which identifies about 66 acres of jurisdictional waters (wetlands) within the Park. Mr. Wear and Messrs. Job and Todd Kraemer (PWA hydrologist) discussed his wetland delineation observations on August 4, 2015.

4.1. Findings

The majority of the Park is located on an alluvial terrace along the right bank of the SF Eel River with more than 66 acres of wetland habitat. The existence of extensive wetland habitat perched on the alluvial terrace implies the presence of a well-developed, less pervious soil substratum at some relatively shallow depth. This is indicative of the development of a “B” soil horizon with lower permeability than that of the topsoil “A” horizon. In such soils, the silt and clay fines have been washed through the surface soil where they plug some of the pores in the “B” horizon soil. These water-retaining soils appear to be locally intact and they slow the percolation of precipitation into the underlying alluvial water table. Restoring and enhancing wetland functions and water retention in the delineated wetlands in the Park could create both hydrologic and environmental benefits (Seiler and Gat, 2007).

Wetlands retain water following precipitation events and increase groundwater recharge. The water surfaces in these areas are typically in equilibrium with a shallow or perched water table. Where the phreatic surface emerges from the ground, the area becomes seasonally inundated (Bradley, 1996). Although no known subsurface or groundwater characterization has been performed on the Park wetlands, it is reasonable to assume that the conditions underlying the Park are similar to many other alluvial wetlands. In typical settings, a series of inter-braided deposits of varying material size classes ranging from course to very fine, gradation ranging from poor to well, and with varying percentages of clay, silt, sand, and gravel, comprise the terrace deposits. In general, the porosity of alluvium is in the 30%-35% range and, as a result, alluvium can hold a significant volume of water if subsurface drainage is restricted by a low permeability horizon beneath it. The flow of water through inter-braided alluvial deposits is controlled by material physical properties, where finer-grained alluvium yields water more slowly and open-graded gravel or cobble units yield relatively high groundwater flow velocities (Niswonger and Fogg, 2008).

On the simplest level, the velocity of flow via wetland seepage and subsequent groundwater discharge to the SF Eel River ranges from many hundreds to millions of times slower than occurs with overland flow (Chen and Chen, 2003). Measures that enhance water retention in the existing wetland areas will recharge the alluvial water table and eventually result in more groundwater discharging to the SF Eel River along the Park’s affected reach. Significant characterization is necessary to estimate the parameters that dictate the rate of absorption and release of water, but the physical principles are irrefutable. We conservatively estimate that roughly 33 acre-feet, or about 10.8 million gallons of increased groundwater storage would result from prospective wetland enhancement. However, more refined analysis is necessary to estimate the duration and volume of the increased groundwater discharge to the SF Eel River.

4.1.1. Biological conditions

A field investigation was performed to characterize the existing hydrologic and aquatic habitat conditions in the Park and the adjacent segment of the Eel River, and to determine the potential for creating adverse impacts and/or fish migration barriers resulting from increased water demand and extraction. The field investigation involved examining each drainage that flows within the Park boundaries. The only water bodies that could be affected by the Park’s water consumption are the SF Eel River and the one ephemeral drainage located closest to the Park’s eastern boundary. The largest increase in proposed water use is for irrigation to service the agricultural area and the sports fields proposed for the Park. The future plans propose a several-fold increase in the amount of water to be drawn from the SF Eel River at the infiltration gallery during summer low-flow periods. Because of the timing and volume of this irrigation diversion, it represents a non-negligible, but easily mitigatable impact to aquatic habitat in the project area.

4.1.2. On-site drainages

The three ephemeral streams that transect the Park were assessed by traversing the channels and visually assessing limiting conditions such as absence of well-established riparian vegetation, lack of habitat complexity, lack of cover, and chronic sediment inputs. At the time of assessment, all of the channels were dry. The U.S. Geological Survey (USGS) quadrangle map dated 1970, shows no mapped stream channels within or adjacent to the Park other than the SF Eel River itself. All three streams have very little sinuosity and have likely been realigned from their natural courses to maximize the agricultural production area.

