RECLAMATION

Managing Water in the West

Percha Tree Farm Vegetation, Soil and Groundwater Assessment: Addendum

Rio Grande Project, New Mexico

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, CO

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Percha Tree Farm Vegetation, Soil, and Groundwater Assessment: Addendum

Rio Grande Project, New Mexico

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Introduction

The southwestern willow flycatcher (*Empidonax traillii extimus*; hereafter SWFL) and western yellow-billed cuckoo (*Coccyzus americanus;* hereafter YBCU) are federally listed species of endangered and threatened status, respectively. Both species occupy territories along the Rio Grande in New Mexico. The U.S. Bureau of Reclamation (Reclamation) is interested in identifying potential sites to restore or enhance SWFL and YBCU habitat. The purpose of this study was to assess existing vegetation, soil types, and groundwater levels within the Percha Tree Farm to determine whether current conditions are conducive to native riparian restoration as well as to aid in the development of restoration and fire risk reduction plans for the site.

Percha Tree Farm is a 170 acre parcel that is federal property under the jurisdiction of the Bureau of Reclamation. Percha is located approximately 1.25 miles downstream of Caballo Dam, lies immediately adjacent to the western bank of the Rio Grande, and is bounded on the west by Percha Dam Canal Road (Figure 1). The study area is located immediately upstream of Percha Diversion Dam and Percha Dam State Park.

Reclamation began monitoring the groundwater levels throughout the Percha Tree Farm in 2015 (Ahlers et al. 2016). This addendum is an incorporation of the additional groundwater monitoring data collected from December 2015 through October 2016.

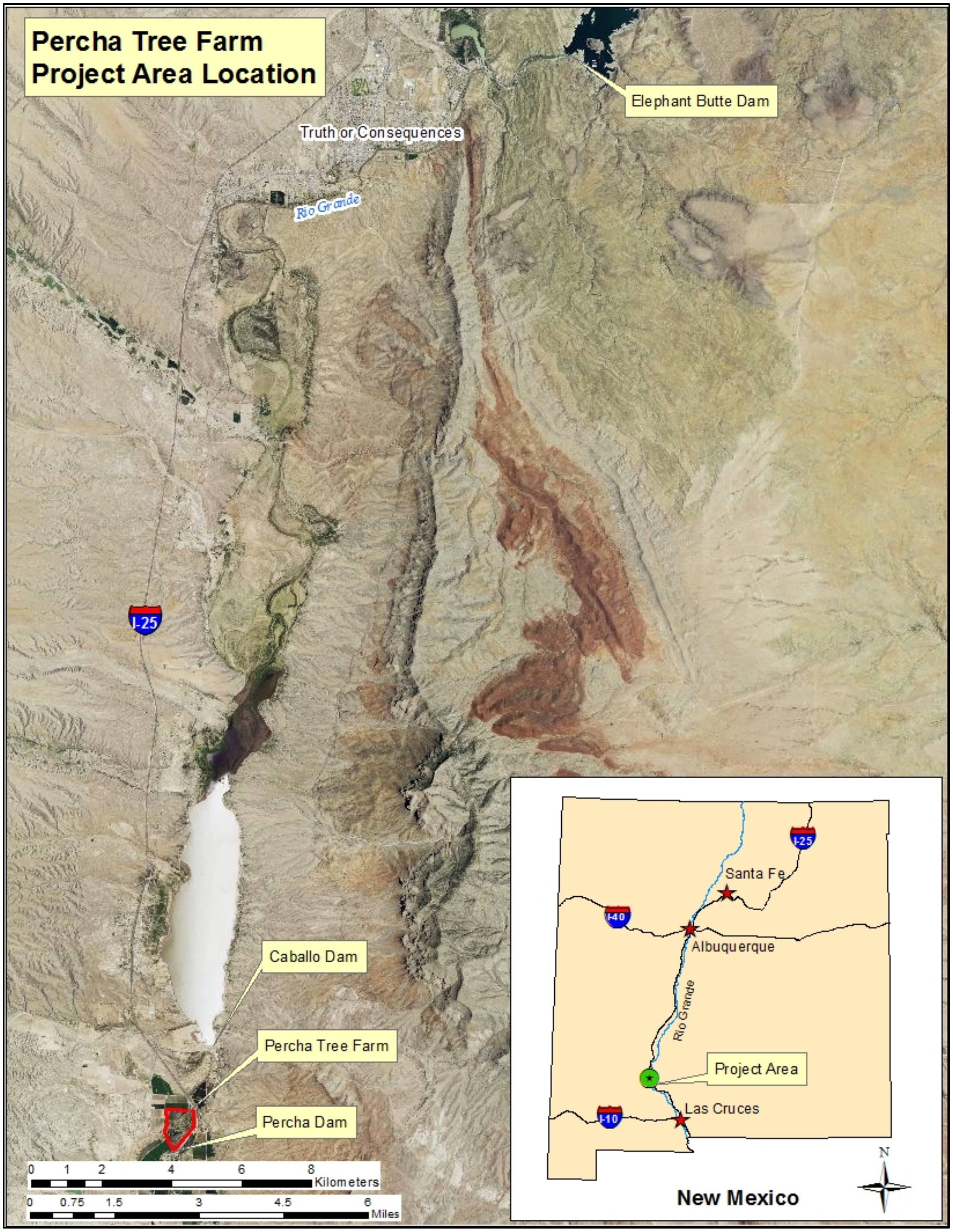


Figure 1. Percha Tree Farm Project Area location.

Methods

The study included three components: 1) vegetation mapping; 2) soil sampling; and 3) groundwater well monitoring. Following are detailed descriptions of these efforts.

Vegetation Mapping

Vegetation mapping was conducted in June 2015 using a modified Hink and Ohmart (1984) vegetation classification process. Aerial photographs were used as base maps for fieldwork; preliminary polygon boundaries were drawn on field maps using ArcGIS, based on photo interpretation of the vegetation. Aerial photography was acquired in June 2014 by the U.S. Department of Agriculture, National Agriculture Imagery Program (NAIP New Mexico 1 meter [m] Natural Color). Center points for each polygon were marked on field maps, which provided a waypoint to navigate towards while evaluating vegetation in the area as well as providing a reference point to determine approximate location on the ground. If ground-truthing found that preliminary vegetation boundaries were inaccurate, polygons were revised on the field map. A photograph was taken at a location that best represented each of the polygons (typically near the center of the polygon) to document the vegetation community and structure.

Biologists completed data sheets for each polygon (Table 1). The vegetation classification process consisted of categorizing vegetation polygons into community types and structure classes using an alphanumeric descriptive code. Each woody riparian plant species was assigned a letter code (i.e. the species code, listed in Table 1). Codes were also assigned for non-woody vegetation and non-vegetated land types (listed in Table 1).

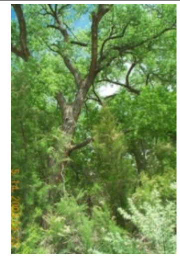
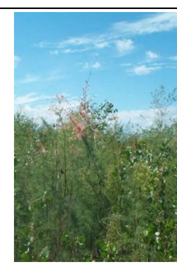
The Hink and Ohmart code consisted of species codes for the canopy layer, species codes for the understory layer, and a community type number signifying the height of the canopy and density of the understory. Community type classifications are described in Table 2.

In the field, the mapping process began by estimating total percent canopy cover within four layers of woody vegetation which included two overstory layers [i.e. >40 feet (ft) and 15-40 ft] and two understory layers (i.e. 5-15 ft and 0-5 ft). Plant species were recorded based on relative percentage of cover within each layer, with the most dominant species listed first. Species within the same layer were separated by a hyphen (-). Canopy and understory layers were separated by a back-slash (/). Typically, one or two species were recorded for each layer, but as

Table 1. Data form used for the Hink and Ohmart vegetation classification and mapping.

H&O Classification Form						
Date				**Time**		
Recorder						
Polygon ID			**Photo Number**			
UTM NAD 83 Coordinates	**X**					
	Y					
Riparian Woody Vegetation						
	>40 ft	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
		Total % Dead	1-24%	**25**-49%	**50**-74%	**75**-100%
	Species (Relative foliage cover) - Circle one for each species present List with most dominant 1st then decreasing dominance					
	>40 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
Species Codes	>40 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
ATX = Fourwing Saltbush	>40 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
B = Baccharis (Seep Willow)						
C = Cottonwood	**15-40 ft**	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
CAT = Cattail		Total % Dead	1-24%	**25**-49%	**50**-74%	**75**-100%
CR = Creosote	**Species (Relative foliage cover) -** Circle one for each species present					
CW = Coyote Willow	15-40 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
HMS = Honey Mesquite	15-40 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
MB = Mulberry	15-40 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
NMO = New Mexico Olive	15-40 Species #4		1-24%	**25**-49%	**50**-74%	**75**-100%
RO = Russian Olive						
SBM = Screwbean Mesquite	**5-15 ft**	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
SC = Salt cedar		Total % Dead	1-24%	**25**-490%	**50**-74%	**75**-100%
SE = Siberian elm	**Species (Relative foliage cover) -** Circle one for each species present					
TW = Tree Willow	5-15 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
VA = Velvet ash	5-15 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
WB = Wolfberry	5-15 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
	5-15 Species #4		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 ft*	Total % Cover	1-24%	**25**-49%	**50**-74%	**75**-100%
		Total % Dead	1-24%	**25**-490%	**50**-74%	**75**-100%
	Species (Relative foliage cover) - Circle one for each species present					
	<5 Species #1		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 Species #2		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 Species #3		1-24%	**25**-49%	**50**-74%	**75**-100%
	<5 Species #4		1-24%	**25**-49%	**50**-74%	**75**-100%
*Circle cover type for areas with woody vegetation < 25 %						
Wetlands/Herbaceous Vegetation /Non-vegetated						
MH = Cattail marsh	MH = Wet Meadow (sedges, rushes)		MS = Grass Meadow			
OW = Open Water	OP = Open Area (<25% vegetation cover)					
Notes						

Table 2. Community types used in the Hink and Ohmart classification.

Type 1 Tall/mature trees with well-developed understory	Tall or mature-aged trees (>40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering ≥ 25% of the area of the community (polygon). *Type 1d* – Type 1 with ≥ 50% total cover of one of the layers (canopy or understory)	
Type 2 Tall/mature trees with little or no understory	Tall or mature-aged trees (>40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering < 25% of the area of the community (polygon) *Type 2d* – Type 2 with ≥ 50% total cover of the canopy layer	
Type 3 Intermediate-sized trees with well-developed understory	Intermediate-sized trees (15-40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering ≥ 25% of the area of the community (polygon) *Type 3d* – Type 3 with ≥ 50% total cover of one of the layers (canopy or understory)	
Type 4 Intermediate-sized trees with little or no understory	Intermediate-sized trees (15-40 ft) with canopy covering ≥ 25% of the area of the community (polygon) ***and*** understory layer (0-15 ft) covering < 25% of the area of the community (polygon) *Type 4d* – Type 4 with ≥ 50% total cover of the canopy layer	
Type 5 Shrub-sized stands	Understory layer (5-15 ft) covering ≥ 25% of the area of the community (polygon) with no overstory layer. *Type 5d* – Type 5 with ≥ 50% total cover of the understory layer	
Type 6 Very young and low growth	Understory layer (0-5 ft) covering ≥ 25% of the area of the community (polygon) with no overstory layer.	

many as four species could qualify. Each height category in both layers (i.e. canopy and understory) had to comprise at least 25 percent total cover to qualify as a component in classification types and only one of the height categories in each layer was used for classification purposes (whichever was dominant). Each species had to cover at least 25 relative percent of the vegetation to be included in the Hink and Ohmart classification code. Plant cover, along with tree and shrub height, was determined by visual estimates.

The Hink and Ohmart code was written in the following format:

When a canopy and understory layer of $\geq$ 25% total cover were present:
Canopy Layer / Understory Layer + Type (1 or 3)
Example: C-TW/SC3
When a canopy layer was present but no understory:
Canopy Layer + Type (2 or 4)
Example: C2
When a canopy layer was not present:
Shrub or Young Growth Layer + Type (5 or 6)
Example: SC-B5

Vegetation maps were produced in GIS by using the information gathered in the field with each polygon being assigned a classification code. Vegetation species and community types were identified in order to provide information on existing conditions within the project area, which will provide an indicator for the success of potential restoration species.

Soil Sampling

Soil units as mapped by the USDA-NRCS soil survey (2015) are shown in Figure 2. A total of 30 soil samples were collected from 10 soil pedons (Figure 2) in March 2015. Soils were sampled at three depth increments [0-6 inches (in), 6-18 in, and 18-36 in] within each pedon. The chemical and physical properties of the samples were analyzed by the Colorado State University soils laboratory in Fort Collins, Colorado. The samples were analyzed on a number of parameters, including saturated paste pH, paste extract electrical conductivity (EC), lime estimate, percent organic matter (%OM), nitrate nitrogen (NO_3-N), phosphorous (P), potassium (K), zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), and texture.

Photos were taken at each pedon site to depict associated vegetation.

Soil lab analysis was used to characterize the chemical and physical properties of the soils within the project area and to identify potential limitations to riparian restoration.

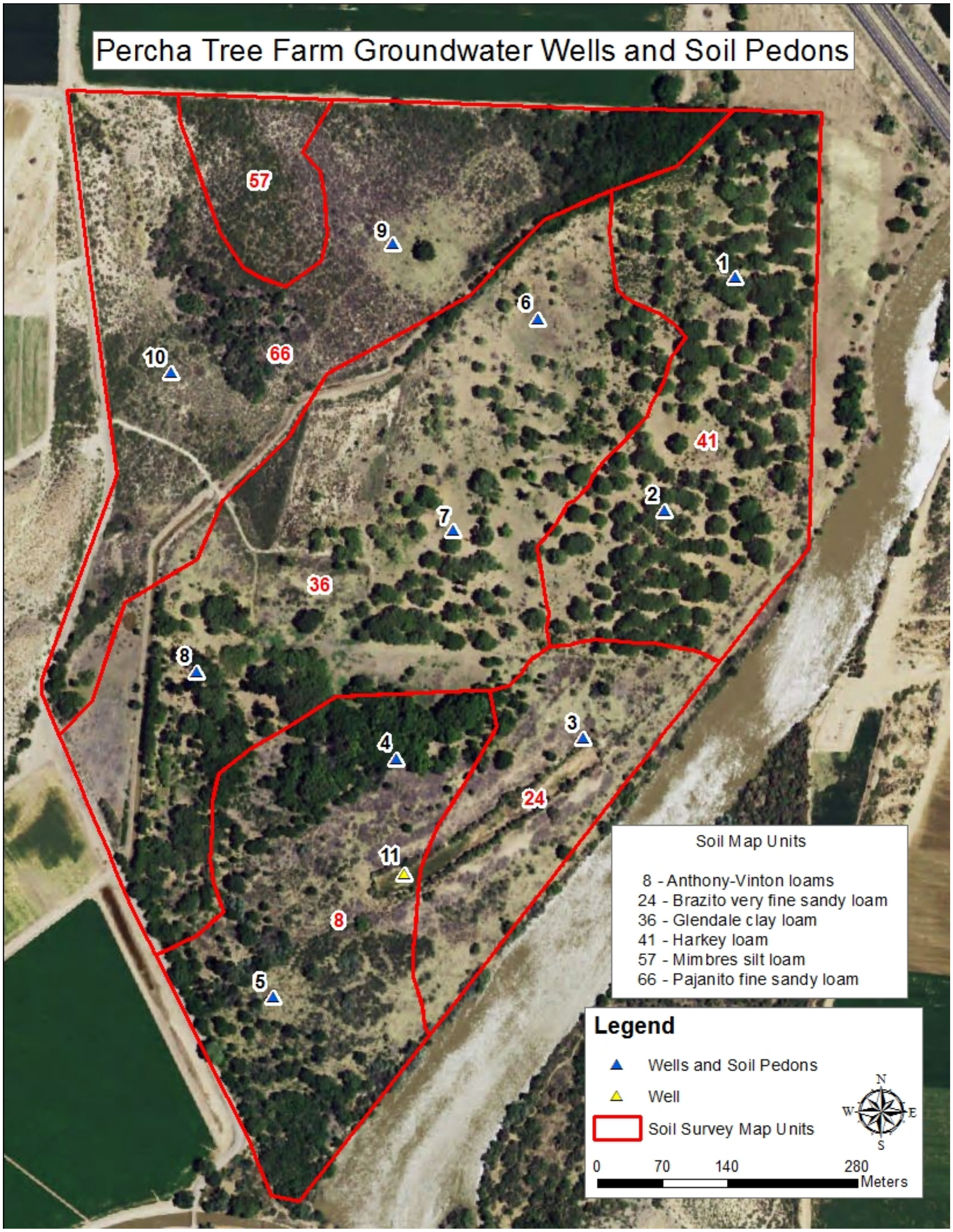


Figure 2. Groundwater well and soil pedon locations and USDA NRCS soil map units.

Groundwater Monitoring

Ten shallow ground water wells were installed in March 2015; an eleventh was installed in May 2015 in a former retention pond adjacent to the river channel in an effort to more closely monitor the relationship between river flows and water table elevation (Figure 2). All wells were installed using the Army Corps of Engineers (2000) methodology. Depth of wells ranged from 48 to 84 inches. Well 4 was deepened from 60 inches to 84 inches in March of 2016. The groundwater depths vary at each well, in order to get a better indication of the deeper groundwater fluctuations Well 4 was deepened. All of the wells were dry at the time of installation with the exception of the retention pond well. Elevational data was gathered at each well with Trimble survey grade GPS equipment using the North American Datum 1983 (NAD83). A HOBO Water Level Logger was inserted into each well and attached to the well cap via a braided stainless steel wire. Loggers were programmed to collect readings every two hours. Data were downloaded from the loggers by Reclamation staff and correlated to surface flows based on releases from Caballo Dam.

A shallow water table is imperative for sustaining a healthy community of native riparian plant species. Data provided by monitoring wells indicate the depth and duration of groundwater levels within the project area.

Results

Vegetation Mapping

A list of common plant species observed during vegetation mapping is shown in Table 3. This list includes all species used in classification of vegetation types as well as other important species that were documented, however the list does not include every species within the project area.

Table 3. Common plant species detected within Percha Tree Farm Project Area.

Plant species list - Percha Tree Farm		
Common name	**Scientific name**	**Lifeform***
Rio Grande cottonwood	*Populus deltoides ssp. wislizeni*	NT
Tree willow	*Salix gooddingii*	NT
White mulberry	*Morus alba*	IT
Velvet ash	*Fraxinus velutinous*	NT
Siberian elm	*Ulmus pumila*	IT
Russian olive	*Elaeagnus angustifolia*	IT
Saltcedar	*Tamarix ramosissima*	IT/S
Seep willow	*Baccharis salicifolia*	NS
Four-wing saltbush	*Atriplex canescens*	NS
Honey mesquite	*Prosopis glandulosa*	NS
Screwbean mesquite	*Prosopis pubescens*	NS
Wolfberry	*Lycium torreyi*	NS
Skunkbush sumac	*Rhus trilobata*	NS
Mormon tea	*Ephedra viridis*	NS
Cattail	*Typha spp*	NG
Alkali sacaton	*Sporobolus airoides*	NG
Salt grass	*Distichlis spicata*	NG
Johnson grass	*Sorghum halepense*	IG
Field bindweed	*Convolvulus arvensis*	IF

* N=native; I=introduced; T=tree; S=shrub; G=grass; F=forb

The vegetation map of Percha Tree Farm is shown in Figure 3. The total acreage within each of the vegetation types is listed in Table 4. A fire in April of 2015 burned approximately 40 acres in the northwest corner of the project area just prior to mapping in June – all vegetation was lost. Vegetation in the remainder of the Percha Tree Farm project area is characterized by occasional tree stands interspersed with open areas (most created by fire), dry meadows, and low shrubs. Tree stands are comprised of various dominant canopy species that include cottonwood (with tree willow understory); cottonwood and tree willow; mulberry and velvet ash; velvet

Figure 3. Vegetation map of the Percha Tree Farm Project Area using the Hink and Ohmart classification (NAIP 2014 natural color photography).

Table 4. Acreages of community types within Percha Tree Farm Project Area.

Type*	Acres
C/B-SBM1	40
Open (burned)	37
Open	24
Grass meadow	14
C-TW4d	12
SE-MB/HMS3	10
VA2d	6
Irrigation ditch/road	6
SBM/WB3	5
WB-B-SBM6	5
MB-VA2d	4
HMS-ATX6	2
SC-TW/WB-B3d	1
Cattail marsh	1
Open water	<1
TOTAL ACRES	168

* See Figure 3 for species and community type codes

ash (only with mulberry understory), and Siberian elm and mulberry. Most of these dominant species are native with the exception of mulberry and Siberian elm.

While navigating the site during vegetation mapping, a number of wildlife species were observed, either visually or aurally (Table 5). Detections were only through casual observation and were not identified in a formal survey.

Table 5. Wildlife species observed through visual or auditory detection in the Percha Tree Farm Project Area.

Wildlife species list - Percha Tree Farm	
Common name	**Scientific name**
Mammals	
Rocky Mountain elk	*Cervus elaphus nelsoni*
Mule deer	*Odocoileus herionus*
Javelina	*Peccary angulatus*
Desert cottontail	*Sylvilagus auduboni*
Mexican woodrat	*Neotoma mexicana*
Coyote	*Canis latrans*
Reptiles	
Western painted turtle	*Chrysemys picta belli*
Birds	
Great horned owl	*Bubo virginianus*
Cooper's hawk (pair)	*Accipiter cooperii*
Gambel's quail	*Callipepla gambelii*
Mourning dove	*Zenaida macroura*
White winged dove	*Zenaida asiatica*
Barn swallow	*Hirundo rustica*
Yellow-breasted chat	*Icteria virens*
Northern mockingbird	*Mimus polyglottos*
Vermillion flycatcher	*Pyrocephalus rubinus*
Mallard	*Anas platyrhynchos*

Soil Sampling

Results from the soil analysis are in Table 6. Based on soil textures provided in the analysis, soil units did not correlate with the USDA-NRCS soil survey of the area. Soil samples collected had higher clay content than those described in the survey with most pedons consisting of sandy clay over clay or primarily clay throughout the profile to 36 inches.

Table 6. Soil Lab Results, Percha Tree Farm Project Area.

				Paste				AB-DTPA (ppm)							
Pedon	**Depth (in)**	**H&O Veg Type**	**Soil Unit**	**pH**	**EC (mmhos/cm)**	**Lime**	**%OM**	**NO3-N**	**P**	**K**	**Zn**	**Fe**	**Mn**	**Cu**	**Texture**
1	**0-6**	C/B-SBM1	41	7.9	0.8	very hi	2.5	3.6	3.7	706	2.16	5.17	3.91	10.4	SCL
	6-18			8.0	0.8	very hi	1.8	0.9	0.9	337	3.43	13.5	2.22	24.2	SC
	18-36			7.9	1.3	very hi	2.0	2.0	0.6	308	2.88	13.8	2.24	27.0	C
	Avg			7.9	1.0		2.1	2.2	1.7	450.3	2.8	10.8	2.8	20.5	
2	**0-6**	C/B-SBM1	41	8.0	1.9	very hi	3.3	2.1	4.0	723	2.17	11.7	4.27	12.7	SC
	6-18			7.9	3.1	very hi	2.2	1.4	1.8	361	2.6	30.3	3.35	34.2	SC
	18-36			8.1	4.0	very hi	1.3	0.3	0.1	194	0.52	27.2	1.95	6.5	C
	Avg			8.0	3.0		2.3	1.3	2.0	426.0	1.8	23.1	3.2	17.8	
3	**0-6**	MS	24	8.5	1.2	very hi	2.6	6.5	2.8	630	1.21	30.2	3.96	6.56	SC
	6-18			9.0	2.0	very hi	1.0	3.0	1.8	448	0.53	14.2	2.04	3.87	SC
	18-36			8.1	3.8	very hi	5.3	0.5	0.9	386	0.36	7.92	1.62	1.98	C
	Avg			8.5	2.3		3.0	3.3	1.8	488.0	0.7	17.4	2.5	4.1	
4	**0-6**	VA2	8	7.9	3.7	very hi	2.6	20.4	27.1	1153	5.3	12.1	5.2	9.19	SC
	6-18			8.1	6.6	very hi	0.5	3.9	6.5	673	2.1	13.8	3.7	11.8	C
	18-36			8.6	4.4	very hi	2.4	1.1	2.5	149	0.5	7.1	1.78	3.98	SC
	Avg			8.2	4.9		1.8	8.5	12.0	658.3	2.6	11.0	3.6	8.3	
5	**0-6**	MS	8	8.1	0.7	very hi	0.8	1.5	8.4	609	0.88	11.3	3.48	5.34	C
	6-18			8.6	0.6	very hi	0.1	16.0	2.8	210.0	0.32	5.21	0.88	1.47	SC
	18-36			9.1	0.3	low	3.0	5.6	2.1	44.4	0.21	1.92	0.68	0.77	LS
	Avg			8.6	0.5		1.3	7.7	4.4	287.8	0.5	6.1	1.7	2.5	
6	**0-6**	OP	36	8.0	0.7	very hi	2.9	2.7	7.1	588	1.47	11.3	2.97	9.07	SC
	6-18			8.0	1.0	very hi	1.9	5.6	2.8	383	0.8	13.9	1.7	6.24	C
	18-36			8.0	1.8	very hi	1.5	2.6	1.2	267	0.33	8.16	1.49	3.03	C
	Avg			8.0	1.2		2.1	3.6	3.7	412.7	0.9	11.1	2.1	6.1	
7	**0-6**	C/B-SBM1	36	8.1	0.7	very hi	2.9	5.7	4.6	863	1.38	21.7	3.59	8.34	C
	6-18			8.1	1.3	very hi	1.8	2.6	2.1	552.0	0.5	15.2	2.17	4.55	C
	18-36			7.8	2.9	very hi	1.1	1.3	2.8	340	0.27	15.6	1.91	2.46	C
	Avg			8.0	1.6		1.9	3.2	3.2	585.0	0.7	17.5	2.6	5.1	
8	**0-6**	C-TW4d	36	7.8	1.7	very hi	6.8	12.5	9.6	1075	3.66	18.0	9.2	8.37	SC
	6-18			7.8	2.3	very hi	2.3	1.1	1.2	862	1.5	20.3	5.49	11.3	C
	18-36			7.7	4.9	very hi	1.4	0.4	1.2	512	0.45	16.3	4.05	3.77	C
	Avg			7.8	3.0		3.5	4.7	4.0	816.3	1.9	18.2	6.2	7.8	
9	**0-6**	OP(burn)	66	8.0	0.7	very hi	4.3	14.6	6.5	1085	1.74	2.8	3.02	4.0	SC
	6-18			8.2	0.6	very hi	1.9	7.4	1.8	876	0.67	2.9	1.69	2.98	SC
	18-36			7.7	3.0	very hi	1.2	12.4	1.2	503	0.19	3.3	1.67	1.22	SC
	Avg			8.0	1.4		2.5	11.5	3.2	821.3	0.9	3.0	2.1	2.7	
10	**0-6**	OP(burn)	66	8.0	0.9	very hi	1.5	32.9	6.8	2340	0.47	2.8	1.62	1.79	SC
	6-18			7.8	3.1	very hi	1.9	99.9	2.5	841	0.41	4.8	2.19	2.08	C
	18-36			7.8	5.6	very hi	2.4	16.8	1.8	550	0.33	5.9	4.34	1.9	C
	Avg			7.9	3.2		1.9	49.9	3.7	1243.7	0.4	4.5	2.7	1.9	

Saline conditions were detected in four of the 30 samples (Pedons 4, 8, and 10; Table 6 and Figure 4) in the 6 to 36 inch depth range. Saline soils are defined as those having an EC >4 (Flynn and Ulery 2011). High salt in the plant root zone interferes with the uptake of water and depending on the species' tolerance to salt can lead to poor growth or mortality. Saline soil samples were collected along a transect from the south central toward the northwest region of the project area.