The easternmost unnamed ephemeral tributary to the SF Eel River within the Park boundaries has about 205 acres of catchment area extending up to the ridge above Highway 101. It is the only channel in the Park that has well-established riparian vegetation along its entire length. A spring that is hydrologically connected to this drainage supplies the 50,000 gallon water tank and is the source of potable water for the Park. The LSAA allows diversion of up to 2,000 gallons per day or 10 % of the flow, whichever is less. It is our understanding that the spring had gone dry at the time of our July, 2015 stream assessment. Given the relatively low diversion rate from the spring, the size of the catchment, and the absence of surface water flow at the time of our site inspection, it is unlikely that the presence or absence of flow in this channel hinges on this one (and possibly the only) spring diversion near the top of this drainage. It is likely that the bottom portion of this channel, which discharges into the SF Eel River at Tooby Memorial Park, provides spawning and rearing habitat for steelhead and possibly coho during the wet season. However, utilization of this channel by fish almost certainly ceases soon after the conclusion of the rainy season. The channel is deeply incised and has virtually no in-channel woody debris.

The channel that more-or-less centrally bisects the Park is particularly linear, deeply incised, and has very few well-established riparian trees. This stream does not appear to have a well-defined channel on the lower floodplain terrace that connects it to the SF Eel River. It discharges into a wetland on the western margin of the lower floodplain terrace, which is drained by a 48” culvert under Camp Kimtu Road. Although wet season observations would be required to rule out utilization of the wetland by salmonids, it appears unlikely that it provides significant fish habitat except for in the most extreme high flow conditions. The wetland provides valuable habitat for a variety of other species, but regardless, there is no current or planned diversion from this channel and water utilization by the Park has very little or no impact on the flow conditions.

The westernmost channel skirts the Park’s boundary. There are small, delineated wetland pockets on Park property that contribute to this channel. Although the lower reach of this channel may provide some seasonal fish habitat and velocity refugia, similar to the central channel described above, water use by the Park will have very little or no effect on flow in this incised channel.

Thus, it appears highly unlikely that current or future water use by the Park will adversely affect fish habitat in any of the three minor stream channels within the Park. The primary benefits of these channels are seasonal and likely involve velocity refugia during peak flows and a limited amount of spawning in the short stream segments below the culverted crossings on Camp Kimtu Road.

4.1.3. SF Eel River

The SF Eel River channel is characterized as a pool-riffle channel type. Because there is a general lack of structural elements that can create the hydrologic conditions necessary to form deep pools, pools are scarce, relatively shallow and small. The sole exception is a six-foot deep pool near the left abutment of the Sproul Creek Road Bridge. In addition, riparian cover is absent that could provide shade for the relatively shallow low-flow channel. Under conditions at the time of this assessment, water temperatures appear to approach the lethal zone for some salmonids. Along with the high water temperatures, abundant algae covered most of the wetted channel, which can cause large diurnal fluctuations in dissolved oxygen concentrations that often result in hypoxia and anoxia, conditions that are deleterious to fish.

Based primarily on water quality, especially the warm water temperatures we observed, it was PWA's opinion that flow in the SF Eel River was too low to allow turf grass irrigation at the river stage that was occurring at the time of our initial site visit. Based on the extreme low flows in the SF Eel River channel during current drought conditions, it is conceivable that flows in the SF Eel River will become hyporheic, creating isolated pools and possibly stranding fish. Certainly, any significant increase of water drawn from the infiltration gallery during summer low flow conditions will exacerbate, however slightly, the undesirable conditions that already exist (high water temperatures, low dissolved oxygen, elevated nutrient concentrations), and would contribute to the creation of conditions that could be lethal for salmonids.

The low-flow conditions that have existed for the past several summers are a limiting factor for survival of juvenile coho and Chinook salmon, and steelhead trout, which are listed as threatened species (NOAA, 2014). Based on the two site evaluations, the velocity of flow during summer drought conditions was about 0.56 feet per second. There were no observable fish barriers along the SF Eel's Park reach because the riverbed was very low gradient. We estimate that on July 29, the cross sectional area of the shallowest observed segment of channel was about 30 square feet with a minimum riffle crest depth of about 8 inches. The discharge at that time was about 16.9 cubic feet per second (cfs) per the record at USGS Gauge 11476500. The resultant flow velocity was about 0.56 feet per second.

To assess the potential for the Park's diversion to create fish migration barriers, we assume that the velocity of flow at this stage is mostly governed by the channel morphology and streambed longitudinal profile. If the Park's infiltration gallery was being pumped at its maximum diversion rate of 0.24 cfs, as directed by the CDFW LSAA, the riffle crest water surface elevation would drop roughly about 1/8" inch. This worst-case reduction in water depth is relatively unlikely to affect summertime juvenile fish passage along the SF Eel River. Even under the projected maximum diversion rate allowed by the Park's water rights would not lead to a break in surface flows. One can safely assume that the hydrologic effects of water consumption and human-caused hydrologic connectivity in the 500 square miles (320,000 acres) of upstream watershed have a vastly greater effect on fish passage than would the effects of irrigating five or ten acres of sports field on the mainstem South Fork Eel River.