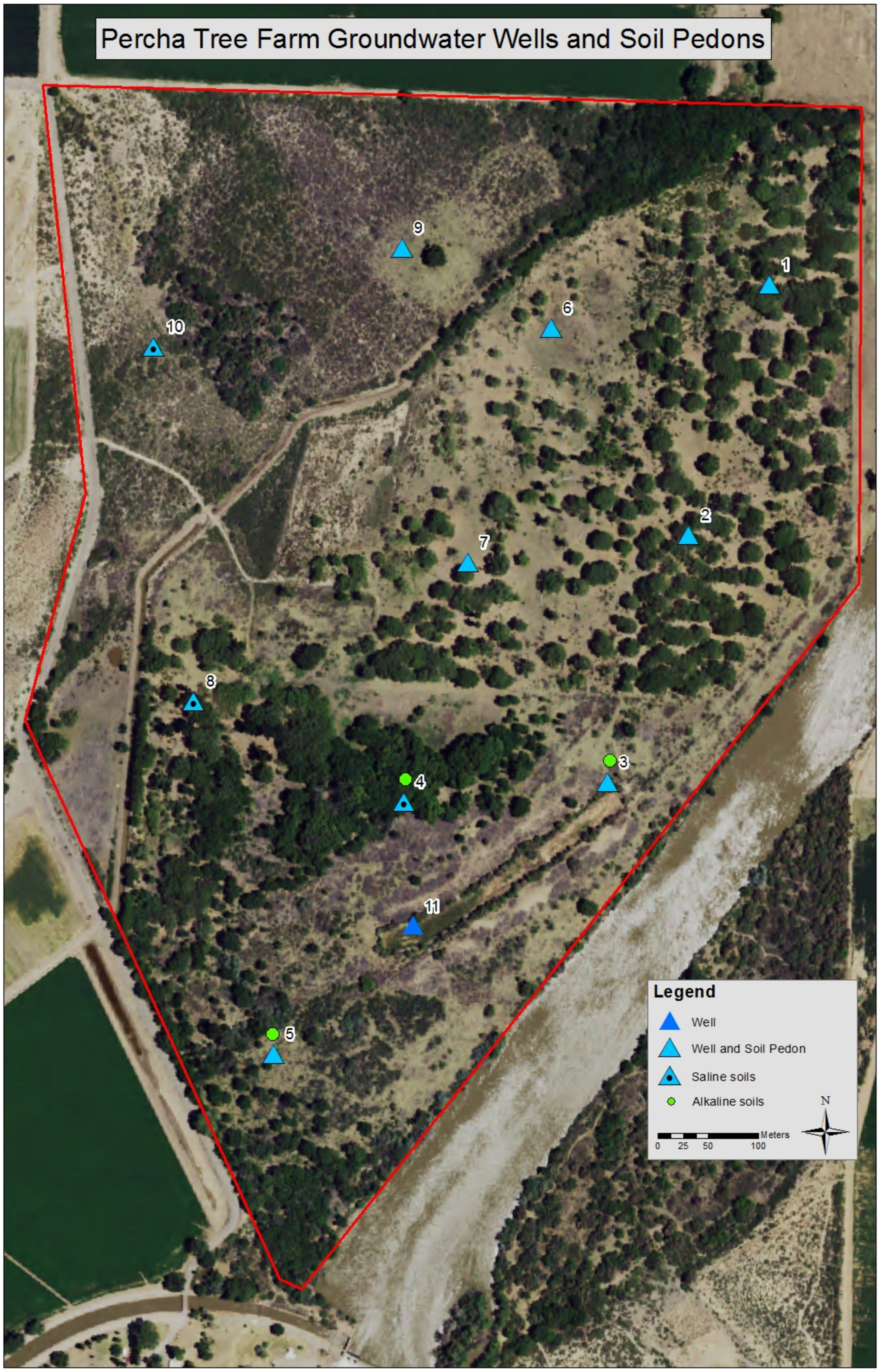


Figure 4. Soil pedons in which saline or alkaline conditions were detected.

Salts were visible in the soil profile while field sampling at Pedon 4, located at the edge of a velvet ash stand with mulberry understory and adjacent to a grass meadow. Saline soils did not appear to affect the health of the vegetation at this site even though the salt tolerance level of velvet ash is rated “sensitive” according to the USDA Plants Database (Flynn and Ulery 2011). On the other hand, lab analysis detected saline conditions from 18 to 36 inches within Pedon 8, which was located in a cottonwood and tree willow stand where trees appeared to be dying, or at least unhealthy. Cottonwood and tree willow have low levels of salt tolerance (Myers and Bazely 2003,Vandersande et al 2001) with growth inhibited when EC is greater than 2.3 mmhos/cm (Wiesenborn 1996), which was the case in the majority of soil pedons > 6 inches from the surface.

Figure 4 shows that the pH levels detected in samples from Pedons 3, 4, and 5 strongly indicated alkaline conditions (pH>8.5; Herrera 2000). Soil pH affects the availability of nutrients and also the activity of beneficial microorganisms. The majority of plants grow best in slightly acidic soils in the 6 to 7 pH range. Alkaline soil samples were collected from pedons in the southern portion of the project area. Pedons 3 and 5 were located in an alkali sacaton and saltgrass meadow. Pedon 4 was located at the edge of a velvet ash and mulberry stand (adjacent to the grass meadow) and also exhibited saline conditions as included above. Alkaline conditions appeared to be associated with the grass meadow at the southern portion of the project area.

Table 7 shows classifications used in interpreting soil nutrient tests for gardening in New Mexico (Flynn and Ulery 2011). Though these limits should not be interpreted strictly for native plant requirements in riparian soils, they do provide a general guideline. According to this classification, percent organic matter (%OM), nitrate nitrogen (NO_3-N), and phosphorous (P) were the only limiting factors in the soil. The concentration of these nutrients have been classified as low to very low throughout various depths of the soil profile (see Tables 6 and 7). This is not surprising since NO_3-N and P are typically the most limiting of plant growth nutrients, particularly in soils of the arid southwestern United States and where development of organic matter - a source of available plant N and P – is limited due to slow decomposition associated with a dry climate. Phosphorous is also unavailable to plants in alkaline pH which is characteristic of western soils.

Micronutrients were found in high concentrations in most of the the Percha soils, with K, Cu and Fe having high to very high concentrations in almost all pedons. Manganese was also highly concentrated in most samples while Zn levels ranged from low to highly concentrated. The reason for the high concentrations of micronutrients is unknown but could be linked to agriculture surrounding the project area or to past management practices at the site. For example, the use of agrochemicals is linked to Cu toxicity (Sheldon and Menzies 2005) and can also be a source of excess Zn (Spectrum Analytic 2015, Alloway 2008).

Table 7. Classifications used in interpreting soil nutrient tests in New Mexico.

Parameter	Classification				
	Very low	**Low**	**Medium**	**High**	**Very high**
%OM					
Sandy texture	< 0.5	0.5 - 1	1 - 1.5	> 1.5	NR
Clay texture	< 1	1 - 2	2 - 3	> 3	NR
NO3-N (ppm)	< 3	3 - 10	11 - 30	31 - 50	> 50
P (ppm)	< 7	8 - 14	15 - 22	23 - 30	> 31
K (ppm)	< 10	11 - 30	31 - 60	61 - 80	> 80
Zn(ppm)	NR	< 0.5	0.5 - 1	> 1	NR
Fe (ppm)	NR	< 2.5	2.5 - 4.5	> 4.5	NR
Mn (ppm)	NR	< 1	1 - 2.5	> 2.5	NR
Cu (ppm)	NR	< 0.3	0.3 - 1	> 1	NR

NR = No rating

Many soils of western states have high concentrations of K because soils are formed from geologically young parent materials and under conditions of lower rainfall where leaching is limited (Tisdale et al 1993). There is no evidence that K has a direct elemental toxicity to plants, however, excess K may appear as damage from excess salts and stress the plants (Spectrum Analytic 2010). Sheldon and Menzies (2005) found the effects of Cu toxicity on Rhodes grass (*Chloris gayana*) to be consistent with other similar studies. No foliar symptoms were observed as a result of Cu toxicity, however root growth was severely inhibited. Solubility of Cu, Zn and Fe decreases as pH increases and these micro nutrients are usually deficient in calcareous (alkaline) soils; pH levels did not appear to correlate with levels of these elements found at the site. Iron toxicity is most common in acid soils or in flooded conditions where the soil is reduced and Fe is highly available (Fageria et al 1990); neither of these conditions were recorded at the Percha study site. Manganese toxicity generally occurs in acid or poorly drained soils and effects plant foliage, which again were not detected within Percha Tree Farm.

Photos taken in association with each of the soil pedons are shown in Appendix A.

Groundwater Monitoring

Ground water data from monitoring wells in 2015 were collected and analyzed from March 13, 2015 through December 1, 2015. A second set of groundwater data was collected from December 1, 2015 through October 27, 2016, with the exception of Well 4 (March 15, 2016 to October 27, 2016). Water table levels and river flows are graphed by well and presented in Appendix B. Daily mean flow data was a measure of cubic feet per second (cfs) released out of Caballo Dam from May 11, 2015 to September 28, 2015 and from March 26, 2016 through October 2, 2016.

In 2015 flows were highest from June to August - between approximately 1,500 and 2,500 cfs - with essentially no flow recorded from March to May and from October to December. Flows in 2016 were highest from late March through September - between approximately 1,000 and 2,500 cfs - with essentially no flow recorded from January to early March and from October to December. During the high flow period in 2015, Wells 3, 4, 5, and 8 contained water between four and five feet from the surface. In 2016 during the period of high flow, Wells 3, 4, and 5 again contained water between four and five feet from the surface. Well 8, however, did not contain any water in it during the period of high flow in 2016. Well 11, which was located in the ponded area, contained water during the entire monitoring period and was often surrounded by standing water in both 2015 and 2016. All of these wells were located in the southern portion of the study area nearest the river (Figure 2). Ground water levels generally correlated closely with river flows, indicating a hydrologic regime influenced by the riverine system at the project site.

The soil surface level of all groundwater wells was collected, as was the elevation of Percha Dam spillway, which is essentially the river’s level at base flow. Waypoints and elevations are shown in Table 8, which also lists differences between the surface elevations of each well and the spillway elevation. The graphs in Figures 5 and 6 compare surface elevation, well depth (elevation), and water table elevation by well. The value used for water table elevation was estimated using the shallowest depth recorded (during peak flows) and only includes the first five wells on the x-axis. For the other six wells, where the water table was not logged, estimations were made based on known water table elevations. Water table elevation was highest when river flows were between 1,500 and 2,500 cfs; when river discharge was 0 cfs it is assumed that the water table was closer to base flow elevation. Estimated water table depths ranged from 5.5 to 14.5 ft below the surface during peak flows. During base flows, the water table is estimated to range from 7.5 to 19.2 ft below the surface within all wells except Well 11, which is located in the pond and below base flow elevation. These estimates are probably conservative since it is likely that the water table is deeper further from the river.

Table 8. Waypoints and soil surface elevation by well and differences between soil surface and spillway (base flow) elevations.

Point ID	Easting	Northing	Surface Elevation (ft)	Difference between spillway and surface elevation (ft)
Spillway	284,419	3,639,110	4142.2	0.0
Well 1	284,830	3,640,149	4154.5	12.3
Well 2	284,754	3,639,899	4152.4	10.2
Well 3	284,677	3,639,654	4150.9	8.7
Well 4	284,466	3,639,632	4150.5	8.3
Well 5	284,334	3,639,376	4149.8	7.6
Well 6	284,618	3,640,105	4155.5	13.3
Well 7	284,527	3,639,877	4152.7	10.5
Well 8	284,252	3,639,725	4149.9	7.7
Well 9	284,463	3,640,185	4160.3	18.0
Well 10	284,224	3,640,047	4161.4	19.2
Well 11	284,475	3,639,508	4143.1	0.9

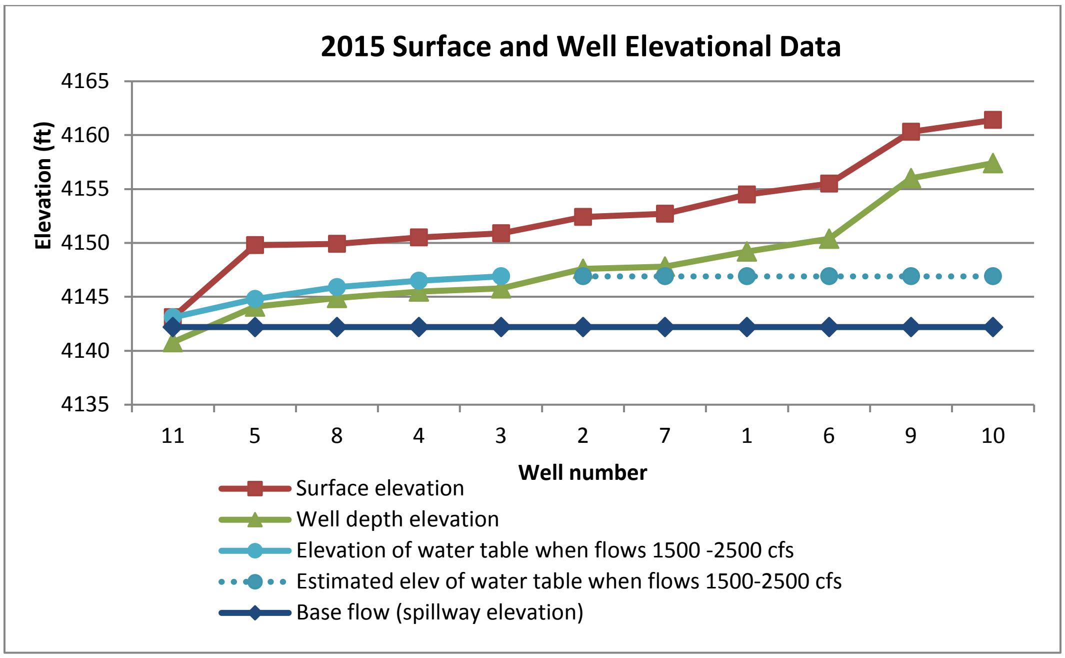


Figure 5. 2015 surface elevation, well depth elevation, water table elevation at peak flows, and base flow (spillway) elevation by well.

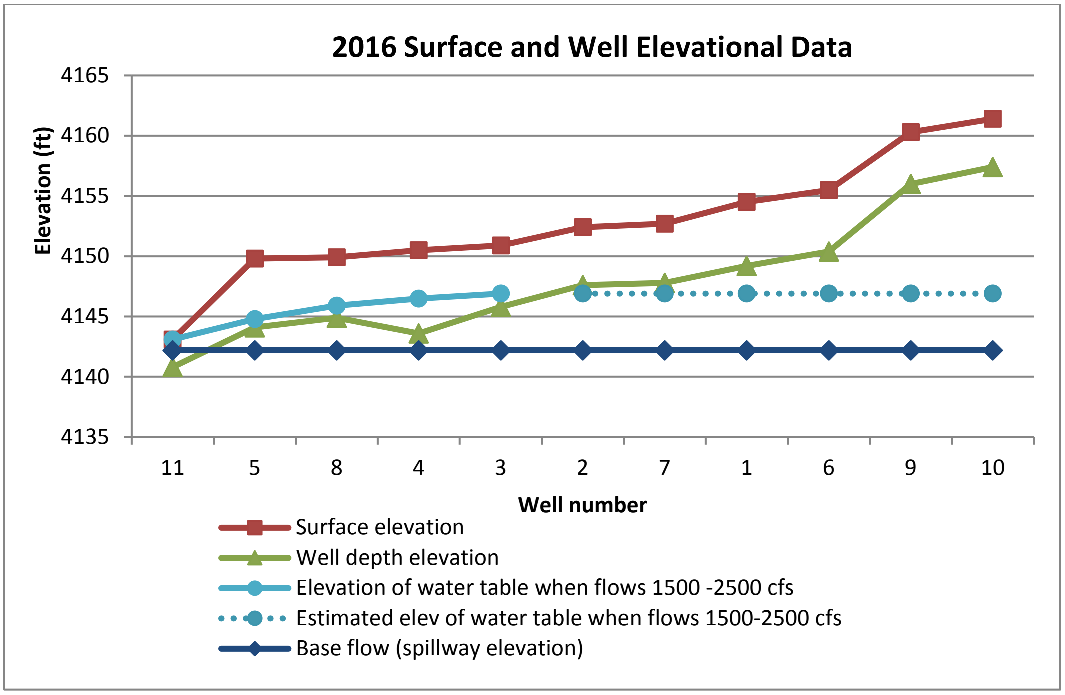


Figure 6. 2016 surface elevation, well depth elevation, water table elevation at peak flows, and base flow (spillway) elevation by well.

Data collected during the second seasonal effort from December 1, 2015 through October 27, 2016 essentially confirmed the findings of the initial study period. The depth to the ground water was nearly identical throughout both study periods. The only noticeable change from 2015 to 2016 was the well depth of Well 4 and its proximity to the base flow. Since Well 4 was deepened it was closer to the spillway's elevation at base flow.

Restoration Considerations

Based on vegetation, soil, and ground water monitoring results as well as observations by Reclamation biologists, the Percha Tree Farm property is not an optimal riparian restoration site for a number of reasons.

The majority of the dominant plant species are not considered wetland indicator species, suggesting that currently the site does not provide conditions conducive to this habitat type. Exceptions were tree willow, which is categorized as facultative wetland species (usually occur in wetlands, but may occur in non-wetlands) on the National Wetland Plant List (Army Corps of Engineers 2014). Seep willow, saltcedar, and saltgrass are considered facultative (occur in wetlands and in non-wetlands) to facultative wetland species. Cattail is an obligate wetland species (almost always occurs in wetlands) and was only found in the retention pond. As mentioned above, tree willow did not appear to be thriving which may have been due to saline soils or to insufficient groundwater.

Soil analysis identified areas in which salinity and alkalinity were at levels high enough to inhibit the establishment and development of most plant species. These areas were mostly concentrated in the southern portion of the study area, a large part of which is occupied by dry meadow with grass species adapted to alkaline and saline conditions. Most of the soils in the area have EC levels high enough to inhibit cottonwood and tree willow growth, which are sensitive to soil salinity. Even though many of the micronutrients were found in high to very high concentrations in the soil, they do not appear to be a threat to the plant’s health based on dry, non-acid conditions.

The factor that may pose the greatest challenge for habitat restoration at the site is depth to ground water. In 2015, the water table was only documented within four to five feet of the surface and was estimated to be as deep as 14.5 ft when flows were above approximately 1,500 cfs, an occurrence that is completely dependent on Caballo Dam releases. Reclamation observed flows in 2016 exceeding 1,500 cfs for 11 weeks out of the year. The remainder of the year the Caballo Dam releases were less than 1,500 cfs, most being 0 cfs. The ground water was estimated to be as high as four to five feet below the surface and in some wells to be as deep as 19 feet below the surface. Tree willow, an important species in both SWFL and YBCU habitat, requires relatively shallow groundwater and is sensitive to drought associated with groundwater declines (Shafroth et al. 2000). Saturated soil conditions are especially important for the establishment of seedlings. Mature willows can eventually access deeper groundwater, with actual depth estimates varying by study. Terlep (2014) reports rooting depths of cottonwood and tree willow fluctuating between 2-3 meters (m; 6.6-9.8 ft; Glenn and Nagler 2005) and 3-4 m (9.8-13.1 ft; Stromberg 1993). Zimmerman (1969) noted root depths of up to seven feet (2.1 m) in tree willow in Arizona. Similarly a USGS (1999) study found that where water table depth was greater than about seven feet, or in areas where permanent water table declines were greater than about five feet, there was a 50 to 100 percent mortality rate in cottonwood/willow woodlands.

Shafroth et al (2000) emphasized the importance of change in groundwater depth relative to a previous condition or pattern as opposed to the absolute depth to the water table on tree willow survival. Results of this study showed that a site along the Bill Williams River in Arizona where the lowest observed groundwater depth in one year (1.97 m) was 1.11 m lower than the previous year (0.86 m) had 92–100 percent mortality of cottonwood and tree willow saplings compared to a site with greater absolute water table depths (2.55 m), but less change in the same time period (a decline of 0.55 m), which showed less mortality and increased basal area.

With regards to restoration, soil saturation is an important component in the establishment of seedlings and is directly influenced by the pace of water table declines. Horton and Clark (2001) found greater mortality and less biomass in tree willow treatments subjected to water table decline as compared to those that experienced no decline. Tree willow roots tend to develop laterally rather than elongate in early stages of growth which is why saturated conditions appear to be necessary. The plant's response to the water table level change is mediated by soil water retention. Therefore trees growing in finer-textured soils, which are capable of holding water for longer periods, may survive greater water table changes than trees growing in coarser soils (Condra 1944). Soils within the project area are predominately clay textures, and therefore do exhibit water holding capacity.

Groundwater monitoring at the Percha Tree Farm site was limited by well depths and the short duration in which data was collected. No long-term trends could be predicted from a two year study period. It is also unknown whether water table depths persisted at approximately seven feet (2.1 m) from the surface, which seems to be commonly accepted as a threshold for tree willow rooting depths. However, data does indicate that the water table reaches a minimum depth of four feet for short periods correlated with higher river flows when dam releases occur and only in the southern portion of the study area. Estimations based on the available ground well data suggest that the water table in the northern portion of the study area is deeper than seven feet, even during periods of highest flows. During low flow periods, which was a more common condition, the water table was estimated to be at depths greater than seven feet except in the retention pond. It can also be surmised that there are rapid water table declines associated with decreasing river discharge. These conditions are not conducive to willow seedling establishment, which requires saturated soils that could not be sustained based on current water table depths which were not observed at the site over the monitoring period. Current conditions may support mature tree willow; the species does currently occur within the project area as a second-tier species within the cottonwood stand in the northeast, within the cottonwood-tree willow stand in the southwest, and around the pond in the south. Tree willow does not appear to be flourishing, which could be related to groundwater depths or to its low tolerance for soil salinity.

An irrigation ditch currently crosses the site (Figure 4), which could potentially serve as a water source in restoration depending on existing water rights and management. Based on current surface elevation and ground water depths, irrigation would most likely need to be a perpetual management tool for sustaining riparian vegetation. Another consideration with irrigation is the potential to increase soil salinity, particularly at this site where saline soils are already present. Irrigation water often contains salts, either naturally occurring or picked up as water moves across the landscape. When plants absorb water, salts are left behind in the soil and eventually begin to accumulate. In turn, soil salinity alters water uptake, making it more difficult for plants to absorb soil moisture. Surface diversions or irrigation may be more beneficial when paired with bank lowering, as discussed below.

The areas that offer the best potential for tree willow recruitment and survival based on ground water levels were associated with soil pedons where saline and alkaline soils were detected, factors that inhibit plant growth. The existing vegetation in this area is predominantly salt and alkaline tolerant grasses and mesquite, which indicates soil conditions are not optimal for willow development. Saline conditions may potentially be ameliorated with periodic overbank flooding and surface diversions that would flush salts from the soil profile.

To encourage overbank flooding and create hydrologic conditions where the water table is shallow enough to support riparian vegetation, the most effective solution would be to excavate the site, lowering the river banks and adjacent ground surface. A minimum size of 2-5 ha of dense riparian vegetation would be desirable to accommodate the habitat requirements of both the SWFL and YBCU. Bank lowering should be engineered to accommodate overbank flooding during periods of peak flows (2000-2500 cfs) which would aid in the establishment of native riparian vegetation by creating moist soil conditions. As previously mentioned, bank lowering would also reduce the depth to groundwater (likely to within a couple feet from the surface) and aid in the long-term maintenance and development of the riparian community**.**

An engineering feasibility study should be considered to determine: 1) the elevational requirements which would permit overbank flooding during flows of 2000-2500 cfs, 2) the post bank-lowering depth to groundwater based on current depth to groundwater data, and 3) the estimated cubic yards of overburden that would need to be excavated to achieve these conditions.

While meeting water delivery obligations, scheduled periodic pulse releases from Caballo Dam in excess of 2000 cfs would be beneficial by permitting occasional flooding of the area in which banks were lowered. Also, to the extent possible the gates at Percha Diversion Dam should remain closed throughout the year, allowing water to pool behind the gates and keep the water table as high as possible at the upstream restoration site.

Percha Tree Farm provides high quality habitat for a suite of wildlife species that currently occupy the site including the threatened yellow-billed cuckoo. In 2016, three YBCUs were detected during the breeding season. These detections represent a possible breeding pair. No southwestern willow flycatchers have ever been detected at the Percha Tree Farm since surveys began in 2013, although the wildlife habitat is none the less unique and valuable. Given the soil chemistry and groundwater limitations of the site, it appears that successful riparian restoration within the Percha Tree Farm may be difficult at best.