Even with limitations imposed under the CDFW LSAA, water quality conditions in the SF Eel River were deemed unacceptable at the time of our site characterization visits and were clearly impaired, primarily due to low mainstem flow. No apparent irrigation diversion from the Park was ongoing at the time of our site visits. Water temperatures in the shallowest portions of the river were in the mid-sixties, which is too warm for salmonid juveniles to thrive. Water temperatures in the deep pool that lies under the Sproul Creek Road Bridge were moderately cooler than those in the shallowest segments of the Park reach.

Both GHD's and PWA's projected water demand under any scenario is unlikely to result in dewatering of any channel that is utilized by salmonids. Seasonal utilization of the lowest reaches of the three ephemeral streams by fish will almost certainly have ceased by the time irrigation demands start. Nor would water diversion, even at the maximum rates allowed by the LSAA, result in fish stranding. The water diverted from the SF Eel River infiltration gallery will support the vast majority of the projected increased water demand, and the diversion rates allowed by the LSAA are insignificant in relation to flow in the SF Eel River in all but the driest months: July, August, and September. During these months, turf grass irrigation rates should be adjusted based on the principles of good environmental stewardship and water conservation for this relatively small project area.

5. RECOMMENDATIONS AND ADAPTIVE MANAGEMENT STRATEGIES

As stated above, the water use associated with the Park in any future build-out scenario should be adjusted based on the availability of water necessary to support the beneficial uses while honoring senior water rights holders located downstream of the Park. For this reason, it is essential that the Park operate within the bounds of all relevant water rights and water quality laws and regulations. During this period of record drought it is apparent to all parties that irrigation of turf grass is a minor consideration relative to the SF Eel River's highest priority beneficial uses; protecting habitat for threatened salmonids, providing drinking water for people and wildlife, and irrigating food crops.

5.1. General Recommendations

- **Stream and riparian improvements-**The hay flat in the Main Agricultural area is more-or-less bisected by a linearized Class 3 stream. Maintaining and elevating the grade of this stream, while adding some sinuosity to the channel, will promote development of a more natural riparian corridor with increased potential for wildlife habitat, while increasing seepage of surface water into groundwater. It is apparent that this stream was ditched at some point in the past, and has since entrenched itself. Although the stream does not support anadromous fish populations, PWA believes that this creek would be a good candidate for riparian and wetland restoration funding, possibly as mitigation for wetland impacts associated with nearby construction projects.

- **Water storage** - Given that the project area typically receives an average of 58 inches of precipitation each year, water scarcity is more a matter of timing of precipitation rather than the amount that falls from the sky, even in a drought. Most precipitation occurs between mid-October and mid-May. Thus, retaining water on-site during the wet season and allowing it to discharge back into the river during the dry season is the most efficient means of reducing the dry season hydrologic footprint of the Park. Water can be retained on-site by enhancing wetlands, restoring riparian areas, constructing infiltration or water storage ponds, elevating stream grades, and storing water in tanks. It is likely that enhancing groundwater recharge by enhancing wetlands and restoring riparian areas will be the least expensive and infrastructure-intensive means of accomplishing this goal and they bring a suite of additional environmental benefits.

- **Drought-tolerant turf grass** - We recommend planting of drought-tolerant warm turf-grass species, likely among those shown in Table 4. Each species and cultivar has differing benefits and advantages. The factors that must be considered when selecting the type(s) of grass to be planted include evapotranspiration potential, drought tolerance, dormancy, soils structure and fertility, fertilizer demand, mowing height, invasive weed potential, and durability. PWA recommends consultation with a firm experienced in turf-grass cultivation in similar Mediterranean climate zones before the exact species and cultivars for this specific site and field are developed. Hybridized drought resistant grass species and cultivars typically use about 70% of the water required by non-hybridized species (Karlin, 2015).

- **Low-to-the-ground and subsurface irrigation systems** - We also recommend the use of best available irrigation technologies. Generally, sprinkler systems that apply water as close to the ground surface as possible will result in less evaporative loss. In addition, watering should occur at night or in the early morning hours, which also reduces evaporation. One recently developed subsurface irrigation system for sports fields could reduce water use could by up to 70%. Thus, even using GHD’s maximum value of 1,117,873 gal/mo, the water demand could potentially be reduced to as little as 335,000 gallons per month by using high-efficiency irrigation methods. It is important to note that more efficient irrigation methods can also reduce power consumption, nutrient leaching through surface soils, and emissions of greenhouse gasses. At the same time, it is imperative to understand the potential for biofouling within the irrigation system before selecting and constructing one.