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Appendix A

Soil Pedon Site Photos
March 2015


Pedon 1


Pedon 2


Pedon 3


Pedon 4


Pedon 5


Pedon 6


Pedon 7

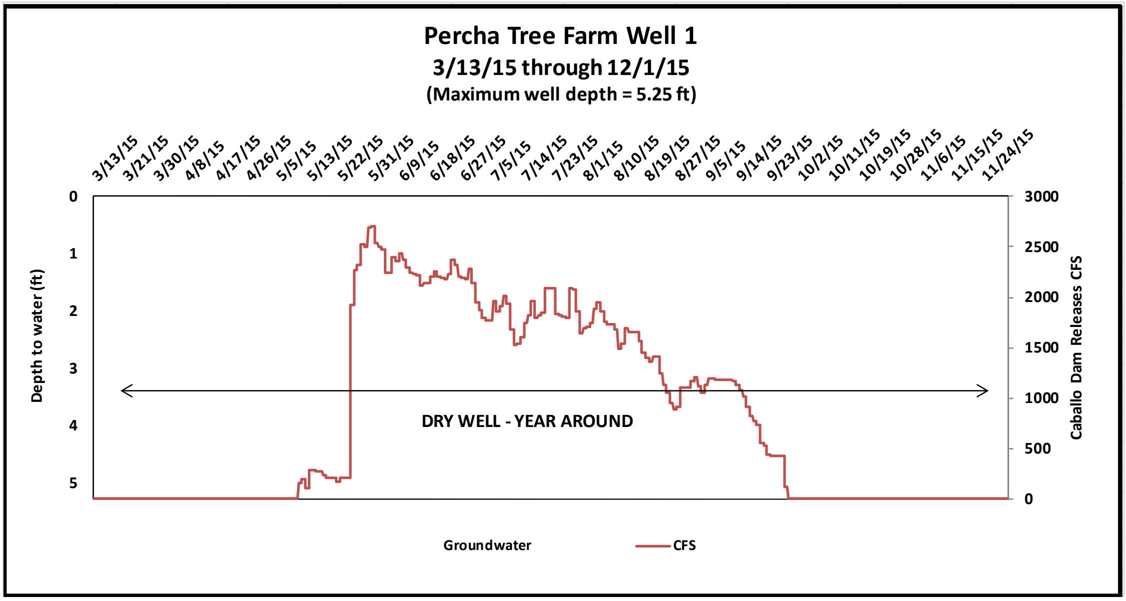

Pedon 8

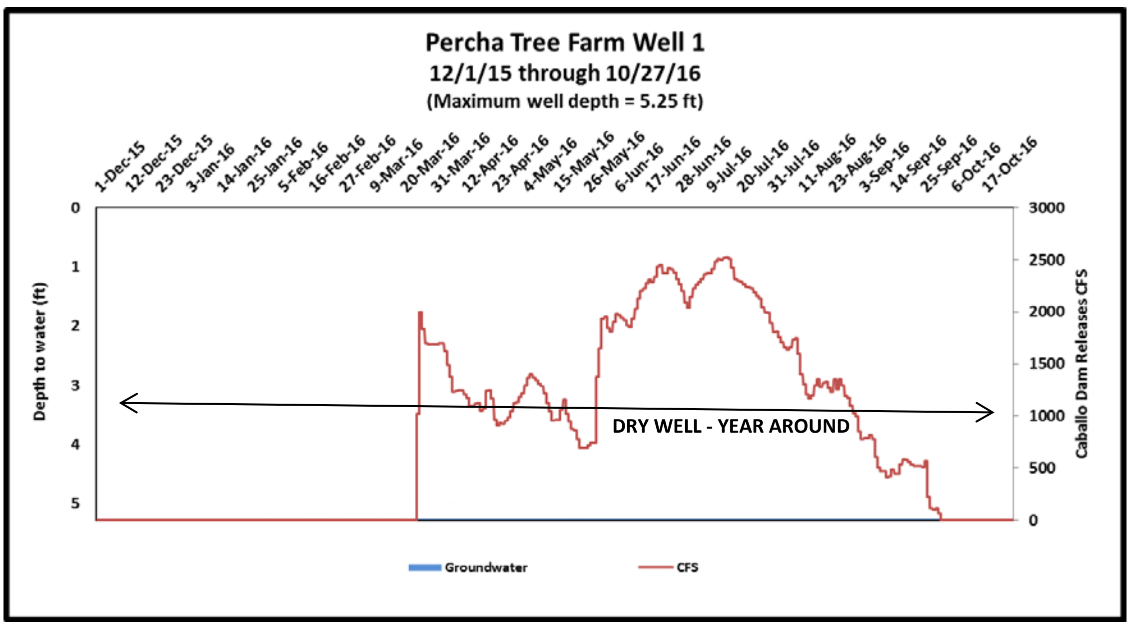

Pedon 9

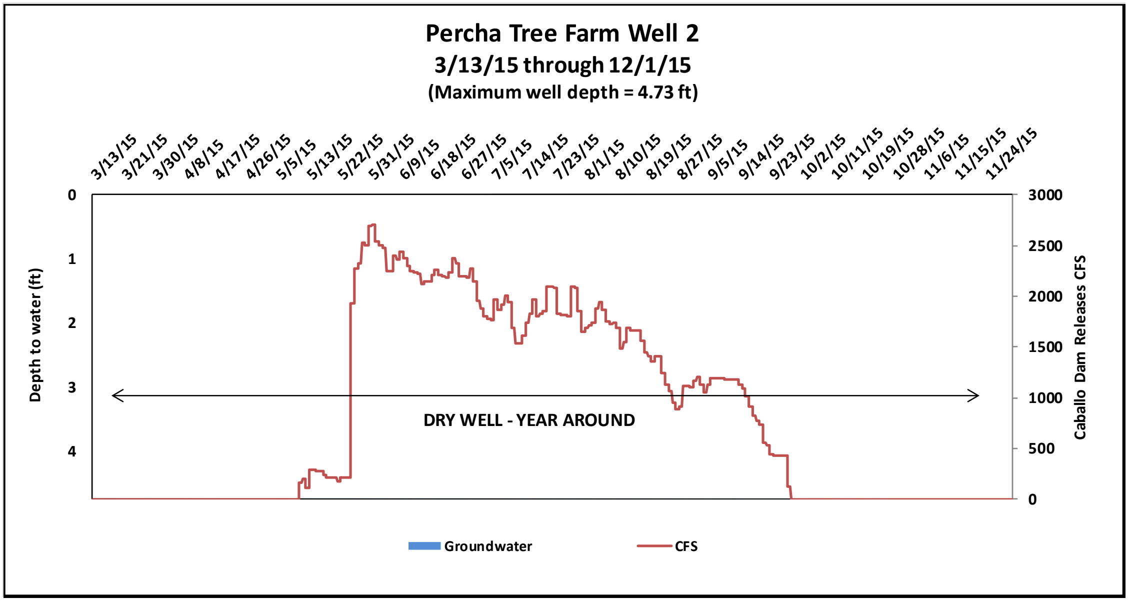

Pedon 10

Appendix B

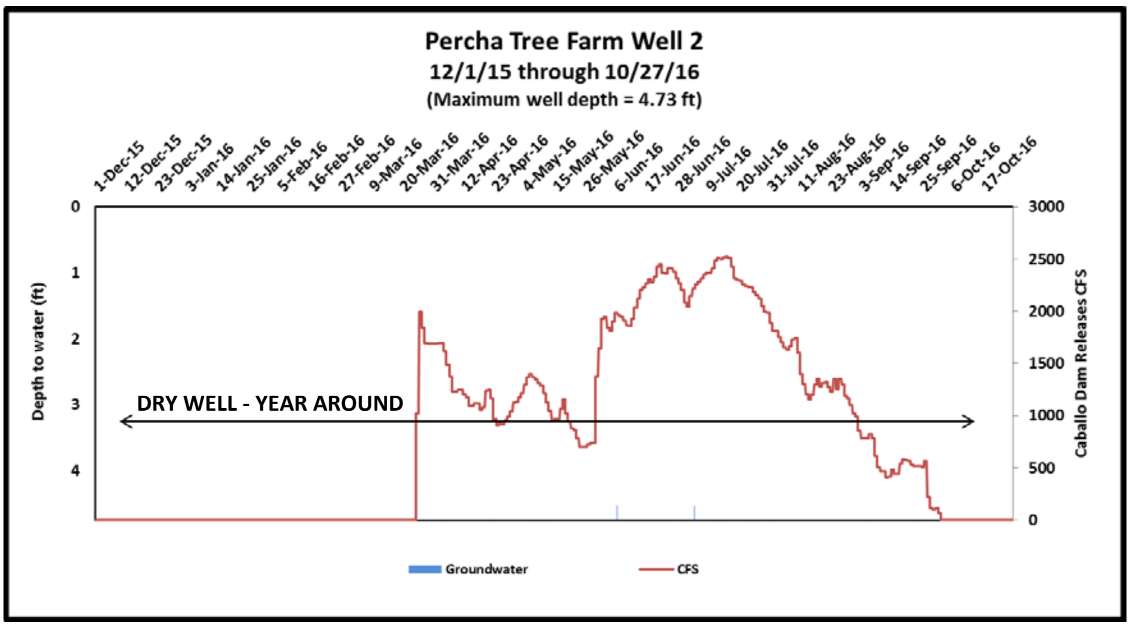
Results of Ground Water Well Monitoring


Percha Tree Farm Well 1
3/13/15 through 12/1/15
(Maximum well depth = 5.25 ft)
3/13/15 3/21/15 3/30/15 4/8/15 4/17/15 4/26/15 5/5/15 5/13/15 5/22/15 5/31/15 6/9/15 6/18/15 6/27/15 7/5/15 7/14/15 7/23/15 8/1/15 8/10/15 8/19/15 8/27/15 9/5/15 9/14/15 9/23/15 10/2/15 10/11/15 10/19/15 10/28/15 11/6/15 11/15/15 11/24/15
Depth to water (ft)
0
1
2
3
4
5
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS

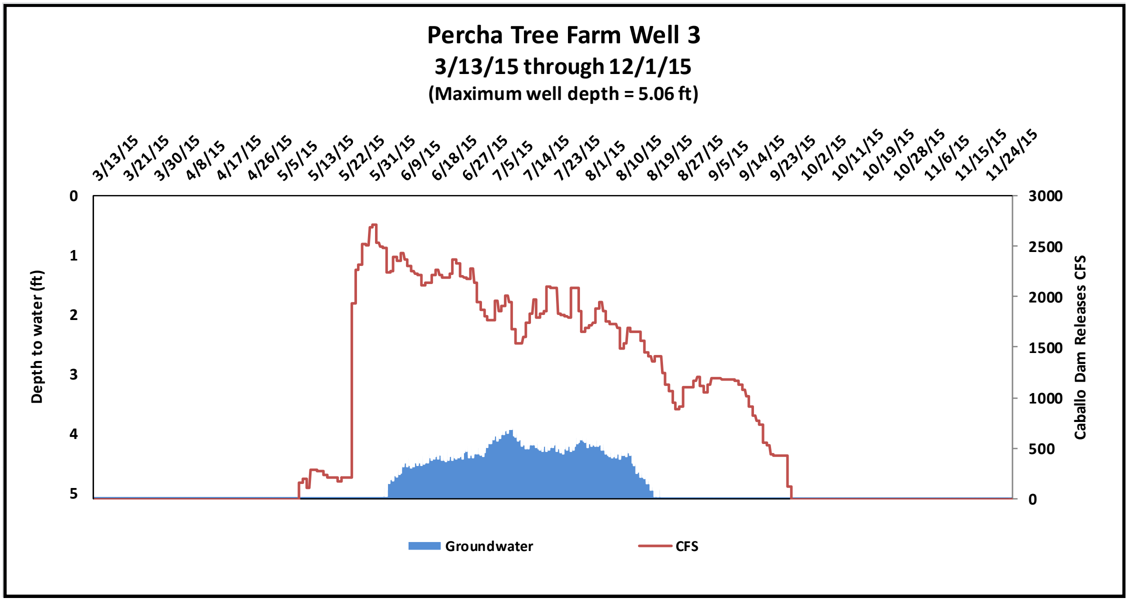

Percha Tree Farm Well 1
12/1/15 through 10/27/16
(Maximum well depth = 5.25 ft)
1-Dec-15 12-Dec-15 23-Dec-15 3-Jan-16 14-Jan-16 25-Jan-16 5-Feb-16 16-Feb-16 27-Feb-16 9-Mar-16 20-Mar-16 31-Mar-16 12-Apr-16 23-Apr-16 4-May-16 15-May-16 26-May-16 6-Jun-16 17-Jun-16 28-Jun-16 9-Jul-16 20-Jul-16 31-Jul-16 11-Aug-16 23-Aug-16 3-Sep-16 14-Sep-16 25-Sep-16 6-Oct-16 17-Oct-16
Depth to water (ft)
0
1
2
3
4
5
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS

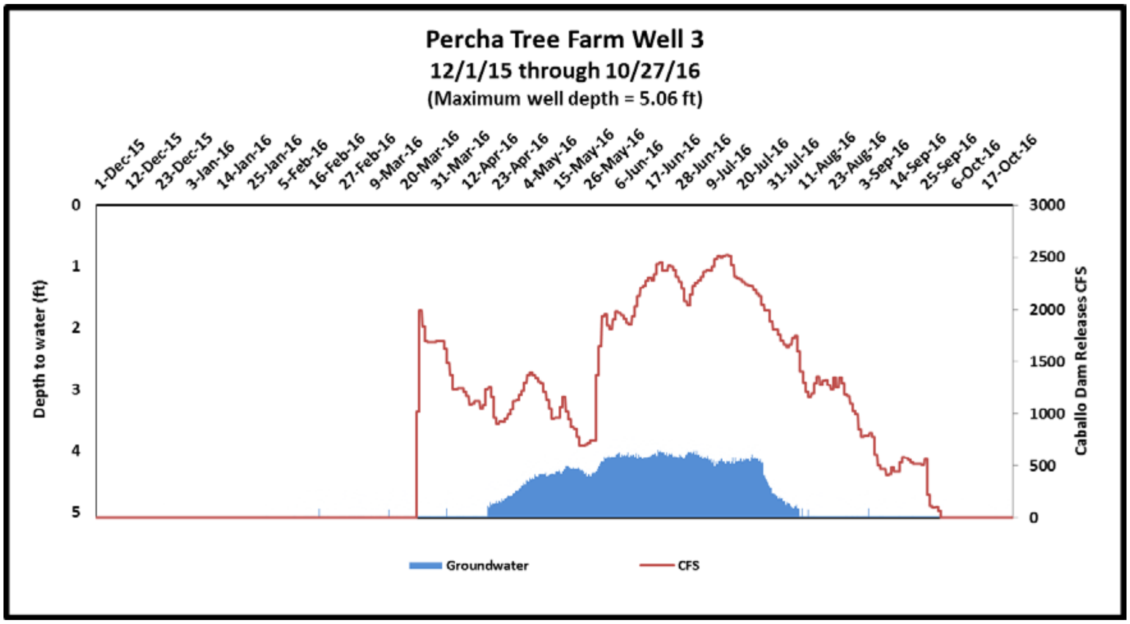


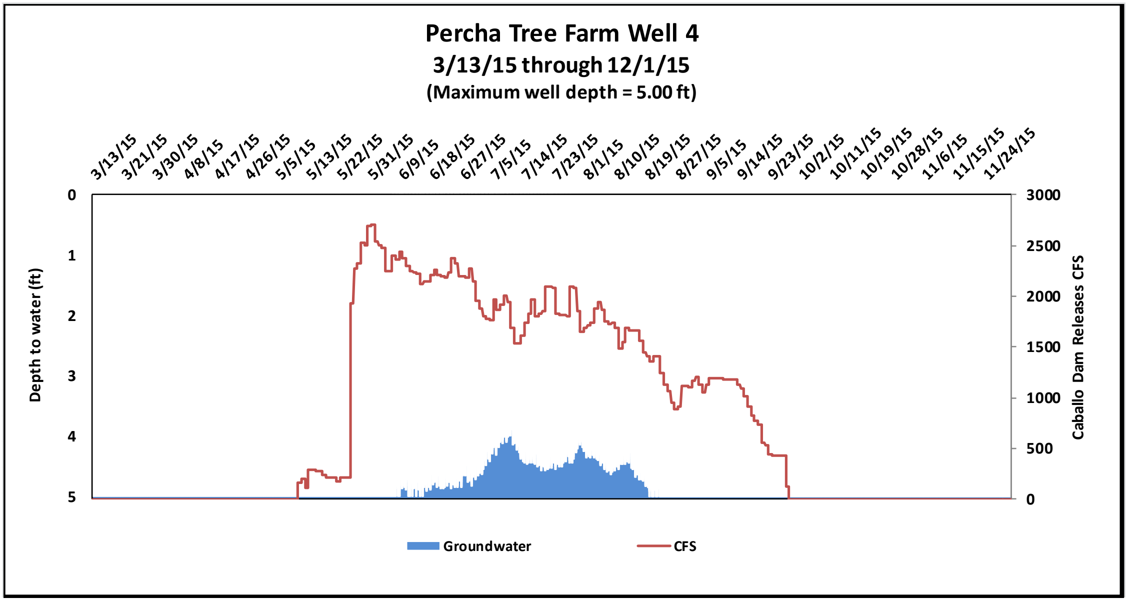
Percha Tree Farm Well 2
3/13/15 through 12/1/15
(Maximum well depth = 4.73 ft)
3/13/15
3/21/15
3/30/15
4/8/15
4/17/15
4/26/15
5/5/15
5/13/15
5/22/15
5/31/15
6/9/15
6/18/15
6/27/15
7/5/15
7/14/15
7/23/15
8/1/15
8/10/15
8/19/15
8/27/15
9/5/15
9/14/15
9/23/15
10/2/15
10/11/15
10/19/15
10/28/15
11/6/15
11/15/15
11/24/15
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS

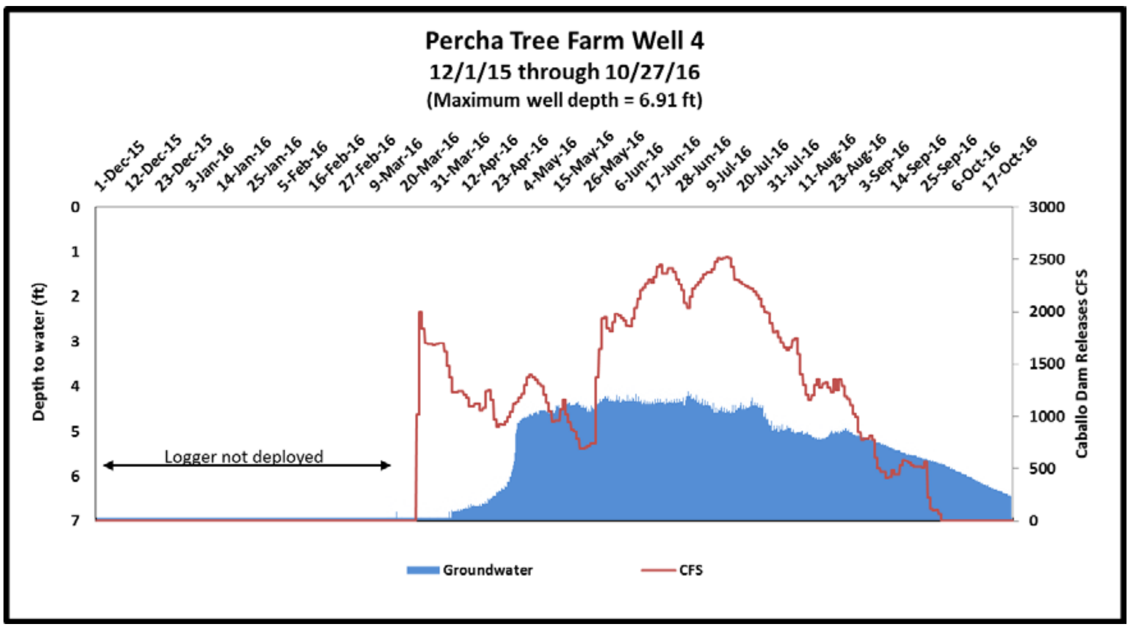


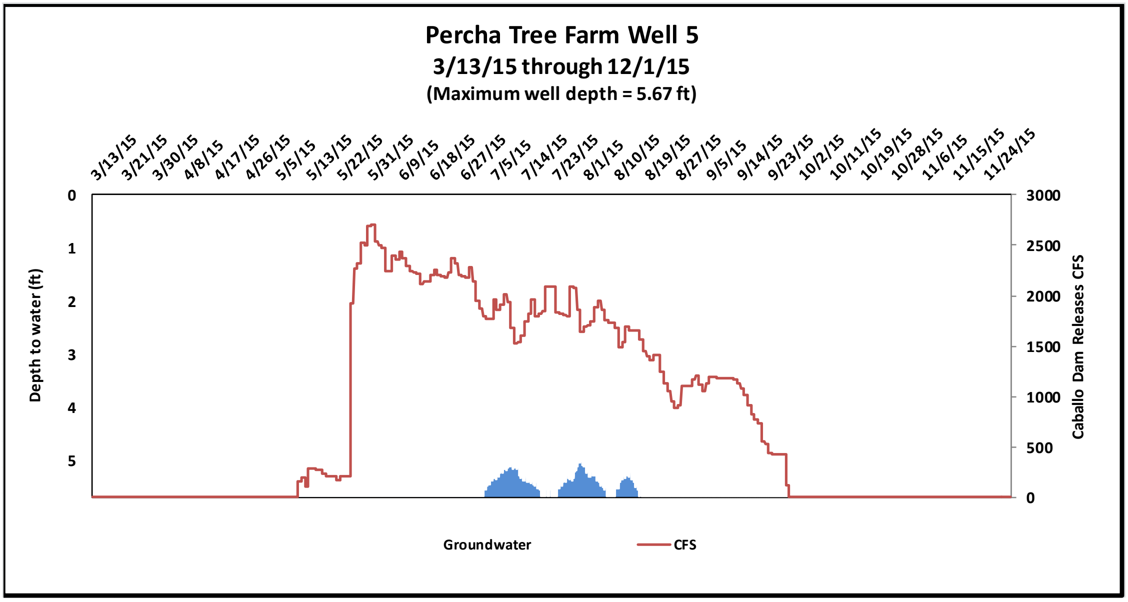
Percha Tree Farm Well 2
12/1/15 through 10/27/16
(Maximum well depth = 4.73 ft)
1-Dec-15
12-Dec-15
23-Dec-15
3-Jan-16
14-Jan-16
25-Jan-16
5-Feb-16
16-Feb-16
27-Feb-16
9-Mar-16
20-Mar-16
31-Mar-16
12-Apr-16
23-Apr-16
4-May-16
15-May-16
26-May-16
6-Jun-16
17-Jun-16
28-Jun-16
9-Jul-16
20-Jul-16
31-Jul-16
11-Aug-16
23-Aug-16
3-Sep-16
14-Sep-16
25-Sep-16
6-Oct-16
17-Oct-16
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS

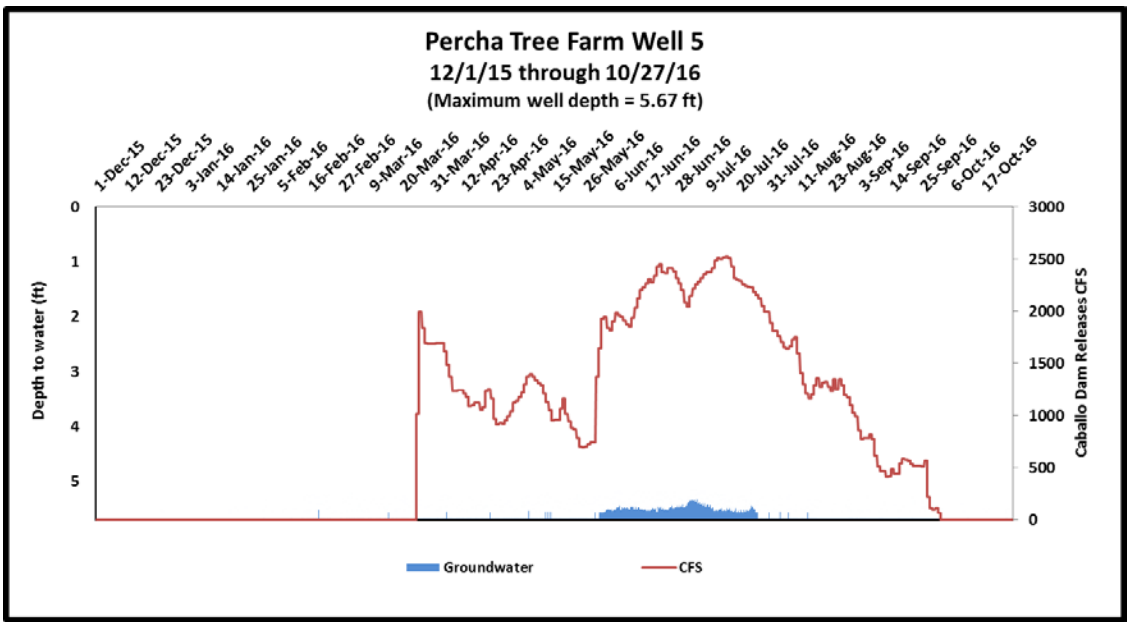

Percha Tree Farm Well 3
3/13/15 through 12/1/15
(Maximum well depth = 5.06 ft)
3/13/15
3/21/15
3/30/15
4/8/15
4/17/15
4/26/15
5/5/15
5/13/15
5/22/15
5/31/15
6/9/15
6/18/15
6/27/15
7/5/15
7/14/15
7/23/15
8/1/15
8/10/15
8/19/15
8/27/15
9/5/15
9/14/15
9/23/15
10/2/15
10/11/15
10/19/15
10/28/15
11/6/15
11/15/15
11/24/15
Depth to water (ft)
0
1
2
3
4
5
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

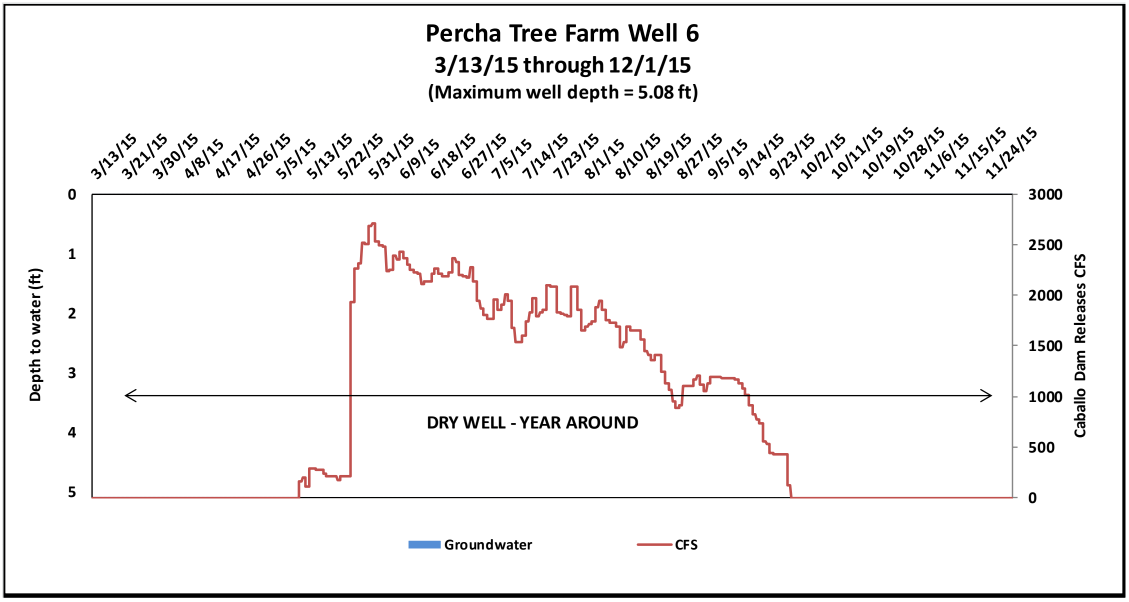

Percha Tree Farm Well 3
12/1/15 through 10/27/16
(Maximum well depth = 5.06 ft)
1-Dec-15
12-Dec-15
23-Dec-15
3-Jan-16
14-Jan-16
25-Jan-16
5-Feb-16
16-Feb-16
27-Feb-16
9-Mar-16
20-Mar-16
31-Mar-16
12-Apr-16
23-Apr-16
4-May-16
15-May-16
26-May-16
6-Jun-16
17-Jun-16
28-Jun-16
9-Jul-16
20-Jul-16
31-Jul-16
11-Aug-16
23-Aug-16
3-Sep-16
14-Sep-16
25-Sep-16
6-Oct-16
17-Oct-16
Depth to water (ft)
0
1
2
3
4
5
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

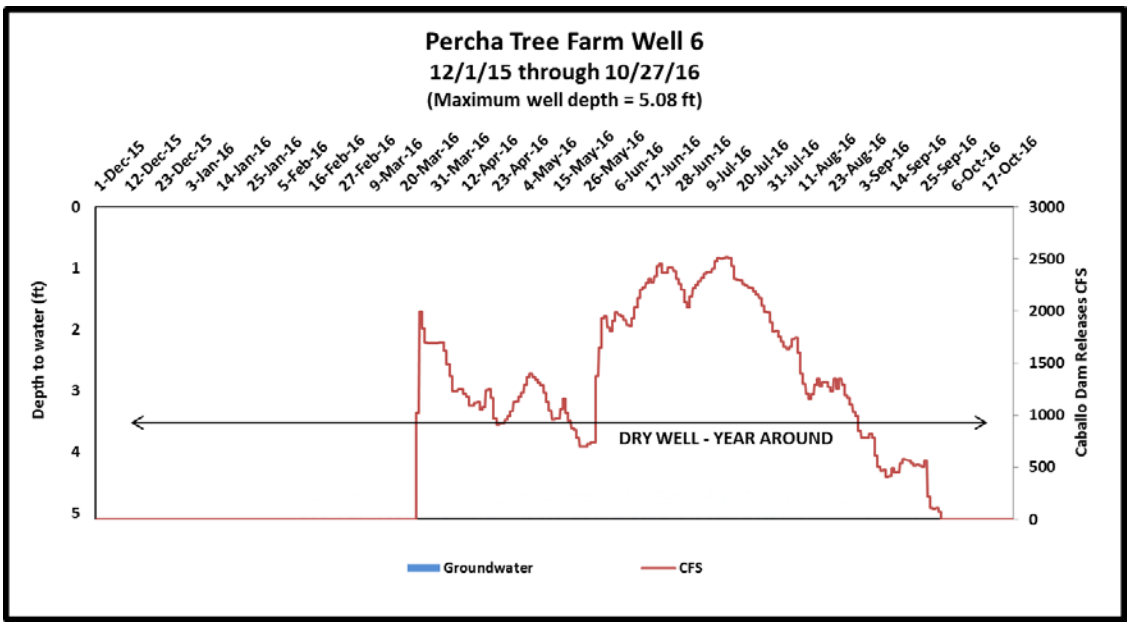

Percha Tree Farm Well 4
3/13/15 through 12/1/15
(Maximum well depth = 5.00 ft)
Depth to water (ft)
Caballo Dam Releases CFS
Groundwater
CFS

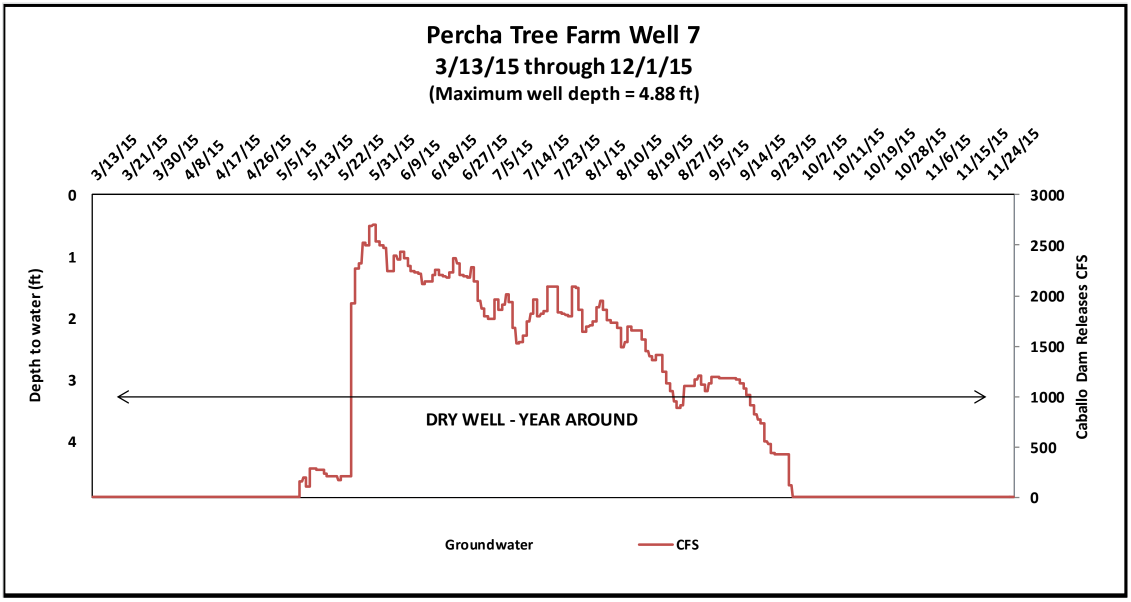

Percha Tree Farm Well 4
12/1/15 through 10/27/16
(Maximum well depth = 6.91 ft)
Depth to water (ft)
Caballo Dam Releases CFS
Logger not deployed
Groundwater
CFS

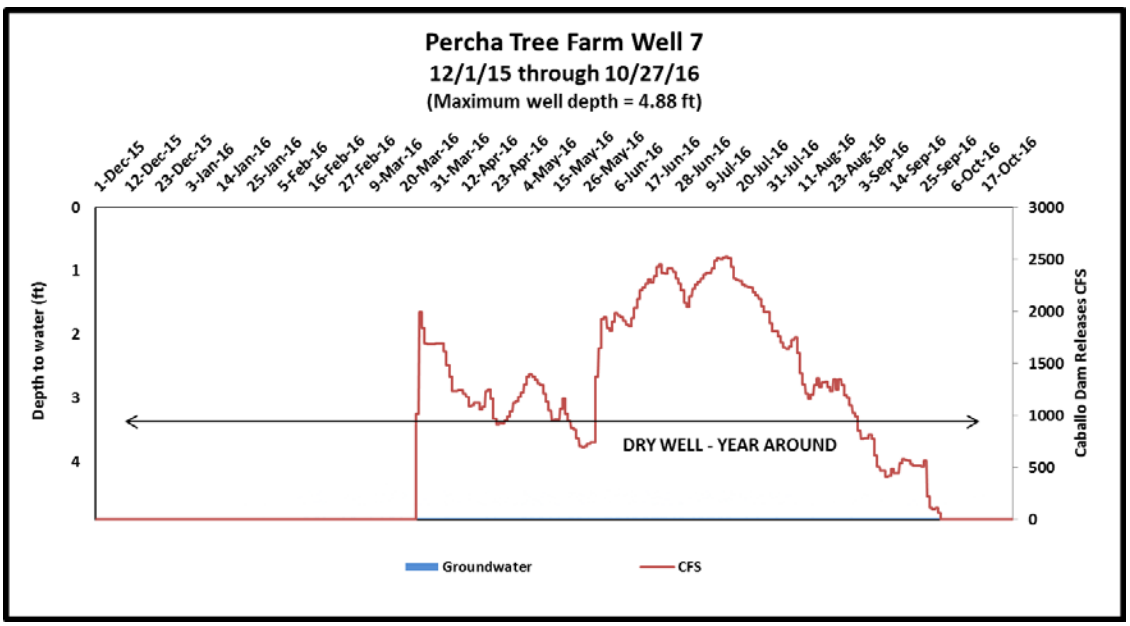

Percha Tree Farm Well 5
3/13/15 through 12/1/15
(Maximum well depth = 5.67 ft)
3/13/15 3/21/15 3/30/15 4/8/15 4/17/15 4/26/15 5/5/15 5/13/15 5/22/15 5/31/15 6/9/15 6/18/15 6/27/15 7/5/15 7/14/15 7/23/15 8/1/15 8/10/15 8/19/15 8/27/15 9/5/15 9/14/15 9/23/15 10/2/15 10/11/15 10/19/15 10/28/15 11/6/15 11/15/15 11/24/15
Depth to water (ft)
0
1
2
3
4
5
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

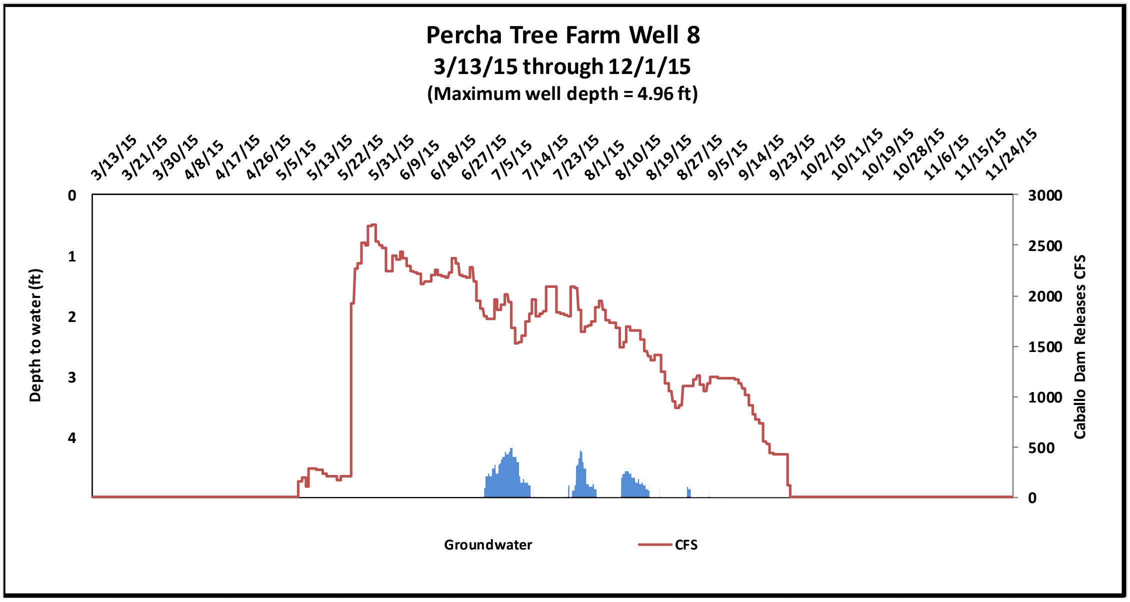

Percha Tree Farm Well 5
12/1/15 through 10/27/16
(Maximum well depth = 5.67 ft)
1-Dec-15 12-Dec-15 23-Dec-15 3-Jan-16 14-Jan-16 25-Jan-16 5-Feb-16 16-Feb-16 27-Feb-16 9-Mar-16 20-Mar-16 31-Mar-16 12-Apr-16 23-Apr-16 4-May-16 15-May-16 26-May-16 6-Jun-16 17-Jun-16 28-Jun-16 9-Jul-16 20-Jul-16 31-Jul-16 11-Aug-16 23-Aug-16 3-Sep-16 14-Sep-16 25-Sep-16 6-Oct-16 17-Oct-16
Depth to water (ft)
0
1
2
3
4
5
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

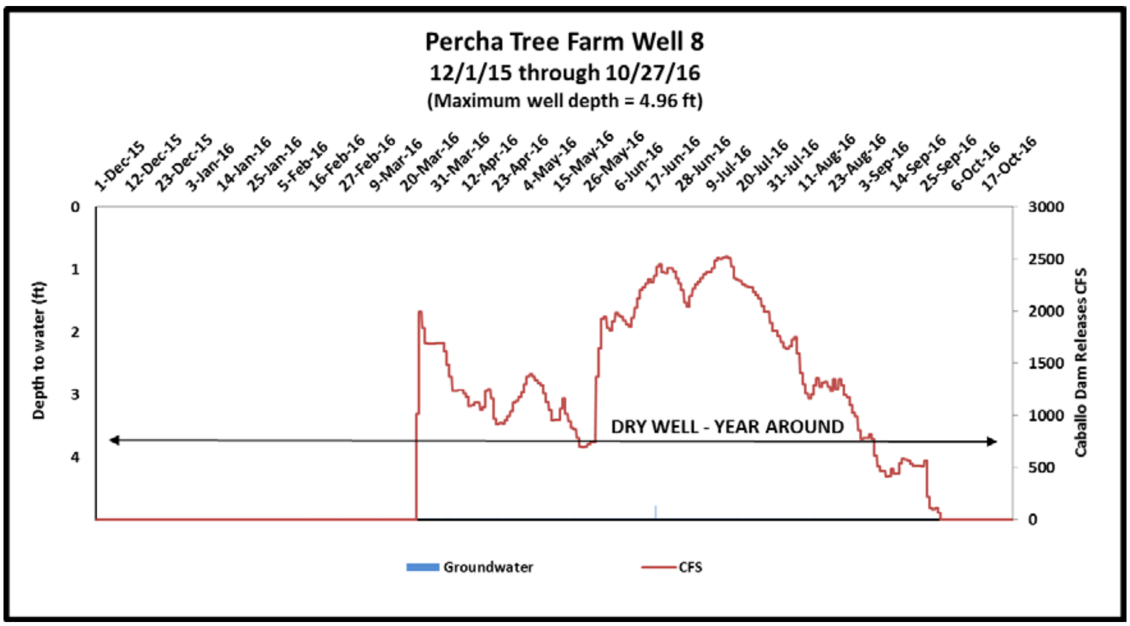

Percha Tree Farm Well 6
3/13/15 through 12/1/15
(Maximum well depth = 5.08 ft)
Depth to water (ft)
Caballo Dam Releases CFS
DRY WELL - YEAR AROUND
Groundwater
CFS

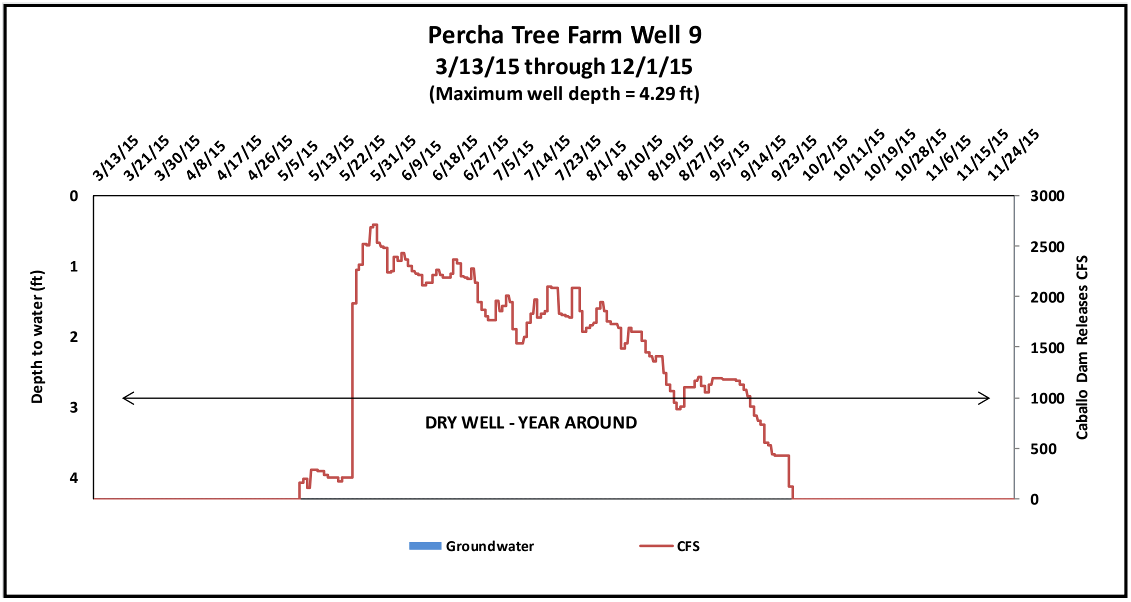

Percha Tree Farm Well 6
12/1/15 through 10/27/16
(Maximum well depth = 5.08 ft)
Depth to water (ft)
Caballo Dam Releases CFS
DRY WELL - YEAR AROUND
Groundwater
CFS

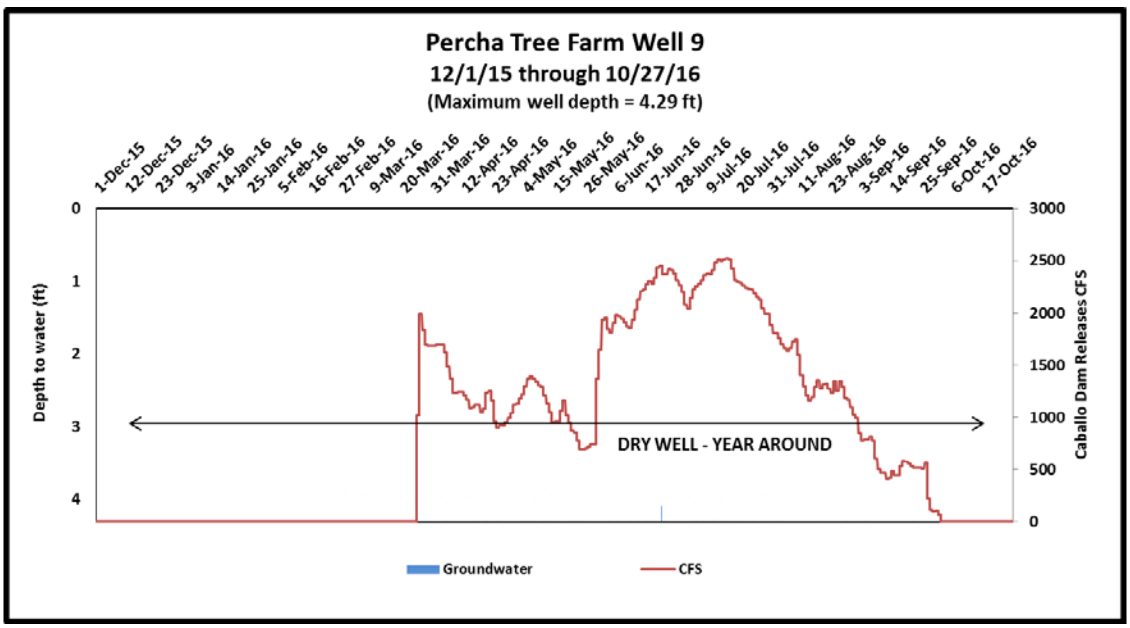

Percha Tree Farm Well 7
3/13/15 through 12/1/15
(Maximum well depth = 4.88 ft)
3/13/15
3/21/15
3/30/15
4/8/15
4/17/15
4/26/15
5/5/15
5/13/15
5/22/15
5/31/15
6/9/15
6/18/15
6/27/15
7/5/15
7/14/15
7/23/15
8/1/15
8/10/15
8/19/15
8/27/15
9/5/15
9/14/15
9/23/15
10/2/15
10/11/15
10/19/15
10/28/15
11/6/15
11/15/15
11/24/15
Depth to water (ft)
Caballo Dam Releases CFS
DRY WELL - YEAR AROUND
Groundwater
CFS