- **Know when and when not to irrigate** - Most importantly, the irrigation allowance should be determined based on the characteristics of each water year (when and how much precipitation falls, as well as dry season river flows and water quality) as that will influence how the Park’s turf is managed. Deciding when to cease irrigating the sports park is one of the most critical adaptive management measures for mitigating the potential adverse impacts associated with turf irrigation.

Table 4: Examples of Drought-Resistant Turf Grass (Cruger, 2009).

Grass type and/or cultivar	Features	Downside	Drought tolerance
Native Bentgrass™ from Delta Bluegrass	"California native sod," medium leaf texture, thrives in full sun and partial shade, withstands low mowing heights, strong sod mat provides effective weed barrier, extremely drought tolerant, uniform growth habit, excellent wear recovery due to self-repairing rhizomes.	Less traffic tolerant than other species / cultivars. Can tolerate low mowing heights or left un-mowed.	Good
Zoysia 'De Anza'	Good traffic tolerance; some shade tolerance. 'De Anza' was developed for improved color retention.	Slow to establish by seed, so sod is better; slow to repair.	Excellent
Buffalo grass 'UC Verde'	Very low water needs; can survive in extreme drought conditions; low fertilizer needs; reduced or no mowing required; meadow-like, rather than a manicured look, when unmowed.	Longer winter dormancy period inland (also goes dormant in extreme drought in summer).	Superior
Bermuda grass	Best overall warm-season grass for California; high traffic tolerance; needs sun; recuperates well; very good drought and salt tolerance; available in sod, sprigs or seed	California Invasive Plant Council (CalIPC) ranked invasive weed (Moderate).	Superior
Kikuyagrass	High traffic tolerance; heat and drought tolerant; best color retention of the warm-season grasses; good for the coast; resembles St. Augustine.	Kikuyu grass is a CalIPC ranked invasive weed (Limited)	Good

5.2. Adaptive Management

There is a hierarchy of need for water in most communities during times of water scarcity. While sports fields are important for communities to congregate, turf grass can be replanted after a drought in which irrigation is halted and grass dies. Water needed for direct human consumption often overrides most other uses, trailed closely by irrigation for food crops, and water needed to support instream beneficial uses. However, while alternative water supplies may sometimes be available for human needs, requirements for aquatic organisms can only be met through maintenance of life sustaining minimum streamflows and viable water quality. Given the drought conditions that have been ongoing for at least three years (at the time of this writing), irrigation of the sports field during extended drought conditions is likely to be highly scrutinized and lower in priority compared to other needs.

For this reason, we propose establishment of a water budget for various irrigation demands on the Park property, as well as a triggering mechanism for the reduction or cessation of irrigation during periods of water shortage, based on higher priority uses. There are likely to be several tiers of demand within the beneficial uses that currently need to be serviced at the Park including direct human consumption, residential uses, irrigation of trees and other established semi-permanent vegetation, irrigation of annual row crops, irrigation of turf grass, and irrigation of pasture/wetlands. The demands shown in Appendix 1 are indicative of an average water year (based on recent history). These irrigation rates are then scaled back based on their relative importance and the antecedent precipitation and streamflow conditions.

One major consideration is our increased ability to monitor and manage water in the landscape, which will likely increase in the future and facilitate our ability to manage use in response to water abundance. The monitoring and management strategy that is ultimately adopted by the Park should consider current riverine, atmospheric, and antecedent precipitation conditions when determining the quantity of water available to irrigate turf grass on sports fields. When the Park is ready to undertake design and construction of new facilities it should do so under the advice of an adaptive irrigation management plan that focuses on the criteria listed above, as well as water rights and diversion management. It is advisable that this plan be considered when determining how many and what type of sports fields are to be constructed. Phasing of sports field construction will allow field capacities (soil water) to equilibrate with user demand and resource availability.

PWA believes that the Sports Field irrigation cutoff threshold can be significantly higher than the 17 cfs flow conditions in the SF Eel River that we witnessed on our July 29, 2015 site visit. We suggest 30 cfs as an interim threshold, beyond which the sports fields can only be irrigated with stored or recycled water. This will undoubtedly result in less-vigorous turf at the onset of the wet season. One adaptation could be rotating the location(s) and layout(s) of fields in active use throughout the dry season in a manner that spreads the recreational impact on desiccated turf throughout the entire Sports Field area. The following measures are recommended to provide adaptive management in future water use at the Park:

- Develop an adaptive irrigation management plan that:
    - determines how many and what types of sports fields are necessary and can be supported with the available irrigation supply,
    - how much irrigation water can be diverted in varying stages of water scarcity, and
    - establishes a reliable means of determining the annual irrigation water diversion cutoff date.
- Consult with turf-grass and sports field irrigation system experts before laying out sports fields and designing irrigation systems in order to determine the best drought tolerant turf grass and irrigation strategies to reduce water consumption.
- Replace the water demand summary for agricultural areas and turf grass from the GHD Memorandum with the PWA Estimated Water Demand.

5.3. Low-Impact Development (LID)

When the Park undertakes design and construction of new facilities, modern development standards and building codes will necessitate the use of low-impact development (LID) best practices. Moreover, we recommend that all new infrastructure should be consistent with the principles of the Leadership on Environmental and Efficient Design (LEED) Standards, which also incorporate LID techniques. The foundation for evolution of LID practices lies in the universal need to decrease the negative hydrological and environmental consequences of infrastructure development on hydrologic connectivity and pollutant loading. Some of the environmental benefits of LID are increased groundwater recharge, decreased peak runoff, reduced flood risk, and reduced delivery of pollutants to surface water.

Examples of LID concepts are permeable pavements, stormwater detention basins, rain gardens, rainwater harvesting into storage or dry-wells where it can percolate into groundwater. There are also infrastructure benefits for LID practices like minimizing flooding, preserving drinking water sources, and reducing maintenance frequencies. Although irrigation with recycled water is not strictly an LID requirement, this measure could dramatically benefit the planned Park's agricultural production, turf irrigation, groundwater storage, and scenic amenity. Features could include a skate park that collects and infiltrates rainwater, construction of vernal-pool-like rain gardens near impervious surfaces, or constructed perennial wetlands that are maintained with recycled water as both a scenic and freshwater habitat amenity.

The use of vault toilets[3] would reduce water consumption, plumbing costs, and the need for on-site wastewater disposal systems in these riparian and/or seasonally inundated locations. Vault toilets have no water demand and when pumped, the contents can be discharged at the nearby GSD treatment plant. Vault toilets in flood zones should be pumped clean prior to the onset of a predicted flood.

The LID design benefits for the built-environment areas of the Park are nearly identical to those that would result from applying comprehensive wetland and riparian enhancement plan to the wildland and agricultural areas of the Park. The application of both LID and a wetland and riparian enhancement plan would provide a robust approach to minimizing water consumption. The following measures are recommended to achieve low-impact development:

- Comply with LID construction standards.
- Use vault toilets where running water is not necessary.

5.4. Wetland and Riparian Restoration and Enhancements

SHCP should seek funding to design and implement a comprehensive wetland and riparian restoration and enhancement program. When implemented, these enhancements are likely to vastly outweigh the hydrologic impacts of turf grass irrigation, especially if implemented using the adaptive irrigation management constraints detailed above. Ideally, environmental conservation and restoration projects would occur contemporaneously with construction of recreational features and offset any hydrological impacts. Some of the priority restoration and enhancement measures could include:

- Repair and maintain the grade control structures that are preventing further upstream migration of head-cuts, and implement measures to raise and stabilize gullied channels.

[3] A vault toilet is a waterless toilet designed for areas with no or little access to running water. It works like an "out house" with a seat installed over a "vault" or hole constructed with reinforced concrete below the ground surface. Waste is pumped from the vault and disposed of off-site. Proper passive solar venting of vault toilets greatly mitigates odor issues.

- Seek funding to prepare a comprehensive plan to enhance the extant wetlands and restore the riparian corridors throughout the Park.
- Manage site vegetation to reduce the presence of exotic plant species, increase riparian shading, and promote succession of forests to achieve older seral stages.

5.5. Future Water Storage and Restrictions on Flow Diversions

PWA recommends that the Park seek funding to install additional water storage tanks in order to minimize its impact on water quality and habitat conditions. Construction of municipal water storage tanks has typically been considered a consistent use within public recreation zoning. Current tank offerings for municipal-scale use can be constructed or planted aesthetically, in a manner that is consistent with most park uses. Storage in ponds and wetlands is a viable and lower-cost option to tank storage, but comes with the tradeoffs of increased evaporative loss and algal growth. Many water districts rely on water storage in park settings, ranging from the Bay Area's vast array of dams and lakes to the City of Arcata's array of relatively small metal tanks in the Community Forest. Partially buried and entirely underground municipal water storage tanks are less numerous but less obvious and less subject to vandalism.

The LSAA allows up to 2,000 gallons per day to be diverted from the spring between November 1 and July 1 of each year. The other diversion is from an infiltration gallery in the South Fork Eel at a maximum diversion rate of 0.24 cubic feet per second (cfs) for irrigation. The infiltration gallery does not have a specified period of diversion. The following measures are recommended to improve future water storage and ensure adequate restrictions on in-channel diversions that could otherwise adversely affect aquatic habitat in the SF Eel River during the dry season:

- Install additional non-potable water storage facilities for irrigation and as a source of fire suppression water for the Main Agricultural and Forestland areas.
- Diversion from the SF Eel River infiltration gallery should cease after the flow at Sylvandale is nominally less than 30 cfs, contingent on a more robust metric. This means that irrigation would not have ceased in calendar years 2011 and 2012, but there would have been interruptions in irrigation diversions in 2008, 2009, 2010, 2013, 2014, and 2015.
- The LSAA requires that streamflow to be measured if water is diverted between July 1 and October 31. We suggest reliance on measured flow at USGS Gauge 11476500.

6. CONCLUSIONS

If employed, the above recommended measures would greatly reduce the cumulative hydrological footprint of the Park. Enhancing groundwater storage during the wet season would increase the discharge of groundwater into the river during the dry season, although it is impossible to estimate the timing and rate of groundwater exfiltration into the SF Eel River with no subsurface geological or hydrological characterization. Providing restrictions on diversions from the SF Eel River during periods of water scarcity would ensure that the Park is not contributing to the cumulative conditions in this waterbody and the essential habitat it provides for anadromous fish and other aquatic life. Moreover, the low impact design (LID) principles and materials that are a requirement of the CBC and County Code would reduce both the hydrologic footprint of the Park and the delivery of sediment and other pollutants to the SF Eel River during precipitation events.

7. LIST OF ATTACHMENTS

Figure 1 – Site Plan
Figure 2 – Wetland Delineation Map
Appendix 1 – Estimates of Minimum Water Demand.

8. REFERENCES

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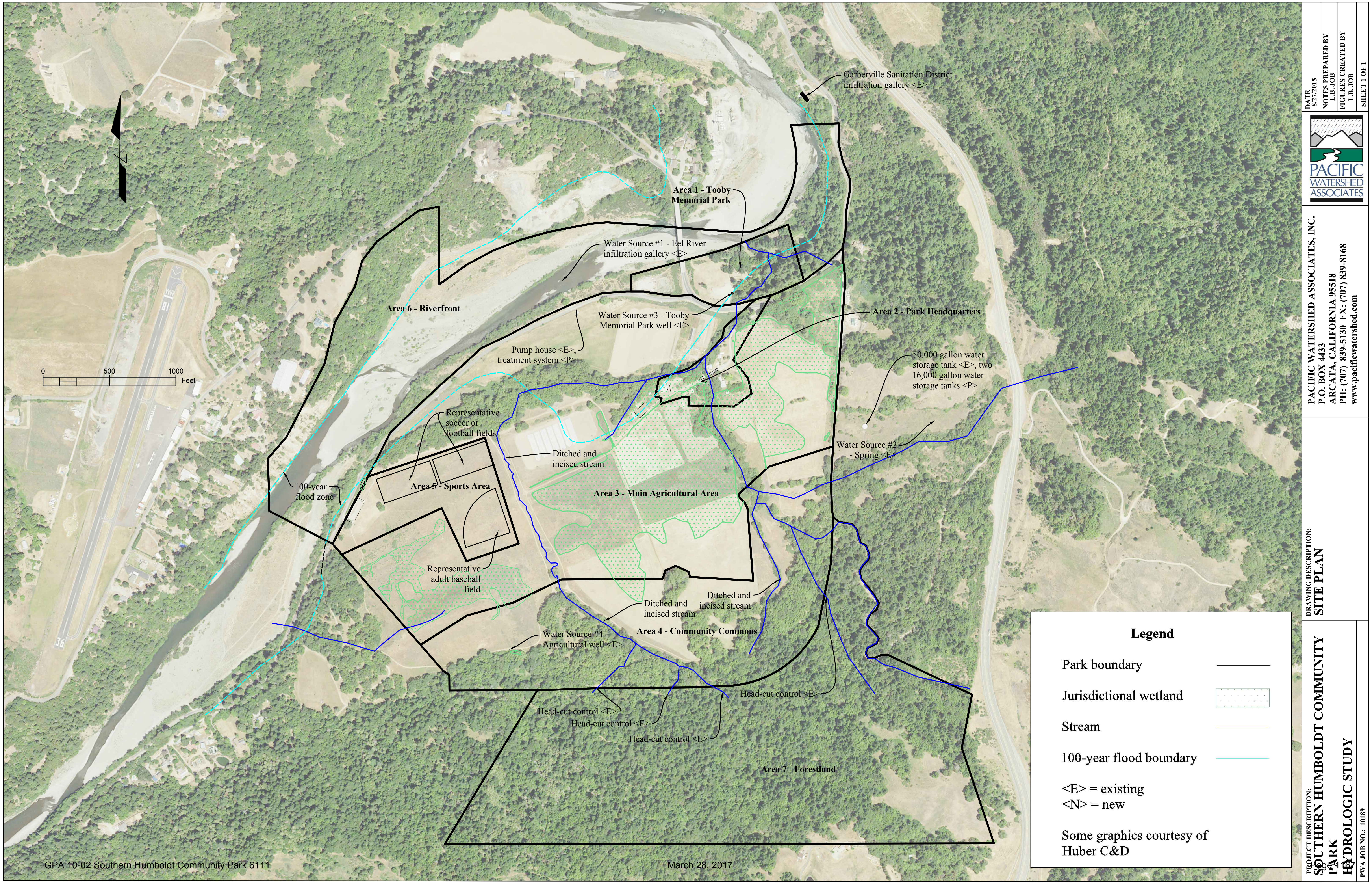
Figure 1 – Site Plan



Garberville Sanitation District infiltration gallery <E>
Area 1 - Tooby Memorial Park
Water Source #1 - Eel River infiltration gallery <E>
Area 6 - Riverfront
Water Source #3 - Tooby Memorial Park well <E>
Area 2 - Park Headquarters
Pump house <E>, treatment system <P>
50,000 gallon water storage tank <E>, two 16,000 gallon water storage tanks <P>
0 500 1000 Feet
Representative soccer or football fields
Water Source #2 - Spring <E>
Ditched and incised stream
100-year flood zone
Area 5 - Sports Area
Area 3 - Main Agricultural Area
Representative adult baseball field
Ditched and incised stream
Ditched and incised stream
Water Source #4 - Agricultural well <E>
Area 4 - Community Commons
Head-cut control <E>
Head-cut control <E>
Head-cut control <E>
Head-cut control <E>
Area 7 - Forestland
Legend
Park boundary
Jurisdictional wetland
Stream
100-year flood boundary
<E> = existing
<N> = new
Some graphics courtesy of Huber C&D
DATE 8/27/2015
NOTES PREPARED BY L.B. JOB
FIGURES CREATED BY L.B. JOB
SHEET 1 OF 1
PACIFIC WATERSHED ASSOCIATES
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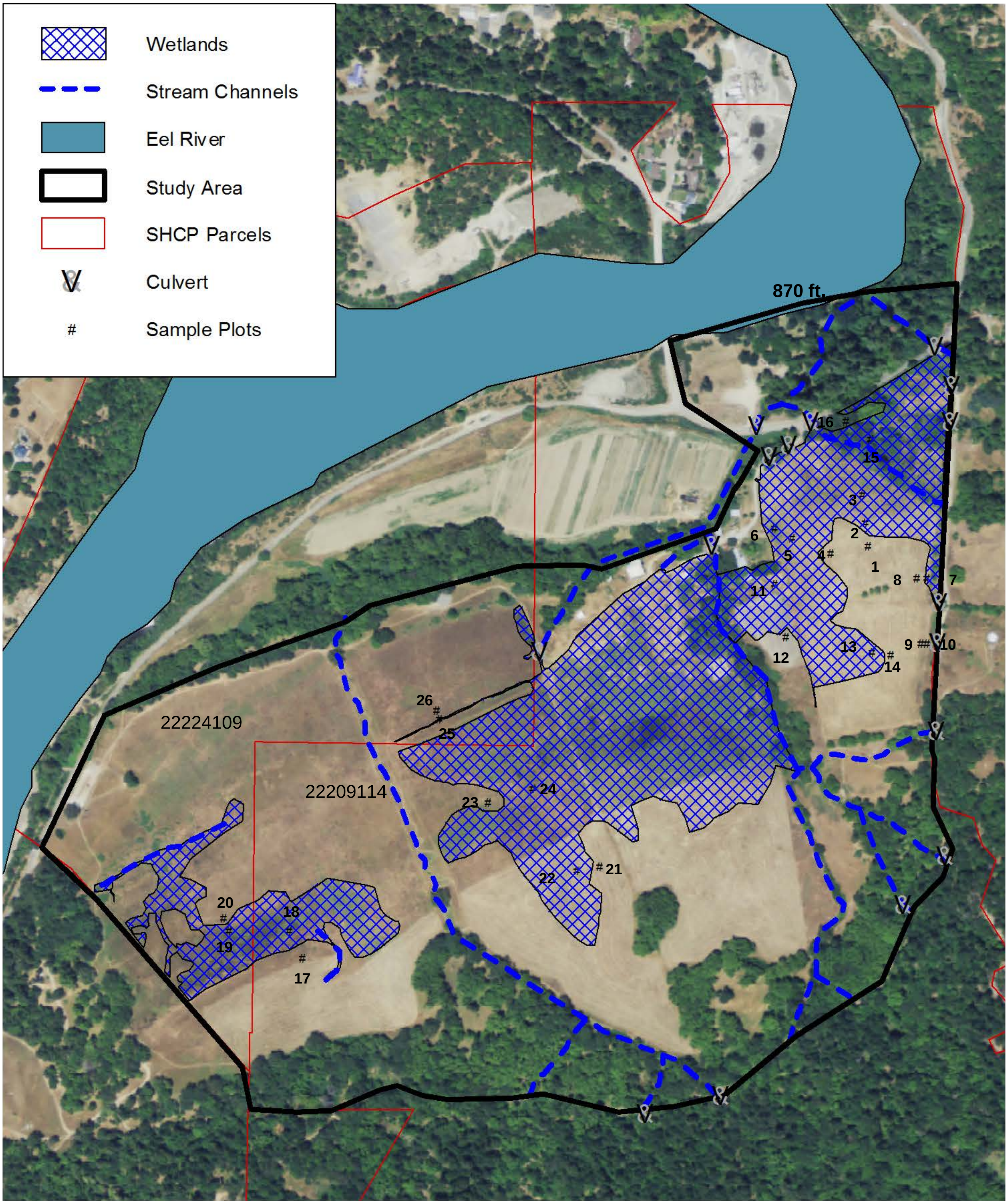
DRAWING DESCRIPTION:
SITE PLAN
PROJECT DESCRIPTION:
SOUTHERN HUMBOLDT COMMUNITY PARK
HYDROLOGIC STUDY
PWA JOB NO.: 10189

Figure 2 – Wetland Delineation Map



Scale: 1:6,800

Base Map: 2009 NAIP

Army Corps of Engineers Jurisdictional Wetland Delineation Map.

Southern Humboldt Community Park
Humboldt County, CA

Appendix 1 – Estimates of Minimum Water Demand.

Comparisson of Projected Irrigation Demands in Gallons Per Month													
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Caretaker Irrigation	0	0	0	0	9,863	9,863	9,863	9,863	9,863	9,863	0	0	59,178
Headquarters Irrigation	0	0	0	0	20,055	20,055	20,055	20,055	20,055	20,055	0	0	120,330
Agricultural Irrigation	0	0	0	0	325,848	325,848	325,848	325,848	325,848	325,848	0	0	1,955,088
Sports Field Irrigation (10 acres turf)	0	0	0	467,210	1,110,719	1,578,078	2,018,435	1,811,978	1,296,234	481,459	0	0	8,764,113
Sports Field Irrigation (5.5 acres turf)	0	0	0	258,756	615,151	873,989	1,117,873	1,003,530	717,895	266,647	0	0	4,853,841
GHD Irrigation Total (10 acres)	0	0	0	467,210	1,466,485	1,933,844	2,374,201	2,167,744	1,652,000	837,225	0	0	10,898,709
PWA revised estimate (10 acres drought tolerant)	0	0	0	327,047	777,503	1,104,655	1,412,905	1,268,385	907,364	337,021	0	0	6,134,879
PWA revised estimate (5.5 acres drought tolerant)	0	0	0	181,129	430,606	611,792	782,511	702,471	502,527	186,653	0	0	3,397,689
PWA revised estimate (10 acres drought tolerant w/ efficient irrigation)	0	0	0	228,933	544,252	773,258	989,033	887,869	635,155	235,915	0	0	4,294,415
PWA revised estimate (5.5 acres drought tolerant w/ efficient irrigation)	0	0	0	126,790	301,424	428,255	547,758	491,730	351,769	130,657	0	0	2,378,382
Relative change in water consumption	**N/A**	**N/A**	**N/A**	**49.0%**	**37.1%**	**40.0%**	**41.7%**	**41.0%**	**38.4%**	**28.2%**	**N/A**	**N/A**	**39.3%**