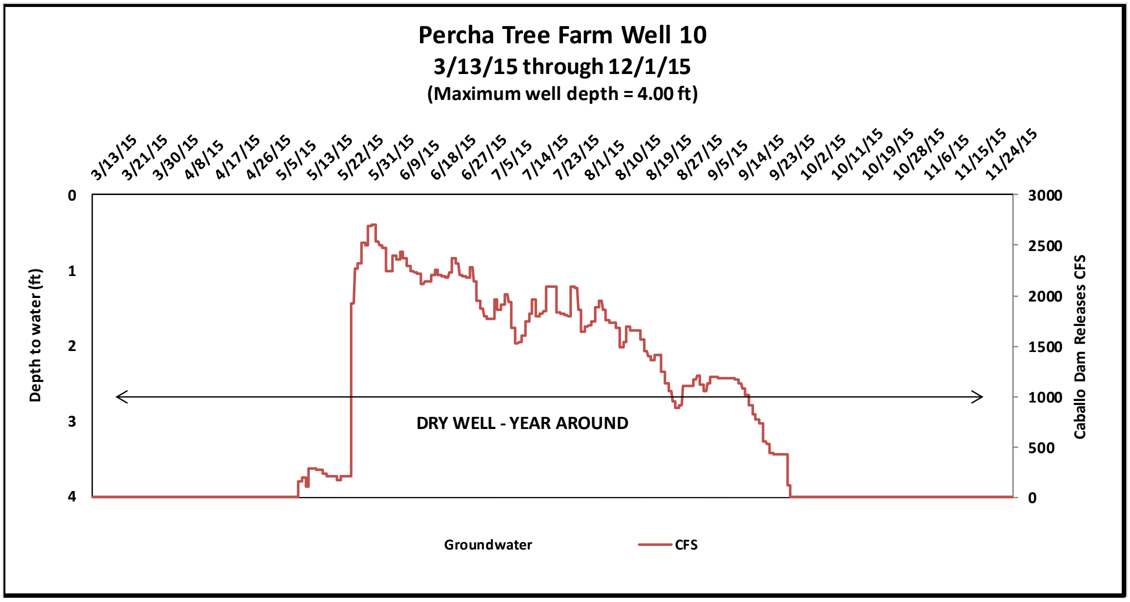

Percha Tree Farm Well 7
12/1/15 through 10/27/16
(Maximum well depth = 4.88 ft)
1-Dec-15
12-Dec-15
23-Dec-15
3-Jan-16
14-Jan-16
25-Jan-16
5-Feb-16
16-Feb-16
27-Feb-16
9-Mar-16
20-Mar-16
31-Mar-16
12-Apr-16
23-Apr-16
4-May-16
15-May-16
26-May-16
6-Jun-16
17-Jun-16
28-Jun-16
9-Jul-16
20-Jul-16
31-Jul-16
11-Aug-16
23-Aug-16
3-Sep-16
14-Sep-16
25-Sep-16
6-Oct-16
17-Oct-16
Depth to water (ft)
Caballo Dam Releases CFS
DRY WELL - YEAR AROUND
Groundwater
CFS

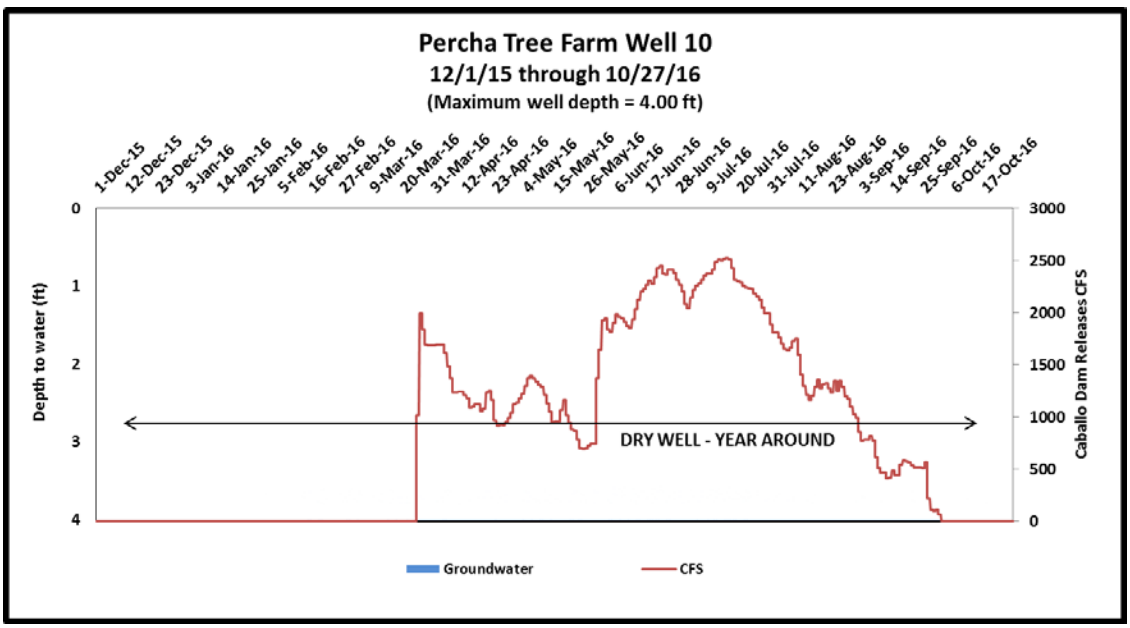

Percha Tree Farm Well 8
3/13/15 through 12/1/15
(Maximum well depth = 4.96 ft)
3/13/15
3/21/15
3/30/15
4/8/15
4/17/15
4/26/15
5/5/15
5/13/15
5/22/15
5/31/15
6/9/15
6/18/15
6/27/15
7/5/15
7/14/15
7/23/15
8/1/15
8/10/15
8/19/15
8/27/15
9/5/15
9/14/15
9/23/15
10/2/15
10/11/15
10/19/15
10/28/15
11/6/15
11/15/15
11/24/15
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
Groundwater
CFS

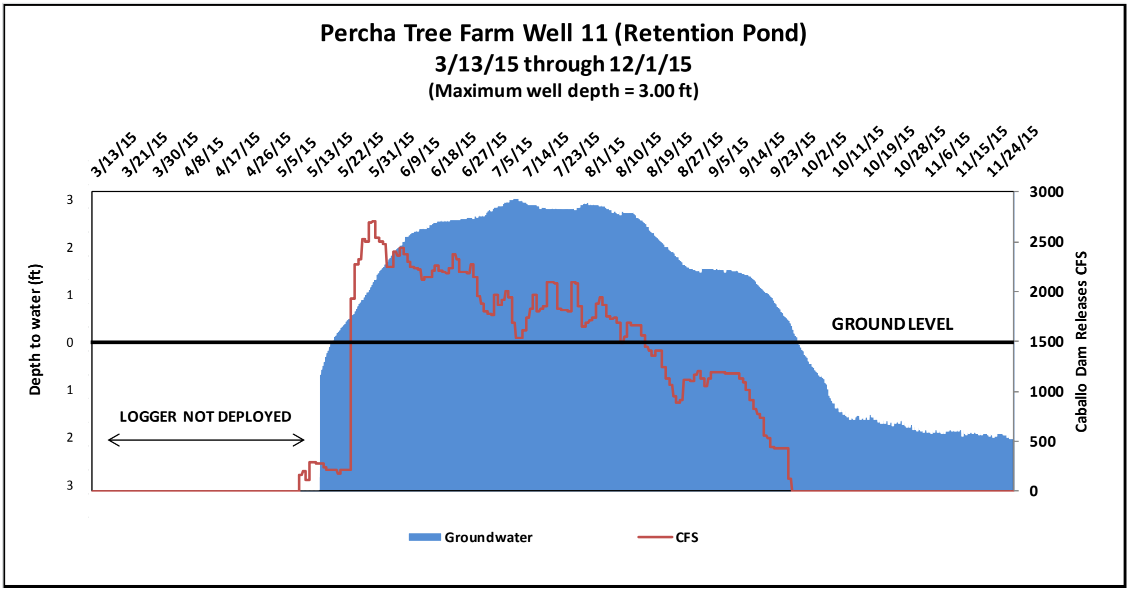

Percha Tree Farm Well 8
12/1/15 through 10/27/16
(Maximum well depth = 4.96 ft)
1-Dec-15
12-Dec-15
23-Dec-15
3-Jan-16
14-Jan-16
25-Jan-16
5-Feb-16
16-Feb-16
27-Feb-16
9-Mar-16
20-Mar-16
31-Mar-16
12-Apr-16
23-Apr-16
4-May-16
15-May-16
26-May-16
6-Jun-16
17-Jun-16
28-Jun-16
9-Jul-16
20-Jul-16
31-Jul-16
11-Aug-16
23-Aug-16
3-Sep-16
14-Sep-16
25-Sep-16
6-Oct-16
17-Oct-16
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS

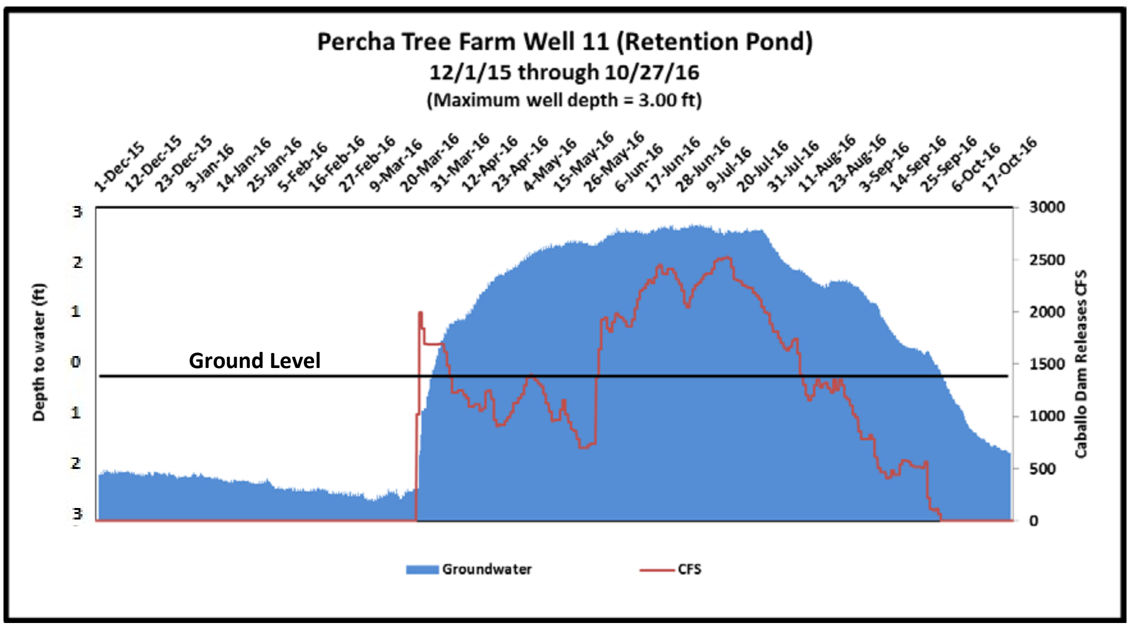

Percha Tree Farm Well 9
3/13/15 through 12/1/15
(Maximum well depth = 4.29 ft)
3/13/15 3/21/15 3/30/15 4/8/15 4/17/15 4/26/15 5/5/15 5/13/15 5/22/15 5/31/15 6/9/15 6/18/15 6/27/15 7/5/15 7/14/15 7/23/15 8/1/15 8/10/15 8/19/15 8/27/15 9/5/15 9/14/15 9/23/15 10/2/15 10/11/15 10/19/15 10/28/15 11/6/15 11/15/15 11/24/15
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS


Percha Tree Farm Well 9
12/1/15 through 10/27/16
(Maximum well depth = 4.29 ft)
1-Dec-15 12-Dec-15 23-Dec-15 3-Jan-16 14-Jan-16 25-Jan-16 5-Feb-16 16-Feb-16 27-Feb-16 9-Mar-16 20-Mar-16 31-Mar-16 12-Apr-16 23-Apr-16 4-May-16 15-May-16 26-May-16 6-Jun-16 17-Jun-16 28-Jun-16 9-Jul-16 20-Jul-16 31-Jul-16 11-Aug-16 23-Aug-16 3-Sep-16 14-Sep-16 25-Sep-16 6-Oct-16 17-Oct-16
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS


Percha Tree Farm Well 10
3/13/15 through 12/1/15
(Maximum well depth = 4.00 ft)
3/13/15
3/21/15
3/30/15
4/8/15
4/17/15
4/26/15
5/5/15
5/13/15
5/22/15
5/31/15
6/9/15
6/18/15
6/27/15
7/5/15
7/14/15
7/23/15
8/1/15
8/10/15
8/19/15
8/27/15
9/5/15
9/14/15
9/23/15
10/2/15
10/11/15
10/19/15
10/28/15
11/6/15
11/15/15
11/24/15
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS


Percha Tree Farm Well 10
12/1/15 through 10/27/16
(Maximum well depth = 4.00 ft)
1-Dec-15
12-Dec-15
23-Dec-15
3-Jan-16
14-Jan-16
25-Jan-16
5-Feb-16
16-Feb-16
27-Feb-16
9-Mar-16
20-Mar-16
31-Mar-16
12-Apr-16
23-Apr-16
4-May-16
15-May-16
26-May-16
6-Jun-16
17-Jun-16
28-Jun-16
9-Jul-16
20-Jul-16
31-Jul-16
11-Aug-16
23-Aug-16
3-Sep-16
14-Sep-16
25-Sep-16
6-Oct-16
17-Oct-16
Depth to water (ft)
0
1
2
3
4
Caballo Dam Releases CFS
3000
2500
2000
1500
1000
500
0
DRY WELL - YEAR AROUND
Groundwater
CFS


Percha Tree Farm Well 11 (Retention Pond)
3/13/15 through 12/1/15
(Maximum well depth = 3.00 ft)
Depth to water (ft)
Caballo Dam Releases CFS
GROUND LEVEL
LOGGER NOT DEPLOYED
Groundwater
CFS


Percha Tree Farm Well 11 (Retention Pond)
12/1/15 through 10/27/16
(Maximum well depth = 3.00 ft)
Depth to water (ft)
Caballo Dam Releases CFS
Ground Level
Groundwater
CFS

PEER REVIEW DOCUMENTATION

PROJECT AND DOCUMENT INFORMATION

Project Name Percha Tree Farm Restoration Study WOID A806F

Document Percha Tree Farm Vegetation, Soil, and Groundwater Assessment

Document Date March 2016

Team Leader Darrell Ahlers

Document Author(s)/Preparer(s) Rebecca Siegle, Gregory Reed, Darrell Ahlers, Dave Moore

Peer Reviewer Dave Moore

Peer Reviewer

REVIEW REQUIREMENT

Part A: Document Does Not Require Peer Review

Explain

Part B: Document Requires Peer Review: SCOPE OF PEER REVIEW

Peer Review restricted to the following Items/Section(s): Reviewer:

REVIEW CERTIFICATION

Peer Reviewer - I have reviewed the assigned Items/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: Dave Moore Review Date: January 2016 Signature:

Reviewer: Review Date: Signature:

I have discussed the above document and review requirements with the Peer Reviewer and believe that this review is completed, and that the document will meet the requirements of the project.

Team Leader: Darrell Ahlers Date: 3/29/2016 Signature: