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BEFORE THE STATE WATER RESOURCES CONTROL BOARD

PETITION FOR RULEMAKING TO SET MINIMUM FLOWS ON THE SCOTT RIVER

Pursuant to the California Constitution, Article 1, Section 3 and Government Code Section 11340.6

Karuk Tribe of California,
Environmental Law Foundation,
Pacific Coast Federation of Fishermen's Associations,
and Institute for Fisheries Resources,
Petitioners

I. INTRODUCTION

The Scott River goes dry in most summers. Even in the wettest years, flows today are less than in the driest years half a century ago. As a direct result, populations of federal Endangered Species Act– and California Endangered Species Act–listed salmonid species are in constant danger of extinction. The State Water Resources Control Board (State Board) has the authority and the duty to act to set a minimum streamflow standard for the Scott River. The State Board has already established emergency regulations that set minimum streamflows during the current drought. It is time to make those protections permanent.

By this petition, the Karuk Tribe of California (Karuk Tribe or Tribe), Environmental Law Foundation, Pacific Coast Federation of Fishermen's Associations, and Institute for Fisheries Resources formally request that the State Board do so.

The low flows in the Scott and the resulting decline in fish populations are relatively recent phenomena. Until the 1970s, despite the development of a thriving agricultural economy in the Scott Valley, flows remained high enough even in dry years to support fisheries. But starting in the 1970s, the situation changed. Now, every summer, growers divert and pump enough water to dewater the Scott in all but the wettest years. For instance, flows in 2017, the most recent very wet year, were less than those in very dry years in the 1950s. Similar rivers in the Klamath Basin have not similarly declined. The problem is not climate. The problem is that people are taking too much water out of the river.

And the fish have stopped coming back. First to disappear were the spring-run Chinook, which were extirpated in the 1970s. Fall-run Chinook are in decline. And Coho, a species which finds its ideal habitat in the Scott, is at imminent risk of extirpation; it has been decades since the Scott has seen the 6,500 Coho spawners NOAA Fisheries has specified as the recovery target. The vanishing of the salmon is an ongoing crisis for the Karuk, whose cultural, economic, and religious relationship with these species goes back millennia. And it is an existential disaster for California's commercial salmon fishing industry, leading to devastating shutdowns of the once abundant Klamath-supported ocean fisheries nearly every year.

The time for the State Board to act is now. Science shows a robust connection between flows and fish population health. Low autumn flows prevent access to favored spawning locations, leaving returning fish either blocked or forced to fruitlessly spawn in an inhospitable canyon where winter floods scour their eggs. Without sufficient summer flow, Coho cannot survive their first year—the long, hot summer where they must feed and grow in cold, clean fresh water before migrating to the ocean. These low summer flows bring a disconnected river with degraded water quality—lethally high temperatures, disconnected or dry pools, low dissolved oxygen, and parasites. Winter and spring high flows are necessary to flush sediment and algae, restore favorable channel structure, and provide outmigration for juvenile salmonids.

No other agency can or will act to protect flows in the Scott. The California Department of Fish and Wildlife (CDFW) has done its part by promulgating two flow recommendations—including one for drought years—and transmitting them to the State Board. But the groundwater sustainability agency (GSA) for the basin has declared that the recently enacted Sustainable Groundwater Management Act (SGMA) will not restore flows in the Scott. The North Coast Regional Water Quality Control Board has stated that it cannot achieve water quality objectives without State Board action on flows. And the federal government will not act. Therefore, the State Board must.

The State Board has already taken a promising first step. By promulgating emergency regulations in 2021 and readopting them in 2022, it has established that minimum flows are a necessary tool for regulating the Scott. And it has begun the process of implementing that minimum flow standard by requiring curtailments, limiting inefficient livestock watering restrictions, and issuing information orders. While the river did not reach the emergency minimum flows in 2021 or 2022, the curtailments still had measurable, positive impacts on stream conditions. These steps, while imperfect, have promise for efforts to protect flows during future drought years.

If the Governor were ever to revoke the drought Executive Order, however, the Scott would lose the benefit of those emergency regulations. Summer flows in nondrought years routinely fail to meet the 62 cfs September flow that CDFW found necessary for salmonid recovery. In fact, only *once* in the last decade have flows in any water year type exceeded the 33 cfs September drought minimum that CDFW says is necessary to prevent extirpation.

The State Board must, therefore, protect the Scott permanently. It must adopt, under its statutory, public trust, and waste and unreasonable use authority and other authorities, a permanent regulation setting minimum flows in the Scott that, informed by yearly hydrology and the needs of these crucial species, will allow survival and recovery of Coho and Chinook.

II. PARTIES

The following parties petition the State Board:

A. The Karuk Tribe

Petitioner Karuk Tribe of California is a federally recognized Indian Tribe with a population of approximately 3,700 enrolled members and 5,300 enrolled descendants. Its headquarters is located in Happy Camp, along the Klamath River and in the vicinity of the Salmon and Scott Rivers. The Karuk Tribe has lived in northern California since time immemorial.

The stated mission of the Karuk Tribe is to promote the general welfare of all Karuk people; establish equality and justice for the Tribe; restore and preserve Tribal traditions, customs, language, and ancestral rights; and secure for themselves and their descendants the power to exercise the inherent rights of self-governance. Among the many goals of the Tribe is the protection and restoration of native fish and wildlife species that the Tribe has depended upon for traditional cultural, religious, and subsistence uses. The fisheries, environmental and aesthetic assets, and the cultural values associated with them are at the core of the interests the Tribe seeks to promote and protect. A long-term goal of the Karuk Tribe is to restore fisheries habitat by improving hydrologic function and water quality in the Klamath River and key tributaries. Since time immemorial, the Karuk People have relied on aquatic species including salmon, lamprey, mussels, steelhead, and sturgeon for survival. Over time the Tribe developed strategies to manage and enhance populations of these species through active management techniques. Indeed, the Tribe has incorporated fisheries management into its religious and ceremonial practices.[1]

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[1] Luis Neuner & S. Craig Tucker, Suits and Signs Consulting, Karuk Traditional Ecological Knowledge and the Management of Spring Chinook Salmon (2023), at pp. 3-4, available at https://www.karuk.us/images/docs/dnr/20230202KarukTraditionalEcologicalKnowledgeAndTheManagementOfSpringChinookSalmonFINAL.pdf (accessed March 22, 2023).

For example, the Spring Salmon Ceremony marked the beginning of the fishing season for spring-run Chinook (Karuk: *ishyâat*), a rule adhered to not only by the Karuk but by other Klamath tribes.[2] The ceremony took place only after the first fish, the "head of the run," had migrated upstream, allowing those fish to spawn unmolested.[3] Because the Spring Salmon Ceremony requires eating spring-run Chinook, the extirpation of the "springers" means that the Tribe can no longer perform this ceremony.[4]

The last several decades have seen a general trend of declining fish populations in the entire Klamath Basin, including the Scott River. The Scott River is one of the most important Klamath tributaries providing spawning and rearing habitat for Chinook salmon, steelhead trout, Pacific lamprey, and ESA-listed Coho salmon. As such, the Karuk Tribe has an immediate and concrete interest in the mitigation of harms to and the long-term preservation of the fisheries and wildlife resources in the Scott.

B. Environmental Law Foundation

ELF is a California nonprofit organization founded on Earth Day in 1991 that has a longstanding interest in aiding the recovery of anadromous fish populations. ELF has been advocating for improved flows in the Scott River for more than ten years. As such, ELF has a direct interest in the State Board's failure to regulate flows in the Scott and in the contents of any regulation.

C. Pacific Coast Federation of Fishermen's Associations and Institute for Fisheries Resources

PCFFA is by far the largest trade organization of commercial fishing families on the west coast and is organized as a federation of 17 local and regional commercial fishing port associations, marketing associations, and type-of-vessel owner groups representing approximately 750 family commercial fishing businesses west coast-wide, including in California, Oregon, and

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[2] *Ibid.*

[3] *Id.* at p. 4.

[4] *Id.* at p. 12

Washington. PCFFA's individual members generally are small- and mid-sized commercial fishing boat owners and operators, most of whom derive all or part of their income from the harvesting of Pacific salmon, including salmon that originate in the Klamath Basin, and which can and do spawn and rear in the Scott River when there are sufficient instream flows to allow that to successfully happen. Northern California ports in which PCFFA has active member associations include the Ports of Bodega Bay, Fort Bragg, Eureka, and Crescent City, California. Ocean salmon harvests in and around all these ports depend upon the abundance of salmon from the Klamath Basin to determine whether those northern California and southern Oregon ocean salmon fisheries will be open or closed in each year.

IFR is a separate nonprofit, public interest, marine resources protection and conservation organization originally incorporated by PCFFA. It manages, directs, and helps fund most of PCFFA's many fisheries and habitat conservation and public education programs, including salmon restoration projects in the Klamath Basin. Throughout northern California, Oregon, and Washington, IFR also works to improve forest and agricultural land use practices generally, on both private and public lands, to lessen their impacts on salmonid spawning and rearing habitat.

PCFFA and IFR both have a particularly longstanding and strong interest in the protection and recovery of Klamath River salmon, and more specifically, Klamath fall-run Chinook, which is the only Klamath-origin salmon species that is still abundant enough to allow for a commercial ocean fishery. As adults, Klamath River fall-run Chinook salmon migrate from the Klamath River (including from the Scott River) at least as far south as Monterey, California, and as far north as central Washington State. Along hundreds of miles of California and Oregon coastline, and well into central Washington State, Klamath fall-run Chinook are a dominant stock intermingling at sea with many other stocks of salmon. Because of this ocean intermingling, opportunities for fishing for *any* salmon stock within this more than 700-mile-long region are *significantly* affected by the health and abundance of Klamath fall-run Chinook salmon. When Klamath spawner return numbers are poor, fishing for *all* salmon in this area of the coast—*even on very abundant runs*—can be severely restricted and even closed. This is what is called "weak stock management," in which the weakest (i.e., least abundant) salmon stock is the limiting factor in all other fisheries in which it intermingles. PCFFA and IFR also work as organizations to protect Klamath-origin spring-run Chinook and Southern Oregon/Northern California Coast (SONCC) Coho, both salmon species with very similar habitat needs to those of fall-run Chinook, and so that protecting both Coho and spring-run Chinook from the Klamath River also benefits fall-run Chinook.

III. PETITION FOR RULEMAKING

This Petition is brought under the Petition Clause of the First Amendment to the U.S. Constitution and article I, section 3 of the California Constitution, both of which permit citizens to petition the government for redress of grievances. The California Administrative Procedures Act sets out the specific procedures for a petition for rulemaking: any "interested person may petition a state agency requesting adoption" of a regulation. (Gov. Code § 11340.6.) Upon receipt of such a request, the agency has 30 days to either schedule the matter for a hearing or deny the petition in writing, with reasons given for any such denial. (*Id.* § 11340.7, subds. (a), (d).)

Under section 11340.6, a petition for rulemaking must state the "substance or nature of the regulation, amendment, or repeal requested," the "reason for the request," and "[r]eference to the authority of the state agency to take the action requested."

The "substance . . . of the regulation" requested here is a permanent regulation setting a minimum streamflow standard for the Scott River in all years that is protective of salmonid population recovery, with appropriate monitoring, informational, and enforcement requirements.

The "reason for the request" is, as discussed at length in the discussion that follows, the consistent lack of flow in the Scott River during the summer and fall of even normal and wet years, leading to significant harm to Chinook and Coho salmon, both of which are culturally and economically vital species that are at significant risk of extirpation.

And as discussed in more detail below, the State Board has the authority to issue the requested regulation under, inter alia, Water Code sections 174, 186, 1058, and 275; the waste and unreasonable use doctrine; and the public trust doctrine.

IV. FACTUAL BACKGROUND

A. The Scott River

Flows have been declining in the Scott River since European settlers began intensive agriculture in the late 19th century. This accelerated—to the point where salmonid populations began to plummet—in the latter half of the 20th century. A robust body of research establishes very clear causality: agricultural extractions of groundwater and surface water cause low flows, and low flows impact fish populations.

While the State Board recently adopted temporary emergency regulations designed to address flows in drought years (at least as long as the Governor's drought proclamation remains in effect and the State Board readopts the emergency regulations), there is no current regulatory protection for flows in nondrought years nor any assurance such emergency regulations will be enacted in the next drought. Summer and fall flows in these nondrought years have rarely met the CDFW flow recommendations.[5]

1. Geographic Setting

The Scott is one of the most important rivers on the Pacific Coast for threatened Coho (Karuk: *achvuun*) and Chinook salmon (Karuk: *àama* [fall Chinook] and *ishyâat* [spring Chinook]), as well as a host of other species, including steelhead, mussels, and Pacific lamprey. The Scott's Coho population has been recognized as a "core independent" population of the ESA-threatened Southern Oregon/Northern California Coast Evolutionarily Significant Unit (ESU).[6] These species have experienced significant population declines.[7]

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[5] CDFW, Interim Instream Flow Criteria for the Protection of Fishery Resources in the Scott River Watershed, Siskiyou County (Feb. 6, 2017) (hereafter CDFW Flow Criteria), at p. 7, attached as Exhibit A.

[6] National Marine Fisheries Service (NMFS), Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*) (2014) (hereafter NMFS Recovery Plan), at pp. 2-10, available at https://www.fisheries.noaa.gov/resource/document/final-recovery-plan-southern-oregon-northern-california-coast-evolutionarily (accessed May 17, 2023). An "independent" population is one which is capable of persisting in isolation over a 100-year time scale. (*Id.* at pp. 2-9.) A "core" population is one for which NMFS has determined that recovery is necessary in order for the ESU as a whole to reach recovery targets. (*Id.* at pp. 2-12 to 2-13.)

[7] CDFW Flow Criteria, supra, at pp. 8-13. On May 3, 2021, CDFW transmitted a package containing four documents to the State Board: (1) a letter from Charlton H. Bonham to Eileen Sobeck regarding the need for immediate action on the Scott River (hereafter CDFW Letter), attached as Exhibit B; (2) the CDFW Flow Criteria, (3) a memorandum from Tina Bartlett, CDFW with the subject Influence of Scott River in-stream flow on the distribution and migration timing

The Scott River is one of the major tributaries to the Klamath and one of the few streams in northern California that is not blocked by a major dam and reservoir.[8] Its headwaters are in the 7,000- to 8,000-foot Scott, Scott Bar, Marble, and Salmon Mountains. Numerous tributary creeks join the Scott River in its broad alluvial plain—a plain which holds a large aquifer as well as provides for a significant agricultural industry. The river flows south to north through this fertile plain from the community of Callahan to Fort Jones. Downstream of Fort Jones, it turns sharply west and drops steeply down a canyon to the confluence with the Klamath.

The climate in the Scott River Basin is characterized by cool, wet winters and hot, dry summers. Flows peak during winter storms and the spring snowmelt. In the summer, after mountain snow is gone, flows in the mainstem and tributaries are largely dependent on contributions from groundwater.[9]

Salmon, especially Coho, use the steep canyon reach to migrate to better spawning terrain in the Scott Valley and its tributaries.[10]

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of fall Chinook Salmon and Coho Salmon, dated May 3, 2021 (hereafter CDFW Flow Memo), attached as Exhibit C; and (4) CDFW's comments on the Scott Valley Groundwater Sustainability Plan (hereafter CDFW SGMA Comments), attached as Exhibit D. The CDFW Flow Memo contains updated population figures for Chinook and Coho at pages 9 to 11.

[8] See generally Siskiyou County Flood Control & Water Conservation District, Scott Valley Groundwater Sustainability Plan (2022) (hereafter Scott Valley GSP), at pp. 22-28, available at https://sgma.water.ca.gov/portal/service/gspdocument/download/6317.

[9] *Id.* at pp. 84-89.

[10] CDFW Flow Memo, *supra*, at p. 12-13; CDFW Flow Criteria, *supra*, at p. 11; NMFS Recovery Plan, *supra*, at pp. 36-3 to 36-8.

2. Flows in the Scott

Flows have been decreasing in the Scott, and not just in dry years. Table 1 below, compiled using data from USGS, shows the decline in flows from 1942 until 2022.[11] Flow figures that are marked yellow (△) represent years where mean flows measured at Fort Jones were less than CDFW's 2017 recommended interim stream flow criteria[12] of 77 cfs for August and of 62 cfs for September. Figures marked in red (■) represent years where mean flows were less than CDFW's drought emergency minimum flow requirements[13] of 30 cfs for August and 33 cfs for September. Flow figures in green (○) represent years when flows exceeded both requirements.

TABLE 1. Mean Flows in the Scott River, 1942-2022

Water Year	Water Year Type[a]	Mean Flows (cfs)		Water Year	Water Year Type[a]	Mean Flows (cfs)	
		Aug.	Sept.			Aug.	Sept.
1942	Wet	89.6 ○	67.8 ○	1962	Dry	63.8 △	56.1 △
1943	Wet	92.5 ○	64.7 ○	1963	Wet	68.4 △	61.8 △
1944	Very Dry	74.9 △	48.6 △	1964	Normal	58.7 △	48.6 △
1945	Normal	70.0 △	51.7 △	1965	Very Wet	78.3 ○	70.7 ○
1946	Wet	93.5 ○	64.2 ○	1966	Normal	47.7 △	46.9 △
1947	Very Dry	52.5 △	40.9 △	1967	Normal	67.4 △	52.9 △
1948	Normal	88.0 ○	76.0 ○	1968	Dry	43.6 △	42.9 △
1949	Dry	59.9 △	44.5 △	1969	Wet	60.0 △	60.6 △
1950	Normal	71.3 △	52.9 △	1970	Wet	50.8 △	48.0 △
1951	Very Wet	73.3 △	57.1 △	1971	Very Wet	90.8 ○	87.1 ○
1952	Very Wet	166.8 ○	103.8 ○	1972	Very Wet	62.7 △	68.9 ○
1953	Very Wet	148.1 ○	107.9 ○	1973	Dry	28.4 ■	28.6 ■
1954	Wet	97.5 ○	89.0 ○	1974	Very Wet	113.4 ○	70.2 ○
1955	Very Dry	42.8 △	32.1 ■	1975	Wet	100.3 ○	79.6 ○
1956	Very Wet	103.0 ○	80.0 ○	1976	Dry	72.8 △	61.7 △
1957	Normal	74.7 △	57.0 △	1977	Very Dry	10.3 ■	10.7 ■
1958	Very Wet	133.4 ○	97.2 ○	1978	Wet	64.6 △	138.7 ○
1959	Dry	42.0 △	40.1 △	1979	Very Dry	23.0 ■	22.0 ■
1960	Dry	61.0 △	47.9 △	1980	Wet	37.9 △	31.9 ■
1961	Normal	57.7 △	62.5 ○	1981	Very Dry	7.4 ■	8.0 ■

[11] Monthly flow data for the Scott River at the Fort Jones gage is available at https://waterdata.usgs.gov/nwis/monthly/?referred_module=sw&site_no=11519500& por_11519500_11850=2210314,00060,11850,1941-10,2022-03t (hereafter Monthly Flow Data).

[12] CDFW Flow Criteria, *supra*, at p. 26, tbl. 13.

[13] Tina Bartlett, CDFW, Letter to Eileen Sobeck, SWRCB, June 15, 2021 (hereafter CDFW Emergency Flow Letter), at p. 2, attached as Exhibit E.

Water Year	Water Year Type[a]	Mean Flows (cfs)		Water Year	Water Year Type[a]	Mean Flows (cfs)	
		Aug.	Sept.			Aug.	Sept.
1982	Very Wet	68.1 ▲	56.9 ▲	2003	Wet	87.7 ●	49.3 ▲
1983	Very Wet	269.1 ●	228.3 ●	2004	Normal	13.3 ■	14.0 ■
1984	Very Wet	51.3 ▲	51.9 ▲	2005	Dry	21.9 ■	16.1 ■
1985	Dry	31.1 ▲	39.0 ▲	2006	Very Wet	52.3 ▲	47.2 ▲
1986	Wet	34.1 ▲	43.9 ▲	2007	Normal	8.2 ■	7.1 ■
1987	Very Dry	13.4 ■	13.5 ■	2008	Normal	22.6 ■	16.9 ■
1988	Dry	15.0 ■	11.9 ■	2009	Dry	10.7 ■	7.0 ■
1989	Normal	20.6 ■	32.1 ■	2010	Normal	40.4 ▲	36.2 ▲
1990	Dry	13.8 ■	12.2 ■	2011	Very Wet	95.5 ●	61.7 ▲
1991	Very Dry	12.9 ■	11.5 ■	2012	Normal	17.3 ■	12.2 ■
1992	Very Dry	7.9 ■	25.8 ■	2013	Dry	11.3 ■	11.6 ■
1993	Wet	57.0 ▲	47.6 ▲	2014	Very Dry	6.9 ■	7.0 ■
1994	Very Dry	5.8 ■	4.8 ■	2015	Dry	7.1 ■	7.2 ■
1995	Very Wet	92.1 ●	48.9 ▲	2016	Wet	14.0 ■	10.0 ■
1996	Wet	32.2 ▲	28.0 ■	2017	Very Wet	49.2 ▲	52.3 ▲
1997	Wet	28.2 ■	37.2 ▲	2018	Dry	6.2 ■	8.1 ■
1998	Very Wet	119.3 ●	68.2 ●	2019	Wet	19.0 ■	24.2 ■
1999	Wet	71.0 ▲	58.1 ▲	2020	Very Dry	9.3 ■	6.3 ■
2000	Normal	19.3 ■	24.0 ■	2021	Very Dry	9.0 ■	9.5 ■
2001	Very Dry	5.5 ■	4.4 ■	2022	Very Dry	10.0 ■	9.2 ■
2002	Dry	14.9 ■	11.6 ■				

Source: Monthly Flow Data, *supra*.

[a] Water year types are based on the total annual run off at the USGS gage at Somes Bar on the Salmon River.

Since 1980, coincident with rapidly intensifying agriculture, September flow in normal years is now less than half what it was in the period from 1942 to 1980—22.4 cfs as compared to 55.9 cfs.[14] Table 2 on the next page takes the data from Table 1 and computes average September flows in the period between 1942 and 1970 and the forty years since 1980, along with a figure indicating the percentage of decline going from the first period to the second.[15]

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[14] CDFW Flow Memo, *supra*, at p. 8.

[15] Flow monitoring data in the Scott only goes back to 1942. It should be noted that the period from 1942-1970 does not represent a period of unimpaired flow: increasing agricultural withdrawals, the local extirpation of beaver in the 19th century, mining impacts, and channelization all likely reduced both flow and habitat quality by the 1940s. (CDFW Flow Criteria, *supra*, at p. 16; NMFS Recovery Plan, *supra*, at pp. 36-2 to 36-5.) But as the period before 1970 contains the least impaired timeframe for which flow data is available, it is a useful comparison point. Between 1970 and 1979, irrigation withdrawals increased significantly, making the data from that decade not as useful an illustration of less-impaired conditions in the Scott Valley. (See Scott Valley GSP, *supra*, at p. 89.)

TABLE 2. Mean September Flows in the Scott River and Percentage of Decline by Water Year Type

Water Year Type	Mean September Flows (cfs) 1942-70	Mean September Flows (cfs) 1980-2020	% Decline
Extremely Wet	81.8	76.9	6%
Wet	77.2	46.5	40
Normal	55.9	22.4	60
Dry	44.4	14.9	66
Critically Dry	33.1	9.7	71

Note that the average flow in Septembers of normal years is now well below the CDFW emergency minimum flow recommendation of 33 cfs for drought years.

These figures understate the extent of recent flow impacts. Table 3 below shows the mean September flows since 2012 only:

TABLE 3. Mean September Flows in the Scott River by Water Year, 2012-22

Water Year	Water Year Type	Mean September Flows (cfs)
2012	Normal	12.2
2013	Dry	11.6
2014	Very Dry	7.0
2015	Dry	7.2
2016	Wet	10.0
2017	Very Wet	52.3
2018	Dry	8.1
2019	Wet	24.2
2020	Very Dry	6.3
2021	Very Dry	9.5
2022	Very Dry	9.2

As shown above, in the last decade, even in the “normal” and “wet” years, September flows are a fraction of what they were in the middle of the 20th century, below the mean figures since 1980, and far below the CDFW interim recommendation of 62 cfs and its minimum drought requirements of 33 cfs. Notably, this decline is apparent even in the wettest years. The year 2017 was a “very wet” year, yet September flows were less than in “normal” years during the 1942-70 period and also below the recommended flow criteria.

Since the 1970s, the number of days when the Scott experiences flows below 15 cfs has increased dramatically.[16] Before 1975, the Scott never saw flows below 15 cfs. In the last decade, it averages flows below 15 cfs in all but the wettest summers.

The two charts in Figures 1 and 2 on the next page illustrate the trend of increasing severity of flow conditions over time, plotted using the data and color-coding system from Table 1 above.

Climate change is not the major cause of the decline in flows in the Scott. Other rivers in the Klamath Basin, including the Salmon and the Trinity, have not experienced a similar decline.[17] Researchers instead attribute 60 percent of the decline in the Scott's flows to factors other than climate change, particularly the expansion of groundwater use.[18]

And these low flows lead to disconnections and drying up of the riverbed itself. Dewatering of the mainstem Scott is becoming common in dry and even normal years. Regular monitoring of river-reach connection status, conducted by the Scott River Watershed Council, took place in 2022. This monitoring shows that despite precipitation events in September and November, the mainstem of the Scott remained disconnected for more than twenty kilometers above Fort Jones into November. And major tributaries such as Shackleford Creek, Moffet Creek, Kidder Slough, Kidder Creek, Patterson Creek, and Etna Creek remained disconnected from the mainstem Scott through mid-December. Modeling performed by Dr. Thomas Harter of UC Davis shows a relationship between flows and stream-reach disconnection.

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[16] CDFW Flow Criteria, *supra*, at p. 7; see also Flow Memo, *supra*, at p. 7.

[17] Robert W. Van Kirk & Seth W. Naman, *Relative Effects of Climate and Water Use on Base-Flow Trends in the Lower Klamath Basin* (2008) 44 J. Am. Water Resources Assn. 1035, 1042 (hereafter Van Kirk & Naman), attached as Exhibit F.

[18] *Id.* at 1044-46. This study concluded that 61 percent of the decline in Scott late-summer baseflows was attributable to factors other than climate, including irrigation and other consumptive use. See also SS Papadopulos & Associates Inc., Groundwater Conditions in Scott Valley, California (2012) (hereafter Papadopulos Report), at pp. 33-34, attached as Exhibit G.

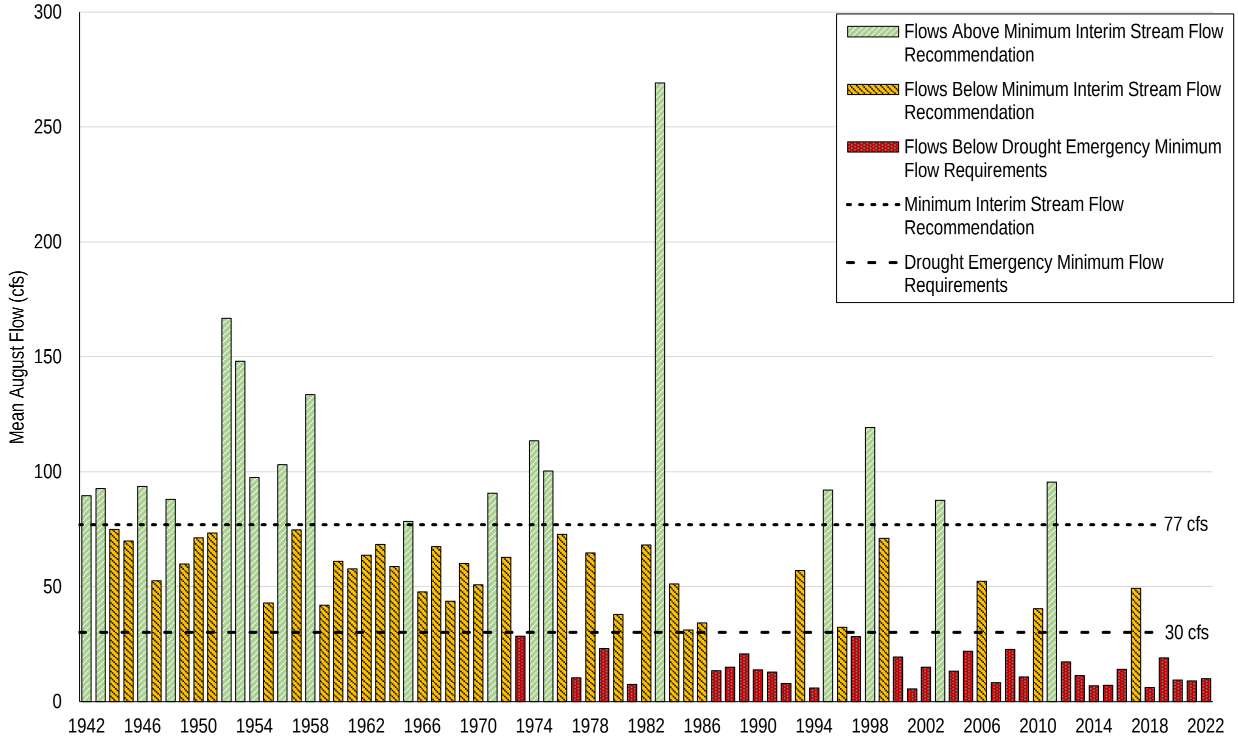

Figure 1. Mean August flows for the Scott River for the 1942 to 2022 water years.

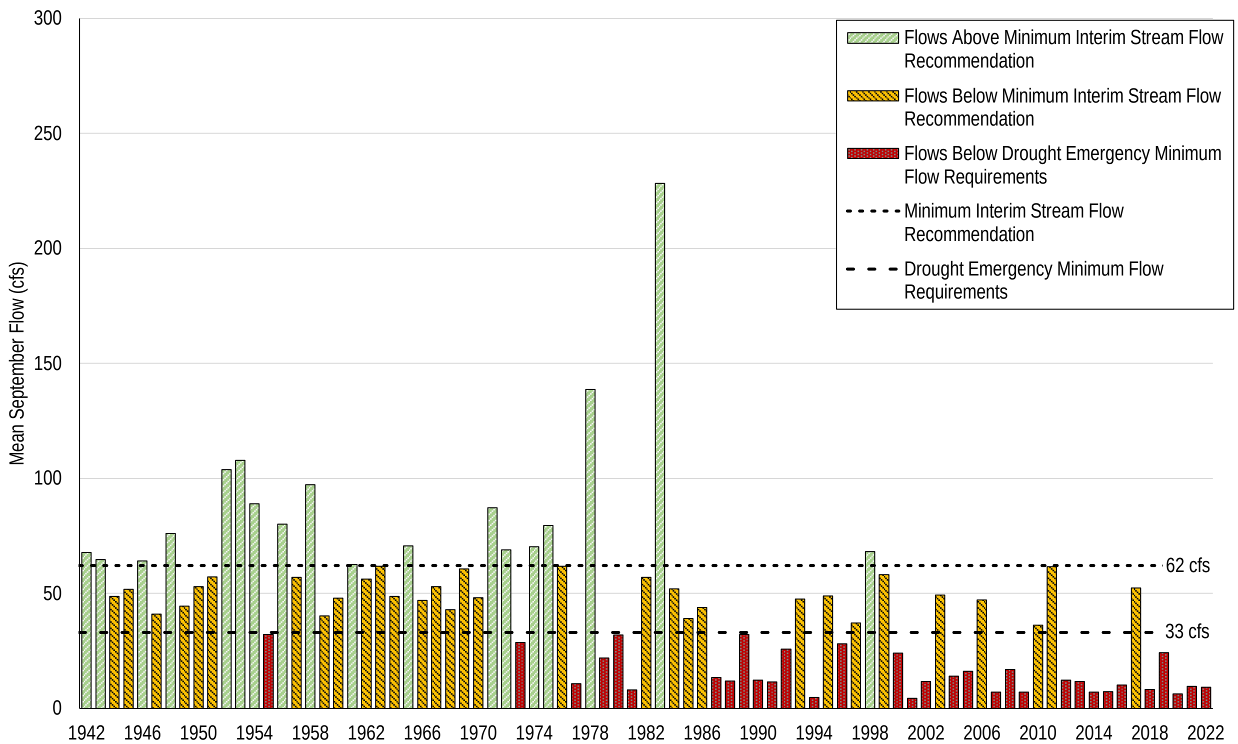

Figure 2. Mean September flows for the Scott River for the 1942 to 2022 water years.

3. Flow Impacts on Salmonids

The Scott's low flows have had devastating impacts on native Chinook and Coho. Both species need flows to migrate upstream to spawn, to rear, and to migrate downstream to the ocean. And each species has a specific lifecycle that requires flows at different times of the year.

a. Fall-Run Chinook

Chinook usually migrate upstream during a narrow window in October.[19] This migration is constrained by flow: in years when October flows are above 22 cfs, more than half of Chinook can travel upstream of Fort Jones to spawn.[20] But in years with low flows, Chinook struggle to reach the Scott Valley and are forced to spawn in far less suitable habitat in the canyon reach.[21] Spawning in the canyon is disadvantageous for Chinook because redds are more vulnerable to scour during high winter flows.[22]

Chinook rear for only a few months before migrating out of the Scott to the Pacific in the spring and summer.[23]

Chinook populations have declined significantly in recent years. While the fall run

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[19] CDFW Flow Memo, *supra*, at pp. 11-12. This discussion uses the term "Chinook" to refer to fall-run Chinook. Spring-run Chinook have been extirpated in the Scott since the 1970s. While they are not the focus of this Petition, the flow regulation requested by this Petition would likely benefit efforts to recover and/or reestablish spring-run Chinook in the future.

[20] *Id.* at p. 17.

[21] *Id.* at pp. 11-18.

[22] *Id.* at p. 14; CDFW Flow Criteria, *supra*, at pp. 10-11 ("Valley reaches allow access to high quality spawning habitat that is largely connected to its floodplain. Valley reaches also provide access to seasonal high quality rearing habitat that degrades as the dry season progresses. The importance of connectivity between spawning reaches and floodplain habitat cannot be understated. Floodplain connectivity allows water to spread out as flows increase, mitigating increasing water velocities, protecting incubating eggs from scour and providing rearing juvenile salmonids flow refuge, cover and feeding opportunities that is less abundant in canyon reaches. Additionally, when adult salmon have access to upstream reaches for spawning, more rearing habitat is seeded with juvenile fish. Access to more rearing habitat increases potential production, which can in turn increase adult returns.").

[23] CDFW Flow Criteria, *supra*, at p. 9.

averaged 4,977 from 1978 to 2020, that figure plummeted to only 1,738 in the period from 2015 to 2020, a decrease of 65 percent.[24] This decline in the Scott is more severe than the decline in the Klamath basin as a whole.[25]

In 2022, only 72 Chinook reached the fish counting station near Fort Jones.[26]

b. Coho

The Scott's Coho population is a "core independent" population of the SONCC ESU.[27] As such, Coho's recovery in the Scott is vital for the recovery of SONCC populations as a whole.[28] NMFS has concluded that a yearly Coho spawning population of 6,500 is necessary for recovery.[29] And it has set a depensation threshold—the figure below which extirpation is likely—at 250 spawners.[30] NMFS also found that "Altered Hydrologic Function" including "Water quantity and flow regime" are a "Very High" stressor on fry, juvenile, and smolt Coho, and a "High" stressor on eggs.[31] NMFS identified the effect of limited flows on juvenile Coho, along with degraded riparian conditions, as the two "key limiting stresses" on the species.[32]

Coho salmon's lifecycle is dependent on sufficient cold water year round. Coho migrate

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[24] CDFW Flow Memo, *supra*, at p. 9.

[25] *Ibid.*

[26] CDFW, Klamath River Project Adult Fish Counting Facility In-season Update (Jan. 13, 2023) (hereafter Jan. 13, 2023 Fish Counting Update), at p. 1, attached as Exhibit H. It is likely that a number of Chinook spawned in the canyon reach during the 2022 run.

[27] NMFS Recovery Plan, *supra*, at pp. 2-10.

[28] *Id.* at pp. 2-12 to 2-13.

[29] *Id.* at pp. ES-5, 4-6.

[30] *Id.* at pp. 2-18, 2-35.

[31] *Id.* at pp. 36-15 to 36-17.

[32] *Id.* at pp. 36-15 to 36-16.

upstream in late fall and early winter, peaking in November and early December.[33] Coho tend to stage in the mainstem Klamath near the confluence with the Scott and wait for freshwater flows to increase before attempting to migrate.[34] If insufficient flows are present during this period, an entire cohort may fail to migrate. As of December 26, 2022, only 236 adult Coho—fewer than the depensation level of 250 spawners—have been identified at the fish counting station in Fort Jones.[35]

Coho prefer to spawn in areas with less current than the mainstem Scott, such as in flood-plains and tributaries.[36] Sufficient flows are therefore necessary for Coho to access those tributaries during the spawning season. As discussed above, in fall 2022 many tributaries were not connected as of mid-December.

Upon emerging, Coho need to rear for 18 months in cold water before out-migrating.[37] High temperatures associated with low flows thus greatly limit Coho's rearing success.[38] And disconnections restrict the fish from moving to more hospitable stream reaches. Connection between pools is also vital for the movement of the invertebrates that juvenile Coho rely on for food;

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[33] CDFW Flow Memo, *supra*, at p. 13.

[34] *Ibid.*

[35] Jan. 13, 2023 Fish Counting Update, *supra*, at p. 1; NMFS Recovery Plan, *supra*, at pp. 2-18, 2-35. The Scott River fish counting station was removed on December 26, 2022 due to high flows associated with significant winter storms. It is not clear how many additional Coho migrated after the counting station was removed. The Scott River Watershed Council conducted spawning ground surveys in January 2023 on sections of the Scott as well as French, Miners, and Sugar Creeks. (Scott River Watershed Council, 2022-2023 Coho Salmon Spawning Ground Surveys (2023), at p. 1, attached as Exhibit I.) The surveys found "fewer than expected" redds, live fish, and Coho carcasses based on the number of fish passing the CDFW fish counting station. (*Id*. at p. 3.) It is possible that high flows allowed greater dispersal of Coho throughout the Scott basin or that higher than usual turbidity masked redds and other observations. (*Ibid.*)

[36] CDFW Flow Memo, *supra*, at p. 12-13; CDFW Flow Criteria, *supra*, at p. 11; NMFS Recovery Plan, *supra*, at pp. 36-3 to 36-8. Major tributaries to the Scott include Etna, French, Miners, Kelsey, Kidder, Mill, Patterson, Shackleford and Sugar Creeks.

[37] CDFW Flow Criteria, *supra*, at pp. 11-12.

[38] NMFS Recovery Plan, *supra*, at p. 3-27.

with less food, competition increases and fewer and smaller juveniles survive the summer.[39] Coho have shown the highest in-river productivity in years with the highest flows.[40]

And while certain of the three brood years of Coho have shown signs of recovery, the population remains listed as threatened. The low flows of 2020 were close to the last straw for one cohort, with only a December rainstorm permitting passage to spawning areas.[41]

Low flows in 2022 continued to put stress on salmonids. Late fall rains in 2021 permitted fish passage starting in October 2021.[42] But a long dry spell followed, leaving the 2021-22 water year with well-below-average precipitation.[43] And while spring rains permitted out-migration, the fall of 2022 has proven to be potentially disastrous, with only 72 Chinook and 236 Coho making it past the fish counting station into the main stem of the Scott.[44] Higher flows are necessary to preserve these species.

4. Agriculture in the Scott River Basin

The decline in Scott flows is largely attributable to the increase in intensity in agricultural

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[39] *Id.* at pp. 3-27 to 3-28.

[40] *Ibid.*; CDFW Flow Criteria, *supra*, at p. 18.

[41] CDFW Flow Memo, *supra*, at p. 18. Coho keep a fairly rigid three-year cycle of spawning, rearing for 18 months in fresh water, then migration, and return. Thus, the Scott coho population can be divided into three cohorts, or brood years, each of which return to spawn every three years. (*Id.* at p. 12.) Brood Year 1 was devastated by the 2013-14 drought year, when its run was reduced from 2,644 fish in 2013 to 250 in 2016; only 365 returned in 2019. Brood Year 3 increased from 80 fish in 2009 to 727 in 2018. (*Ibid.*) Fortunately, and due in no small part to the efforts of CDFW, Tribes, the Scott Valley Watershed Council, local landowners, and the State Board, more than 80,000 juvenile Coho from the 2020 brood year survived to out-migrate in 2022. (CDFW, Scott and Shasta River Juvenile Salmonid Outmigration Monitoring (June 24, 2022), at p. 1, attached as Exhibit J.)

[42] CDFW, Klamath River Project Adult Fish Counting Facility In-season Update (Jan. 7, 2022), at p. 1, attached as Exhibit K. CDFW reported 1,324 Chinook and 829 Coho passing the fish counting station in fall 2021 and winter 2022.

[43] State Board, Finding of Emergency and Informative Digest (June 20, 2022) (hereafter Informative Digest), at p. 6, available at https://www.waterboards.ca.gov/drought/scott_shasta_rivers/docs/2022/ssd-digest-06202022.pdf (accessed March 3, 2023).

[44] Jan. 13, 2023 Fish Counting Update, *supra*, at p. 1.

use over the past half-century. Scott flows have declined much more than in other rivers with similar watershed characteristics but which lack intensive agriculture.[45] And irrigation withdrawals increased 115 percent between 1953 and 2001 while irrigated land area increased by 89 percent during the same period.[46] This finding is consistent with a groundwater modeling study that found that the impact of increased pumping (leaving aside surface diversions) between the 1980s and 2000 is responsible for a decrease in 16 cfs of Scott baseflows.[47]

As of 2020, agriculture uses approximately 69,000 acre-feet (AF) per year in the Scott, of which 26,000 AF comes from surface water diversions and 42,000 AF comes from groundwater pumping.[48] And this use has increased recently, with an estimated use of 68,000 AF in 2018 and 2019 compared to an estimated average use of 61,500 AF per year from 2015 to 2017.[49] Groundwater levels in monitoring wells also declined between 3.4 and 7.6 feet between 2019 and 2020.[50]

5. Previous Efforts to Address Flow Issues in the Scott Have Been Unsuccessful

Despite the involvement of the courts, the State Board, NOAA Fisheries, CDFW, the GSA, and the Regional Board, no agency has yet succeeded in establishing a binding and effective permanent stream flow standard on the Scott.

a. The Scott River Adjudication

The first major attempt to provide flows in the Scott was the statutory adjudication that the

[45] Kirk & Van Naman, *supra*, 44 J. Am. Water Resources Assn. at 1045-46.

[46] *Id.* at 1046.

[47] Papadopulos Report, *supra*, at p. 32. "Baseflows" refers to the summer flow remaining in the river system when recent precipitation or snowmelt are not contributing to flow.

[48] Dept. of Water Resources, Adjudicated Basins Annual Reporting System (2021), Excerpt from Scott River Stream System Annual Report, 10/01/2019–9/30/2020 (hereafter Scott River Adjudication Annual Report), available at https://sgma.water.ca.gov/adjudbasins/report/preview/215 (accessed May 18, 2023). The remaining 1,000 AF is for domestic use. This reporting is based on estimation, as growers are not required to meter their groundwater extractions.

[49] *Ibid.*

[50] *Ibid.*

Siskiyou Superior Court entered in 1980. The Scott River Decree reserves 30 cfs to the U.S. Forest Service in September, with higher amounts in other months, for "minimum subsistence-level fishery conditions including spawning, egg incubation, rearing, downstream migration, and summer survival of anadromous fish, and can be experienced only in critically dry years without resulting in depletion of the fishery resource."[51] It additionally reserves 32 cfs in September for other environmental flows, but at a lower priority right.[52] As discussed above, the USFS 30 cfs flow has not been satisfied even in recent normal precipitation years.

The adjudication simply does not give USFS's flow right a sufficiently high priority to protect a 30 cfs flow in dry years. This is because the USFS flow right is too junior to require curtailment of other rights if flows are below 30 cfs. Paragraph 45 of the adjudication decree gives the Forest Service a first-priority right in Schedule D4; but that level of right does not permit curtailment of rights in most other schedules. As former State Board Executive Director Thomas Howard put it in a letter to the Forest Service: "[T]he vast majority of the water rights recognized in the Adjudication Decree are not subject to curtailment during periods when flows are insufficient to satisfy the Forest Service instream flow rights."[53]

Moreover, even where the USFS right does require curtailment, there is no watermaster on the Scott mainstem.[54] As a result, until the State Board adopted the emergency regulations in 2021, no entity was responsible for monitoring diversions or pumping. And no entity was responsible

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[51] Siskiyou County Superior Court, Decree No. 30662, Scott River Stream System (1980), ¶ 45 (hereafter Scott River Decree), available at https://www.sswatermaster.org/_files/ugd/25fb50_732ff15e812b4e6bbaff52a6e89afe4c.pdf (accessed May 18, 2023).

[52] *Ibid.*

[53] Thomas Howard, State Board, Letter to Patricia Graham, USFS, Dec. 3, 2013, at p. 1, attached as Exhibit L.

[54] The portion of the Scott Valley covered by a watermaster has steadily decreased. Now, only portions of the French and Wildcat Creek watersheds are covered—a tiny fraction of the total area. See Siskiyou County Superior Court, Notice of Reduction of Scott River Watermaster Service Area (Dec. 20, 2018), available at https://www.sswatermaster.org/_files/ugd/25fb50_3406687f26c24a06a207c3629ad930e4.pdf (accessed May 18, 2023.).

for informing junior rights holders that insufficient water was available to meet the USFS water right and to require curtailments of those rights if diversions did not cease voluntarily.

And the Scott River adjudication has another major flaw: it regulates certain, but not all, groundwater extractions in the Scott Valley. Following the Legislature's declaration that groundwater in the Scott Valley should be adjudicated as being connected to the Scott River (Water Code section 2500.5), the court included some, but not all, of the groundwater in the Scott Valley.[55] A map included in the adjudication delineates a zone near the river where the court declared the groundwater to be "interconnected."[56] This has led to a situation where claimants listed in Schedule C of the adjudication are governed by the adjudication, but those with land outside the adjudicated zone may drill groundwater wells and pump groundwater with almost no oversight. And for those growers within the adjudicated zone, there is no numeric limit on pumping—the adjudication permits pumping sufficient to irrigate certain acreage without specifying maximum acre footage of water use.[57]

Moreover, the zone established by the court is too small and is unsupported by evidence. The report that formed the basis of the adjudication's line demarcating the "interconnected" zone was not based on streamflow calculations nor did it consider the cumulative depletion impact from pumping over many years.[58] Rather, it relied only on inferences based on the relative permeability of the sediments in the Scott Valley.[59] Indeed, the report acknowledged that it lacked the

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[55] Scott River Decree, *supra*, ¶¶ 1, 4, 20.

[56] *Id.* ¶ 4; Scott River Adjudication Map, attached as Exhibit M.

[57] Scott River Decree, *supra*, ¶ 20, sched. C.

[58] State Water Resources Control Board, Report on the Hydrogeologic Conditions of Scott Valley Siskiyou County, California (1975) (hereafter 1975 Hydrogeologic Report), attached as Exhibit N; see also Deborah L. Hathaway, Memorandum, Stream Depletion Impacts Associated with Pumping from Within or Beyond the "Interconnected Groundwater" Area as Defined in the 1980 Scott Valley Adjudication (Aug. 27, 2012) (hereafter Hathaway Memo), pp. 1-2, attached as Exhibit O.

[59] See 1975 Hydrogeologic Report, *supra*, at pp. iii, 5-18; Hathaway Memo, *supra*, at p. 2 (stating the 1975 Hydrogeologic Report "does not support a conclusion that pumping from beyond the zone would not result in a stream depletion impact within the same irrigation season or in

information to draw a bright line between "ground water obviously not interconnected" and "ground water freely and completely interconnected."[60] And according to a technical memorandum using the Scott Valley Groundwater Model, pumping outside the adjudicated zone has a clear and measurable impact on Scott River flows, impacts which have accumulated over time.[61]

b. The Regional Board Has Not Acted on Flows

In 2005, the North Coast Regional Water Quality Control Board adopted a Scott River Total Maximum Daily Load (TMDL) for temperature and sediment.[62] However, this program did not address flows, despite the recognized relationship between temperature and flow. Instead, the TMDL attempted to remedy impairments to temperature solely by improving shade.[63] As discussed above, any improvements in shade have not reversed the decline in salmonid populations.

Beginning in 2006, the Regional Board waived Waste Discharge Requirements for agricultural dischargers in the Scott and Shasta Valleys pursuant to Water Code section 13269. The Regional Board renewed that waiver in 2012 and 2017.[64] The Regional Board has proposed to renew these waivers in 2023. In the Staff Report for the proposed waiver renewal, the Regional

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future years").

[60] 1975 Hydrogeologic Report, *supra*, at p. iii.

[61] Hathaway Memo, *supra*, at p. 4.

[62] North Coast Regional Water Quality Control Board, Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads (2005), available at https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/scott_river/staff_report/ (accessed May 18, 2023).

[63] *Id.* at p. xviii. Lowered groundwater levels resulting from overpumping also lead to loss of riparian vegetation. (NMFS Recovery Plan, *supra*, at p. 36-16.) Overpumping therefore hurts temperatures both by reducing influxes of cool water and also by decreasing shade.

[64] The Karuk Tribe filed a petition with the State Board challenging the 2018 renewal on multiple grounds. (Petition Challenging Scott River TMDL Conditional Waiver of Waste Discharge Requirements (Petition No. A-2602), available at https://www.waterboards.ca.gov/public_notices/petitions/water_quality/petitions.shtml [list of petitions]; https://www.waterboards.ca.gov/public_notices/petitions/water_quality/docs/petitions/a2602petition.pdf [copy of petition].)

Board notes that a flow standard is a "[c]ritical [e]lement [m]issing from the [w]aivers" for meeting water quality objectives in the Scott.[65] The Staff Report goes on to note that in both the Scott and the Shasta, flows are directly linked to temperatures.[66] The Regional Board states that its agricultural discharge waivers do not provide "an approach to addressing flow needs." Rather, it points to the need for State Board action: "The Division of Water Rights has the strongest authority to [address low flows]. Both watersheds have critical issues related to instream flows that impact their respective TMDLs."[67]

c. CDFW Flow Criteria

In 2017, pursuant to Public Resources Code sections 10000 to 10005, CDFW established an interim instream flow criteria for the Scott, with minimum late-summer flows of 62 cfs (or the river's natural flow) along with higher amounts in other months.[68] But neither the State Board nor the Regional Board has taken action to implement this flow criteria through a Basin Plan amendment, a permanent regulation under their waste and unreasonable use or public trust authority, or any other regulatory tool. On June 15, 2021, CDFW sent a second letter to the State Board again urging immediate action and setting out proposed "drought emergency minimum flow recommendations" intended to preserve salmonid survival during the severe drought that the river was (and is) experiencing.[69]

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[65] North Coast Regional Water Quality Control Board, Staff Report for Draft Order No. R1-2023-0005 Short-Term Renewal of Order No. R1-2018-0018, Scott River TMDL Conditional Waiver of Waste Discharge Requirements, and Order No. R1-2018-0019, Shasta River TMDL Conditional Waiver of Waste Discharge Requirements (hereafter Ag Waiver Staff Report), at p. 11, available at https://www.waterboards.ca.gov/northcoast/board_info/board_meetings/12_2022/pdf/3/220926_Staff-Report.pdf (accessed May 18, 2023).

[66] *Id.* at pp. 11-13.

[67] *Id.* at p. 11.

[68] CDFW Flow Criteria, *supra*, at pp. 25-26.

[69] CDFW Emergency Flow Letter, *supra*, at p. 1.

d. State Board Notices of Unavailability

In 2014-16 and again in 2020, facing a dry year, the State Board issued Notices of Unavailability to junior water rights holders.[70] Yet in none of those years were flows sufficient to meet the USFS flow right of 30 cfs or emergency CDFW flow recommendation of 33 cfs during late summer.[71] Instead, flows in September of each of those years did not exceed 10 cfs.

One reason these notices were unsuccessful in restoring flows is that they did not address extractions of interconnected groundwater. Because groundwater is closely connected to Scott River flows, even ending surface water diversions will not allow flows to recover if groundwater extraction both within and outside the adjudicated zone is not addressed.[72] Additionally, without watermaster service or an emergency regulation in place, no regulatory entity monitored or curtailed diversions.

e. SGMA

Despite high hopes, the Sustainable Groundwater Management Act (SGMA) has not provided a plan for adequate flows in the Scott. SGMA requires that Groundwater Sustainability Agencies (GSAs) adopt plans that, among other things, avoid “undesirable results” including impacts on interconnected surfaces waters and the beneficial uses and users that rely on them. (Wat. Code § 10721, def. (x).)

The Siskiyou County Flood Control and Water Conservation District, composed of the County’s five supervisors and acting as the GSA for the Scott Basin, adopted a Groundwater Sustainability Plan in 2021.[73]

But the GSP, by its terms, is not designed to restore flows to levels compatible with species recovery: “Given the history of stream depletion associated with groundwater pumping outside

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[70] See, e.g., State Water Resources Control Board, Notice of Unavailability of Water (2020), attached as Exhibit P.

[71] CDFW Flow Memo, *supra*, at p. 5.

[72] See Hathaway Memo, *supra*, at pp. 1-4.

[73] Scott Valley GSP, *supra*.

the adjudicated zone, SGMA does not require the GSA to address undesirable results associated with depletion of interconnected surface water."[74] This is for at least two reasons: the exclusion of the adjudicated zone and the refusal to address conditions prior to 2015.

SGMA provides that it does not "apply" to "adjudicated areas" including to the Scott River Stream System. (Wat. Code § 10720.8, subds. (a), (e).) The GSP excludes the adjudicated area and pumping from that area from its determination of whether groundwater pumping causes "undesirable results" for depletions of interconnected surface waters in the Scott River.[75]

The Scott Valley GSP also relies on SGMA to consider all stream depletions that occurred before January 1, 2015 as not being "undesirable results."[76] The GSP concludes that it need only address depletions that are more severe than those occurring on that date—despite this date falling several years into one of the worst droughts California has ever seen (prior to the present drought, that is).

As a result of these two dubious interpretations of SGMA, the GSP does not require any reduction in pumping within the adjudicated zone. And outside the adjudicated zone, it requires reversals of streamflow depletion by only 15 percent.[77] The GSP is explicit that it does not expect to restore adequate streamflows in the Scott—a project it refers to as the "aspirational watershed goal."[78] And the GSP does not quantify what this aspirational watershed goal is, but notes that the State Board has not acted to establish instream flow requirements based on the CDFW Flow Criteria.[79]

In sum, the GSP as written is not designed to either set a minimum streamflow standard

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[74] *Id.* at p. 209.

[75] *Id.* at p. 208.

[76] *Id.* at p. 208; see Wat. Code § 10727.2, subd. (b)(4).

[77] Scott Valley GSP, *supra*, at p. 213.

[78] *Id.* at p. 209.

[79] *Id.* at p. 208.

for the Scott or to manage groundwater in such a way as to meaningfully address any standard that could be implemented.[80]

f. 2021 Emergency Regulations

In the summer of 2021, following a petition by the Karuk Tribe and ELF, the State Board adopted drought-related emergency regulations setting a minimum flow standard for the Scott River. (Cal. Code Regs., tit. 23, § 875 et seq.) The regulations additionally contain restrictions on inefficient livestock watering and information and reporting requirements.

The flow standard in the emergency regulations is based on the drought minimum flows recommended by CDFW in 2021.[81] The regulations permit the State Board to curtail both surface water diversions and groundwater pumping when flows drop below the minimums. In 2021, the State Board curtailed flows and pumping almost immediately upon adoption of the regulation. In the summer of 2022, the State Board again imposed curtailments when flows dropped in July. The curtailments remained in place until large rainstorms arrived in December.[82]

The regulations also impose restrictions on livestock watering during the winter.[83] Winter livestock diversions often use large amounts of water delivered through leaky ditches.[84] These

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[80] And even if the GSP did adequately address streamflow impacts from groundwater pumping, the GSP would not have authority over surface water diversions. Only the State Board has the authority to curtail all forms of water withdrawal in the Scott.

[81] CDFW Emergency Flow Letter, *supra*, at p. 2. These flows were slightly modified by CDFW in 2022. The State Board incorporated these modifications when it readopted the Emergency Regulations in 2022. (State Water Resources Control Board, Resolution No. 2022-0025 (June 21, 2022), available at https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2022/rs2022-0025.pdf.)

[82] State Board, Addendum 36 to the Order for Reported Water Rights in the Scott River Watershed Issued September 9, 2021 (for water rights included in List A), Order WR 2021-0083-DWR (for water rights included in List B), and Order WR 2021-0084-DWR (for water rights included in List C) (Dec. 27, 2022), available at https://www.waterboards.ca.gov/drought/scott_shasta_rivers/docs/2022/scott-addendum36.pdf (accessed March 2, 2023).

[83] Cal. Code Regs., tit. 23, § 875.7, as amended.

[84] Informative Digest, *supra*, at pp. 60-62.

diversions—especially on smaller tributaries during dry winters—can completely dewater streams, stranding Coho redds.

The regulations permit diverters and pumpers to comply by proposing "local cooperative solutions" rather than by simply ceasing diversions or pumping. These solutions—for surface water—permit diversions and pumping at some levels greater than zero, but with restrictions in place to prevent dewatering of streams. For groundwater, the local cooperative solutions are permitted to reduce groundwater pumping by a total of 30 percent.

Under Water Code section 1058.5, emergency regulations to regulate flows may only be adopted either in certain extremely dry years or while a Governor has declared a drought emergency. The Governor issued his drought emergency proclamation for the Klamath Basin, including the Scott, on May 10, 2021, and it remains in effect.[85]

The emergency regulations also require reporting—in some cases for the first time—of key information relating to water pumping and surface water diversions. (Cal. Code Regs., tit. 23, § 875.6.)

The success of the emergency regulations has been mixed. In 2021, curtailments went into effect only in September, after most diversions had already occurred. Nonetheless, the State Board found improvements in groundwater levels.[86] And the winter restrictions on livestock watering had positive effects on winter habitat, especially during the long dry spell from January to March 2022. Perhaps as a result, spring outmigration numbers for both Coho and Chinook were strong—a surprising result given the lack of precipitation the previous summer and the long stretch with no rain during the winter.[87]

But the summer of 2022 told a different story. Late spring rains kept the river flowing into

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[85] Governor's Executive Proclamation of a State of Emergency Due to Drought (May 10, 2021), available at https://www.gov.ca.gov/wp-content/uploads/2021/05/5.10.2021-Drought-Proclamation.pdf; Governor's Exec. Order No. N-7-22 (Mar. 28, 2022); Governor's Exec. Order No. N-3-23 (Feb. 13, 2023); Governor's Exec. Order No. N-5-23 (Mar. 24, 2023).

[86] Informative Digest, *supra*, at p. 24.

[87] *Ibid.*

June, but flows plummeted in July. By the time curtailments were in place, it may have been too late. Flows bottomed out around 8 cfs and stayed there well into the fall.

Nonetheless, there are some signs that curtailments had a positive effect. River connectivity monitoring showed that while flows at Fort Jones did not begin to significantly increase until late fall, sections of the mainstem and tributaries began to slowly refill and reconnect over the course of September and October. A September rainstorm aided this process. One potential explanation is that curtailments kept groundwater levels somewhat higher than they would have been, allowing quicker stream response to cooler weather and precipitation. All eyes will be on the spring outmigration monitoring to see if Coho were able to survive the summer.

g. California's Water Supply Strategy

In August 2022, Governor Newsom released the state's strategy for adapting to California's "hotter, drier" climate.[88] The strategy calls for "regulations that would allow for curtailments of water rights in years when there is not a declared drought emergency."[89] The regulation requested in this Petition would fulfill the Governor's strategy by empowering the State Board to curtail water rights in all years when low flows threaten vulnerable species, not just declared drought years.

V. LEGAL FRAMEWORK

A. The State Board's Statutory Authority to Issue a Flow Regulation

The State Board has the authority to "exercise the adjudicatory and regulatory functions of the state in the field of water resources." (Wat. Code § 174.) It has "any powers . . . that may be necessary or convenient for the exercise of its duties authorized by law." (*Id.* § 186.) It may "make such reasonable rules and regulations as it may from time to time deem advisable in carrying out its powers and duties under this code." (*Id.* § 1058.) And it is required to "take all

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[88] Office of the Governor et al., California's Water Supply Strategy: Adapting to a Hotter, Drier Future (2022) (hereafter Water Supply Strategy), at p. 17, available at https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Water-Resilience/CA-Water-Supply-Strategy.pdf.

[89] *Id.* at p. 16.

appropriate proceedings or actions . . . to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water in this state." (*Id.* § 275.) Courts have confirmed that the State Board has the authority to fulfill its waste and unreasonable use duties through a regulation limiting water withdrawals. (*Light v. State Water Resources Control Bd.* (2014) 226 Cal.App.4th 1463, 1483-88.)[90]

B. The State Board's Duty to Act

The State Board has well-established duties to protect public trust resources and prevent waste and unreasonable use of water resources. Both of these doctrines also confer authority on the State Board to issue a regulation that establishes minimum flows in the Scott River.

1. The State Board's Public Trust Authority and Duty

The State Board has the authority and the duty to protect public trust uses in California's navigable waters. Forty years ago, the California Supreme Court held that the public trust doctrine "imposes a duty of continuing supervision over the taking and use of . . . appropriated water." (*National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419, 447 (*National Audubon*).) The State Board must "consider the effect of such diversions upon interests protected by the public trust, and attempt, so far as feasible, to avoid or minimize any harm to those interests." (*Id.* at 426.) And in exercising its continuing supervision, "the state is not confined by past allocation decisions which may be incorrect in light of current knowledge or inconsistent with current needs." (*Id.* at 447.) The court recognized that failing to consider and mitigate impacts to public trust values "may result in needless destruction" of those resources. (*Id.* at 426.)

Public trust uses include fisheries, navigation, and commerce, but are not limited to that "traditional triad" and can evolve over time "in tandem with the changing public perception of the

[90] The recent decision in *Water Curtailment Cases* (2022) 83 Cal.App.5th 164 is no bar to such a regulation. That court held that a different procedure—curtailments triggered by a simple State Board declaration that certain diverters lacked available water under their priority rights—could not be used against riparian and pre-1914 diverters and not without evidentiary hearings. (*Id.* at 191.) But the court specifically limited the scope of its decision to State Board actions under that procedure and did not disturb the Board's authority under the "public trust doctrine, applicable emergency regulations, or other appropriate authority." (*Id.* at 196.)

values and uses of waterways," and can include "habitat for birds and marine life" and as subjects of study as well as for their scenic value as open space. (*National Audubon*, *supra*, 33 Cal.3d at 434-35.)

In 2018, the Court of Appeal confirmed that the public trust doctrine places the same duties and grants the same authority to the State Board when groundwater extractions affect public trust uses in navigable waters. (*Environmental Law Foundation v. State Water Resources Control Bd.* (2018) 26 Cal.App.5th 844, 858 (*ELF*).) The *National Audubon* case concerned nonnavigable tributaries to Mono Lake, which, like the Scott River, is a navigable waterway. (*National Audubon*, *supra*, 33 Cal.3d at 437.) The *ELF* court considered whether the public trust doctrine applies to extractions of groundwater that affect surface flows. It held that those extractions do implicate the public trust: "the analysis begins and ends with whether the challenged activity harms a navigable waterway and thereby violates the public trust." (*ELF*, *supra*, 26 Cal.App.5th at 859-60.) And it reaffirmed that the public trust doctrine "imposes an affirmative duty on the state to act on behalf of the people to protect their interest in navigable water." (*Id.* at 857.) Further, the court held that this duty is not subsumed or extinguished by the enactment of SGMA in 2014. (*Id.* at 863.)

As a result, the public trust doctrine empowers the State Board to restrict both groundwater extraction and surface water diversions as necessary to protect flows in the Scott. And the doctrine demands that the state affirmatively act to protect the people's interest in a healthy, navigable Scott River that hosts abundant fisheries.

2. Waste and Unreasonable Use Doctrine

The State Board has an affirmative duty to prevent waste and unreasonable use. The Constitution prohibits the "waste or unreasonable use or unreasonable method of use of water." (Cal. Const., art. X, § 2.) The Supreme Court has held that the Constitution "establishes state water policy" that all "uses of water . . . must now conform to the standard of reasonable use. (*National Audubon*, supra, 33 Cal.3d at 443.) And the Legislature has directed that the Board "shall take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water in this state." (Wat. Code § 275.)

Courts have repeatedly upheld the State Board's authority to directly regulate water extraction that results in insufficient flows. (E.g., *Stanford Vina Ranch Irrigation Co. v. State* (2020) 50 Cal.App.5th 976, 999-1008 (*Stanford Vina*); *Light*, *supra*, 226 Cal.App.4th at 1482-90.) And extractions of groundwater may be restricted to prevent waste and unreasonable use. (*City of Barstow v. Mojave Water Agency* (2000) 23 Cal.4th 1224, 1240-42.)

Light demonstrates the State Board's authority to adopt regulations that prevent diversions of surface and groundwater that unreasonably harm salmonids. In response to sudden diversions on the Russian River for vineyard frost protection that dropped flows, leading to juvenile salmon deaths, the Board adopted a regulation declaring such diversions unreasonable use unless they complied with certain rules. (*Light*, *supra*, 226 Cal.App.4th at 1473-76.) The Court of Appeal upheld the regulation, holding that the Board's authority under the Constitution and the Water Code extended to promulgating regulations for the protection of the salmonids at risk from the vineyards' actions. (*Id.* at 1482-88.) Moreover, the court held that the "Board has the ultimate authority to allocate water in a manner inconsistent with the rule of priority, when doing so is necessary to prevent the unreasonable use of water." (*Id.* at 1489.)

Stanford Vina provides an illustration of the State Board's authority to adopt emergency measures regulating pre-1914 and riparian water rights, even where a stream had been adjudicated. During the 2012-16 drought, the State Board issued emergency regulations to protect flows in Deer, Mill, and Antelope Creeks, all Sacramento tributaries with vulnerable salmonid populations, explicitly declaring diversions causing flows to fall below CDFW-recommended minimum levels to be a waste and unreasonable use of water. (*Stanford Vina*, *supra*, 50 Cal.App.5th at 989.) Shortly after adoption of the emergency regulations, the Board issued curtailment orders.

After a challenge from one of the large diverters, the court found that the regulations were within the State Board's regulatory authority under Water Code sections 275 and 1058.5 and article X, section 2 of the Constitution. (*Stanford Vina*, supra, 50 Cal.App.5th at 1002-03.) It further found that the Board could issue regulations to curtail not only post-1914 appropriators, but riparian diverters and pre-1914 appropriators. (*Ibid.*) Further, and relevant to the Scott, the Court held that the State Board could issue emergency regulations setting emergency flows even on streams subject to an adjudication. (*Id.* at 1007.) And the Court held that the Board did not need to hold an evidentiary hearing before issuing the curtailment orders. (*Id.* at 1003-04.)

After *Light* and *Stanford Vina*, therefore, there is no doubt that the State Board has the power to: (1) issue both emergency and nonemergency regulations setting minimum flows; (2) issue curtailment orders against all surface water users, including those within an adjudication; and (3) do so quickly and without holding an evidentiary hearing pertaining to each water right user.

3. The State Board's Racial Equity Resolution

In 2021, the State Board adopted Resolution No. 2021-0050, Condemning Racism, Xenophobia, Bigotry, and Racial Injustice and Strengthening Commitment to Racial Equity, Diversity, Inclusion, Access, and Anti-Racism (Racial Equity Resolution).[91] The Racial Equity Resolution recognizes that "the Water Boards' programs were established over a structural framework that perpetuated inequities based on race."[92] It further recognizes that:

> The colonization, displacement, and genocide of Native American people in the United States have contributed to the loss of water resource and watershed management practices that supported Native American people's traditional food sources and ways of life. Watersheds are now primarily managed through large-scale diversion of water for municipal, industrial, agricultural, and commercial beneficial uses to the detriment of traditional, local, and cultural uses and without compensation, recognition, or replacement. Historical land seizures, broken promises related to federal treaty rights, and failures to recognize and protect federal reserved rights, have resulted in the loss of associated water rights and other natural resources of value, as well as cultural, spiritual, and subsistence traditions that Native American people have practiced since time immemorial.
>
> As a result, California Native American Tribes continue to face barriers to defining, quantifying, accessing, protecting, and controlling their ancestral lands, water rights, instream flows, cultural resources, and beneficial uses. Redistribution of water has reduced or eliminated access to healthy traditional food sources such as smelt, salmon, freshwater mussels, and freshwater plants. Disconnection from traditional ancestral land and water and the unavailability of traditional foods have been linked to serious and pervasive health issues. In addition, low or non-existent instream flows, and associated water quality problems, impair or prevent water-related cultural, spiritual, and subsistence practices. These injustices are exacerbated by climate change

[91] Available at https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2021/rs2021-0050.pdf (accessed January 28, 2023).

[92] *Id.* at p. 2.

and complex water resource and watershed management processes.

> The historical seizures of land from people of color have had, and continue to have, long-standing, oppressive impacts that extend beyond the loss of the land itself. These impacts include the loss of the associated water rights and other natural resources of value, lack of access to affordable and reliable governmental services, and forced relocation to areas with fewer or lower quality natural resources.[93]

The Racial Equity Resolution calls on the State Board to "take action to address racial Inequity . . . as part of the programs the Water Boards[] carry out for the communities we serve."[94] It "[c]ommits to making racial equity, diversity, inclusion, and environmental justice central" to the State Board's work, including ensuring that the outcomes the Board influences "are not determined by a person's race."[95] It "reaffirms" the State Board's "commitment to the protection of public health and beneficial uses of waterbodies in all communities, and particularly Black, Indigenous, and people of color communities disproportionately burdened by environmental pollution through . . . impaired surface waters and degraded aquifers."[96] And it "[r]eaffirms [the Board's] commitment to improving communication, working relationships, and co-management practices with all California Native American Tribes, including seeking input and consultation on the Water Boards' rules, regulations, policies, and programs to advance decisions and policies that better protect California's water resources."

VI. REQUEST FOR ACTION

A. The State Board Should Issue a Permanent Streamflow Regulation for the Scott River

The State Board has a duty under the public trust doctrine to protect fish populations in the

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[93] *Id.* at p 3. The Karuk Tribe does not concede, despite the wording of the Racial Equity Resolution, that it or any other Tribe has "lost" any water rights. Rather, the State and Federal governments continue to fail to recognize and/or quantify tribal rights, including rights to flows sufficient to sustain the abundant fisheries that have supported Tribal ways of life, that exist and have existed since time immemorial.

[94] *Id.* at p. 4.

[95] *Id.* at p. 7.

[96] *Ibid.*

Scott River. It has a duty to prevent waste and unreasonable use of water. It has stated that depriving Tribes of water and the ecosystems that depend on that water is the result of racial discrimination, displacement, and genocide perpetrated in part by the State of California and has committed to rectifying those wrongs. It has plenary legal authority to act. It has already determined that dewatering the Scott in drought years is unreasonable and requires action. There is no legal or factual reason why the State Board should permit the Scott to go dry during normal or wet years. It must act now.

The Scott River is in a precarious position. As long as the drought emergency persists and the State Board continues to readopt the emergency regulations, there will be a bare minimum flow requirement in place for the river. But the Governor could revoke the executive order declaring such an emergency at any time. Whether that occurs this year or in the future, the river will lose its flow protection. Because the river does not meet the CDFW flow criteria in normal and wet years, more precipitation could ironically bring worse outcomes than if the drought—and the emergency regulation—were to continue.[97] And this dynamic will continue: California routinely cycles through wet and dry years. The only constant is increasing water withdrawals and decreasing flows. A permanent flow regulation would replace ad hoc, emergency management with a sustainable, long-term approach that is protective of public trust values.

The unreasonableness of the harms to the Scott is highlighted by the flow records over the last half century. Before the 1970s, the Scott routinely experienced late summer flows in excess of the CDFW recommendations of 62 cfs September. In fact, flows dropped below the CDFW-recommended levels on only a few occasions, and rarely in other than dry or very dry years.[98]

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[97] With recent precipitation, it is highly unlikely that 2022-23 will be a "critically dry year" for the purposes of Water Code Section 1058.5, subdivision (a)(2). But the Scott suffers from low flows in normal and wet years as well. And while parts of California have seen extremely high precipitation this winter, the Scott basin has seen below-average to average precipitation for this date for the water year. (See data available at https://www.cnrfc.noaa.gov/?product=hucPrecipSeasonal&zoom=8&lat=41.484&lng=-122.402 (accessed May 18, 2023).)

[98] Before 1973, records show mean August below 60 cfs in 1947, 1949, 1955, 1959, 1964, and 1966. They show mean September flows below 60 cfs in 1944, 1945, 1947, 1950-51, 1955,

Indeed, before 1972, Scott flows *never* dropped below the drought minimum 30 cfs, and never did so for two years in a row until 1987. It was also in the 1980s that the Scott began to experience very low flows for the first time: flows dropped below 10 cfs for the first time in 1981; they have been at or below 10 cfs in six of the last ten years.

The last normal year where flows exceeded the drought minimum flows of 30 cfs in August or 33 cfs in September was 2010. The last wet year where flows exceeded these drought minimums was 2003.

But the drought minimum flows are appropriate only for drought years: they "are not intended to set the stage for long-term management considerations, nor should they be construed to provide adequate protections for salmonids over extended periods of time."[99] CDFW's flow criteria for years that are not drought emergences are 77 cfs in August and 62 cfs in September. The last year that the river met these numbers was the very wet year of 1998.

And the river is not just failing to meet flow targets—it routinely experiences flows low enough to result in significant disconnections. Since 1980, flows in dry years have dropped to near zero. And flows in normal and wet years have also regularly dropped below 22 cfs—the minimum level necessary to allow Coho access to the Scott Valley and its tributaries.[100]

The recent droughts have not explained the drop in flows—water use does.[101] Agricultural acreage, groundwater withdrawals, and intensity of cultivation have all increased simultaneously with the drop in flows.[102] But even if agricultural use does not further intensify, the climate is changing. And modeling suggests that a warmer climate could bring smaller snowpacks, more

1957, 1959, 1960, 1962, 1964, 1966-68, and 1970.

[99] CDFW Emergency Flow Letter, *supra*, at p. 1.

[100] CDFW Flow Memo, *supra*, at p. 17.

[101] Van Kirk & Naman, *supra*, 44 J. Am. Water Resources Assn. at 1042-46.

[102] Scott Valley GSP, *supra*, at pp. 89.

abrupt floods, and higher temperatures.[103] Thus, in order to prevent additional harm to salmonid populations, and pursuant to the Governor's Water Supply Strategy, the State Board must take proactive steps to address flows.[104]

In *ELF*, the Court of Appeal held that the State Board has a duty to protect public trust resources in the Scott from harm caused by groundwater extraction. (*ELF*, *supra*, 26 Cal.App.5th at 858.) The historical record detailed in this Petition demonstrates that until 2021, it had not done so. For decades, water extractions have increased year over year and the river has dwindled and salmon stocks have dropped. The decrease in flows directly harms the public's right to the Scott as a navigable river by allowing frequent stream disconnections. And the devastating effects on salmon are harms to public trust resources including "fisheries," "habitat for . . . marine life," and scenic and cultural value. (*National Audubon*, *supra*, 33 Cal.3d at 434-35.) For decades, the State Board took no action to analyze or halt these harms. But to its immense credit, the State Board finally enacted the emergency drought regulations in 2021. But the Board cannot rest on its laurels; it cannot now allow the river to return to the unregulated race to the bottom that previously existed.

And the Board should recognize what it did in enacting the Scott emergency regulations, the Mill and Deer emergency regulations in 2014-15, and the Russian River frost protection regulations: allowing unlimited water withdrawals that cause existential harm to fisheries is a waste and an unreasonable use of water. (See *Stanford Vina*, *supra*, 50 Cal.App.5th at 989; *Light*, *supra*, 226 Cal.App.4th at 1473-76.)

Further, the current declines in flows and the concomitant declines in salmon populations should offend the State Board's self-professed commitment to racial justice. The Scott River is an exemplar of the dynamic described in the Racial Equity Resolution: settlers divested Indigenous people of their lands and their historic use of the waters of their homeland.[105] And the State of

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[103] NMFS Recovery Plan, *supra*, at pp. 3-43 to 3-44.

[104] Water Supply Strategy, *supra*, at pp. 2, 14.

[105] See Racial Equity Resolution, *supra*, at p. 3.

California has permitted ongoing, increasing water extractions over the past 150 years with no permanent, binding streamflow protections in place.

As a direct result, the Karuk Tribe and other Tribes are experiencing severe impacts on their way of life. Salmon are crucial to the Tribe's religion and provide a vital source of food. In order to hold the annual Spring Salmon Ceremony each spring, the priest must catch and eat a Spring Chinook salmon. Without this sacrament, this ceremony is at risk. During annual World Renewal Ceremonies, dance owners are obligated to celebrate by serving fresh fall Chinook. Again, a loss of fish undermines these ceremonial and cultural practices. In order to vindicate the language of its recent Racial Equity Resolution, the State Board must act to restore flows and fisheries that were unjustly taken from the Tribe.

B. There Is No Legal Impediment to a Permanent Flow Regulation

To the extent that objections may exist to the State Board's authority and duty to adopt a permanent streamflow regulation for the Scott River, any such concerns are unfounded.

For example, enacting a flow regulation, emergency or otherwise, should not require read-judication of the river. In *Stanford Vina*, the Court of Appeal held that even judicially decreed water rights were "limited by the rule of reasonableness." (*Stanford Vina*, *supra*, 50 Cal.App.5th at 1007.) Thus, the existence of the Scott River adjudication is no obstacle to a flow regulation: the State Board has both the duty and the authority to regulate both surface and groundwater extractions to the extent that they prevent the river's reaching adequate flows.

And the State Board has the statutory and constitutional authority to act even if there is no drought emergency. Water Code section 174 gives the Water Board the power to "exercise the adjudicatory and regulatory functions of the state in the field of water resources." Section 186 gives the Board "any powers . . . that may be necessary or convenient for the exercise of its duties authorized by law." Section 1058 empowers it to "make such reasonable rules and regulations as it may from time to time deem advisable." And section 275 states that the Board "shall take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water in this state." The *Light* court held that these authorities gave the Board the power to issue the frost protection regulation on the Russian River. (*Light*, *supra*, 226 Cal.App.4th 1481-82.) Importantly, this regulation was not reliant on a drought proclamation, but was a permanent regulation issued in response to a recurring dewatering of the river. And it covered groundwater extractions. (Cal. Code Regs., tit. 23, § 862, subd. (a).)

Nor must the State Board be necessarily bound by the rule of priority in issuing any regulation. (*Stanford Vina*, *supra*, 50 Cal.App.5th at 1007.) In other words, should the Board find that curtailing water rights in an order other than the traditional rules is necessary to best protect public trust resources and avoid unreasonable use, it may do so. For instance, the Board could find that certain pumping locations or methods have outsized impacts on the river and should be curtailed before other, even more junior water rights. The Board may lawfully make such a finding.

In sum, the Board has a duty to act. And there is no legal impediment to acting and there is every reason to act now.

C. Any Regulation Should Improve Upon the Emergency Regulations

As discussed above, the emergency regulations have been a necessary first step towards protecting the Scott's flows. For the first time, they have set a binding minimum flow standard, enforced that standard through curtailments, and collected key information. Yet the implementation of that minimum flow standard has suffered from severe limitations.

The experience of the summer of 2022 is highly concerning for the effectiveness of the regulations as currently written. The Scott failed to achieve a level of flow anywhere near the required levels in the summer and fall of 2022—averaging less than 10 cfs from mid-July into the late fall. The parties to this petition are highly concerned that local cooperative solutions that cap groundwater pumping reductions at 30 percent are insufficient to maintain minimum flows. (See Cal. Code Regs., tit. 23, § 875, subd. (f)(4)(D).) Further, we have concerns that such local cooperative solutions do not contain sufficient monitoring and reporting requirements to show that the reductions are actually taking place. These agreements may also be approved without public notice and comment. While the State Board may have seen these measures as appropriate for an emergency regulation, we urge the Board to improve any local cooperative solution procedure in a permanent regulation to ensure that such solutions have sufficient effects on flows, are measurable and monitored, and that the public can play a role in developing them. While recognizing that an incentive for voluntary participation is valuable, a permanent regulation should have the flexibility to increase pumping restrictions above 30 percent if necessary to protect flows.

A second issue with the emergency regulations is that Board staff have waited to impose curtailments until flows have already dropped to near the minimum flow. While this approach can be successful in certain hydrological settings, we have concerns that a regulation for the Scott must be more proactive to protect flows in this highly interconnected system. Because late-summer flow in the Scott Valley is so closely tied to groundwater, it may be necessary to curtail groundwater extractions well before river flows drop in order to preserve connectivity between the river and groundwater.

We hope that a permanent regulation—and staff's implementation of that regulation—incorporates the best available modeling to ensure that groundwater levels stay sufficiently high during the summer to support sufficient flows. For example, due to historically low rainfall, it was likely foreseeable that flows would be very low in the summer of 2022 despite some late spring rains. But staff did not impose curtailments on any water users until July 2, 2022.[106] Despite curtailments, flows dropped below 10 cfs within weeks. The State Board should explore more proactive approaches using full-year precipitation data and modeling to project flows for the whole summer, not just the week ahead.

A permanent regulation should also not be restricted to drought or low-precipitation years. Flood flows are necessary to scour fine sediment from gravel, distribute beneficial large wood, and restore channel function, especially in less-degraded parts of the watershed.[107] And higher summer flows—above the 62 cfs recommended by CDFW in September—may be appropriate in

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[106] State Board, Addendum 32 to Order for Reported Water Rights in the Scott River Watershed Issued September 9, 2021, Order WR 2021-0083-DWR, and Order WR 2021-0084-DWR (July 1, 2022) (Curtailment Orders), available at https://www.waterboards.ca.gov/drought/scott_shasta_rivers/docs/2022/scott-addendum32.pdf (accessed March 3, 2023).

[107] NMFS Recovery Plan, *supra*, at pp. 3-19, 3-43.

high-precipitation years to allow fish populations to not just survive, but to recover.[108] A process to set a permanent flow regime should allow for fish to benefit from the abundance of wet years as well as simply preventing the worst-case scenarios in dry years.

D. Any Analysis of Economic Impact Should Favor Adoption of a Flow Regulation

Under Government Code section 11346.3, an economic impact analysis is required for a permanent regulation. Such an analysis should find in favor of a flow regulation.

First, any required economic impact analysis must find that the benefits of the regulation outweigh any factors to the contrary. Under section 11346.3, when the State Board proposes to adopt a regulation, it must consider, among its factors, benefits of the regulation to the "the state's environment." (Gov. Code § 11346.2, subds. (b)(1)(D) [nonmajor regulations], (c)(1)(F) [major regulations].) In enacting the California ESA, the Legislature declared that it is "the policy of the state to conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat" (Fish & G. Code § 2052), and as a result, "all state agencies, boards, and commissions shall seek to conserve endangered species and threatened species and shall utilize their authority in furtherance of the purposes" underlying the ESA (*id.* § 2055). As Coho are listed as threatened under the ESA—and as their population has declined significantly since that listing—it is a clear and significant benefit to the state to adopt a regulation that furthers the survival of this evolutionarily significant unit of the species.

Second, the State Board should consider the economic impact of a regulation in light of *National Audubon*'s direction that the State Board should protect public trust resources "whenever feasible." (*National Audubon*, *supra*, 33 Cal.3d at 446.) The standard for economic feasibility of a regulation is not whether there will be economic impacts. Regulations are not " 'infeasible' because they impose financial burdens on some businesses or consumers." (*California Manufacturers & Technology Assn. v. State Water Resources Control Bd.* (2021) 64 Cal.App.5th 266, 282; see

[108] *Id.* at pp. 3-27 to 3-28 (increased flows lead to better outcomes for Coho along a number of parameters: higher migration success, smolt size, survival rate, abundance, and growth rate).

id. at 282-83 [quoting *United Steelworkers of America, AFL-CIO-CLC v. Marshall* (D.C. Cir. 1980) 647 F.2d 1189, 1265 ("A standard is not infeasible simply because it is financially burdensome . . . , or even because it threatens the survival of some companies within an industry.")].) The State Board should find that any economic burdens a regulation imposes are justified in light of the existential risk to Coho and Chinook populations in the Scott.

An economic impact analysis should also take into account the benefits of a regulation that would allow for salmonid recovery. Tribes, including the Karuk, have relied on annual salmon runs for millennia. And while the cultural and religious importance of salmon transcends economics, the decline of populations has significant economic impacts as well. Karuk people—largely as a result of historic dispossession, discrimination, and disinvestment—experience unemployment rates over 16 percent and poverty rates over 40 percent.[109] Subsistence fishing is an important source of food for many Karuk people, people for whom the weekly cost of groceries is a significant economic burden. Restoring salmon populations in Karuk territory will thus have a significant positive impact on the economic life for Karuk people.

And the State Board must also consider the positive impacts on the California fishing industry. Once a billion-dollar industry, the California commercial salmon fishing fleet has been prohibited from fishing within the Klamath Management Zone (KMZ) for the past several years due to insufficient Klamath-origin salmon stocks. Restoring flows to the Scott is vital for allowing Klamath salmon populations to recover to the point that the State's once extremely valuable commercial salmon fishing industry can recover.[110] This is also true for California's economically important recreational salmon fishing industry, once also an important economic powerhouse for many coastal, San Francisco Delta and inland river communities, and a major draw for tourism in

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[109] Karuk Tribe, Comprehensive Economic Development Strategies 2021-2026 (2021), at pp. 11-13, available at https://www.karuk.us/images/Karuk_Tribe_CEDS_-_Public_Review_Draft_9_14_21.pdf (accessed January 28, 2023).

[110] For a recent measure of the value of commercial salmon fisheries to the State's economy see Southwick Associates, Report on the Economic Impacts of Salmon in the State of California (2012), available at https://ifrfish.org/wp-content/uploads/2023/01/Southwick-Report-CA-Salmon-Values-2012.pdf (accessed March 13, 2023).

much of the state. All of these major California economic sectors suffer greatly when the salmon runs they are built upon diminish and effectively disappear.

VII. CONCLUSION

For the reasons stated above, the State Board should act immediately to fulfill its duties under the waste and unreasonable use doctrine, the public trust doctrine, and its stated policy under the Racial Equity Resolution by adopting a permanent flow regulation on the Scott River.

The regulation should have the following features:

- Establish minimum flows based on CDFW's 2017 Flow Criteria, with consideration of higher minimums as hydrologically appropriate;
- Include mandatory monitoring and information reporting to demonstrate compliance and refine modeling;
- Include mandatory groundwater pumping limitations—both within and without the adjudicated zone—sufficient to preserve adequately high groundwater levels to maintain stream connection during the summer and fall;
- Maintain the Emergency Regulation's prohibition on inefficient livestock watering.

There is no time for further delay. The State Board must act.

Respectfully submitted,

Dated: May 23, 2023

ENVIRONMENTAL LAW FOUNDATION

By: Nathaniel Kane

Attorneys for Petitioners Karuk Tribe of California, Environmental Law Foundation, Pacific Coast Federation of Fishermen's Associations, and Institute for Fisheries Resources

Exhibit A

INTERIM INSTREAM FLOW CRITERIA FOR THE PROTECTION OF FISHERY RESOURCES IN THE SCOTT RIVER WATERSHED, SISKIYOU COUNTY

Prepared By

California Department of Fish and Wildlife

February 6, 2017

Table of Contents

Cover photo: Low flow barrier to upstream migrating Chinook Salmon in the Scott River Canyon November 20, 2015.

1. Introduction

This document describes the methods and results of an analysis using historical flow data and regional regression relationships to develop interim instream flow criteria suitable for anadromous fish in the Scott River watershed in Siskiyou County. The Scott River watershed provides aquatic habitat for four species of anadromous fish; Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), steelhead trout (*O. mykiss*), and Pacific Lamprey (*Lampetra tridentata*). Specifically, the Scott River is one of the most important Coho Salmon spawning and rearing tributaries in the Klamath River watershed.

Instream flow requirements can be generated from flow standard setting techniques or from the results of site specific studies. The interim instream flow criteria presented for the Scott River were developed using flow standard setting techniques. Stream flow standards derived from standard setting techniques are designed to identify the environmental resource in need of flow protection, identify biologically significant criterion that can be used to measure potential flow related impacts, and specify the amount of flow required to protect the resource. Most individual standards evaluate only one or more, but not all the criterion needed to fully evaluate the flow needs of an aquatic species. This limitation can lead to prescribing a single minimum threshold or “flat-line” affect (Poff et al. 1997). The seasonal and inter-annual variability in the hydrograph must be maintained to protect stream ecology and provide an ecosystem based standard (Annear 2004).

To account for the seasonal and the inter-annual hydrologic variability of the Scott River, the Department applied a detailed hydrologic analysis along with application of three standard setting methods to evaluate the life history flow needs of salmonids in the Scott River near Fort Jones. Adult fish passage was estimated using the equation developed by R2 Resources (R2 2008) for the State Water Resources Control Board’s (SWRCB) North Coast Instream Flow Policy (SWRCB 2014), spawning and juvenile rearing were evaluated using the Hatfield and Bruce regional equations (Hatfield and Bruce 2000), and the results were adjusted monthly based on estimates of unimpaired hydrology using Tessmann’s adaptation (Tessmann 1980) of the Tennant or Montana Method (Tennant 1975).

2. Background

Coho Salmon were listed as “threatened” in the Southern Oregon Northern California Coast (SONCC) Evolutionarily Significant Unit (ESU) under the federal Endangered Species Act (ESA) in 1997 (Federal Register 1997). In 2014, NOAA- Fisheries released the *Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon.* The highest priority Coho Salmon recovery actions identified for the Scott River watershed includes, “increase instream flows.” Specifically, the Coho Salmon recovery tasks identified in Table 1 below address the need to identify instream flow needs and implement a flow needs plan for the Scott River watershed. Low summer and fall streamflow is a major factor limiting survival of juvenile Coho Salmon (CDFG 2004).

Table 1. SONCC Coho Recovery Plan Tasks related to instream flow in the Scott River.

NOAA-Fisheries SONCC Coho Recovery Plan Task ID	Description
SONCC-ScoR.3.1.68.1	Conduct study to determine instream flow needs of coho salmon at all life stages
SONCC-ScoR.3.1.68.2	If coho salmon instream flow needs are not being met, develop plan to provide adequate flows. Plan may include water conservation incentives for landowners and re-assessment of water allocation.
SONCC-ScoR.3.1.68.3	Implement coho salmon instream flow needs plan.

Coho Salmon were also listed as “threatened” by the California Fish and Game Commission (Commission) for the area from Punta Gorda north to the California/Oregon border under the California Endangered Species Act (CESA) in 2005. In 2004, the Department of Fish and Wildlife (Department) published the *Recovery Strategy for California Coho Salmon* which identifies restoration activities necessary to protect and recover Coho Salmon populations to a sustainable level (CDFG 2004). Developing target instream flows for the Scott River was identified as a priority recovery task (Recovery Task WM-9) that needs to be implemented to improve Coho Salmon rearing habitat, fish passage, and stream connectivity.

Public Resources Code (PRC) 10000-10005 mandates the Department to identify instream flow needs for the long-term protection, maintenance and proper stewardship of fish and wildlife resources. The Scott River in Siskiyou County appears on the Department priority stream list for Instream Flow Assessments (CDFG 2008). The Department has participated in a comprehensive effort to develop study plans that would provide the scientific information needed for PRC recommendations for the protection of aquatic resources in the Scott River watershed

3. Scott River Watershed

The Scott River is located in Siskiyou County and is part of the Klamath Mountains Province (Figure 1). The Scott River is one of four major tributary streams to the Klamath River. The watershed drains an area of approximately of 812 square miles. The mainstem Scott River is approximately 58 river miles in length and begins at the confluence of the East Fork Scott River and South Fork Scott River. The lower 21 miles of the Scott River flows through a relatively steep mountainous canyon reach which is primarily owned and managed by the Klamath National Forest. Elevations in this reach range from approximately 1,538 ft. (469 m) at the mouth to 2,635 ft. (803 m) at river mile (RM) 21 near the United States Geological Survey (USGS) stream gage station USGS 11519500 SCOTT R NR FORT JONES CA (USGS 115195500). By contrast, the upper reach that flows through Scott Valley has low stream gradients. The upper reach begins at RM 58 near the town of Callahan and flows north to RM 21 near USGS 115195500. Elevations in this reach range from 2,635 ft. (803 m) at RM 21 to 3,140 ft. (958 m) at RM 58 near Callahan to the north. The headwater tributaries originate in the high mountain ranges of the Trinity Alps Wilderness Area, Russian Wilderness Area, and Marble Mountain Wilderness Areas located to the south and west of Scott Valley. The major tributary streams that contribute to the Scott River around Scott Valley include the East Fork

Scott River, South Fork Scott River, Sugar Creek, French Creek, Etna Creek, Kidder Creek, Shackleford Creek, Patterson Creek, and Moffett Creek.

The watershed has a Mediterranean type climate characterized by warm dry summers and cold wet winters. Rainfall is the primary source of precipitation along the lower elevations present on the valley floor and adjacent lower elevation hill slopes. Snowfall is predominant at higher elevations (>5,000 ft.) along the mountain ranges to the south and west side of Scott Valley. The mountains to the south and west of the valley capture most of the precipitation receiving about 60 to 80 inches of precipitation annually. The mountains along the east side of the valley lie within the rain shadow of higher elevation mountain ranges to the south and west, and only receive about 12 to 15 inches of precipitation annually.

There are two rainfall stations located within Scott Valley, Callahan and Fort Jones, which provide a long history of precipitation data dating back to 1943 and 1944, respectively. Annual rainfall amounts recorded at the Callahan station range from a low of 9.75 inches in 1977 to a high of 36.5 inches in 1958 and averages 20.8 inches. Annual rainfall amounts recorded at the Fort Jones station range from a low of 7.62 inches in 1955 to a high of 35.3 inches in 1958 and averages 21.5 inches.

Aquatic habitat for anadromous fish species within the Scott River basin has been altered by numerous human activities, affecting both instream conditions and adjacent riparian and upland slopes. Alterations to habitat and changes to the landscape include historic beaver trapping, road construction, agricultural practices, river channelization, dams and diversions, timber harvest, mining/dredging, gravel extraction, high severity fires, groundwater pumping, and rural residential development (NOAA-Fisheries 2014). These impacts, along with natural factors such as floods, erosive soil, and a warm and dry climate, have simplified, degraded, and fragmented anadromous fish migrating, spawning, and rearing habitat throughout the Scott River basin (NOAA-Fisheries 2014).

Water rights on the Scott River and its tributaries have been fully adjudicated in the Superior Court of Siskiyou County through three separate decrees, the Shackleford Creek Decree (No. 13775) in 1950, the French Creek Decree (No. 14478) in 1958, and the Scott River Decree (No. 30662) in 1980. The Scott River Decree (SWRCB 1980) describes the water allocations for the vast majority of the watershed. There is presently no watermaster service for this decree or the Shackleford Creek Decree.

A minimum baseflow of 30 cubic feet per second (cfs) during the summer months was allotted to the Klamath National Forest (USFS) for the “instream use for fish and wildlife” within the 1980 Scott River Decree. Additionally, USFS has a right to flow measured at USGS 115195500 for instream uses, but this right is junior to other first priority rights in the decree area. The minimum base flow of this junior right is an additional 32 cfs. USGS gage records at Fort Jones show summer discharge frequently falling below 30 cfs, and often falling below 10 cfs in critically dry water years. Flows failed to meet the USFS water right of 30 cfs in at least nine years since 1977 (QVIR 2011).

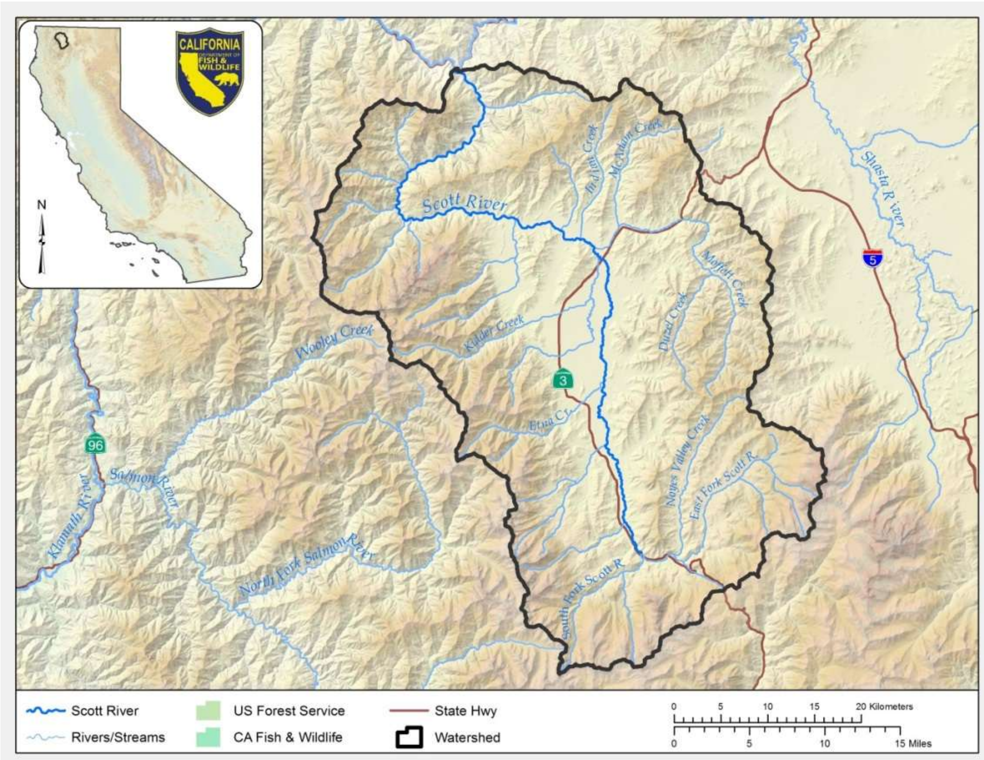


Figure 1. Scott River Watershed in Siskiyou County, California.

Van Kirk and Naman (2008) found that late summer baseflows in the Scott River were 40.3% lower in the recent past (1977 to 2005) than in the historic period (1942 to 1976). Sixty one percent of this drop in discharge is caused by factors other than regional-scale climate change (Van Kirk and Naman 2008). Currently, valley-wide agricultural water diversions, groundwater extraction, and drought have all combined to cause surface flow disconnection along the mainstem Scott River. Figures 2 and 3 illustrate the increase in the frequency of low flow conditions in the Scott River over time. These conditions restrict or eliminate available rearing habitat, elevate water temperature, decrease fitness and survival of over- summering juvenile salmonids, and sometimes result in juvenile fish strandings and mortality.

Agriculture and related activities are the major land use within the Scott Valley. Starting in 1953 there has been an increase in irrigation withdrawals in the Scott Valley of 115% (Van Kirk and Naman 2008). This increase in irrigation withdrawals was accompanied by an 89% increase in irrigated land area (Van Kirk and Naman 2008). Another important shift in the recent past was the change from flood to sprinkler irrigation, which increased efficiency and reduced groundwater recharge (Van Kirk and Naman 2008). Currently, a large proportion (80% or more) of water used for irrigation comes from ground water (Van Kirk and Naman 2008). During the summer, large portions of the mainstem Scott River become completely dry, leaving only a series of stagnant isolated pools inhospitable to salmonids (Figure 4).

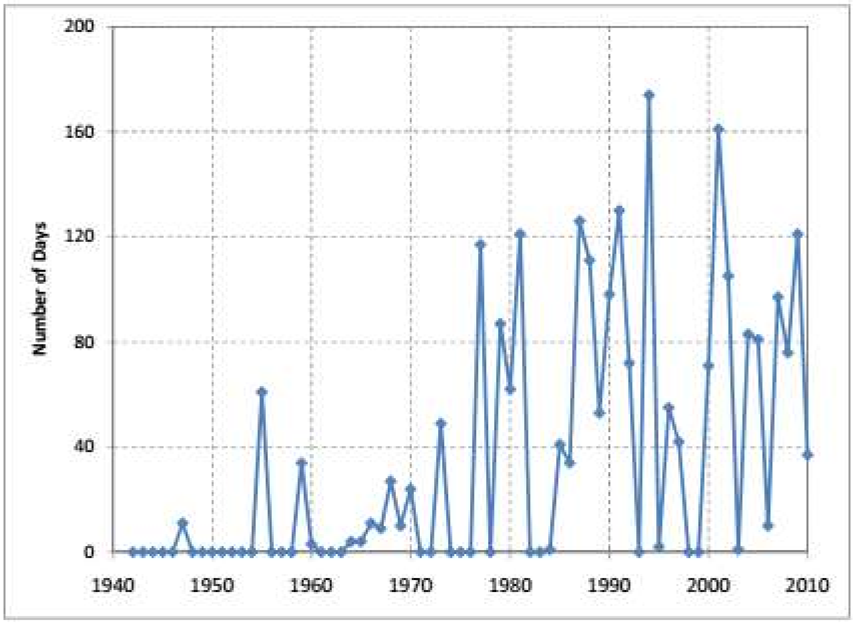


Figure 2. Number of days with flow at Fort Jones below 40 cfs (excerpted from: S.S. Papadopulos & Associates, Inc. 2012)

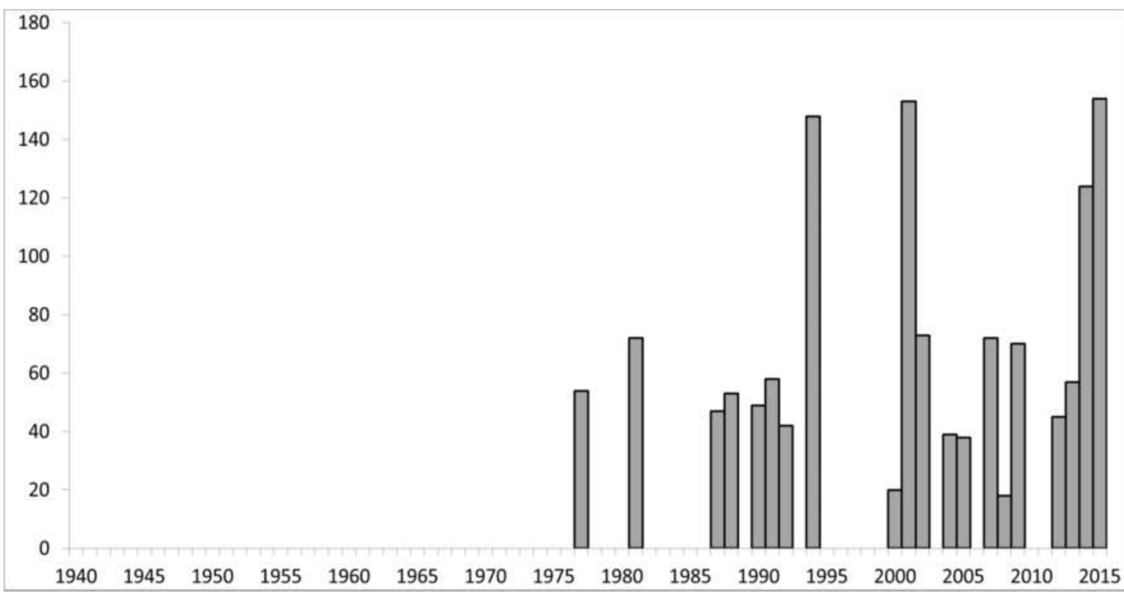


Figure 3. Continuous days of average daily flows less than 15 cfs on the Scott River at the Fort Jones gage (prepared by Steven Stenhouse 2016).

Figure 4. The Scott River at Horn Lane Bridge (photo taken on August 13, 2014 by Chris Adams).

4. Anadromous Fishery Resources

The Scott River provides habitat for four species of anadromous fish species; Chinook Salmon, Coho Salmon, steelhead trout, and Pacific Lamprey. The Department's Klamath River Project (KRP) has been monitoring the escapement of adult anadromous salmonids into the Klamath Basin, including the Scott River, since 1978. Although most of this monitoring effort is focused towards fall-run Chinook Salmon, information regarding Coho Salmon and steelhead trout is also collected as these fish are encountered (Knechtle and Chesney 2016). Unfortunately, high flows and lack of adequate funding has sometimes prevented the collection of complete run size data for either Coho Salmon or steelhead trout and little information exists for Pacific Lamprey.

In 1999, the Department began implementation of the Anadromous Fish Research and Monitoring Program the primary objective of which is to monitor status and trends of juvenile salmonid populations. The original focus for this program was directed towards steelhead trout however, the focus of the program was officially expanded to include the other anadromous salmonid species in 2003. Monitoring of juvenile salmonid emigration from the Scott River was first conducted in the spring of 2000 and has been conducted annually ever since. These two programs combined provide information regarding the relationship between adult returns and juvenile production which improve our understanding of population dynamics and environmental factors that may impact survival of these fish.

A. Chinook Salmon

<u>Status</u>

Chinook Salmon in the Scott River watershed are part of the federally-designated Upper Klamath and Trinity Rivers Chinook ESU, which includes all populations upstream of the confluence of these two rivers. Upper Klamath – Trinity River Chinook Salmon were proposed for federal listing in 1998, but listing was determined to be not warranted.

Life Cycle

The life history patterns of Chinook Salmon vary among runs. The Scott River currently supports only fall-run Chinook Salmon (NRC 2004). Adult Chinook Salmon typically enter the Scott River watershed between mid-September and late-December (Knechtle and Chesney 2016). Chinook Salmon tend to spawn in lower gradient reaches than Coho Salmon, primarily in rivers and larger streams. The timing and distribution of Chinook Salmon spawning within the Scott River watershed has been documented annually during cooperative spawning ground surveys since 1992 (Meneks 2015). Chinook Salmon primarily utilize the mainstem Scott River from its confluence with the Klamath River to approximately Fay Lane. However, Chinook Salmon have been documented in some years spawning in habitat above this point and in the lower portions of some major Scott River tributaries when access is available (M. Knechtle pers. comm.). Spawning distribution within the mainstem can be limited during periods of low flow. Sometimes adult Chinook Salmon are unable to swim upstream of the Scott Canyon reach due to a lack of streamflow. The majority of juvenile Chinook Salmon spend only a few months rearing in freshwater before outmigrating in the spring and early summer. A small proportion of the total juvenile Chinook Salmon production rears in the Scott River for a full year prior to emigrating as age 1 juveniles in late winter/early spring. Peak smolt outmigration from the Scott River typically occurs from April through June (Jetter and Chesney 2016).

Habitat Requirements

Although the life history patterns of Chinook Salmon differ from that of Coho Salmon, the overall habitat requirements of the two species are fairly similar. Like Coho Salmon, Chinook Salmon require adequate flows, cool temperatures, water depths and velocities, appropriate spawning and rearing substrates, and availability of instream cover and food.

Adult Chinook Salmon are particularly dependent on adequate streamflows in the fall, prior to the cessation of irrigation and the onset of significant precipitation, to enable successful migration to their spawning sites. In low flow years like 2015, most of the adult Chinook Salmon were unable to get upstream of the canyon reach during the spawning period. The majority of the observed redds were constructed in the canyon and were subject to a high flow event in March of 2016. The term “redds” refers to the nests that the female salmon digs in the gravel to deposit her eggs.

Water temperatures under 14 °C are optimal for adult Chinook Salmon migration and chronic exposure of migrating adults to temperatures between 17 °C and 20 °C can be lethal (National Research Council [NRC] 2004). Most juvenile Chinook Salmon leave freshwater habitat in the spring and are therefore not as susceptible to the high water temperatures and low streamflows that are common in the Scott River watershed during summer and early fall (Jetter and Chesney 2016). The optimal rearing water temperature range for juvenile Chinook Salmon is approximately 7.2 °C to14.5 °C (Carter 2005).

Population Trends

Prior to the 1950s, there are no estimates of Chinook Salmon populations available for the Scott River watershed. In the mid-1960s, fall-run Chinook Salmon run sizes in the Scott River were estimated at approximately 10,000 fish (CDFG 1965). Fall-run Chinook Salmon escapement estimates for the Scott River watershed have been made annually since 1978 (Figure 3). Since 1978, the Chinook Salmon run in the Scott River has ranged from 14,477 fish (1995) to 497 fish (2004) and has averaged 5,413 fish (Knechtle and Chesney 2016).

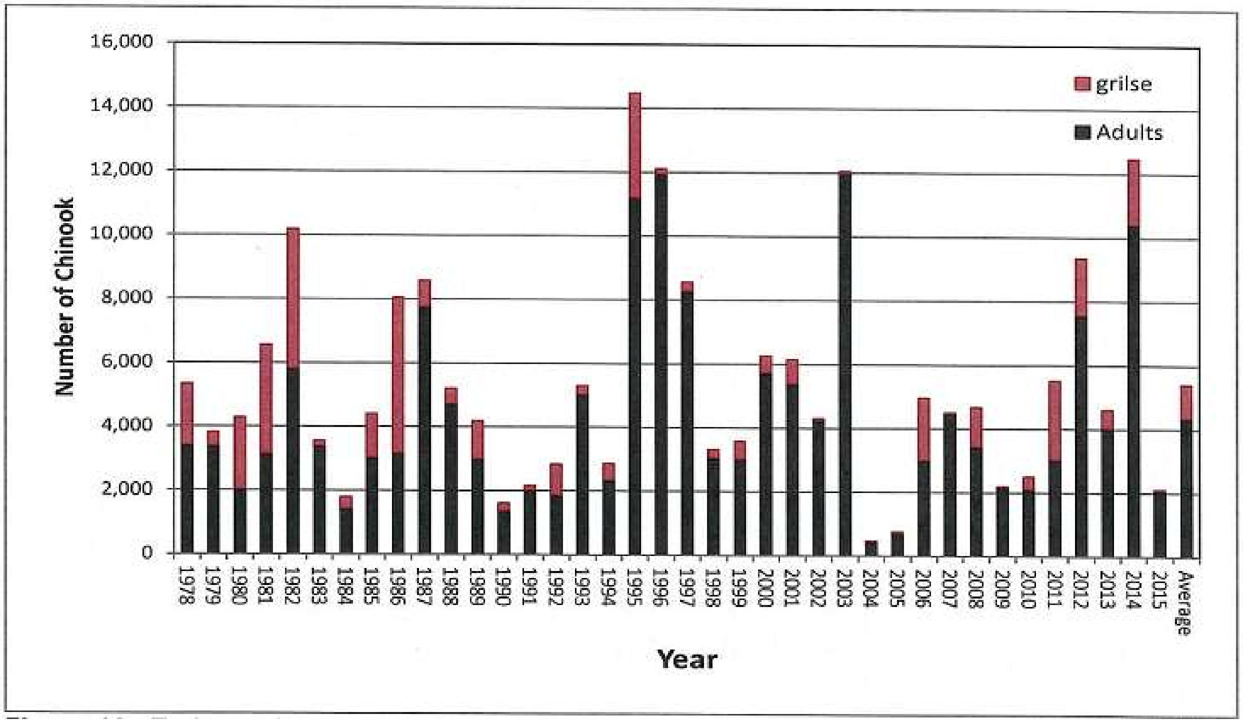


Figure 3. Estimated escapement of Fall-Run Chinook Salmon returning to the Scott River from 1978-2015.

B. Coho Salmon

Status

Coho Salmon in the Klamath River watershed are part of the federally-designated SONCC ESU, which includes all Coho Salmon stocks between Cape Blanco in southern Oregon and Punta Gorda in northern California.

Based on its review of the status of Coho Salmon north of San Francisco, the Department concluded that California Coho Salmon have experienced a significant decline (CDFG 2002). The Department also concluded that Coho Salmon populations have been individually and cumulatively depleted or extirpated and that the natural linkages between individual populations have been fragmented or severed. For the California portion of the Coho Salmon SONCC ESU, an analysis of presence-by-brood-year data indicated that Coho Salmon occupied about 61% of the streams that were previously identified by others (e.g., Brown and Moyle 1991) as historical Coho Salmon streams (i.e., any stream for which published records of Coho Salmon presence could be found). Based on this information, the Department concluded that Coho Salmon populations in the California portion of the SONCC ESU are threatened and will likely become endangered in the foreseeable future in the absence of special protection and management efforts required by CESA. In response to these findings, the Commission adopted amendments to § 670.5 in title 14 of the California Code of Regulations on August 5, 2004, adding California Coho Salmon populations between Punta Gorda and the northern border of California to the list of threatened species under CESA, effective as of March 30, 2005. The Commission adopted the *Recovery Strategy for California Coho Salmon* (CDFG 2004) the previous year.

The NOAA-Fisheries conducted a similar status review of the SONCC Coho Salmon populations in 1995 (Weitkamp et al. 1995). They arrived at similar conclusions as the

Department regarding the likelihood that Coho Salmon in this ESU may become endangered in the foreseeable future if observed declines continue. NOAA-Fisheries listed the ESU as threatened under ESA on May 6, 1997, and designated critical habitat[1] for the ESU on May 5, 1999. The critical habitat designation encompasses accessible reaches of all streams and rivers within the range of SONCC Coho Salmon, including the Scott River. NOAA-Fisheries published the *Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionary Significant Unit of Coho Salmon* in 2014.

Life Cycle

Adult Coho Salmon enter freshwater from the ocean in the fall in order to spawn. In the Klamath River watershed, Coho Salmon begin entering in early to mid-September and the migration reaches a peak in late September to early October. Arrival in the upper tributaries such as the Scott River generally peaks in November and December. The majority of the Coho Salmon spawning activity in this area occurs mainly during these two months.

The Department has been operating a video fish counting station on the Scott River at RM 19.8 since 2007. In addition, joint interagency and volunteer spawner surveys have been conducted on the Scott River and tributaries since 2001. During the 2007 season, Coho Salmon redds were observed in Scott River canyon, east and south forks, Scott River tailings and the following tributaries: Etna, French, Miners, Kelsey, Kidder, Mill, Patterson, Shackleford and Sugar Creeks (Walsh 2008). Data shows a correlation between increased flows and Coho Salmon moving through the counting station (Knechtle pers comm).

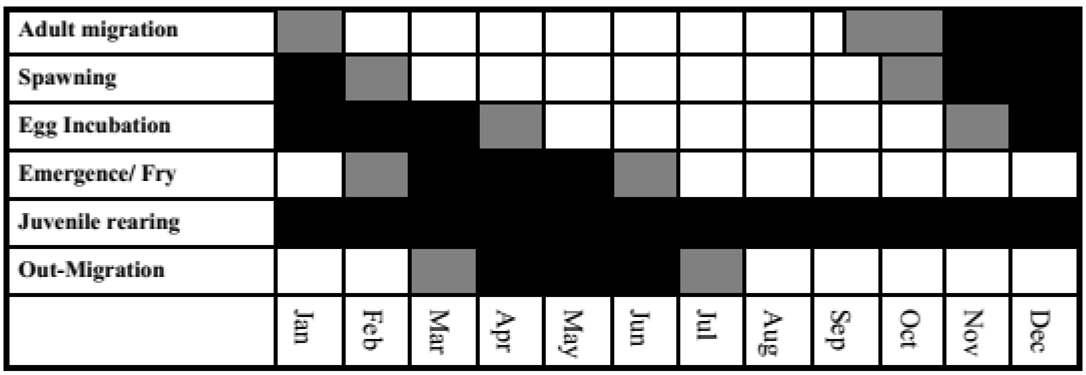
Females usually choose spawning sites near the head of a riffle, just below a pool, where the water changes from a smooth to a turbulent flow. Spawning sites are often located in areas with overhanging vegetation. Medium to small-sized gravel is essential for successful Coho Salmon spawning. After fertilization, the eggs are buried by the female digging another redd just upstream, which carries streambed materials a short distance downstream to the previous redd. The flow characteristics of the redd location usually ensure good aeration of eggs and embryos, and the flushing of waste products.

In California, Coho Salmon eggs generally incubate in the gravels from November through April. However, stream temperatures affect the timing of fry emergence and in the Scott River and its tributaries, incubation may extend into May. After hatching, the hatchlings, called “alevins,” remain within the gravel bed for two to 10 weeks before they emerge as fry into the actively flowing channel between February and June. The fry seek out shallow, low velocity water, usually moving to the stream margins, where they form schools. As the fish feed heavily and grow, the schools generally break up and individual fish set up territories. At this stage, the juvenile fish are called “parr”. As the parr continue to grow and expand their territories, they move progressively into deeper cooler water until July and August, when they inhabit the deepest pools. Rearing areas used by juvenile Coho Salmon include low-gradient coastal streams, lakes, sloughs, side channels, estuaries, low-gradient tributaries to large rivers, beaver ponds, and large slackwaters. The most productive juvenile habitats are found in smaller streams with low-gradient alluvial channels, containing abundant pools formed by large woody debris (LWD) such as fallen trees.

[1] The Endangered Species Act requires the federal government to designate “critical habitat” for any species it lists under the Act. “Critical habitat” is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

Juvenile Coho Salmon typically rear in freshwater for an entire year before ocean entry (Table 2). This necessitates appropriate habitat conditions for juvenile Coho Salmon in streams through the summer and winter months. Flows throughout Scott River watershed are reduced dramatically during the summer months due to surface water diversions, ground water pumping, drought conditions and climate change. These conditions typically result in salmonids being trapped in isolated pools. Fish relocation efforts have been conducted by the Department for decades, moving salmonids from their natal streams prior to dewatering. Inland winter streamflows are characterized by periods of cold low flows interspersed with freshets and possibly floods. Juvenile Coho Salmon require areas of velocity refuge during periods of high flows. Potential habitats offering velocity refuge during winter include off-channel habitats and beaver ponds.

Table 2. Generalized life stage periodicity of Coho Salmon in California watersheds. Gray shading represents months when the life stage is present, black shading indicates months of peak occurrence. (excerpted from CDFG 2002)



After spending one year in fresh water, the majority of the juvenile Coho Salmon hatched during the previous spring begin migrating downstream to the ocean in late March/early April through June. Juvenile salmonids migrating toward the ocean are called “smolts.” Upon entry into the ocean, the immature salmon remain in inshore waters, congregating in schools as they move north along the continental shelf. After 18 months of growing and sexually maturing in the ocean, Coho Salmon return to their natal streams as three-year-olds to begin the life cycle again.

This three-year cycle is fairly rigid among Coho Salmon as they rarely spend less than two years in the ocean.[2] Since all wild female Coho Salmon are typically three years old when spawning, there are three distinct and separate maternal brood year lineages for each stream. For example, almost all Coho Salmon produced in 2015 were progeny of females produced three years earlier in 2012, which in turn were progeny of females produced three years earlier in 2009, and so on (Table 3).

[2] Some Coho Salmon return to spawn after spending only 6 months in the ocean. These fish are referred to as grilse or jacks.

Table 3. Coho Salmon brood year lineages

Brood Year Lineage I	2006	2009	2012	2015
Brood Year Lineage II	2005	2008	2011	2014
Brood Year Lineage III	2004	2007	2010	2013

Loss of one of the three Coho Salmon brood years in a stream is referred to as brood-year extinction or cohort failure. Brood year extinction may occur for reasons including, inability of adults to return to their place of origin, productivity failure, or high mortality (CDFG 2004). This life cycle is a major reason for Coho Salmon's greater vulnerability to catastrophic events compared to other salmonids. Should a major event, such as El Niño floods or anthropogenic disturbance severely deplete Coho Salmon stocks during one year, the effects will be noticed three years later when few or no surviving female Coho Salmon return to continue the brood year lineage.

Habitat Requirements

Suitable aquatic habitat conditions are essential for migrating, spawning, and rearing Coho Salmon. Important components of productive freshwater habitat for Coho Salmon include a healthy riparian corridor, presence of LWD in the channel, appropriate substrate type and size, a relatively unimpaired hydrologic regime, low summer water temperatures, and relatively high dissolved oxygen concentrations. The importance of these habitat parameters is further described below, based on a summary provided in the Department's Recovery Strategy (2004).

Riparian vegetation provides many essential benefits to stream conditions and habitat. It serves as a buffer from sediment and pollution, influences the geomorphology and streamflow, and provides streambank stability. The riparian buffer is vital to moderating water temperatures that influence spawning and rearing by providing the canopy, which protects the water from direct solar heating, and the buffer, which provides a cooler microclimate and lower ambient temperatures near the stream. The riparian canopy also serves as cover from predators, and supplies both insect prey and organic nutrients to streams, and is a source for LWD.

LWD within the stream channel is an essential component of Coho Salmon habitat with several ecological functions. It stabilizes substrate, provides cover from predators and shelter from high water velocities, aids in pool and spawning bed establishment and maintenance, and provides habitat for aquatic invertebrate prey.

The channel substrate type and size, and the quantity and distribution of sediment, have essential direct and indirect functions at several life stages of Coho Salmon. Adults require gravel of appropriate size and shape for spawning (building redds and laying/fertilizing the eggs). Eggs develop and hatch within the substrate, and alevins remain there for some time for protection and shelter. An excess of fine sediment such as sandy and/or silty materials is a significant threat to eggs and fry because it can reduce the interstitial flow necessary to regulate water temperature and dissolved oxygen, remove excreted waste, and provide food for fry. Fine sediments may also envelop and suffocate eggs and fry, and reduce available fry habitat. The substrate also functions as habitat for rearing juveniles by providing shelter from faster flowing water and protection from predators. Furthermore, some invertebrate prey inhabit the benthic environment of the stream substrate.

The characteristics of the water and geomorphology of the stream channel are fundamentally essential to all Coho Salmon life stages. Important characteristics include water velocity, flow volume, water depths, and the seasonal changes and dynamics of each of these (e.g., summer flow, peak flow, and winter freshets). Appropriate water temperature regimes, in particular, are critical throughout the freshwater phases of the Coho Salmon life cycle. Water temperature affects the rate and success of egg development, fry maturation, juvenile growth, distribution, and survival, smoltification, initiation of adult migration, and survival and success of spawning adults. Water temperature is influenced by many factors including streamflow, riparian vegetation, channel morphology, hydrology, soil-geomorphology interaction, solar radiation, climate, and impacts of human activities. The heat energy contained within the water and the ecological paths through which heat enters and leaves the water are dynamic and complex.

The optimal water temperature range for juvenile Coho Salmon is 10 °C to15.5 °C (Stenhouse et al. 2012). When water temperatures exceed 20.3 °C they become detrimental (Stenhouse et al. 2012). Juveniles exposed to temperatures in excess of 25 °C experience high mortality rates (Sandercock 1991). However, duration of exposure is an important factor regarding the effects of water temperature on salmonids. Additionally, environmental conditions in specific watersheds may affect the normal range and extreme end-points for any of these temperature conditions for Coho Salmon. The water temperature requirements for Coho Salmon are dependent on their metabolism, health, and food supply. These factors also need to be considered together when trying to understand the habitat needs of Coho Salmon in a particular watershed or river system.

An adequate level of dissolved oxygen is necessary for each life stage of Coho Salmon and is affected by water temperature, instream primary productivity, and streamflow. Fine sediment concentrations in gravel beds can also affect dissolved oxygen levels, impacting eggs and fry. Dissolved oxygen levels in streams and rivers are typically lowest during the summer and early fall, when water temperatures are higher and streamflows lower than during the rest of the year. Dissolved oxygen concentrations of eight mg/L or higher are typically considered ideal for rearing salmonids including Coho Salmon. Rearing juveniles may be able to survive when concentrations are relatively low (e.g., less than five mg/L), but growth, metabolism, and swimming performance are adversely affected (Bjornn and Reiser 1991).

C. Steelhead/Rainbow Trout

Status

Steelhead within the Scott River basin are part of the federally-designated Klamath Mountains Province Distinct Population Segment (DPS). Listing of this DPS under ESA was determined not to be warranted by NOAA- Fisheries on April 4, 2001. Summer-run steelhead within this DPS are a Department recognized species of special concern.

Life Cycle

Steelhead exhibit one of the most complex life histories of any salmonid species. The resident rainbow trout form spends its entire life in freshwater environments, while the anadromous steelhead form migrates between its natal streams and the ocean. Furthermore, two reproductive forms of steelhead are recognized, the summer-run (stream-maturing) and winter-run (ocean-maturing), which describes the level of sexual development following return to the freshwater environment. Some researchers further divide the winter steelhead into early (fall-run) and late (winter-run) (e.g., Hardy and Addley 2001), but the two forms have similar life histories (NRC 2004) and are treated together here as winter-run steelhead. In addition, the Klamath River Basin is distinctive in that it is one of the few basins producing ‘‘half-pounder’’ steelhead. This life history type refers to immature steelhead that return to fresh water after only two to four months in the ocean, generally over-winter in fresh water, then outmigrate again the following spring (Federal Register 2001).

Unlike salmon, steelhead are iteroparous, meaning they can spawn more than once before they die. In California, females commonly spawn twice before they die. Adult winter-run steelhead typically enter the Klamath River from late August to February before spawning, which extends from January through April, peaking in February and March (NRC 2004). Summer-run steelhead enter freshwater as immature fish from May to July, migrate upstream to the cool waters of larger tributaries, and hold in deep pools roughly until December, when they spawn (NRC 2004). Juvenile steelhead rear in freshwater for one to three years (mostly two) before migrating downstream toward the ocean in spring, primarily during the months of March through May. They then typically reside in marine waters one to three years prior to returning to their natal stream to spawn as three- or four-year olds.

<u>Habitat Requirements</u>

The overall habitat requirements of the various salmonid species are fairly similar. Like Coho Salmon, steelhead require adequate flows, temperatures, water depths and velocities, appropriate spawning and rearing substrates, and availability of instream cover and food. The importance of these habitat parameters are described above for Coho Salmon.

Notable differences in habitat preferences include the fact that while juvenile Coho Salmon prefer pools with low average velocities and are not as common in riffles with high current velocities, juvenile steelhead tend to occupy riffles, as well as deep pools with relatively high velocities along the center of the channel (Bisson et al. 1988). Similar to spring-run Chinook Salmon, adult holding areas are of particular importance to summer-run steelhead who must reside in the freshwater streams and rivers throughout the summer. The thermal tolerance of steelhead is generally higher than that of most other salmonids. Preferred temperatures in the field are usually 15 °C to 18 °C (59-64 °F), but juveniles regularly persist in water where daytime temperatures reach 26 °C to 27 °C (79-81 °F) (Moyle 2002). Long-term exposure to temperatures continuously above 24 °C, however, is usually lethal (NRC 2004; Moyle 2002).

5. Scott River Flows

The primary source of instream flow information for the Scott River is provided by the operation of USGS gage 11519500 located downstream of the town of Fort Jones at the northern end of Scott Valley (RM 21). Additional USGS flow data is available for a few of the tributary streams located around Scott Valley. However, the period of record for most of these gages are generally limited to only a few years (Table 4). USGS 11519500 is the only gage within the watershed that provides a continuous historical record of flows dating back to October 1, 1941. The data from USGS 11519500 was used to estimate instream flow criteria using standard setting techniques. The applicability of the criteria is limited to monitoring and compliance of flow levels at USGS 11519500.

Table 4. Stream gaging stations in the study area.

River and Tributary	Data Source (Period of Record)	Complete Water Years Recorded
Mainstem		
Scott River	USGS #11519500 (1942-present)	73+
West Side Tributaries		
South Fork Scott River	USGS #11518200 (1959-1960)	2
Sugar Creek	USGS #11518300 (1958-1960)	3
Cedar Gulch (Nr Callahan)	USGS #11518310 (1967-1973)	7
French Creek	DWR Data Library (2005-2007)	3
Kidder Creek	Siskyou RCD Flow Data (2009-2005, 2007)	4
Shackleford Creek (Nr Mugginsville)	USGS #11519000 (1957-1960)	4
East Side Tributaries		
East Fork Scott River	USGS #11518050 (1960-1974)	15
Moffett Creek (Nr Fort Jones)	USGS #11518600 (1959-1967)	9
East Fork Scott River (Nr Callahan)	USGS #11518000 (1911)	1
East Fork Scott River (Ab Kangaroo)	USGS #11517950 (1971-1972)	2
East Fork Scott River (Bl Houston)	USGS #11517900 (1971-1972)	2

Typical of streams located along the interior of California, flows in the Scott River are characterized by a snowmelt driven hydrologic pattern with fairly consistent high flows occurring in the spring (Figure 4). Occasional flood flows occur during the winter months as a result of heavy rainfall or rain on snow events. The average annual discharge is 455,994 acre-feet (AF) and the mean annual daily discharge is 631 cfs. The driest water year (WY) on record occurred during the 1977 WY when the total annual discharge was only 54,106 AF. The wettest year on record occurred during the 1974 WY when the total annual discharge was 1,081,013 AF. It is important to note that even though USGS 11519500 has a fairly long period of record, the entire record represents an impaired state to varying degrees due to the long history of agricultural diversions that exist within the basin. Given the lack of diversion data through time it is extremely difficult to develop a reasonable description of unimpaired flow conditions for the historic flow data available at the USGS gage, let alone for each of the tributary streams.

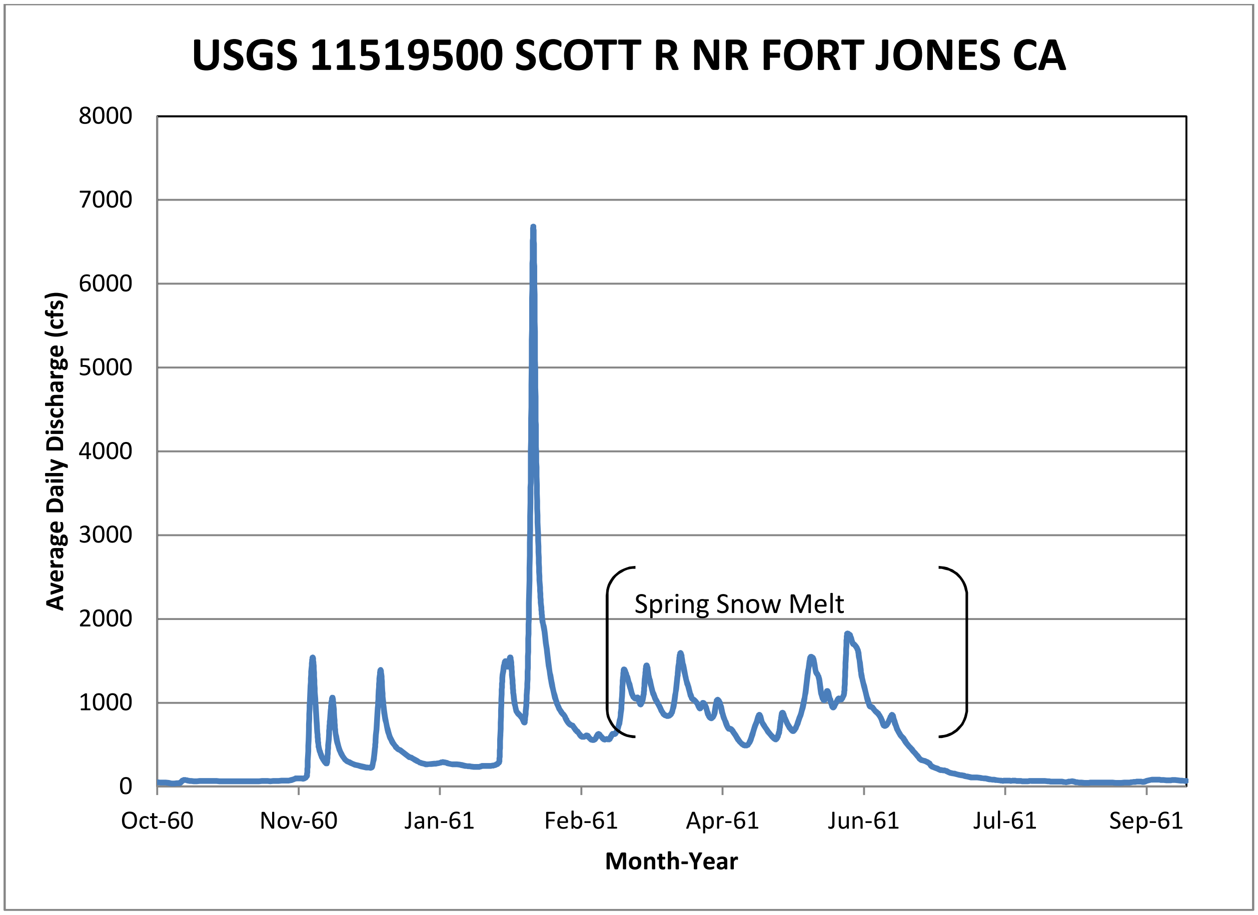


Figure 4. Typical annual hydrograph for the Scott River depicting the influence of large winter storms, spring snow melt, and summer base flows. The data displayed are for the 1961 WY as recorded at USGS 11519500.

Unimpaired flow levels occurring at the north end of the valley were estimated by considering only the first 30 water years of average daily discharges recorded at USGS 11519500, from October 1st, 1942 through September 30th, 1971. Based on historical use information, agricultural demand increased markedly in the 1950's. The period of record used to estimate unimpaired flows represents a period when water supply was changing and is not a completely accurate estimate of unimpaired flows. Due to trends in climate change, estimating current unimpaired flow levels using data from the mid-twentieth century is also flawed. The hydrologic record used represents the best available estimate of unimpaired flows. The total annual flow during this shortened period was 482,162 AF and the mean annual discharge was 666 cfs. The driest WY during this shortened period was the 1955 WY when the total annual flow was only 158,549 AF. The wettest year during this shortened period occurred during the 1958 WY when the total annual flow was 944,053 AF. The instream flow characteristics of the Scott River were described using annual flow duration curve analysis. Two curves were developed: 1) for the entire period of record and 2) for the estimated unimpaired period expressed in terms of probability of exceedance (Figure 5). The discharge level for each percent exceedance increment is provided in Table 5.

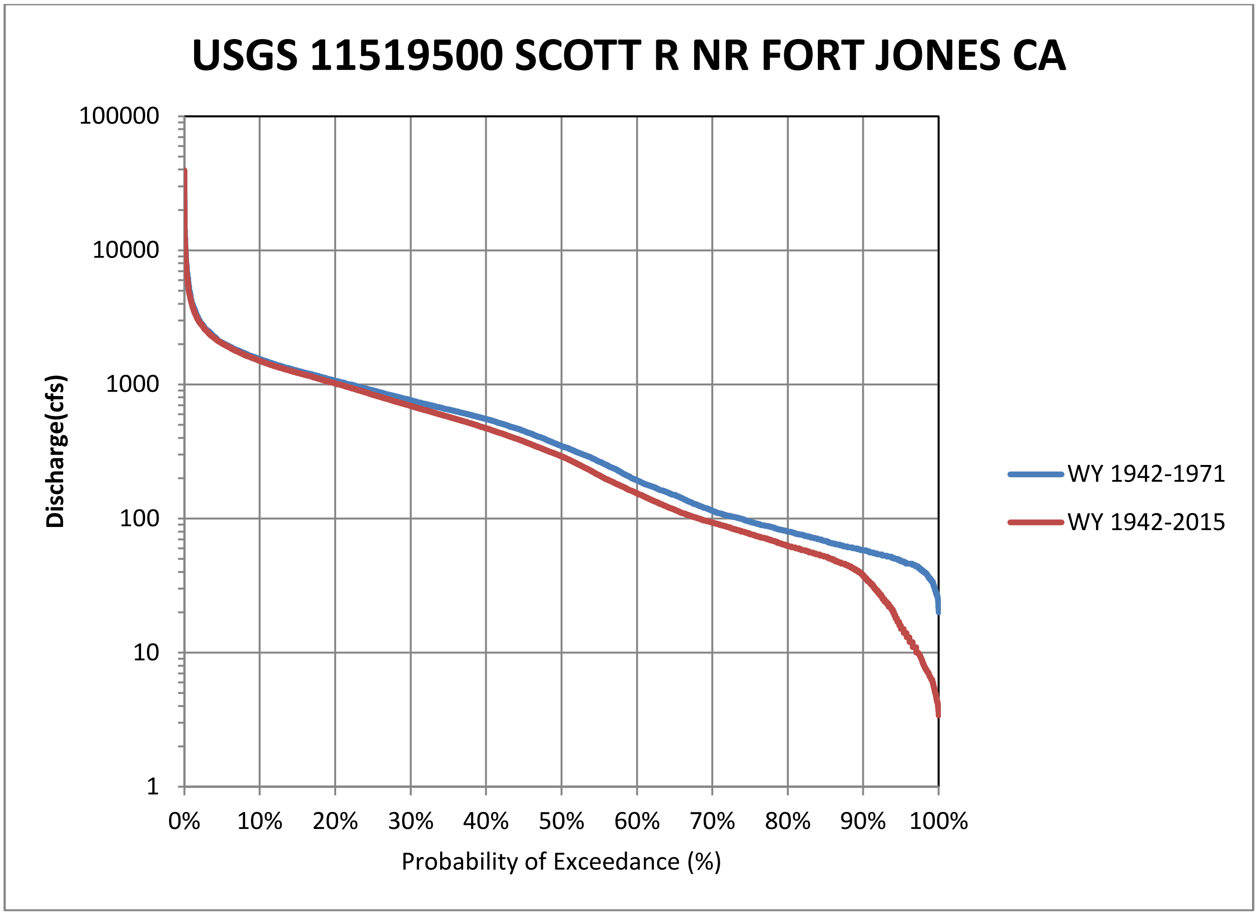


Figure 5. Annual flow duration curves developed for the Scott River (Scott Valley HSA) from USGS 11519500 for WYs 1942 through 2015 (red) and WYs 1942 through 1971 (blue). Water years 1942 through 1971 are assumed to represent an unimpaired condition.

Table 5. Exceedance probability variance between the estimated unimpaired portion of the record (1942-1971) and the full period of record (1942-2015) based on USGS 11519500.

Exceedance Probability	Discharge (cfs)		
	WY 1942 - 1971	Numeric Difference/ Percent Difference	WY 1942 - 2015
90%	58	20 / 66%	38
80%	80	17 / 79%	63
70%	114	21 / 82%	93
60%	192	38 / 80%	154
50%	347	56 / 84%	291
40%	553	82 / 85%	471
30%	763	71 / 91%	692
20%	1070	50 / 95%	1020
10%	1540	40 / 97%	1500

Table 5 illustrates that flows with a higher probability of exceedance from the full period of record were generally found to be lower in magnitude than those from the unimpaired portion, while less likely flow levels were of similar magnitude. The study objectives focus on summer low flow conditions for fishery resources. The use of unimpaired hydrology is necessary to understand the likelihood of flow levels that have historically supported instream resources.

A. Estimated Unimpaired Water Year Types

Water year type classifications were determined from mean annual discharge (MAD) of the unimpaired flow record and segregated by exceedance percentage (Table 6). Classifications were limited to three types due to the shortened period of record, wet (exceedance probability less than 30%), normal (exceedance probability between 30% and 70%), and dry (exceedance probability greater than 70%). The break out years into class types is shown in Figure 6.

Table 6. Exceedance probability and water year type based on water years 1942 through 1971.

Water Year	MAD (cfs)	Exceedance Probability	Water Year Type
1958	1304	3.23%	Wet
1956	1253	6.45%	Wet
1971	1085	9.68%	Wet
1965	1078	12.90%	Wet
1952	1019	16.13%	Wet
1953	955	19.35%	Wet
1951	925	22.58%	Wet
1963	910	25.81%	Wet
1970	863	29.03%	Wet
1943	831	32.26%	Normal
1954	800	35.48%	Normal
1969	785	38.71%	Normal
1942	708	41.94%	Normal
1967	651	45.16%	Normal
1946	632	48.39%	Normal
1957	581	51.61%	Normal
1961	529	54.84%	Normal
1948	488	58.06%	Normal
1966	477	61.29%	Normal
1950	474	64.52%	Normal
1968	446	67.74%	Normal
1964	435	70.97%	Dry
1945	405	74.19%	Dry
1949	399	77.42%	Dry
1962	399	80.65%	Dry
1959	396	83.87%	Dry
1960	389	87.10%	Dry
1947	302	90.32%	Dry
1944	233	93.55%	Dry
1955	219	96.77%	Dry

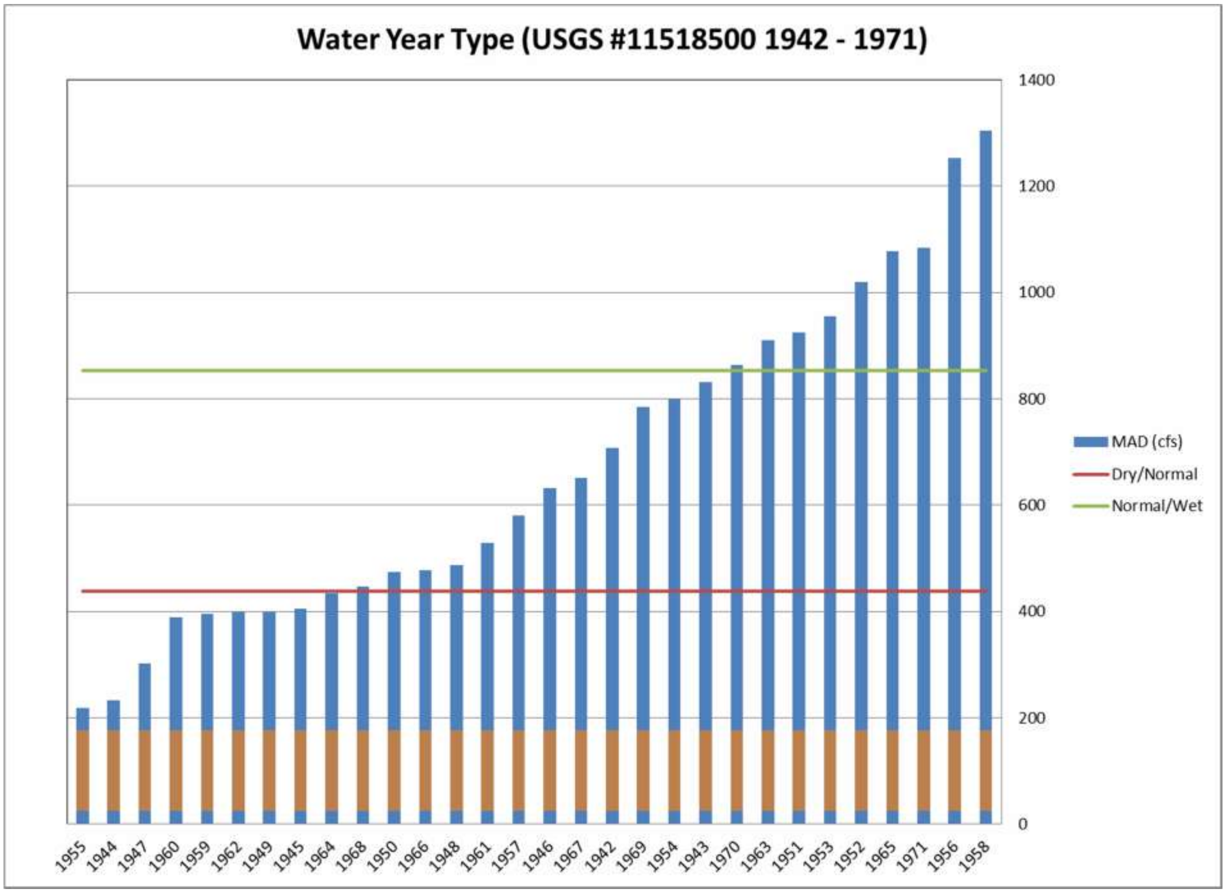


Figure 6. Water year typing for Scott River unimpaired flow near Fort Jones.

B. Stream Assessment Methods

Instream flow assessments fall under three broad categories 1) standard setting hydrology based “desktop” methods that typically do not involved field data collection, 2) single flow monitoring level field surveys, and 3) field data based instream flow studies that develop predictive models that simulate habitat conditions over a range of flows and indicate incremental benefits to resources with changing conditions (Annear et al. 2004). The three categories represent increasing levels of effort, but are also geared towards answering different questions needed to evaluate stream health. For example, incremental studies are designed to answer site and species specific questions by estimating habitat/flow relationships, but not necessarily to provide a flow prescription to protect overall riverine health.

The Department recognizes that interim flow prescriptions are needed for the Scott River while developing and implementing a series of more detailed instream flow study plans. For interim flow determinations, the Department supports the use of the following “desktop” methods, which were developed to support the passage and physical habitat requirements of Pacific salmonids. The main limitation of “desktop” methods is they often prescribe a single minimum flow threshold and do not provide the variable flow regime important for stream health. To avoid the pitfall of prescribing a single minimum threshold, three different standard setting methods were applied to the Scott River using the long term hydrologic time series recorded at USGS 11519500. Each method was selected to identify flow needs for priority stream functions as follows:

- Q_{fp} fish passage equation (R2 2008);
- Hatfield & Bruce (2000) for spawning and rearing; and
- Tessmann's adaption of the Tennant Method for basin wide hydrology (1980).

The results were combined below depending upon fish species life stage periodicity to develop an annual flow prescription in half month increments.

Interim flows that support fish passage can be developed by applying the Q_{fp} formula contained in Appendix E of R2 Resources (2008), which was prepared to support the North Coast Instream Flow Policy (SWRCB 2014). The Q_{fp} regression formula uses watershed area, mean annual discharge, and minimum passage depth to estimate an appropriate passage flow. This formula was developed using data from Idaho (R2 2004), Deitch (2006) and 22 cross sections collected in 13 streams in Mendocino, Sonoma, Napa, and Marin counties. The authors note "The relation appears to be descriptive of streams over a region broader than the Policy area, and is generally consistent across passage depth requirements."

The Q_{fp} formula is: $Q_{fp} = 19.3 * Q_m * D_{min}^{2.1} * DA^{-0.72}$

Where Q_{fp} = the minimum fish passage flow (cfs), Q_m = mean annual flow (cfs), D_{min} = minimum passage depth criterion (feet), and DA = drainage area (mi^2). As reported above, the mean annual discharge was 666 cfs for the less-developed period of water year 1942 through water year 1971. The D_{min} for Chinook Salmon and Coho Salmon and for steelhead trout was selected from the values of CDFG (2012) as noted in Table 7 below:

Table 7. Minimum depths required for passage.

Species	Minimum Passage Depth (ft)
Chinook Salmon (adult)	0.9
Steelhead (adult) Coho Salmon	0.7

Interim minimum flows that support the spawning and juvenile rearing life stages were estimated using the Hatfield and Bruce (2000) regression equations. These equations were developed using the "peak of the curve" results (i.e. optimum flow) from 127 Physical Habitat Simulation (PHABSIM) studies conducted across western North America, with most of the data representing California, Washington, Idaho, and Oregon. The regressions equations use MAD, latitude, and/or longitude to identify appropriate flows for each life stage. Thirteen species were included in the database, but only four had sufficient sample size to be analyzed separately and those included Chinook Salmon, Rainbow Trout, steelhead trout, and Brown Trout. The data from Coho Salmon streams with PHABSIM results were included in the all species category regression equations. The equations applied in this analysis are provided in Table 8.

Table 8. Hatfield & Bruce equations for Chinook Salmon and Coho Salmon and steelhead trout in the Scott River.

Species	Life stage	Equation
Chinook Salmon	Spawning	$\log_e$ (optimum flow) = -51.71 + 0.682 * $\log_e$(MAD) + 11.042 * $\log_e$(longitude)
	Juvenile	$\log_e$ (optimum flow) = -0.998 + 0.939 * $\log_e$(MAD)
All Species (Coho Salmon)	Spawning	$\log_e$ (optimum flow) = -12.392 + 0.660 * $\log_e$(MAD) + 1.336 * $\log_e$(latitude) + 1.774 * $\log_e$(longitude)
	Juvenile	$\log_e$ (optimum flow) = -6.119 + 0.679 * $\log_e$(MAD) + 1.771 * $\log_e$(latitude)
Steelhead trout	Spawning	$\log_e$ (optimum flow) = -33.064 + 0.618 * $\log_e$(MAD) + 7.26 * $\log_e$(longitude)
	Juvenile	$\log_e$ (optimum flow) = -8.482 + 0.593 * $\log_e$(MAD) + 2.555 * $\log_e$(latitude)

The latitude and longitude of USGS streamflow gage 11519500 were selected for consistency with the hydrology data (latitude = 41.64083°N, longitude = 123.0139°W).

Table 9 presents the results of the application of the Q_{fp} and Hatfield & Bruce regression equations.

Table 9. Hatfield & Bruce results for Chinook Salmon and Coho Salmon and steelhead trout in the Scott River.

Species	Life stage	Basis	Result
Chinook Salmon	Adult Migration	Q_{fp}	103 cfs
	Adult Spawning	Hatfield & Bruce	351 cfs
	Juvenile Rearing	Hatfield & Bruce	165 cfs
Coho Salmon	Adult Migration	Q_{fp}	61 cfs
	Adult Spawning	Hatfield & Bruce	217 cfs
	Juvenile Rearing	Hatfield & Bruce	129 cfs
Steelhead trout	Adult Migration	Q_{fp}	61 cfs
	Adult Spawning	Hatfield & Bruce	362 cfs
	Juvenile Rearing	Hatfield & Bruce	134 cfs

The results were applied to the seasonal period when the lifestage of each species is expected to occur; Department staff prepared a life stage periodicity chart, Figure 7, based on the most recent experience with the fishery resources in the Scott River.

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Chinook Migration																	X	X	X	X	X	X	X	X
Chinook Spawning	X																			X	X	X	X	X
Chinook Rearing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Adult Coho Migration	X																		X	X	X	X	X	X
Coho Spawning	X	X	X																		X	X	X	X
Coho Rearing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Adult Steelhead Migration	X	X	X	X	X	X[1]	X[1]	X[1]	X[1]	X[1]									X[1]	X[1]	X	X	X	X
Steelhead Spawning	X	X	X	X	X	X	X[1]	X[1]	X[1]										X[1]	X[1]	X[1]	X[1]	X[1]	X
Steelhead Rearing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Figure 7. Chinook Salmon, Coho Salmon, and Steelhead trout life stage periodicity chart (X known to occur in Scott River; X[1] may occur due to life history variations, but not used in calculations).

Integrating the flows developed using Q_{fp} and Hatfield & Bruce with the life stage periodicity, and subsequently selecting the highest semimonthly flow, produces the following flow regime for the Scott River. Although the flows in Table 10 below are protective of Coho Salmon life stage requirements, none of the values generated from the All Species category were incorporated into the table because the other categories given in Table 8 resulted in the highest semimonthly flow.

Table 10. Interim annual streamflow criteria for salmonids in the Scott River using Q_{fp} and Hatfield & Bruce methods.

Time Period	Recommended Interim Streamflow
Jan 1 - Mar 31	362 cfs
Apr 1 - Apr 30	134 cfs
May 1 - Jul 15	165 cfs
Jul 16 - Oct 15	134 cfs
Oct 16 - Dec 15	351 cfs
Dec 16 - Dec 31	362 cfs

It is important to note that this flow regime does not directly consider the hydrology of the Scott River watershed – except through application of the mean annual discharge in the Q_{fp} and Hatfield & Bruce regression equations. To ensure that any recommended flow regime is consistent with basin hydrology, the Department applied Tessmann's adaptation of the Tennant Method. As provided in Table 11, the Tessmann adaptation considers a situational analysis of the mean annual flow and the mean monthly flow when determining the proposed minimum monthly flow prescription. For a given month, if the mean monthly flow is less than 40% of the mean annual flow, the prescribed flow is set at the mean monthly flow. If the mean monthly flow is greater than 40% of the mean annual flow and 40% of the mean monthly flow is less than 40% of the mean annual flow, the prescribed flow is set at 40% of the mean annual flow. If 40% of the mean monthly flow is greater than 40% of the mean annual flow, then the prescribed flow is set at 40% of the mean monthly flow. The results of the application of the Tessmann Adaptation are presented in Table 12.

Table 11. Tessmann situational flow analysis and proposed flow prescription response.

Situation	Minimum Monthly Flow
MMF < 40% MAF	MMF
MMF > 40% MAF and 40% MMF < 40% MAF	40% MAF
40% MMF > 40% MAF	40% MMF

Table 12. Tessmann Adaption of flow data from USGS 11519500.

Month	Mean Monthly Flow	Tessmann Flow[3]	Month	Mean Monthly Flow	Tessmann Flow
October	139 cfs	***139 cfs***	**April**	1,081 cfs	***432 cfs***
November	328 cfs	***266 cfs***	**May**	1,235 cfs	***494 cfs***
December	880 cfs	***337 cfs***	**June**	771 cfs	***308 cfs***
January	1,118 cfs	***447 cfs***	**July**	202 cfs	***202 cfs***
February	1,249 cfs	***500 cfs***	**August**	77 cfs	***77 cfs***
March	885 cfs	***354 cfs***	**September**	62 cfs	***62 cfs***

[3] This application of Tessmann's adaptation of the Tennant Method assumes a mean annual flow of 666 cfs.

6. Recommended Interim Flow Criteria

The recommended interim minimum instream flow criteria for the Scott River was developed by applying the lesser of the minimum flow developed using the Q_{fp} and Hatfield & Bruce regression equations and the monthly flow determined using Tessmann's adaptation of the Tennant Method. The interim flow criteria in Table 12 are intended to be thresholds measured at USGS 11519500. If the flow level falls below the interim criteria, the natural flow level would be maintained instream allowing for natural recession of the hydrograph. This approach provides interim protection for the migration, spawning and rearing life stages of salmon and steelhead while considering basin specific hydrology. The recommended interim flow regime is provided below in both graphic (Figure 8) and tabular form (Table 13).

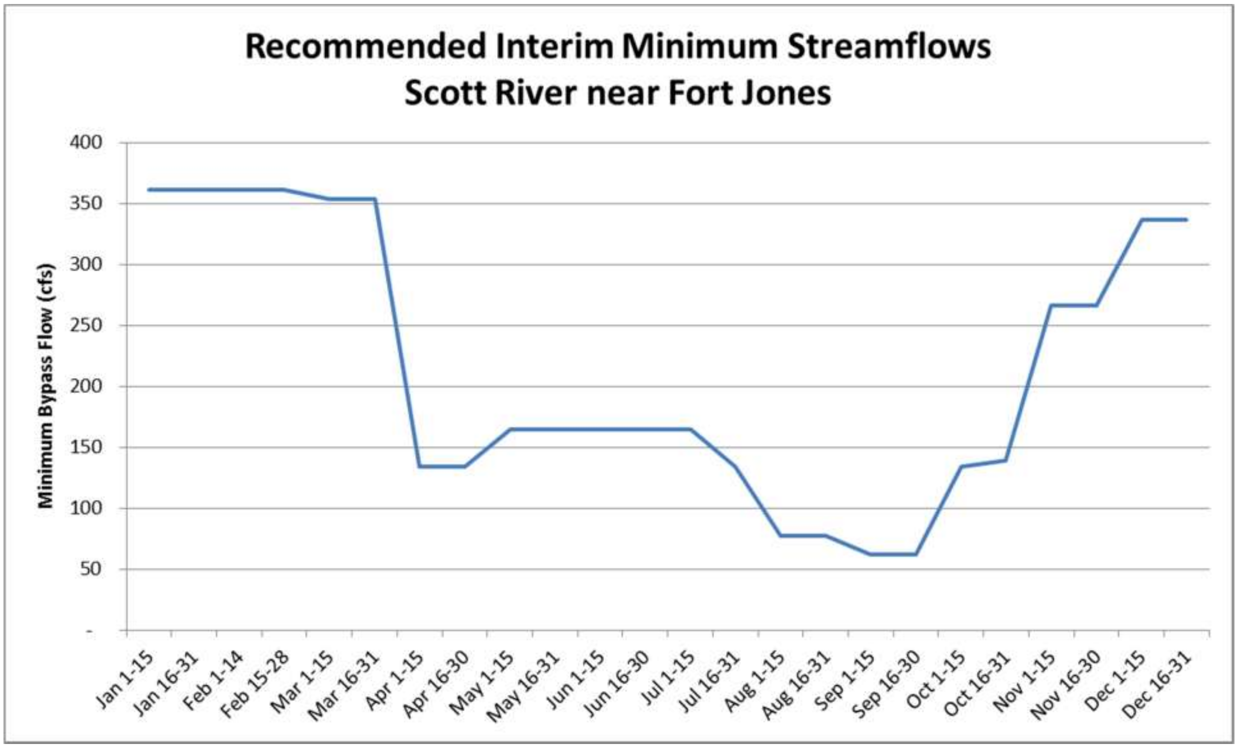


Figure 8. Annual hydrograph of recommended interim flow criteria for the Scott River at the Fort Jones gauge.

Table 13. Scott River Recommended Interim Flow Criteria measured at USGS 11519500.

Time Period	Recommended Flow	Time Period	Recommended Flow	Time Period	Recommended Flow
Jan 1 – 15	362 cfs or NF	May 1 – 15	165 cfs or NF	Sep 1 – 15	62 cfs or NF
Jan 16 – 31	362 cfs or NF	May 16 – 31	165 cfs or NF	Sep 16 – 30	62 cfs or NF
Feb 1 – 14	362 cfs or NF	Jun 1 – 15	165 cfs or NF	Oct 1 – 15	134 cfs or NF
Feb 15 – 28	362 cfs or NF	Jun 16 – 30	165 cfs or NF	Oct 16 – 31	139 cfs or NF
Mar 1 – 15	354 cfs or NF	Jul 1 – 15	165 cfs or NF	Nov 1 – 15	266 cfs or NF
Mar 16 – 31	354 cfs or NF	Jul 16 – 31	134 cfs or NF	Nov 16 – 30	266 cfs or NF
Apr 1 – 15	134 cfs or NF	Aug 1 – 15	77 cfs or NF	Dec 1 – 15	337 cfs or NF
Apr 16 – 30	134 cfs or NF	Aug 16 – 31	77 cfs or NF	Dec 16 – 31	337 cfs or NF

*NF = Natural Flow

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Exhibit B

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May 3, 2021

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Subject: Scott River Best Available Scientific Information for Instream Flow Criteria and Potential Next Steps

Dear Ms. Sobeck:

The California Department of Fish and Wildlife (CDFW) has been collaborating with the National Marine Fisheries Service (NMFS), the State Water Resources Control Board (SWRCB), and other stakeholders including Siskiyou County to address the current dry conditions and ongoing water use impacts in the Scott River, Siskiyou County. CDFW is also participating in ongoing and critically important government-to-government consultations with affected Tribes to facilitate co-management principles. The Scott River provides aquatic habitat for all life stages (migration, spawning, and rearing) of the State and federally listed threatened Southern Oregon Northern California Coast (SONCC) Evolutionarily Significant Unit (ESU) of Coho Salmon (*Oncorhynchus kisutch*), as well as the culturally significant and commercially important Klamath Basin fall Chinook Salmon (*Oncorhynchus tshawytscha)*(Chinook Salmon).

The purpose of this letter is to further a discussion about solutions and emphasize three primary topics. First, CDFW highlights threats facing Coho and Chinook Salmon in the Scott River due to low flow conditions. Second, CDFW provides an overview of the best available scientific information, which may be used as a starting point for assessing flow needs for Coho and Chinook Salmon in the Scott River. Third, CDFW outlines potential next steps and priority actions for the protection of Coho and Chinook Salmon in the Scott River.

Threats to Coho Salmon and Chinook Salmon Due to Low Flow Conditions

CDFW is deeply concerned with the recent pattern of critically dry water years in the Scott River. Surface water withdrawals that are not scaled to water year type contribute to disconnected flows in the mainstem and tributaries that have impeded or prevented migration of Coho and Chinook Salmon. As recently as the fall and winter of 2020, adult Coho and Chinook Salmon were unable to pass above the confluence of Oro Fino Creek on the mainstem, resulting in significant migration delays and almost complete cohort failure. Cohort failure represents loss of a significant component of the population, increases the potential for extirpation, and greatly impedes natural recovery.

The United States Drought Monitor has predicted ongoing drought in Siskiyou County. Flows at the USGS stream flow gage at Fort Jones (11519500) are currently less than the 25th percentile rankings of daily average flows since 1941. The Interim Instream Flow Criteria for the Protection of Fishery Resources in the Scott River Watershed, Siskiyou County (2017 Flow Report, Enclosure 1) identifies the Scott River as one of the most important Coho Salmon spawning and rearing tributaries in the Klamath River watershed. Changes have occurred in the basin in recent decades that are creating lower base flows than in previous decades when similar amounts of annual discharge were available. CDFW has crafted a report (Enclosure 2) that evaluates the influence of Scott River in-stream flow on the distribution and migration timing of fall Chinook Salmon and Coho Salmon.

CDFW monitoring of Coho Salmon populations tracks three separate brood years, and in the Scott River the difference in brood year strength is striking (Enclosure 2). After four generations of monitoring, brood year 2 has increased from 153 fish in 2008 to 1,671 fish in 2020. The increase in this brood year is an example of how quickly the Coho Salmon population can respond when in-river and/or out-of-basin survival conditions are favorable (the out-of-basin survival estimate for the adults that returned in 2020 was 10.64% compared to the period of record average of 4.77%) (Knechtle and Giudice 2021). Similarly, after four generations brood year 3 has increased from 80 fish in 2009 to 727 fish in 2018. Drought conditions persisted in the Scott Basin in the winter of 2013-2014 reducing in-river productivity, and as a result brood year 1 reduced in run size from 2,644 in 2013 to 250 fish in 2016. Brood year 1 returned last to the Scott River in 2019 when an estimated 365 fish returned. While the capacity of the Scott River to produce Coho Salmon is highlighted in the trajectory of brood years 2 and 3, the reduction in brood year 1 indicates how rapidly the population can change when conditions are poor.

Monitoring of the Chinook Salmon runs in the Scott River between 1978-2020 (Enclosure 2) depicts a range from 14,477 fish (1995) to 467 fish (2004) and has averaged 4,977 fish per year. The Chinook Salmon escapement to the Scott River from 2015 to 2020 has averaged 1,738 fish, representing a reduction from the historical average of 65%. The recent 6-year average escapement for the Klamath Basin is also down from the historical average, although the Klamath Basin reduction for this same period is 43% (CDFW 2021). The Scott River Chinook Salmon population is decreasing at a faster rate than the Klamath Basin as a whole.

Overview of Best Available Scientific Information on Salmonid Flow Needs in the Scott River

CDFW's 2004 Recovery Strategy for Coho Salmon and the 2014 NMFS Final Recovery Plan for the SONCC Coho Salmon identify developing target instream flows, and increasing instream flows, as priority actions. Both recovery strategies include increasing Scott River instream flows as a priority task necessary to improve rearing habitat, fish passage, and stream connectivity. Low summer flows and fall stream flows are a major factor limiting survival of juvenile Coho Salmon (CDFG 2004, NOAA 2014). These same limiting factors apply to Chinook Salmon in the Scott River. Chinook Salmon, while not currently listed under the state or federal endangered species acts, are an important fishery for the Klamath Basin Tribes and commercial and recreational fishing. Petitions to list spring-run Chinook as Threatened have been recently submitted to NMFS and CDFW. Given the declining condition of Coho and Chinook Salmon in the Scott River there is an urgent need to review the best available scientific information and identify appropriate next steps.

The 2017 Flow Report combines the results of three desktop flow assessment methods to develop recommended minimum instream flow criteria which are anticipated to be protective of specific salmonid life stages and general stream function monthly. Interim flow criteria to support fish passage were evaluated using the Q_{fp} formula developed by R2 Resources (2008) for the North Coast Instream Flow Policy (SWRCB 2014). Interim minimum flow criteria to support adult spawning and juvenile rearing were estimated using the Hatfield and Bruce (2000) regression equations. The regressions are based upon the results of 127 site specific studies that used the Physical Habitat Simulation (PHABSIM) method to estimate optimal flow criteria for salmonid adult spawning and juvenile rearing. The salmonid life stages present in the Scott River watershed were identified by month to determine whether flow criteria should be recommended for fish passage (Q_{fp}) or spawning and juvenile rearing (Hatfield and Bruce). To ensure that recommended flow criteria were consistent with Scott River hydrology, CDFW applied the Tessmann's adaption (Tessmann 1980) of the Tennant Method (Tennant 1975). Tessmann's adaption considers the relationship of the monthly mean flow to the mean annual flow. If the flow criteria recommended by Q_{fp} or Hatfield and Bruce exceeded the Tessmann's adaption flow, the recommended flow was truncated to the Tessmann's adaption flow to be consistent with Scott River hydrology. Three water year type conditions (wet, normal, and dry) were identified using data from the USGS stream flow gage at Fort Jones (11519500) and are presented in the report.

Potential Next Steps for Scott River Instream Flow Work

The 2017 Flow Report represents the best available scientific information and sufficient basis to move forward with a flow setting process. A more comprehensive site-specific instream flow study would help to better assess flow needs for Coho and Chinook Salmon in the Scott River watershed. Given the diverse nature of interests within the Scott River watershed, stakeholder coordination and outreach are vital. CDFW is currently working with landowners, Tribes, stakeholders, other agencies, and non-governmental organizations to collect information, identify issues and concerns, and define future study needs. To date, two initial phases of planning for a potential comprehensive flow study have been completed with the assistance of Normandeau Associates. These planning phases have helped to clarify habitat-species relationships, identify potential passage impediments, and identify additional studies that may be helpful to assessing flow needs for Coho and Chinook Salmon recovery. The Instream Flow Study Plan and other documents produced for these two phases can be found at https://wildlife.ca.gov/Conservation/Watersheds/Instream-Flow/Studies/Scott-Shasta-Study.

Additional funding and property access will be sought for phase three (project implementation) for further study. Such funding and access will need to be secured before further comprehensive study efforts can proceed. The top three CDFW priorities for future studies include: 1) west-side tributaries including Sugar, French, and Shackleford/Mill creeks, 2) the mainstem from Shackleford Creek to the South Fork/East Fork confluence, and 3) the canyon from the confluence of the Klamath River to the USGS gage.

Suggested Immediate Actions

Considering ongoing fisheries declines, and current forecast dry conditions, in addition to the longer-term efforts described herein, CDFW recommends immediate actions to help protect Scott River fisheries and habitat. CDFW formally requests the SWRCB consider the instream flow criteria in the 2017 Flow Report and other pertinent data as the best available scientific information regarding fisheries needs in the Scott River. CDFW recommends the instream flow criteria in the 2017 Flow Report be used to initiate a flow setting process, with the understanding that additional information will emerge as part of the process. Similarly, CDFW has provided comments to Siskiyou County, dated March 26, 2020, to consider the recommended instream flow criteria in the 2017 Flow Report when developing the Scott River Valley Basin Groundwater Sustainability Plan due January 1, 2022 to the Department of Water Resources pursuant to the Sustainable Groundwater Management Act (Enclosure 3).

For reasons previously discussed, CDFW urges appropriate consideration of fish and wildlife resources in the regulation of surface and groundwater use as required under the Public Trust Doctrine and other applicable law. CDFW acknowledges that while the 2017 Flow Report focuses on fishery and ecosystem needs, the SWRCB will be required to consider and balance a range of wateruses including irrigation, fisheries protection, municipal, and Tribal cultural uses, in any decision-making regarding minimum instream flows, which may be a consideration in future discussions.

In addition, CDFW recommends collaborating with the SWRCB, NFMS, the Tribes, Siskiyou County, and other stakeholders to evaluate and take actions to protect terrestrial and aquatic species and, wherever possible, work with water users and other parties on voluntary measures to protect species. For example:

1. Recommend additional financial support for water resilience infrastructure projects;
2. Re-evaluate minimum bypass flows and timing of CDFW-regulated and maintained diversions to adjust for water year types;
3. Identify and support enforcement actions to ensure existing laws are followed under the Water Code and Fish and Game Code;
4. Identify and encourage immediate and ongoing voluntary water efficiency actions to increase instream flows;
5. Accelerate funding for water supply enhancement, water conservation, or species conservation projects; and

6. Develop and achieve, this season, minimum flows necessary to maintain connectivity to support fish migration, spawning, and rearing in the Scott River and its west-side tributaries.

CDFW remains committed to supporting investments in voluntary actions including potential water storage projects. Recent examples include the installation of alternative stock water facilities, technical and policy support of point of diversion and irrigation ditch efficiencies, funding restoration of mainstem habitat, and facilitating surface water transactions. Typically, these types of projects require access to private property, some level of environmental analysis, and funding.

To protect fish and wildlife resources, it is imperative that the SWRCB consider the best available scientific information including recommended instream flow criteria from the 2017 Flow Report as a starting point in establishing instream flows. Next steps for these longer-term efforts can include additional support from other agencies, Tribes, and stakeholders to help develop instream flows that balance fish and wildlife needs with other beneficial uses. Through increased coordination with both surface and groundwater management efforts, it is CDFW's desire to work with the SWRCB to achieve resilient and sustainable flows within the Scott River watershed.

If you have any questions regarding this letter, please contact Northern Region Manager Tina Bartlett at tina.bartlett@widlife.ca.gov.

Sincerely,

Charlton H. Bonham
Director

Enclosures:

1 - Interim Instream Flow Criteria for the Protection of Fishery Resources in the Scott River Watershed, Siskiyou County.

2 - Influence of Scott River in-stream flow on the distribution and migration timing of fall Chinook Salmon and Coho Salmon.

3 – CDFW Comments to be Considered for the Scott River Valley Basin Draft Groundwater Sustainability Plan.

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Exhibit C

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DEPARTMENT OF FISH AND WILDLIFE
Region 1 – Northern
601 Locust Street
Redding, CA 96001
(530) 225-2300
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

Memorandum

May 3, 2021

To: Tina Bartlett
Northern Region Manager
California Department of Fish and Wildlife
601 Locust Street
Redding, CA 96001

From: Joe Croteau
Klamath Watershed Program Manager
California Department of Fish and Wildlife
1625 South Main Street
Yreka, CA 96097

Subject: Influence of Scott River in-stream flow on the distribution and migration timing of fall Chinook Salmon and Coho Salmon.

Introduction

This document describes the hydrologic conditions and observed adult fall Chinook Salmon (*Oncorhynchus tshawytscha*, Chinook Salmon) and Coho Salmon (*O. kisutch*) migration response from 2007 to 2020 in the Scott River watershed in Siskiyou County. Concerns over delayed migration and restricted distribution of adult spawning Chinook Salmon and Coho Salmon in recent years has prompted this evaluation. The Scott River is one of the most important salmon producing tributaries in the Klamath River watershed. Since 1978 the Scott River Chinook Salmon population has contributed on average 9% of the Klamath Basin natural area spawners (CDFW 2021). Additionally, the Scott River Coho Salmon population is defined as a “core independent” population of the Southern Oregon Northern California Coast Evolutionarily Significant Unit under the federal Endangered Species Act. Coho Salmon are listed as “threatened” under both the federal Endangered Species Act (NOAA 1997) and the California Endangered Species Act (CDFG 2002).

Watershed Description

The following watershed description has been excerpted directly from CDFW (2017).

> *"The Scott River is located in Siskiyou County and is part of the Klamath Mountains Province (Figure 1). The Scott River is one of four major tributary streams to the Klamath River. The watershed drains an area of approximately of 812 square miles. The mainstem Scott River is approximately 58 river miles in length and begins at the confluence of the East Fork Scott River and South Fork Scott River. The lower 21 miles of the Scott River flows through a relatively steep mountainous canyon reach which is primarily owned and managed by the Klamath National Forest. Elevations in this reach range from approximately 1,538 ft. (469 m) at the mouth to 2,635 ft. (803 m) at river mile (RM) 21 near the United States Geological Survey (USGS) stream gage station USGS 11519500 SCOTT R NR FORT JONES CA (USGS 11519500). By contrast, the upper reach that flows through Scott Valley has low stream gradients. The upper reach begins at RM 58 near the town of Callahan and flows north to RM 21 near USGS 11519500. Elevations in this reach range from 2,635 ft. (803 m) at RM 21 to 3,140 ft. (958 m) at RM 58 near Callahan to the north. The headwater tributaries originate in the high mountain ranges of the Trinity Alps Wilderness Area, Russian Wilderness Area, and Marble Mountain Wilderness Areas located to the south and west of Scott Valley. The major tributary streams that contribute to the Scott River around Scott Valley include the East Fork Scott River, South Fork Scott River, Sugar Creek, French Creek, Etna Creek, Kidder Creek, Shackleford Creek, Patterson Creek, and Moffett Creek.*
>
> *The watershed has a Mediterranean type climate characterized by warm dry summers and cold wet winters. Rainfall is the primary source of precipitation along the lower elevations present on the valley floor and adjacent lower elevation hill slopes. Snowfall is predominant at higher elevations (>5,000 ft.) along the mountain ranges to the south and west side of Scott Valley. The mountains to the south and west of the valley capture most of the precipitation receiving about 60 to 80 inches of precipitation annually. The mountains along the east side of the valley lie*

within the rain shadow of higher elevation mountain ranges to the south and west, and only receive about 12 to 15 inches of precipitation annually.

Aquatic habitat for anadromous fish species within the Scott River basin has been altered by numerous human activities, affecting both instream conditions and adjacent riparian and upland slopes. Alterations to habitat and changes to the landscape include historic beaver trapping, road construction, agricultural practices, river channelization, dams and diversions, timber harvest, mining/dredging, gravel extraction, high severity fires, groundwater pumping, and rural residential development (NOAA-Fisheries 2014). These impacts, along with natural factors such as floods, erosive soil, and a warm and dry climate, have simplified, degraded, and fragmented anadromous fish migrating, spawning, and rearing habitat throughout the Scott River basin (NOAA-Fisheries 2014)."

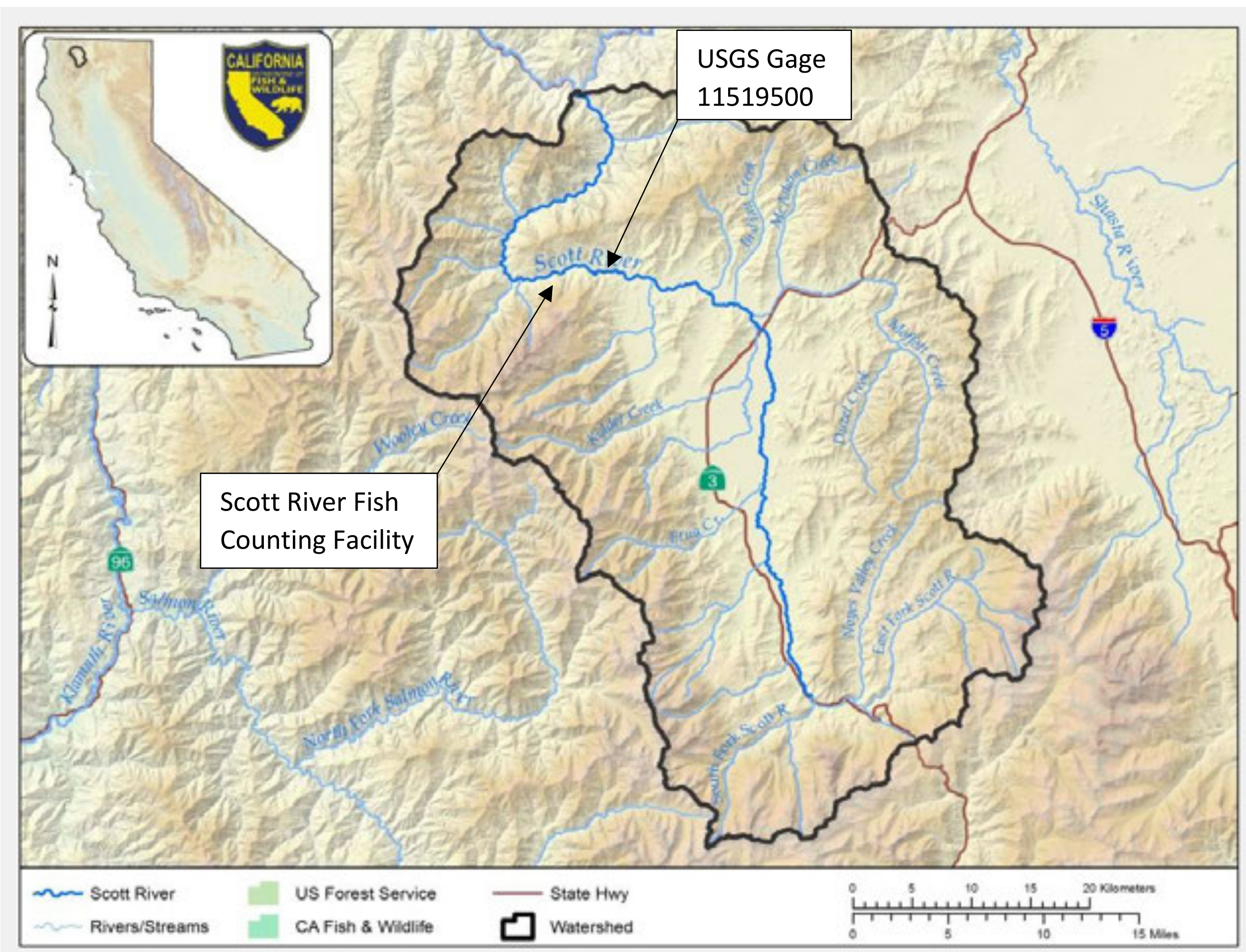

Figure 1. Scott River Watershed in Siskiyou County, California.

Flow Data

The USGS has continuously operated the Scott River near Fort Jones flow gage (Figure 1; USGS 11519500, (41º 38’ 26.07”N; 123º 0’ 54.31”W) on the mainstem of the Scott River downstream of Fort Jones near the transition between the valley and canyon reaches since October 1941. All flow data referenced in this report was collected at the USGS Fort Jones gage. Annual discharge (acre-feet) of each water year (October 1 through September 30) for the period of record (1942-2020) has been ranked based on its probability of exceedance within the flow record and segregated into roughly 20% bins to characterize “extremely wet”, “wet”, “normal”, “dry” and “critically dry” water year types. Annual discharge for the Scott River varies greatly based on this water year type grouping. In “extremely wet” years average basin discharge was 805,998 acre-feet, and in “critically dry” years average annual discharge was 156,964 acre-feet (Figure 2).

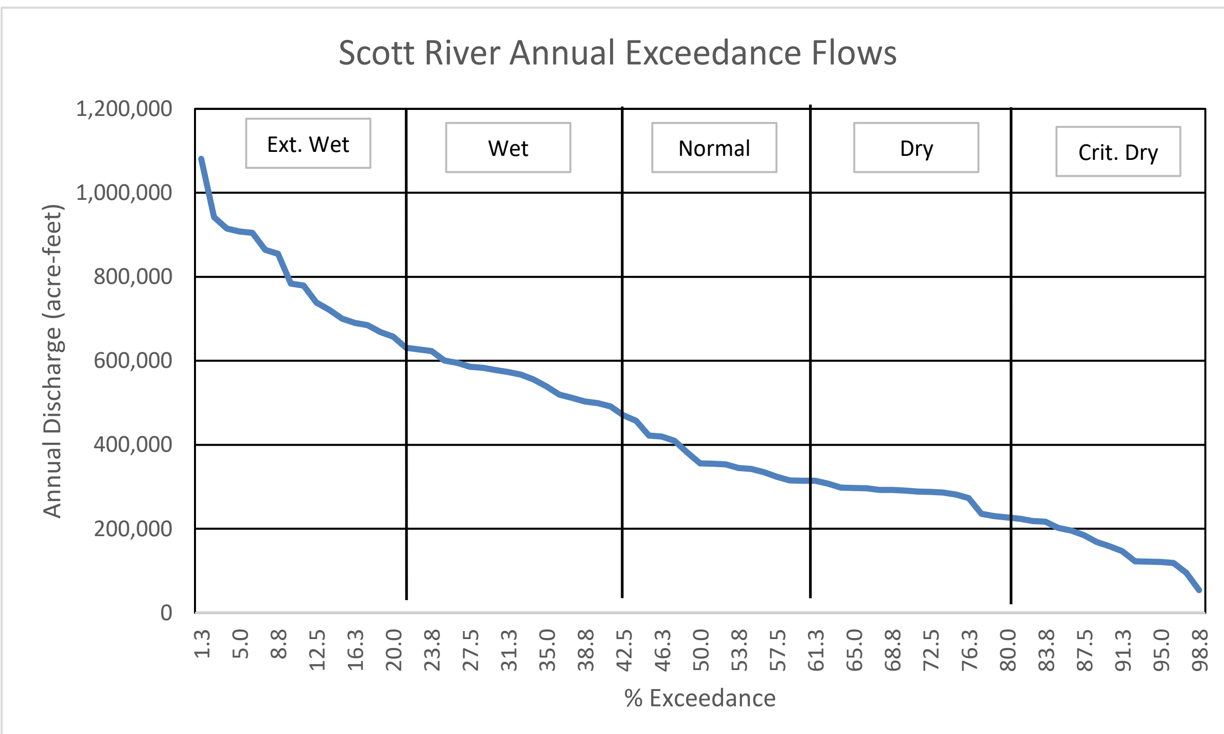

Figure 2. Annual discharge (acre-feet) measured at USGS Fort Jones gage (11519500) ranked by exceedance probability and grouped into roughly 20% bins to characterize annual water year types from 1942-2020.

Seasonal discharge is typical of Mediterranean climates with a rain dominated hydrograph from October through March and a snow melt dominated hydrograph from April through June. After the snowmelt hydrograph period ends streamflow diminishes to summer base flows reaching their minimums in September. From 2007 to 2020 average monthly mean flows ranged from a high of 961.7 cubic feet per second (cfs) in April to a low of 19.1 cfs in September. Average September base flows in the Scott River averaged 19.1 cfs between 2007 and 2020 and have ranged from a low of 6.3 cfs in 2020 to a high of 61.6 cfs in 2011 (Table 1).

Table 1. Mean monthly flows (cfs) measured at USGS Fort Jones gage (11519500) from 2007-2020.

Scott Mean Monthly Flow 2007-2020												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2007	696.29	523.82	1073.65	634.10	539.19	141.78	37.56	8.23	7.08	103.67	112.70	269.90
2008	381.84	496.66	749.03	657.13	1459.06	567.70	100.55	22.64	16.94	36.69	140.12	129.45
2009	234.87	287.07	613.00	497.43	928.97	308.71	35.55	10.74	7.04	17.63	48.02	73.58
2010	498.39	436.82	528.81	863.43	1122.55	1616.87	292.49	40.37	36.17	126.33	348.00	1020.94
2011	1019.87	529.46	1168.00	1452.03	1204.35	1579.80	609.39	95.47	61.65	91.26	102.71	135.24
2012	461.61	334.41	793.39	1632.73	1142.42	411.83	82.54	17.27	12.18	29.89	139.53	1014.00
2013	341.19	378.54	561.61	779.27	500.52	118.08	29.46	11.25	11.58	45.31	50.46	54.21
2014	59.53	488.16	851.00	309.30	131.72	44.45	9.69	6.87	7.01	29.56	147.35	983.74
2015	509.81	2234.89	582.35	253.50	155.32	75.44	10.46	7.06	7.19	6.27	7.75	308.40
2016	1226.65	1341.03	2311.29	1514.07	962.45	359.30	79.07	14.01	10.05	296.59	514.33	1093.00
2017	1518.39	3841.07	2337.74	1659.33	1962.58	1011.70	191.67	49.16	52.34	65.57	317.67	187.71
2018	292.00	327.39	385.39	915.33	460.29	96.54	17.80	6.16	8.13	12.55	37.55	179.86
2019	684.13	853.36	987.65	1980.03	1300.23	661.20	91.27	19.04	24.18	48.96	56.16	144.75
2020	294.10	313.52	200.65	315.70	431.06	184.21	18.02	9.28	6.31	7.13	12.70	52.60
Average	587.05	884.73	938.82	961.67	878.62	512.69	114.68	22.68	19.13	65.53	145.36	403.38

Much attention in the Scott River has focused on maintaining the United States Forest Service water right of 30 cfs for the "instream use for fish and wildlife" (CDFW 2017) as identified in the 1980 Scott River Decree (SWRCB 1980 N. 30662). During "normal," "dry" and "critically dry" water year types the percent of days in September for which the daily average flows are less than 30 cfs were 31%, 56% and 80% respectively. From 1942-2020, during the "wet" and "extremely wet" water years, mean September flows have been above 30 cfs for all years but one (Table 2). To evaluate if September mean flows have changed in recent decades among similar water year types, September mean flows were evaluated prior to and after 1980.

Table 2. Number of years and percent of years that USGS Fort Jones gage (11519500) mean September monthly flows (cfs) are less than 30 cfs for five different water year types from 1942-2020.

Water Year Type	Number of Years	Number of Years Mean September flow <30cfs	Percent of Years Mean September flow <30cfs
Extremely Wet	16	0	0.0%
Wet	16	1	6.3%
Normal	16	5	31.3%
Dry	16	9	56.3%
Critically Dry	15	12	80.0%

Water years have been ranked from wettest to driest by annual discharge (acre-feet) and corresponding mean September flows (cfs) have been grouped into two categories: black bars represent mean September flows from water years prior to 1980, and red bars represent mean September flows from water years after 1979 and are presented in Figure 3. Fourteen water years have been highlighted due to their similarity in annual discharge. These 14 water years had similar annual discharges, but corresponding mean September flows were very different depending on the time period that the water year occurred. The seven water years in this example from 1942-1979 had mean September flows above 30 cfs in six of the seven years and averaged 47 cfs (black highlight). The seven water years in this example from 1980-2020 had mean September flows less than 30 cfs six of the seven years and averaged 16 cfs (red highlight) (Figure 3).

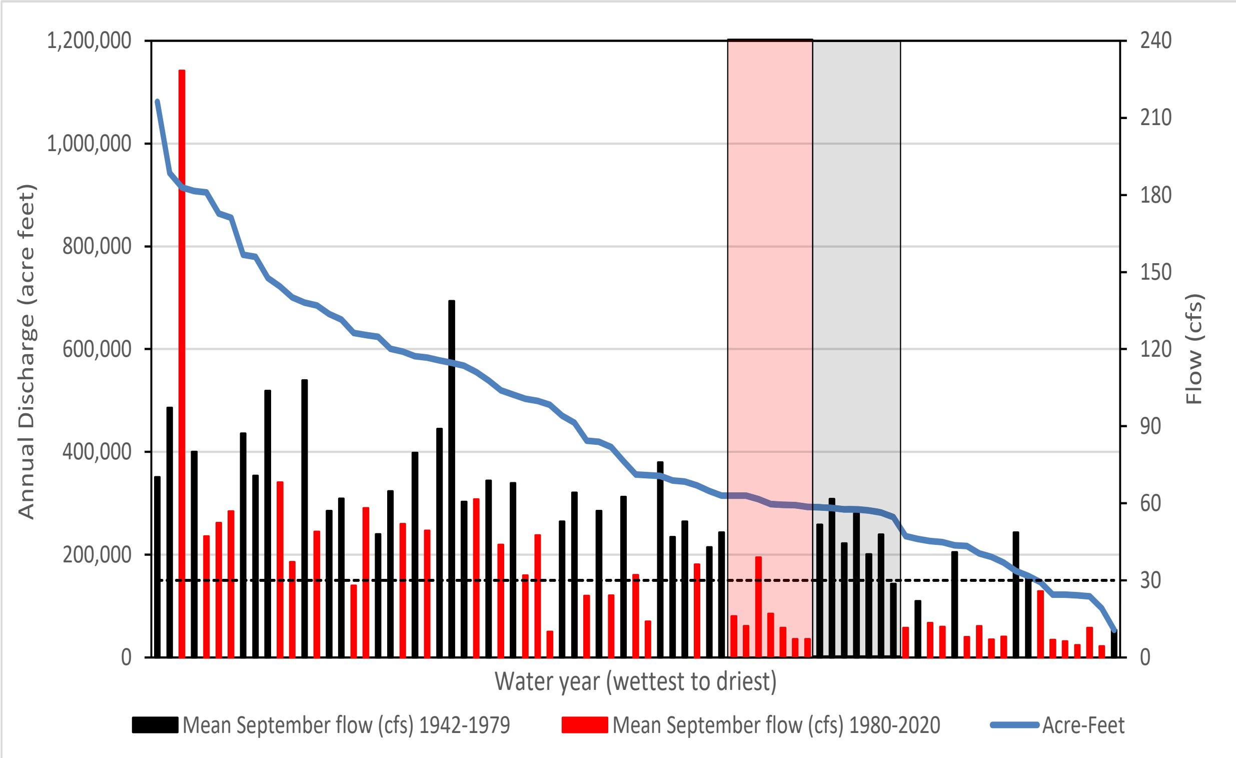

Figure 3. Scott River annual discharge (acre-feet) measured at USGS gage (11519500) for each water year ranked from wettest to driest from 1942-2020 (blue line). Mean September flows (cfs) for corresponding water years are plotted as red (1980-2020) and black (1942-1979) bars. For reference, a dashed black line has been placed at 30 cfs. Red and black highlighted sections show 14 years with very similar amounts of annual discharge (seven years from each time period) and very different mean September flows.

Prior to 1980 there were four "critically dry" water years and the average September flow during these years was 33.1 cfs. After 1980 there have been 11 "critically dry" water years and the average September flow during these years was 9.7 cfs. Similarly, during the 16 "dry" water years average September flows were 44.1 cfs prior to 1980 and 14.9 cfs after 1980. During the 16 "normal" water years average September base flows prior to 1980 were 60.0 cfs and the average after 1980 was 22.4 cfs. Prior to 1980 mean September flows were significantly higher during drier water year types than after 1980 (Table 3). Similarly, Van Kirk and Naman (2008) reported a 40.3% reduction in summer baseflows in the recent past (1977-2005) than in the historic period (1942-1976). Changes have occurred in the basin in recent decades that are creating lower base flows than in previous decades when similar amounts of annual discharge were available.

Table 3. Mean September flow (cfs) at USGS Fort Jones gage (11519500) for five water year types separated into two time periods 1942-1979 and 1980-2020.

Water Year Type	1942-1979 Period Mean September flow cfs	1980-2020 Period Mean September flow cfs
Extremely Wet	81.8	76.9
Wet	77.2	46.5
Normal	55.9	22.4
Dry	44.4	14.9
Critically Dry	33.1	9.7

It is important to acknowledge the degree of influence water year type has on the fall hydrograph and its influence on subsequent Chinook Salmon and Coho Salmon migration. It is also important to note that after spring snowmelt runoff has occurred meaningful increases in base flows are subject to the onset of fall and winter storms. Currently, water withdrawal is not scaled based on water year type, which may further exacerbate low base flows during drier water year types. Surface and ground water withdrawals have not been evaluated in this document to determine if implementation of the Decree is linked to the reductions in observed September flows. In recent decades, demand for groundwater in Scott Valley has increased (S.S. Papadopulus 2012) and the effects of this action are currently under evaluation by Siskiyou County under the authority of the Sustainable Groundwater Management Act.

Adult Population Trends

The Scott River Fish Counting Facility (SRFCF) is located at river mile 18.2 at the transition between the canyon and valley reaches (41º 38' 10.93''N; 123º 04' 3.08''W) (Figure 1). The SRFCF is an important component of the California Department of Fish and Wildlife's (CDFW) annual adult estimation effort and has been used to estimate escapement of Chinook Salmon since 2008 and Coho Salmon since 2007. Traditional mark-recapture, carcass, and redd survey methods are utilized to estimate adult abundance downstream of the SRFCF. Estimates from downstream of the counting station are added to estimates from the counting station to generate a Scott River basin estimate. Additionally, CDFW has operated a rotary screw trap near the mouth of the Scott River (41º 43' 32.30''N; 123º 0' 34.37''W) since 2000 and provides annual estimates of out-migrating salmonids. Information gathered at the adult and juvenile monitoring stations allows for estimating adult returns and juvenile production in the Scott

River. The pairing of these two datasets allows for estimation of in-river productivity and out-of-basin survival.

Chinook Salmon

Since 1978, the Chinook Salmon run in the Scott River has ranged from 14,477 fish (1995) to 467 fish (2004) and has averaged 4,977 fish (Figure 4). Chinook Salmon escapement to the Scott River from 2015 to 2020 averaged 1,738 fish, a 65% reduction from the historical average (4,977). Average escapement for the Klamath Basin from 2015-2020 is also down from the historical average, by 43% (CDFW 2021). It is concerning that the Scott River Chinook population is decreasing at a faster rate than the Klamath Basin as a whole.

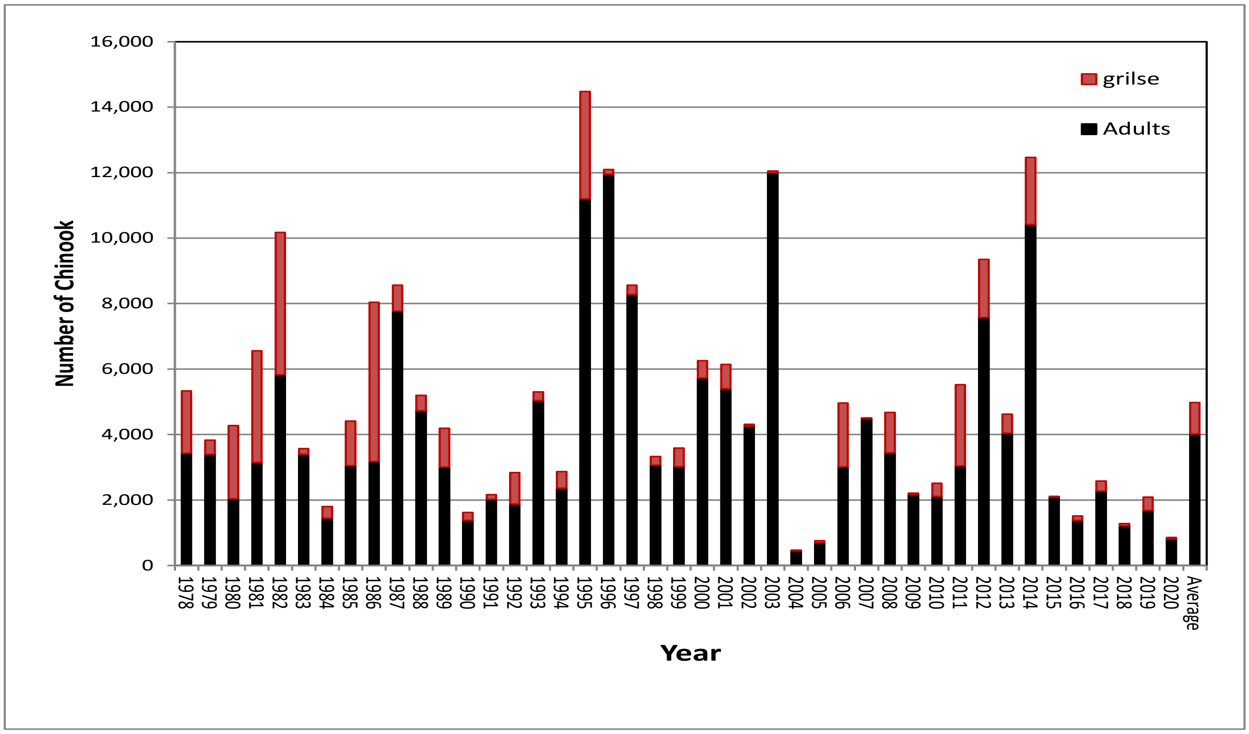

Figure 4. Estimated escapement of Chinook Salmon returning to the Scott River from 1978 to 2020.

Coho Salmon

Since video operations began in 2007 estimated escapement of Coho Salmon in the Scott River has ranged from a low of 63 to a high of 2,752 and averaged 726 (Figure 5). Coho Salmon populations are generally tracked as three separate brood years, with cohorts returning every three years, and in the Scott River the difference in brood year strength is striking. The difference in brood year strength has been observed for multiple decades in the Scott River (CDFG

2006). After four generations of monitoring, brood year 2 has increased from 153 fish in 2008 to 1,671 fish in 2020. The increase in this brood year is an example of how quickly the Coho Salmon population can respond when in-river and/or out-of-basin survival conditions are favorable (the out-of-basin survival estimate for the adults that returned in 2020 was 10.64% compared to the period of record average of 4.77%) (Knechtle and Giudice 2021). Similarly, after four generations brood year 3 has increased from 80 fish in 2009 to 727 fish in 2018. Drought conditions persisted in the Scott Basin in the winter of 2013-2014 reducing in-river productivity, and as a result brood year 1 reduced in run size from 2,644 in 2013 to 250 fish in 2016. Brood year 1 returned last to the Scott River in 2019 when an estimated 365 fish returned. While the capacity of the Scott River to produce Coho Salmon is highlighted in the trajectory of brood years 2 and 3, the reduction in brood year 1 indicates how rapidly the population can change when conditions are poor.

Adult Migration

Chinook Salmon typically return to the Scott River in mid-September and stage for multiple weeks near the mouth of the Scott River prior to migrating upriver to spawn in valley and canyon reaches. CDFW operated a counting station near the mouth of the Scott River from 1985-1991, and in five of the seven years of monitoring the first Chinook Salmon was observed at the counting station on or before September 12. In all seven years Chinook Salmon were observed by September 26. For the purposes of this document, we consider the SRFCF the upstream limit of the canyon and the downstream limit of the valley. In most years Chinook Salmon have access to spawning habitat in all canyon and mainstem areas downstream of the “tailings” just north of the town of Callahan. It has long been assumed that spawning habitat in the valley reaches and tributaries upstream of the canyon provides increased survival potential verses spawning in the canyon. Valley reaches allow access to high quality spawning habitat that is largely connected to its floodplain. Valley reaches also provide access to seasonal high quality rearing habitat that degrades as the dry season progresses. The importance of connectivity between spawning reaches and floodplain habitat cannot be understated. Floodplain connectivity allows water to spread out as flows increase, mitigating increasing water velocities, protecting incubating eggs from scour and providing rearing juvenile salmonids flow refuge, cover and feeding opportunities that is less abundant in canyon reaches. Additionally, when adult salmon have access to upstream reaches for spawning, more rearing habitat is seeded with juvenile fish. Access to more rearing habitat increases potential production, which can in turn increase adult returns.

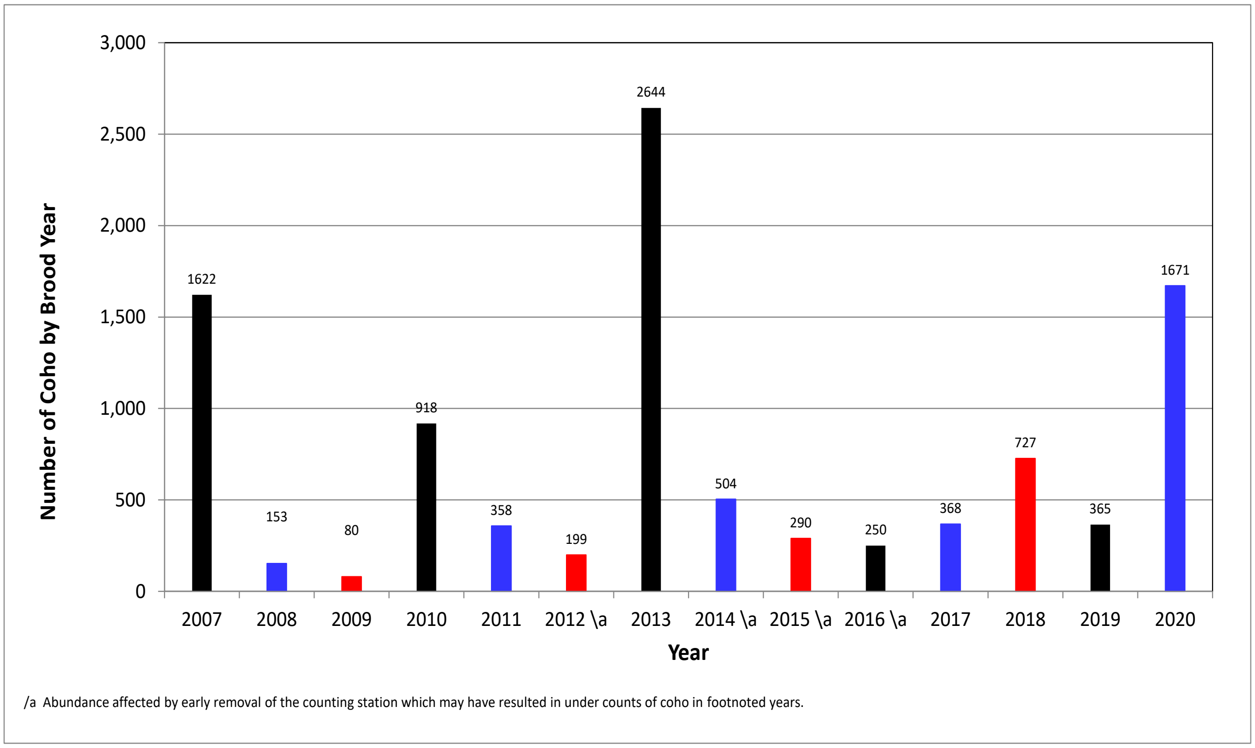

Figure 5. Estimated escapement by brood year of adult and grilse Coho Salmon returning to the Scott River from 2007 to 2020. Individual brood years are represented by different colors.

Adult Passage Timing at SRFCF

The timing of Chinook Salmon passage through the SRFCF has consistently started in early October. With the exception of 2020, the Chinook Salmon run migrated through the SRFCF almost entirely during October, with 50% of the cumulative annual migration occurring in a narrow 17-day period between October 14 and October 30 (Figure 6), and without stage flow increases. The years 2015, 2018 and 2020 were the three driest falls during the period of monitoring at the counting facility. It is unclear why Chinook Salmon migration timing was delayed in 2020 compared to the other 12 years. The run in 2020 was the lowest for the period of analysis, and the few fish that did migrate past the counting station were observed roughly two weeks after peak spawning occurred. The proportion of Chinook Salmon that spawned downstream of the counting station in 2015, 2018 and 2020 were 82%, 68% and 69% respectively which corresponded with the three lowest average October flow years. While the ability of Chinook Salmon to migrate does not appear to be limited by flow, the proportion of fish migrating upstream of SRFCF does appear to depend on flow.

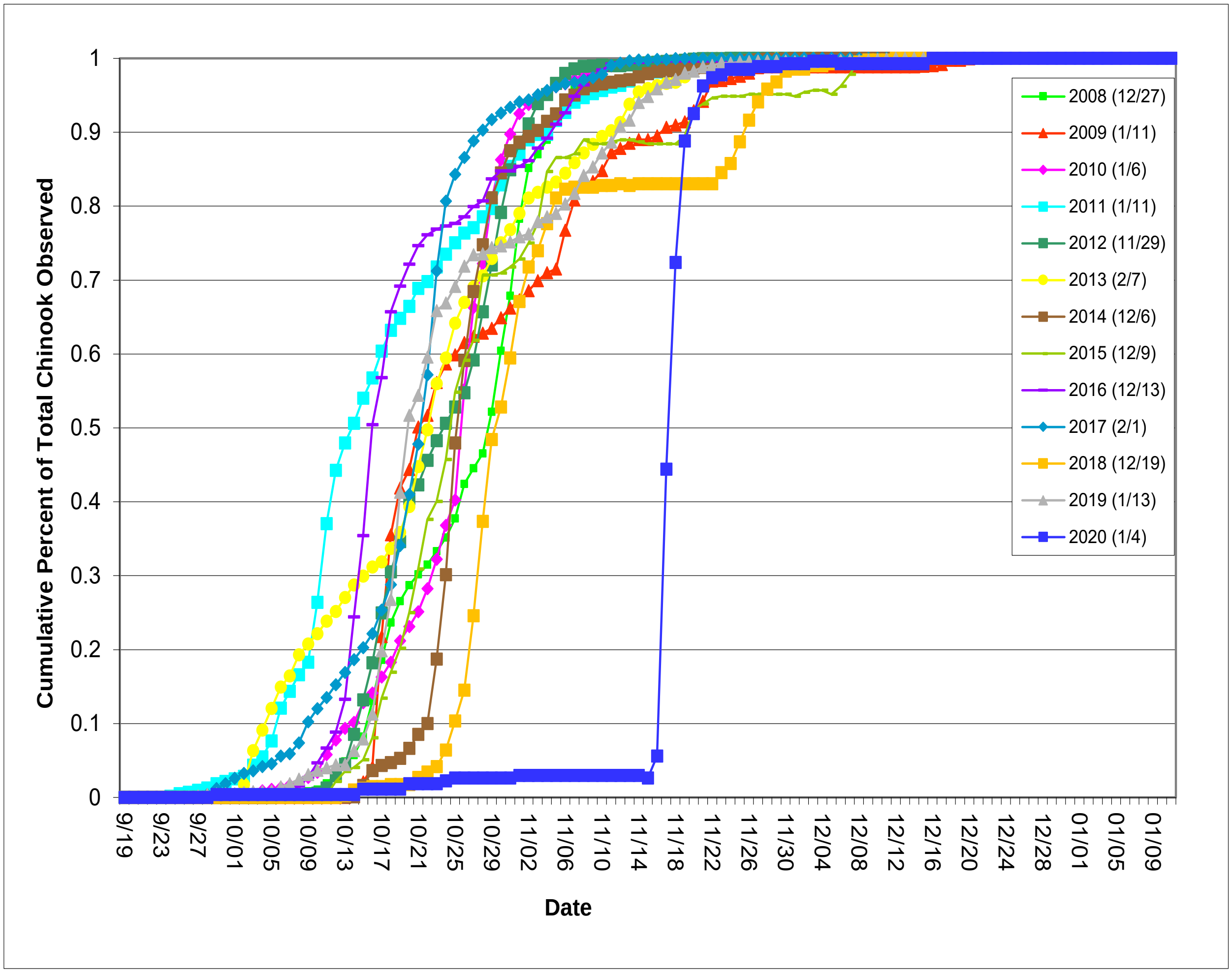

Figure 6. Cumulative percent of total observed Chinook Salmon observations by day at the SRFCF annually from 2008-2020. Dates in parentheses indicate the last date the fish counting facility was operated for each year.

Coho Salmon migration timing through the counting station is much more protracted and is heavily influenced by increases in flow. While Chinook Salmon will attempt to migrate regardless of the base flow condition in the fall, Coho Salmon migration is largely linked to flow events. The tendency for Chinook Salmon to spawn at a higher rate in mainstem habitats and Coho Salmon to spawn in tributaries may help explain this difference (i.e., Coho Salmon have evolved to respond to flows which make tributary habitats accessible). During the 14-year period from 2007 to 2020 the date when 50% of the cumulative annual Coho Salmon migration was achieved has ranged over a 44-day period between November 6 and December 19 (Figure 7). The average peak daily migration observed at the SRFCF from 2007 to 2020 was November 21. It is also common to observe a very high proportion of the entire Coho Salmon run pass through the SRFCF in a very short period of time. For example, in eight of the 14 years of monitoring more than 50% of the annual migration was observed passing through the SRFCF in a four-day period. Coho Salmon response to flow is almost instantaneous indicating that these fish are staging downstream of the counting station in the canyon reaches waiting for a flow increase to migrate upstream. Coho Salmon migration through the SRFCF is not clearly linked to a minimum flow threshold but migration is strongly associated with increases in flow.

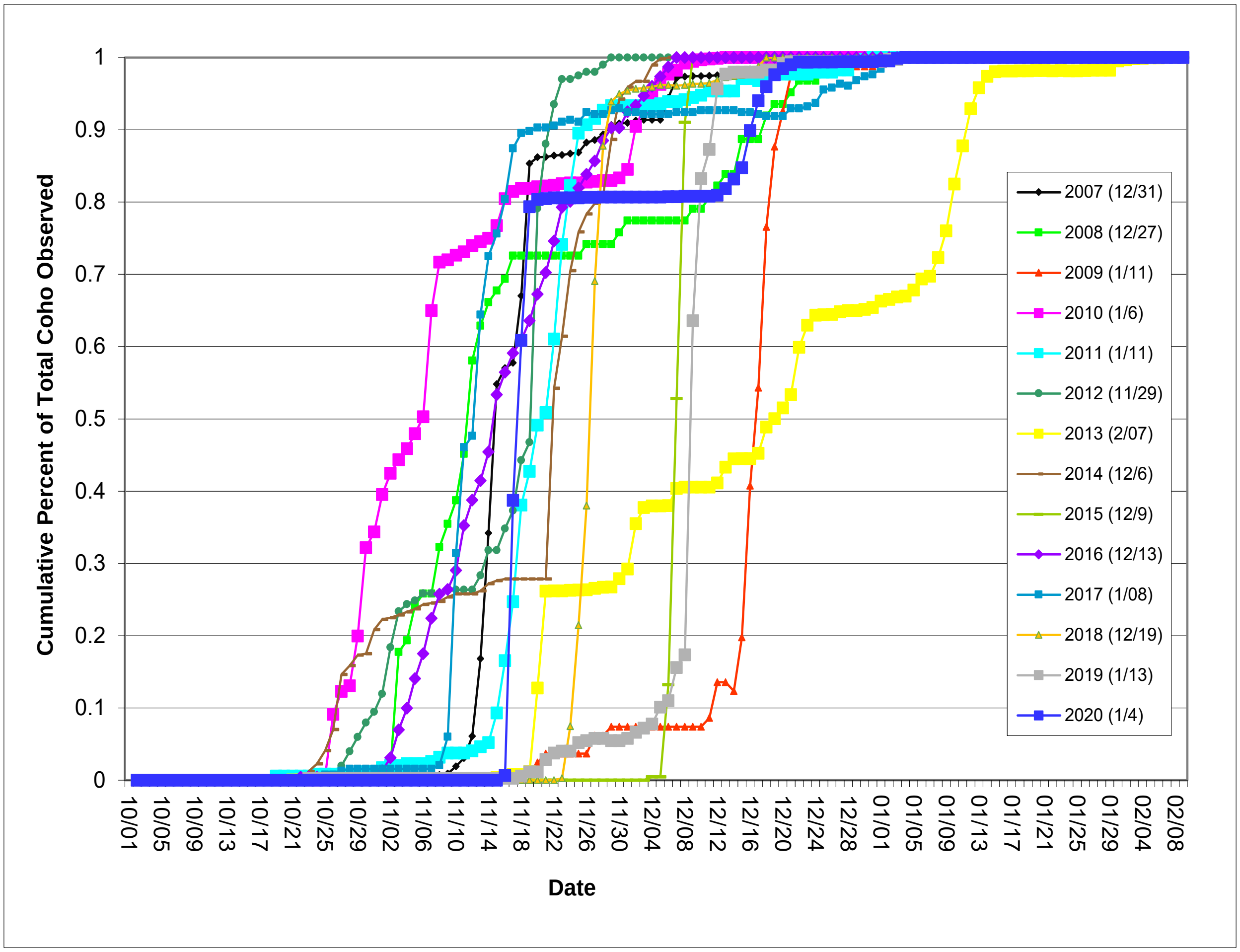

Figure 7. Cumulative percent of total observed Coho Salmon observations by day at the SRFCF annually from 2007-2020. Dates in parentheses indicate the last date the fish counting facility was operated for each year.

Proportion of Run Above and Below SRFCF

Proportions of the Chinook Salmon run distributed upstream versus downstream of the counting station for years 2008-2020 are detailed in Table 4. Over this period an average of 65% of the Chinook Salmon run migrated into the valley. The three years (2015, 2018, 2020) with the lowest percent of fish spawning in the valley coincided with some of the lowest mean October flows since 2008. It is important to track this metric as it helps describe the spatial distribution of annual spawning. There is a lower risk of catastrophic loss due to potential redd scour when eggs are deposited throughout the watershed.

Table 4. Scott River Chinook Salmon abundance estimates by area and percentages of the total above and below the SRFCF during the 2008-2020 seasons.

Year	Downstream of Counting Station	Upstream of Counting Station	% Downstream of Counting Station	% Upstream of Counting Station	Total Basin Estimate
2008	1,439	3,234	31%	69%	4,673
2009	1,014	1,197	46%	54%	2,211
2010	280	2,228	11%	89%	2,508
2011	983	4,538	18%	82%	5,521
2012	1,208	8,144	13%	87%	9,352
2013	1,252	3,372	27%	73%	4,624
2014	2,995	9,476	24%	76%	12,471
2015	1,741	372	82%	18%	2,113
2016	363	1,152	24%	76%	1,515
2017	297	2,279	12%	88%	2,576
2018	875	404	68%	32%	1,279
2019	537	1,553	26%	74%	2,090
2020	586	269	69%	31%	855
Average	1,044	2,940	35%	65%	3,984

To determine what specific time period and flow was most critical to the spawning distribution of Chinook Salmon the proportion of fish that spawned upstream of the counting station was plotted against the average daily flows for different half-month periods from September 1 through November 30. From 2012 to 2020 the average date of peak redd abundance was October 31 (Meneks 2020). The half-month period from October 16-31 was strongly associated with the proportion of the Chinook Salmon run that migrated upstream of the counting station (Figure 8).

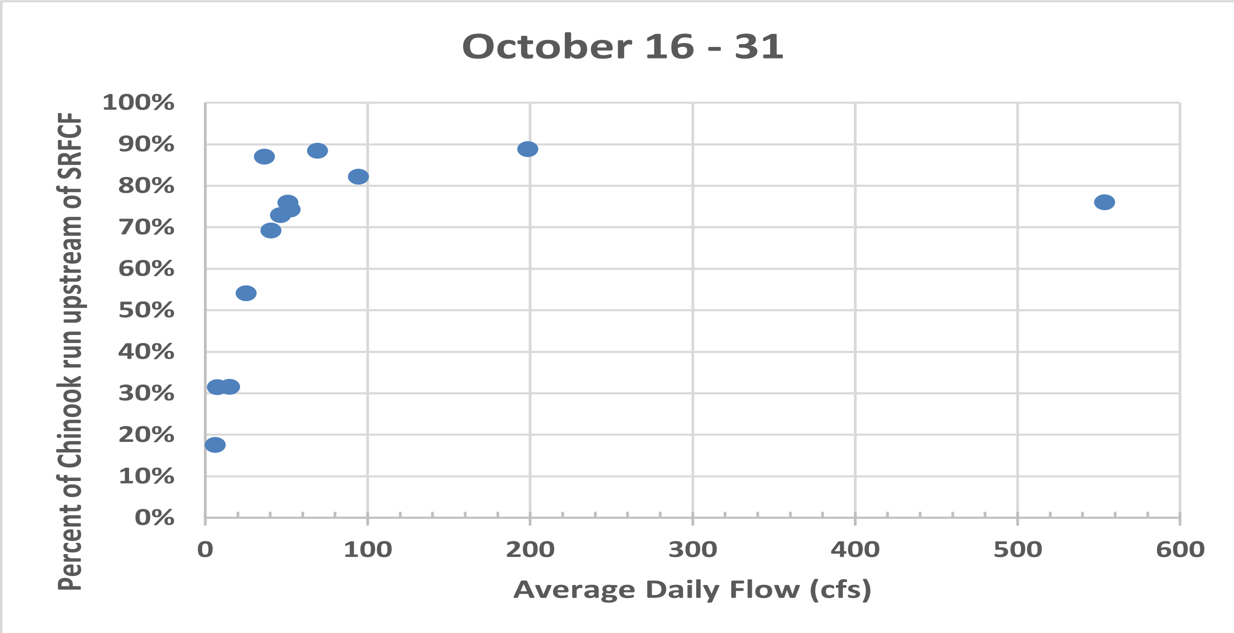

Figure 8. Annual percent of Chinook Salmon observed upstream of SRFCF plotted against the average of daily flows (cfs) at USGS Fort Jones gage (11519500) for October 16 to October 31 from 2008-2020.

In 2014 average flow from October 1-15 was seven cfs and from October 16-31 average flow was 51 cfs. During 2014 the period of October 16-31 was still within the "migration" period for Chinook Salmon and 76% of the run migrated into the valley. In 2012, when 87% of Chinook Salmon migrated upstream of the counting station, Chinook Salmon moved through the counting station the entire month of October. In 2012 the October 1-15, and 16-31 average flows were 23 cfs and 37 cfs respectively. 2016 was very similar to 2012 when average flows between October 1-15 were 22 cfs and were sufficient to distribute Chinook Salmon upstream of the counting station. Flows between October 16-31 of 25 cfs during the 2009 migration were sufficient to distribute 54% of Chinook Salmon upstream of the counting station (Table 5, Figure 9).

Table 5. Percent of Chinook Salmon migration estimated upstream of SRFCF and average daily flows (cfs) at USGS Fort Jones gage (11519500) for half month periods from September 1 - November 30 annually from 2008-2020.

		Averge Daily Flow (cfs)					
Run Year	Chinook Upstream of Counting Station	Sep 1- Sep 15	Sep 16-Sep 30	Oct 1-Oct 15	Oct 16 - Oct 31	Nov 1 - Nov 15	Nov 16 - Nov 30
2008	69%	15	19	33	41	159	122
2009	54%	7	7	10	25	37	59
2010	89%	28	45	49	199	409	287
2011	82%	58	66	88	94	95	111
2012	87%	10	15	23	37	56	223
2013	73%	7	17	44	46	47	54
2014	76%	7	7	7	51	72	222
2015	18%	7	7	6	6	7	8
2016	76%	11	9	22	554	534	495
2017	88%	45	59	62	69	94	541
2018	32%	8	8	10	15	22	53
2019	74%	15	34	45	52	56	56
2020	31%	6	7	7	7	9	16

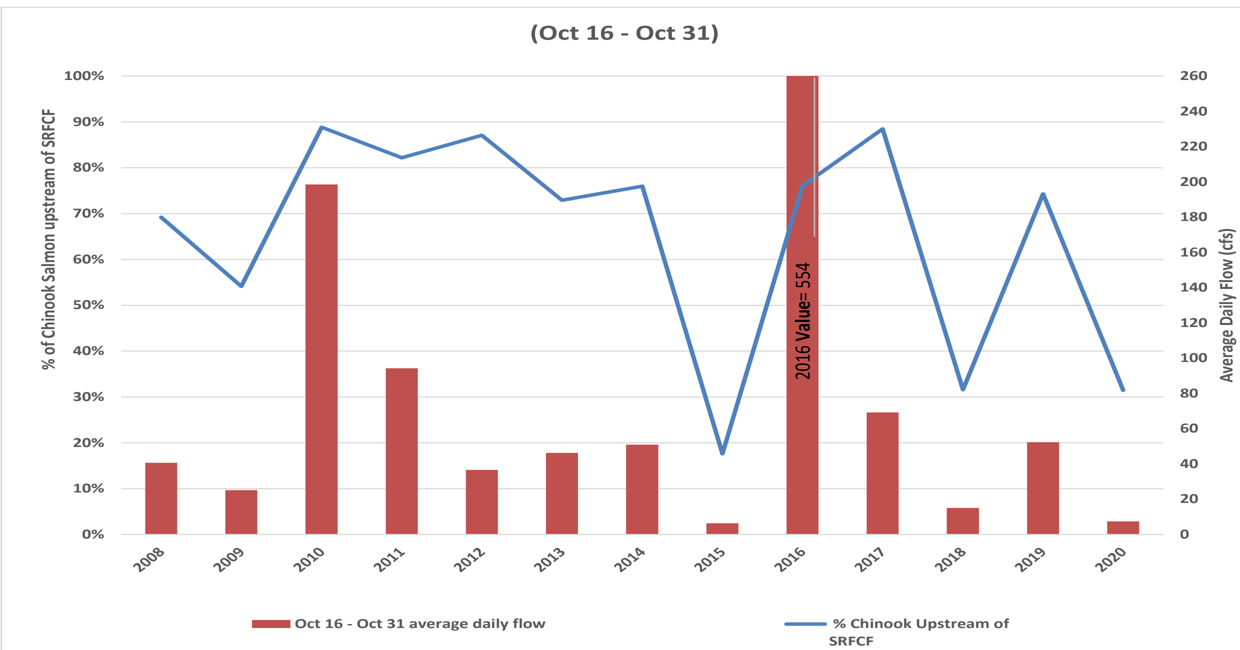

Figure 9. Annual percent of Chinook Salmon observed upstream of SRFCF plotted with average daily flows (cfs) at USGS Fort Jones gage (11519500) for October 16 to October 31 by year from 2008-2020.

In 2015 when 18% of Chinook Salmon migrated upstream of the counting station daily flows were less than 9 cfs for the entire migration period. In 2018, 32% of

Chinook Salmon migrated into the valley and the migration window was largely closed for Chinook Salmon when flows came up during the Nov 15-30 period. During 2020 average daily flows were less than 16 cfs for the entire Chinook Salmon migration period and 31% of the run migrated upstream of the counting station (Table 5, Figure 9). In most years by November 1st the peak of Chinook Salmon spawning has occurred and the opportunity for storms to influence Chinook Salmon spawning distribution decreases (Meneks 2021). October average daily flows measured at the Fort Jones gage at or above 22 cfs have been sufficient to distribute more than 50% of the Chinook Salmon population upstream of SRFCF.

Coho Salmon return to spawn later than Chinook Salmon and passage through the counting station is linked to stage increases in the hydrograph (Appendix A). As a result of Coho Salmon migrating when base flows are increasing and the innate response of Coho Salmon to migrate further upstream than Chinook Salmon, an annual average of 99.2% of the Coho Salmon run has been estimated upstream of the counting station. The SRFCF is a good tool for measuring the proportion of the run that migrates upstream of the canyon, but it does not measure tributary connectivity or mainstem connection upstream of the counting station.

During 2013, 2,752 Coho Salmon were observed migrating upstream of the counting station and had extremely limited access to tributaries, forcing almost the entire 2013 run to spawn in the main stem Scott River. It was estimated that Coho Salmon had access to the lower quarter mile of spawning habitat downstream of a low flow barrier in French Creek (Yokel 2014). Shackelford Creek briefly connected to the mainstem Scott River on November 22, 2013 for roughly two days allowing temporary access for Coho Salmon. Redd surveys during the 2013-2014 season documented 97% of the Coho Salmon spawning occurred in the mainstem Scott River. The remaining 3% of Coho Salmon redds were documented in French Creek (2.5%) and Shackelford Creek (0.5%) (Yokel 2014). During the fall and winter of 2013-2014 daily mean flows at the Fort Jones gage were less than 60 cfs for the entire Coho Salmon migration period and provided minimal access to tributaries (Yokel 2014). Mean daily flows more than 60 cfs were required to restore effective tributary access for Coho Salmon during the 2013-2014 season.

In 2020 1,309 Coho Salmon migrated through the SRFCF on a storm event November 17-19. The November 17-19 mean daily flows (26.4 cfs) were high enough for Coho Salmon to migrate through the counting station but not to connect the mainstem Scott River just upstream of Shackelford Creek.

Shackleford Creek was connected temporarily during the mid-November storm and some Coho Salmon were observed in Shackelford Creek in the third week of November. The mid November 2020 storm was too small to increase base flows for the season and average daily flows at the Fort Jones gage from November 20-December 12 were 11.3 cfs. In 2020, hundreds of Coho Salmon were staging in the main stem Scott River downstream of Shackleford Creek because the main stem river was dry upstream of Shackelford Creek near the confluence of Oro Fino Creek (Meneks 2021). A winter storm in mid-December connected the mainstem Scott River when Fort Jones gage flows from December 16-31 averaged 89.1 cfs. It is unclear how much beyond December 15th the Coho Salmon run could have staged without spawning. In 2020 significant numbers of Coho Salmon were observed spawning in the French Creek and Shackelford Creek watersheds (Voight 2021).

In-River Productivity

Considerable attempts were made to link Chinook Salmon freshwater productivity, defined as 0+ Chinook produced per returning adult, and flows from specific month and half month periods. This analysis did not yield consistent results indicating that flows alone, for these time periods, are not correlated with in-river productivity for Chinook Salmon in the Scott River. This does not demonstrate a lack of influence of flows on in-river Chinook Salmon productivity, but instead suggests that additional environmental factors likely have a larger effect on production or interact with flow to affect production. Scott River Chinook Salmon return to spawn during low flow periods and have a strong tendency to exhibit an "ocean-type" life history (0+ migration to the ocean shortly after hatching) strategy. Except for the migration and spawning phases when stream flow can be low the majority of their remaining rearing and outmigration phases occur during the highest runoff months of the year.

Coho Salmon in-river productivity, as measured by yearlings (1+) produced per returning adult, was compared with annual discharge. Scott River Coho Salmon have a strong tendency to exhibit an extended freshwater rearing life history relying on freshwater rearing habitat for up to 18 months. For the period of record the two years with the highest annual run-off overlapped with the two years of highest in-river Coho Salmon production (Figure 10). While these observations suggest that wetter water years improve in-river production for Coho Salmon additional analysis is needed to better understand this relationship.

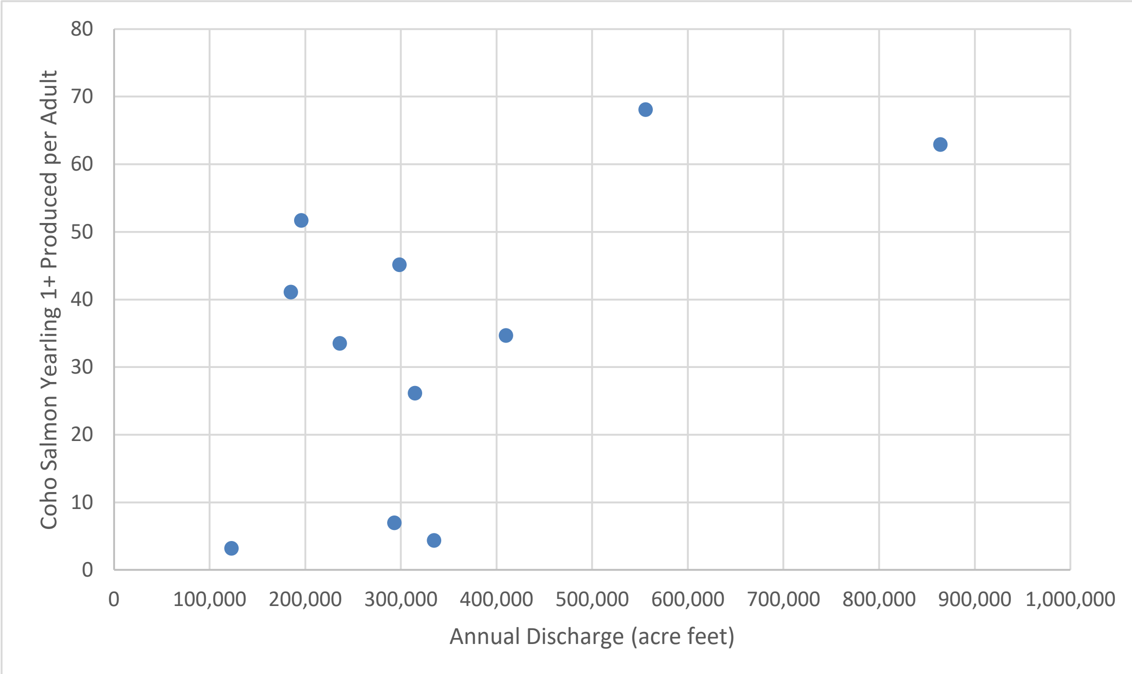

Figure 10. Coho Salmon yearling (1+) produced per returning adult plotted against annual discharge (acre-feet) measured at USGS Fort Jones gage (11519500) for brood years 2007-2014, and 2016-2018.

Summary

This document describes how flow conditions affect annual Chinook Salmon and Coho Salmon migration timing, distribution and rearing conditions. Through this analysis it has been demonstrated that even if the October average daily flows measured at the Fort Jones gage is at or above 22 cfs, roughly only 50% of Chinook Salmon population will migrate upstream of the SRFCF. Additionally, there are significant negative influences on available annual discharge when surface diversions and ground water extractions are not scaled to accommodate differences in water year types ("extremely wet" to "critically dry") The variability of annual discharge directly influences fall migration flows and rearing conditions throughout the year.

During this analysis it was noted that for the period of record the two years with the highest annual discharge corresponded with the two years of highest in-river Coho Salmon juvenile production in terms of recruits per spawner. The capacity of the Scott River to produce Coho Salmon is highlighted in the trajectory of two of the three brood years, but the drastic reduction in brood year 1 indicates how rapidly the population can decline when conditions are poor. Changes in climate and how much and when water is extracted, and crop conversions in recent decades, are resulting in lower base flows than in previous decades when similar amounts of annual discharge were available. Without immediate remedies, mainstem disconnection, tributary disconnection and rearing conditions will continue to be problematic for migrating adult and juvenile salmonids.

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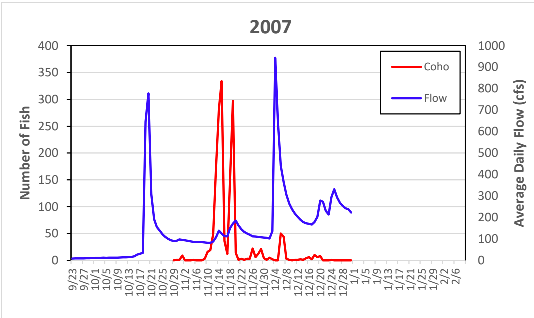
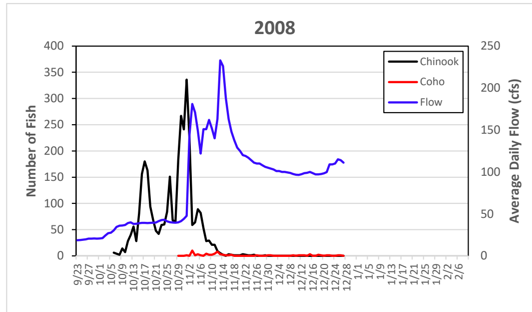
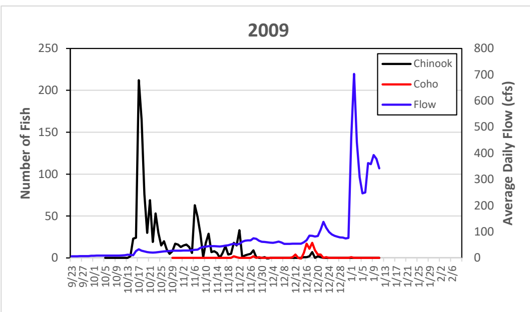
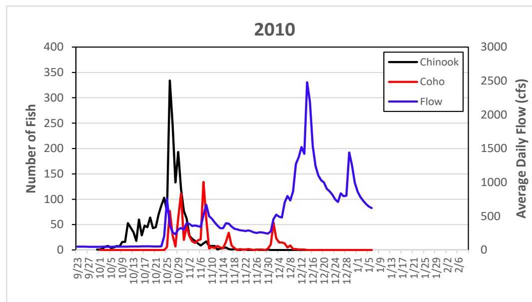
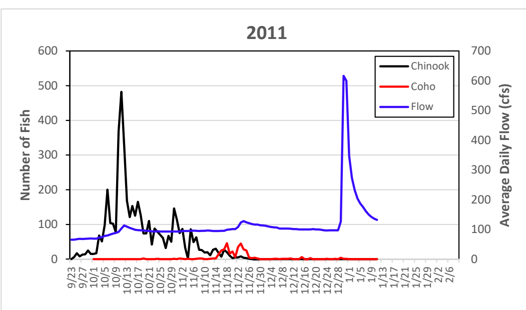
Appendix A. Daily Chinook Salmon and Coho Salmon observations at the SRFCF and daily flow measured at the USGS Fort Jones gage (11519500) from 2007-2020.

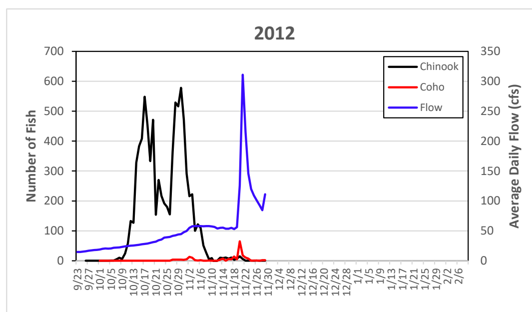


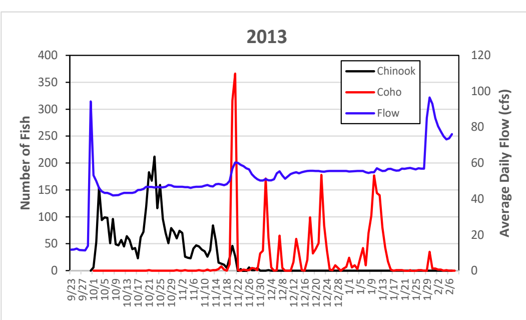


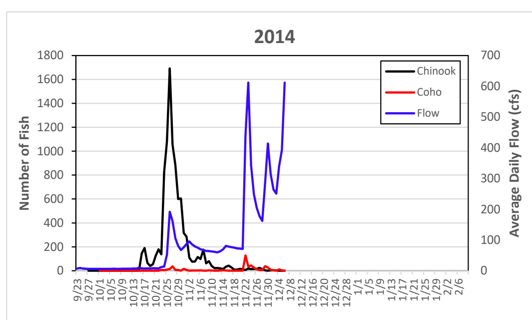




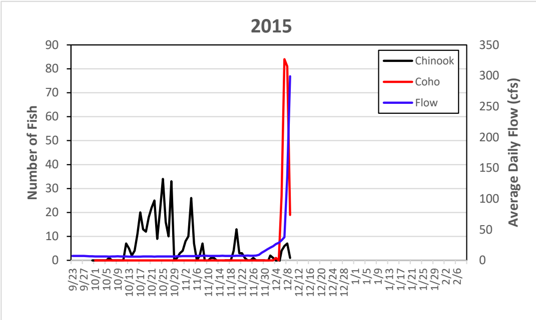


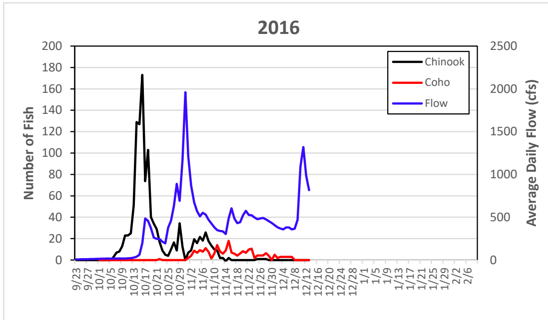


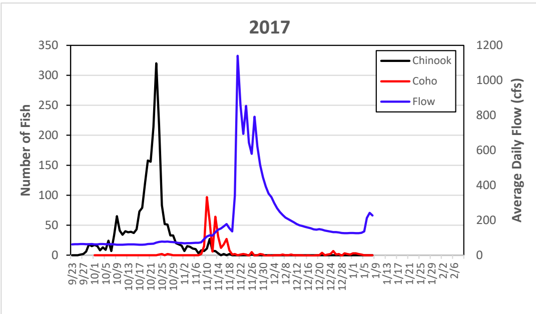


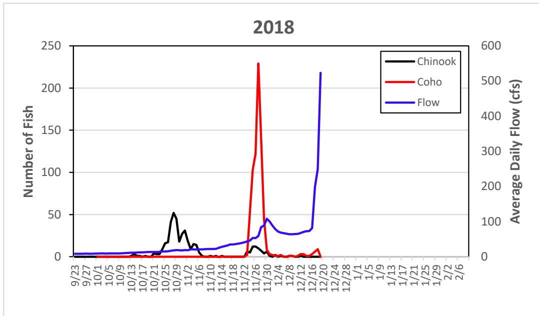


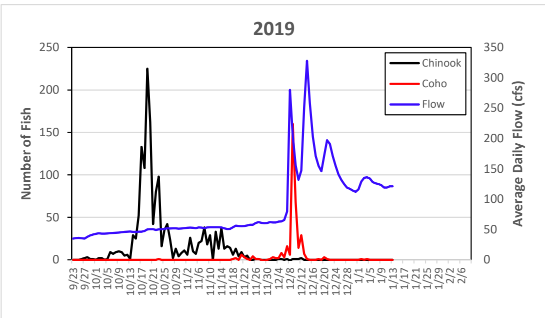
Appendix A. Continued











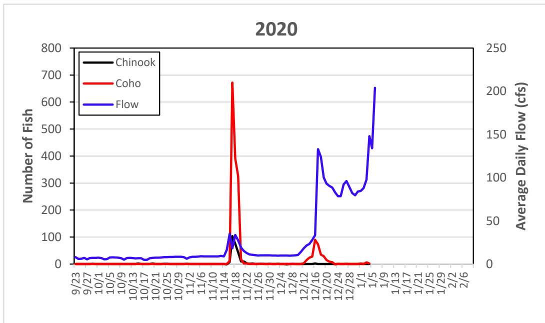


Exhibit D

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Northern Region
601 Locust Street
Redding, CA 96001
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

March 26, 2020

Matt Parker
Natural Resources Specialist
Siskiyou County Flood Control and Water Conservation District
1312 Fairlane Road
Yreka, California 96097

Subject: California Department of Fish and Wildlife Comments to be Considered for the Scott River Valley Basin Draft Groundwater Sustainability Plan

Dear Matt Parker:

The California Department of Fish and Wildlife (Department) Region 1 appreciates the opportunity to provide comments to the Siskiyou County Flood Control and Water Conservation District, designated as the Groundwater Sustainability Agency (GSA), in advance of the preparation of the Scott River Valley Basin (Basin) Draft Groundwater Sustainability Plan (GSP). The GSP will be prepared pursuant to the Sustainable Groundwater Management Act (SGMA). As the trustee agency for the State's fish and wildlife resources, the Department has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of such species (Fish & G. Code §§ 711.7 and 1802).

Development and implementation of GSPs under SGMA represents a new era of California groundwater management. The Department has a strong interest in the sustainable management of groundwater, as many sensitive ecosystems and species depend on groundwater and interconnected surface waters. SGMA and its implementing regulations afford ecosystems and species specific statutory and regulatory consideration, including the following as pertinent to GSPs:

- GSPs shall **identify and consider impacts to groundwater dependent ecosystems** (23 Cal. Code Regs. § 354.16 (g) and Water Code § 10727.4(l));
- GSAs shall **consider all beneficial uses and users of groundwater**, including environmental users of groundwater (Water Code § 10723.2 (e));
- GSPs shall **identify and consider potential effects on all beneficial uses and users of groundwater** (23 Cal. Code Regs. §§ 354.10(a), 354.26(b)(3), 354.28(b)(4), 354.34(b)(2), & 354.34(f)(3));
- GSPs shall **establish sustainable management criteria that avoid undesirable results** within 20 years of the applicable statutory deadline, including **depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water**

(23 Cal. Code Regs. § 354.22 et seq. and Water Code §§ 10721 (x)(6) & 10727.2 (b)) and describe monitoring networks that can identify adverse impacts to beneficial uses of interconnected surface waters (23 Cal. Code Regs. § 354.34 (c)(6)(D)); and

- GSPs shall **account for groundwater extraction for all Water Use Sectors** including managed wetlands, managed recharge, and native vegetation (23 Cal. Code Regs. §§ 351(al) & 354.18(b)(3)).

Furthermore, the Public Trust Doctrine imposes a related but distinct obligation to consider how groundwater management affects public trust resources, including navigable surface waters and fisheries. Groundwater hydrologically connected to navigable surface waters and surface waters tributary to navigable surface waters are also subject to the Public Trust Doctrine to the extent that groundwater extractions or diversions affect or may affect public trust uses (*Environmental Law Foundation v. State Water Resources Control Board* (2018), 26 Cal. App. 5th 844). Accordingly, groundwater plans should consider potential impacts to and appropriate protections for navigable interconnected surface waters and their tributaries, and interconnected surface waters that support fisheries, including the level of groundwater contribution to those waters.

In the context of SGMA statutes and regulations, and Public Trust Doctrine considerations, the Department supports groundwater planning that carefully considers and protects groundwater dependent ecosystems and fish and wildlife beneficial uses and users of groundwater and interconnected surface waters.

General Guidance

The Department is providing guidance on specific information we request be included in the GSP. The Department supports ecosystem preservation and enhancement in compliance with SGMA and its implementing regulations based on Department expertise and best available information and science.

For consideration of fish and wildlife resources during groundwater planning, the Department created documents to assist GSAs with development of the GSP:

- Fish and Wildlife Groundwater Planning Considerations (Attachment 1); and
- Fish and Wildlife Groundwater Planning Considerations: Freshwater Wetlands (Attachment 2).

Both documents can also be downloaded at: www.wildlife.ca.gov/conservation/watersheds/groundwater. Links to relevant information from the Department of Water Resources and State Water Resource Control Board can also be found at this website.

Basin Specific Information

The Department is aware of the following information pertinent to development of the Basin GSP. The Scott River watershed (included in the Klamath River watershed) provides aquatic habitat for four species of anadromous fish: Chinook Salmon, Coho Salmon, Steelhead Trout, and Pacific Lamprey. Additionally, the Scott River watershed also supports populations of bank swallow, western pond turtle, foothill yellow-legged frog, greater sandhill crane, and other bird species that rely on habitats supported and supplemented by both surface water and groundwater.

The Southern Oregon Northern California Coast (SONCC) Evolutionarily Significant Unit (ESU) of Coho Salmon (found in the Klamath River watershed) was listed as "threatened" under the federal Endangered Species Act in 1997, and by the California Fish and Game Commission (Commission) under the California Endangered Species Act (CESA) in 2005. In 2004, the Department published the Recovery Strategy for California Coho Salmon which identifies restoration activities necessary to protect and recover Coho Salmon populations to a sustainable level. Developing target instream flows for the Scott River is identified as a priority recovery task necessary to improve rearing habitat, fish passage, and stream connectivity. In 2014, National Oceanic and Atmospheric Administration - Fisheries released the Final Recovery Plan for the SONCC ESU of Coho Salmon (Recovery Plan). The primary objective in the Recovery Plan is to return Coho Salmon to a level of sustainability, while the highest priority recovery action identified for the Scott River watershed is increased instream flows. Specifically, the recovery tasks address the need to identify instream flow needs and implement a flow needs plan for the Scott River watershed. Low summer and fall streamflows are a major factor limiting survival of juvenile Coho Salmon (CDFG 2004). In 2017, the Department developed a document titled Interim Instream Flow Criteria for the Protection of Fishery Resources in the Scott River Watershed, Siskiyou County, available at the following location: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=143476&inline. The document recommends interim flow criteria to provide protection for the migration, spawning and rearing life stages of salmon and steelhead while considering Basin specific hydrology.

The Scott River is one of the most important Coho Salmon spawning and rearing tributaries in the Klamath River watershed. Scott River is identified by the Department as a high priority watershed for Coho Salmon recovery. Threats to Coho Salmon, such as excessively high-water temperatures in the spring, summer, and early fall, reduce available juvenile rearing habitat. Low flows in the fall and winter can delay adult passage to critical spawning areas.

Many sensitive species and habitats in the Basin comprise groundwater dependent ecosystems (GDEs), the natural communities that rely on groundwater to sustain all or a portion of their water needs. Some of the special status species in the Scott River watershed that rely on surface water supported and supplemented by groundwater include bank swallow, western pond turtle, foothill yellow-legged frog, greater sandhill crane, and other bird species.

Bank swallows were listed as threatened under CESA in 1989. Bank swallows primarily live along bodies of water, such as rivers, streams, reservoirs, and ocean coasts. This species is highly colonial and breeds in nesting burrows that are constructed in near-vertical banks. Their diet consists of aquatic and terrestrial insects that they catch over water bodies and associated floodplain grasslands. Bank swallow reproductive success appears to be positively associated with the previous winter's streamflow, suggesting that higher flows in winter (prior to the initiation of nesting) improve nesting habitat and foraging conditions. If groundwater depletion results in reduced streamflow, the foraging success of bank swallows may be diminished due to the reduced availability of aquatic insects.

The western pond turtle was designated as a California species of special concern (SSC) in 1994. The western pond turtle's preferred habitat is permanent ponds, lakes, streams or permanent pools along intermittent streams, associated with standing and slow-moving water. A potentially important limiting factor for the Western pond turtle is the relationship between water level and flow in off-channel water bodies, which can both be affected by groundwater pumping.

The Northwest/North Coast clade of foothill yellow-legged frog is designated as a SSC. The range and predicted habitat for foothill yellow-legged frog falls within the Basin, as identified in the Department's California Natural Diversity Data Base (CNNDB). Additionally, according to the Department's 2019 document titled "*A Status Review of the Foothill Yellow-Legged Frog (Rana boylii) in California*", foothill yellow-legged frog's historic range falls within the Basin. This species is rarely encountered far from permanent water. Tadpoles require water for at least three or four months while completing their aquatic development. Adults eat both aquatic and terrestrial invertebrates, and the tadpoles graze along rocky stream bottoms. Groundwater pumping that impairs streamflow could have negative impacts on foothill yellow-legged frog populations.

Greater Sandhill crane was listed as threatened in California under CESA in 1983. This species is reliant on freshwater wetlands for breeding, roosting and foraging habitat. Freshwater wetlands may be directly supported by groundwater. The Greater Sandhill crane roosts in shallow ponds, flooded agricultural fields, sloughs, canals or lakes. Cranes forage in wetlands, wet meadows, and wildlife-friendly managed agricultural lands, including pasture, grain crops and alfalfa. Excessive groundwater pumping can lead to a decrease in wetland habitat, which is very important habitat to Greater Sandhill cranes for their breeding, roosting and foraging. When water tables in meadows are lowered as a result of stream incision caused by overgrazing, riparian vegetation removal, or other means, cranes' breeding habitat is adversely affected.

Aquatic habitat within the Basin has been altered by numerous human activities and natural factors, affecting instream conditions, degrading anadromous fish migrating, spawning and rearing habitat, and negatively impacting adjacent riparian and upland slopes throughout the Basin. Alterations to habitat and changes to the landscape include historic beaver trapping, road construction, agricultural practices, river channelization, dams and water diversions, timber harvest, mining/dredging, gravel extraction, high severity fires, groundwater pumping, and rural residential development. Agriculture and related activities are the major land use within the Scott River Valley. Current valley-wide agricultural water diversions, groundwater extraction, and drought, along with historic alterations, have combined to cause surface flow disconnection along the mainstem Scott River. These conditions restrict or eliminate available rearing habitat, elevate water temperature, decrease fitness and survival of over-summering juvenile salmonids, and sometimes result in juvenile fish stranding and mortality. According to Van Kirk and Naman (2008), a large proportion (80 percent or more) of water used for irrigation in the Basin comes from groundwater. During the summer, large portions of the mainstem Scott River become completely dry, leaving only a series of isolated pools inhospitable to salmonids.

The unsustainable use of groundwater can impact the shallow aquifers and interconnected surface waters on which groundwater dependent ecosystems depend and may lead to adverse impacts on fish and wildlife and the habitat upon which they depend. Determining the effects that groundwater levels have on surface water flows in the Basin would provide an understanding of how the groundwater levels may be associated with the health and abundance of riparian vegetation. Poorly managed groundwater pumping and surface water flows have the potential to reduce the abundance and quality of riparian vegetation, reducing the amount of shade provided by the vegetation, ultimately leading to increased water temperatures in the Basin. It is imperative to understand the groundwater hydrology of the Scott River system and its relationship to surface hydrology, especially in areas where groundwater could improve Scott River water temperatures, the health of riparian vegetation, and habitat connectivity for anadromous fish. Additionally, it would be beneficial to evaluate cumulative effects of groundwater and surface water use on the Scott River flows and temperature, particularly between late spring and early fall. Because numerous protected species in the Scott River watershed rely on high quality surface water supplemented by groundwater, both surface and groundwater diversions need to be managed together to effectively to maintain sustainability of the protected species. Additionally, shallow groundwater levels near interconnected surface water should be monitored to ensure that groundwater use is not depleting surface water and affecting fish and wildlife resources in the Basin.

Recommended Tools

To enable Department staff to adequately review and comment on the Scott River Valley Basin GSP, the Department requests the GSA identify and evaluate current and future impacts to fish and wildlife resources and sensitive ecosystems that depend on groundwater and interconnected surface water. In order for the GSA to adequately evaluate impacts to fish and wildlife resources and sensitive resources, we request the following information be included or consulted during GSP development, as applicable:

1. An assessment of groundwater dependent flora and fauna within the Basin area should be conducted, with particular emphasis upon identifying special-status species including rare, threatened, and endangered species. This assessment should also address locally unique species, rare natural communities, and wetlands.

    a. The Department's CNDDB should be searched to obtain current information on previously reported sensitive species and habitat in the Basin. As a reminder, the Department cannot and does not portray the CNDDB as an exhaustive and comprehensive inventory of all rare species and natural communities statewide. Field verification for the presence of sensitive species and habitats will always be an important consideration.

    b. A complete assessment of rare, threatened, and endangered invertebrate, fish, wildlife, reptile, and amphibian species should be presented in the draft GSP. Seasonal variations in use within the Basin should also be addressed. SSC status applies to animals generally not listed under the federal Endangered Species Act or the California Endangered Species Act, but which nonetheless are declining at a rate that could result in listing, or historically occurred in low numbers and known threats to their persistence currently exist.

2. State and Federally Listed Animal Species List http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109405&inline)
3. State and Federally Listed Plant Species Information and List (https://www.wildlife.ca.gov/Conservation/Plants/Info) (http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109390&inline)
4. Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18959&inline=1)
5. California SSC List (https://www.wildlife.ca.gov/Conservation/SSC)
6. Groundwater Resources Hub (https://groundwaterresourcehub.org/)
    a. Identifying Environmental Surface Water Beneficial Users (https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/)
    b. Critical Species LookBook (https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/)
    c. Groundwater Dependent Ecosystems (GDEs) Guidance Document (https://groundwaterresourcehub.org/sgma-tools/gsp-guidance-document/)

   d. Best Practices for Identifying GDEs (https://groundwaterresourcehub.org/public/uploads/pdfs/TNC_NCdataset_BestPracticesGuide_2019.pdf)
   e. GDE Pulse (https://groundwaterresourcehub.org/sgma-tools/gde-pulse/)

7. Drafting SGMA Groundwater Plans with Fisheries in Mind (https://ggucuel.org/wp-content/uploads/CUEL-SGMA-FISHERIES-GUIDEBOOK.pdf)
8. Scott Valley Community Groundwater Study Plan (http://groundwater.ucdavis.edu/files/136426.pdf)
9. Groundwater and Stream Interaction in California's Central Valley: Insights for Sustainable Groundwater Management (https://www.scienceforconservation.org/products/groundwater-and-stream-interaction)
10. Scott Valley Groundwater, various journal articles and reports (http://groundwater.ucdavis.edu/Research/ScottValley)
11. State Water Resources Control Board, SGMA factsheets https://www.waterboards.ca.gov/water_issues/programs/gmp/sgma.html

The Department appreciates the opportunity to provide initial comments on the development of the Scott River Valley Basin GSP. For questions, please contact Region 1 SGMA Coordinator Suzanne Turek at Suzanne.Turek@wildlife.ca.gov. Additionally, you can contact the Klamath Watershed Coordinator Janae Scruggs at Janae.Scruggs@wildlife.ca.gov.

Sincerely,

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Attachment 1.

Fish & Wildlife Groundwater Planning Considerations

California Department of Fish and Wildlife

GROUNDWATER PROGRAM

contents

preface

In 2014, California passed the Sustainable Groundwater Management Act (SGMA) (AB1739, SB 1168, SB 1319), authorizing local groundwater sustainability agencies (GSAs) to develop groundwater sustainability plans (GSPs) for a subset of California's alluvial aquifers. To comply with SGMA, GSAs must achieve sustainable groundwater management, defined by SGMA as the avoidance of locally-defined undesirable results. To achieve sustainability, GSAs must develop and implement effective groundwater management plans that consider the interests of all beneficial uses and users of groundwater, including environmental users of groundwater. [Water Code § 10723.2.]

In many groundwater basins, fish and wildlife that rely on groundwater are among these beneficial uses and users. Many sensitive species and habitats comprise groundwater dependent ecosystems (GDEs), which are natural communities that rely on groundwater to sustain all or a portion of their water needs. The unsustainable use of groundwater can impact the shallow aquifers and interconnected surface waters on which GDEs depend and may lead to adverse impacts on fish and wildlife.

As trustee for California's fish and wildlife resources, CDFW intends to engage as a stakeholder in groundwater planning processes (where resources are available) to represent the groundwater needs of GDEs and fish and wildlife beneficial uses and users of groundwater. The information provided here is intended to help local groundwater planners, groundwater planning proponents and consultants, and CDFW staff work together to consider the needs of fish and wildlife when developing groundwater management plans and implementing SGMA. The document includes three categories of groundwater planning considerations:

- Scientific Considerations;
- Management Considerations; and
- Legal, Regulatory, and Policy Considerations.

Links to additional guidance and considerations developed by CDFW and other organizations that address the impacts of groundwater pumping on GDEs and depletion of interconnected surface water can be found at the end of this document.

Except to the extent that this document directly references existing statutory or regulatory requirements, use of these groundwater planning considerations is not mandated under law and should not be interpreted as a rule, regulation, order, or standard for local groundwater plans. Practical application of these considerations must be based on the best available information and groundwater basin-specific conditions.

Relevance to CDFW Mission

As trustee for the State's fish and wildlife resources, the California Department of Fish and Wildlife (CDFW) has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of such species. [FGC §§ 1802 and 711.7(a).] CDFW has an interest in the sustainable management of groundwater, as many sensitive ecosystems and public trust resources depend on groundwater and interconnected surface waters.

Accordingly, CDFW encourages thoughtful groundwater planning that carefully considers fish and wildlife and the habitats on which they depend. This groundwater planning considerations document focuses on impacts to groundwater dependent ecosystems (GDEs) and interconnected surface waters (ISW), both of which may provide habitat for fish and wildlife and are defined under SGMA as:

GROUNDWATER DEPENDENT ECOSYSTEMS: ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. [23 CCR § 351(m).]

INTERCONNECTED SURFACE WATER:
surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer, and the overlying surface water is not completely depleted. [23 CCR § 351(o).]

SGMA statute and regulations require specific consideration of both GDEs and ISW in the development of a groundwater sustainability plan (GSP). SGMA-governed groundwater plans must:

- **Identify GDEs within the basin** [23 CCR § 354.16(g)];
- Consider **impacts to GDEs** [Water Code § 10727.4(l)]; and
- Address six undesirable results, one of which is **depletions of interconnected surface water** that have significant and unreasonable adverse impacts on beneficial uses of the surface water. [Water Code § 10721(x)(6).]

To encourage GSAs to examine groundwater management impacts on fish and wildlife and the GDE and ISW habitats on which they depend, the CDFW Groundwater Program has catalogued fish and wildlife groundwater planning considerations that address CDFW's key interests.

Key Groundwater Planning Questions

CDFW suggests GSAs consider the following questions during GSP development:

GROUNDWATER DEPENDENT ECOSYSTEMS (GDES)

1. How will groundwater plans identify GDEs and address GDE protection?
2. How will GSAs determine if GDEs are being adversely impacted by groundwater management?
3. If GDEs are adversely impacted, how will groundwater plans facilitate appropriate and timely monitoring and management response actions?

INTERCONNECTED SURFACE WATERS (ISW)

1. How will groundwater plans document the timing, quantity, and location of ISW depletions attributable to groundwater extraction and determine whether these depletions will impact fish and wildlife?
2. How will GSAs determine if fish and wildlife are being adversely impacted by groundwater management impacts on ISW?
3. If adverse impacts to ISW-dependent fish and wildlife are observed, how will GSAs facilitate appropriate and timely monitoring and management response actions?

Groundwater Planning Considerations[1]

CDFW encourages GSAs to think holistically about ecosystem protection and enhancement when designing groundwater plans. The following compilation of fish and wildlife considerations is provided for GSAs to consider during the development of GSPs.

SCIENTIFIC CONSIDERATIONS

The Department of Water Resources GSP Regulations (DWR's Regulations) generally require reliance on 'best available science[2],' consistent with scientific and engineering professional standards of practice. [23 CCR § 351(h).] CDFW relies on ecosystem-based management informed by credible science in all resource management decisions to the extent feasible. [FGC § 703.3.] Accordingly, CDFW expects groundwater plans and supporting documentation to follow 'best available science' practices. Application of the following scientific concepts can improve the likelihood that a groundwater plan will avoid impacts to fish and wildlife beneficial uses and users of groundwater, GDEs, and ISW.

1. Hydrologic Connectivity[3]

Whether terrestrial vegetation can access groundwater and whether surface water is hydrologically connected with groundwater are important determinations in the context of groundwater planning. If hydrologic connectivity exists between a terrestrial or aquatic ecosystem and groundwater, then that ecosystem is a potential GDE and must be identified in a GSP. [23 CCR §354.16 (g).] Aquatic ecosystems reliant on ISW are also specifically relevant to the regulatory requirement to avoid significant and unreasonable adverse impacts to beneficial uses of surface water. [Water Code § 10721 (x)(6).] Hydrologic connectivity between surface water and groundwater, as well as groundwater accessibility to terrestrial vegetation, must therefore be evaluated carefully, and conclusions should be well-supported. Hydrologic connectivity considerations include:

   a. *Connected surface waters:* As defined by DWR's Regulations, ISW are surface waters that are hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. [23 CCR § 351(o).] These waters can receive water from the aquifer, or lose water to the aquifer, depending on hydraulic gradients.
   b. *Disconnected surface waters:* Disconnected streams occur where surface water is not connected by a continuous saturated zone to an underlying aquifer. In disconnected surface water, lowering the groundwater table does not affect the rate of loss from the surface water to groundwater.
   c. *Transition surface waters:* In a transition surface water, the surface waters are hydraulically connected to the underlying aquifer by a capillary fringe[4]. Due to the capillary fringe connection, water table elevation changes can still affect the exchange rate of surface waters[5]. Therefore, in some cases, lowering the groundwater elevation under a streambed without a continuous saturated connection to the underlying aquifer may increase the rate of loss from the surface water body into the underlying aquifer. This potential for increased loss rates during transitional states of connectivity can ultimately increase the area or flow-duration of stream reaches that may be perceived as 'disconnected.'

d. *Terrestrial vegetation:* Many terrestrial plants known as phreatophytes depend on water from shallow aquifers. The depth to which these plants can root and the depth to groundwater collectively determine if the plants can rely on groundwater resources to sustain them. Depth to groundwater fluctuates across seasons and over time, as does plant rooting depth, so connectivity between terrestrial vegetation and shallow groundwater may change over time. Understanding baseline conditions and vegetation groundwater needs across time and species, as well as tolerance for rate of change, can inform groundwater management thresholds.

e. *Geospatial extent of connectivity:* Groundwater interconnectivity with surface water and groundwater accessibility by terrestrial vegetation are impacted by groundwater management regimes that raise or lower the groundwater table. These changes in water table elevation can impact the geospatial extent of connectivity, expanding or decreasing the connected interface. This means gaining and losing stream reaches[6] can grow or shrink in length, and interconnected wetlands and phreatophyte vegetation can grow or shrink in acres of coverage based on changes to groundwater table depth.

f. *Temporal duration of connectivity:* Raising and lowering the groundwater table can also impact the temporal duration of: 1) hydrologic connectivity between the water table and surface waters, and 2) accessibility of groundwater to terrestrial vegetation. Groundwater elevation changes over time can cause transitions from connected/accessible groundwater to disconnected/inaccessible groundwater, and vice versa.

2. Interconnected Surface Water Depletions

ISW depletions attributable to groundwater extraction can occur through two different mechanisms: captured recharge and induced infiltration (described below). Both should be considered when evaluating the possibility of depletions to ISW and establishing ISW sustainability criteria in GSPs. This evaluation is often best accomplished through empirical measurements coupled with numerical modeling.

a. *Captured recharge:* Groundwater withdrawals from aquifers hydrologically connected to surface waters can intercept groundwater travelling downgradient that would otherwise have discharged to surface waters.

b. *Induced infiltration:* Groundwater withdrawal can create a localized cone of depression and induce flow from ISW to groundwater, transforming a previously gaining stream reach to a losing stream reach.

3. Fish and Wildlife Species Water Needs

An evaluation of GDEs and ISW depletions should identify possible impacts to fish and wildlife beneficial uses and users of groundwater and ISW and should consider the following aspects of species water needs across life history phases when defining undesirable results and setting minimum thresholds required by DWR's Regulations.

a. *Temporal Water Needs:* Aquatic and terrestrial species require different quantities and qualities of water at different times and for different durations. There are climate-driven, seasonal variations in water availability to which species are accustomed – for example, migratory water fowl rely on wetlands during fall and spring migrating seasons when surface water was historically available. There are anthropogenic-driven variations in temporal water availability that can compromise species survival – for example, groundwater capture from a stream in summer months caused by irrigation well pumping near a stream can decrease flow, reduce cold groundwater inflows, and increase instream temperatures; thereby degrading cold-water refuge critical to migrating and spawning salmonids. Importantly, groundwater pumping and recharge actions have 'lag' impacts on water availability that are governed by the location and quantity of groundwater extraction as well as aquifer characteristics. Understanding the timing of water availability with respect to species needs across all life history phases will allow groundwater planners to better account for groundwater management impacts to fish and wildlife beneficial uses and users of groundwater and ISW.

b. *Spatial Water Needs:* Similar to temporal water needs, species are sensitive to the location and coverage of ISW and GDE wetland habitat available to them. Wetland geographic coverage dictates associated migratory bird carrying capacities, and specific instream salmonid habitats receiving groundwater inflows can best support spawning and rearing success. Therefore, the location of groundwater extraction and any associated cones of depression can impact GDE and ISW habitats. Wells closer to GDEs and ISW – both laterally and vertically – may have more influence on the location and coverage of available habitat than wells farther away. These spatial relationships between groundwater extraction, and spatial coverage and location of GDE and ISW habitat are dependent on aquifer and well characteristics.

c. *Hydrologic Variability:* Water availability is naturally variable, and many species rely on a degree of hydrologic variability. This variability can be important to cue animal behavior such as spawning, growth, and migration. Groundwater plans should consider how groundwater management influences the hydrologic variability of ISW quality and quantity and what cascading impacts these variations may have on fish and wildlife species and their habitat.

d. *Water Availability:* At a basic level, water available for fish and wildlife species is subject to the same regulatory paradigms and dynamic climate conditions as water available for municipal and agricultural uses. CDFW expects groundwater budget projections to include fish and wildlife water needs and, when possible, anticipate regulatory and climate impacts on water availability.

e. *Water Quality:* Groundwater quality and ISW quality play a significant role in habitat adequacy. Groundwater pumping can impact many components of water quality including water temperature, dissolved oxygen, salinity, turbidity, and contaminants. Pumping can reverse hydraulic gradients and reduce cold and oxygen-rich inflows to ISW, leach soil constituents such as nitrates, and convey underground point source contamination to ISW. Groundwater plans should demonstrate an understanding of how groundwater management actions will affect water quality.

4. Habitat Value

Groundwater management plans that seek to minimize impacts to GDEs and avoid ISW depletion should consider the following:

a. *Connectivity:* Habitat connectivity is a key ecological attribute of thriving ecosystems. A functional network of connected terrestrial and aquatic habitats is essential to the continued existence of California's diverse species and natural communities. Components of natural and semi-natural landscapes must be large enough and connected enough to meet the needs of all species that use them. In identifying and evaluating groundwater management impacts to beneficial uses and users of groundwater, GDEs, and ISW, habitat connectivity impacts should also be considered.

b. *Heterogeneity:* Habitat heterogeneity, such as vegetation age and diversity, is a key ecological attribute of many functional ecosystems and often a predictor of animal species richness. In identifying and evaluating groundwater management impacts to beneficial uses and users of groundwater, GDEs, and ISW; habitat heterogeneity impacts should be considered.

c. *Groundwater Elevation:* Groundwater-dependent habitats, including ISW, are particularly susceptible to changes in the depth of the groundwater. Lowered water tables that drop beneath root zones can cutoff phreatophyte vegetation from water resources, stressing or ultimately converting vegetated terrestrial habitat. Induced infiltration attributable to groundwater pumping can reverse hydraulic gradients and may cause streams to stop flowing, compromising instream dissolved oxygen and temperature characteristics, and eventually causing streams to go dry. The frequency and duration of exposure to lowered groundwater tables and low-flow or no-flow conditions caused by groundwater pumping, as well as habitat and species resilience, will dictate vulnerability to changes in groundwater elevation. For example, some species rely on perennial instream flow, and any interruption to flow can risk species survival. Impacts caused by changes in groundwater elevation should be considered in the evaluation of groundwater management effects on GDEs and ISW.

5. Monitoring Systems

Effective monitoring methods and systems can aid in understanding groundwater management impacts to GDEs and ISW and informing subsequent action. Groundwater planners are encouraged to design robust monitoring systems with meaningful methods for tracking GDE and ISW conditions over time that account for the following monitoring considerations:

a. *Fundamental Components*: An effective monitoring system to evaluate impacts to GDEs and ISW depletions will ideally provide data that is representative of groundwater-dependent habitat throughout the alluvial basin and will be designed to capture geospatial and temporal variability at a scale meaningful to fish and wildlife beneficial uses and users of groundwater and ISW. GSAs should consider frequency of measurements and observation point density to ensure measurements capture seasonal and operational variability. Monitoring methods should follow accepted technical procedures established by the USGS[7,8], (or equivalently robust methods) and reference DWR's best management practices[9].

b. *Early Recognition*: An effective monitoring system to evaluate impacts to GDEs and ISW depletions will be designed to capture early signs of adverse impacts, so that adaptive management can initiate to avoid undesirable results. Early signs of adverse impacts may manifest as stressed phreatophyte vegetation, increased instream temperature, etc.

c. *Meaningful Baselines*: Where historical baseline information on GDEs and ISW is absent, prompt groundwater information collection is critical to understanding the relationship between climatic variations/water year type and groundwater demand/availability. Monitoring systems can help inform baselines that reflect hydrologic variability and that can be used to measure the impact of management actions on groundwater resources.

d. *Interconnectivity Efficacy*: An effective monitoring system to evaluate impacts to GDEs and ISW depletions will be able to identify and help characterize groundwater-surface water interaction by using appropriate methods including but not limited to paired groundwater and streamflow monitoring; seepage measurements; nested piezometers; geochemical and physical property monitoring; and application of monitoring data to water budget calculations, analytical modeling, and numerical modeling.

e. *Monitoring Characteristics*: A groundwater plan may consider tracking a range of GDE and ISW characteristics to determine groundwater management impacts over time. These characteristics include but are not limited to: geospatial and temporal habitat coverage; changes in groundwater interconnectivity status; habitat connectivity, heterogeneity, or density; habitat 'health' (e.g., application of biological indices, remote sensing/aerial imagery); and species/vegetation presence (e.g., biological surveys).

f. *Scalability*: An effective monitoring system will be designed to improve information gaps over time as resources become available; groundwater plans may choose to identify prioritized monitoring locations and systems that can be implemented in phases based on resource availability.

6. Data Quality

Data quality underscores all components of a groundwater plan and subsequent plan updates. Transparent groundwater plans will clearly identify data used to develop plans and include narratives on data collection methods, equipment calibration, quality assurance checks, data processing steps, and on how data were used to inform plan components. Groundwater plans may also choose to identify available data that were not used and explain why it was excluded from analysis.

SCIENTIFIC CONSIDERATIONS		
	✓	Hydrologic Connectivity
	✓	Interconnected Surface Water Depletion
	✓	Fish and Wildlife Species Water Needs
	✓	Habitat Value
	✓	Monitoring Systems
	✓	Data Quality

MANAGEMENT CONSIDERATIONS

CDFW encourages groundwater planners to detail how management actions will consider fish and wildlife beneficial uses and users of groundwater and what management actions will be initiated on what timeline if adverse impacts to fish and wildlife beneficial uses and users of groundwater, GDEs, or ISW are observed. The following are considerations to inform responsive management.

1. Data Gaps and Conservative Decision-Making Under Uncertain Conditions

Current groundwater management suffers from information gaps, but it is expected that groundwater management agencies (local, state, and federal) will develop or expand groundwater monitoring systems to improve information availability over time. Even with existing data gaps, GSAs must avoid significant and unreasonable adverse impacts to beneficial uses of groundwater and ISW. Information shortages should trigger conservative groundwater management decisions that err on the side of caution when it comes to protecting fish and wildlife and their habitats. For example, in determining the presence of GDEs, if hydrologic connectivity with the water table is uncertain, CDFW recommends including a GDE until hydrologic connectivity can be disproven. The same cautionary principle applies to establishing minimum thresholds for sustainability criteria; conservative thresholds have a higher likelihood of avoiding adverse impacts to fish and wildlife beneficial uses and users of groundwater and ISW. For example, groundwater is a critical cold-water reserve for aquatic inhabitants of ISW, and ISW are expected to increase in water temperature under warming climate conditions. The amount of increase in ISW temperature due to climate change is a data gap and sufficient groundwater elevations to buffer increasing ISW temperatures is important to consider.

2. Adaptive Management

Decision-making with imperfect information requires groundwater managers to be agile and responsive to dynamic circumstances. Groundwater plans should detail how groundwater monitoring and management structures will be designed to adapt to changing resource conditions and information availability. Plans should include discussions on how and on what timeline adverse impacts will be addressed, if observed. Plans should also consider implementation of adaptive management strategies to account for 'lag' impacts wherein groundwater responses to changes in management regimes are delayed due to aquifer characteristics. 'Lag' effects may necessitate conservative aquifer-rebound timeline projections.

3. **Prioritized Resource Allocation**
   With limited resources available, groundwater planners may choose to allocate available monitoring and management resources (e.g., DWR Technical Support Services funding) to prioritized GDEs and ISW. Prioritization may reflect criteria such as habitat value or vulnerability, species dependency, and/or 'indicator' GDEs or ISW.

4. **Multi-Benefit Approach**
   Groundwater planners are encouraged to design project and management actions for multiple-benefit solutions, including habitat improvements. Evaluation of supply augmentation management actions (e.g., managed aquifer recharge) and demand reduction management actions (e.g., limitations on groundwater extraction) may include a quantification of impacts on GDEs and ISW to justify actions that serve multiple beneficial uses and users of groundwater. Planners may also consider marginal cost increases in project and management actions to optimize habitat outcomes, thereby broadening funding opportunities, such as recharge projects that contribute both to aquifers as well as instream flow.

MANAGEMENT CONSIDERATIONS		
	✓	Data Gaps and Conservative Decision-Making Under Uncertain Conditions
	✓	Adaptive Management
	✓	Prioritized Resource Allocation
	✓	Multi-Benefit Approach

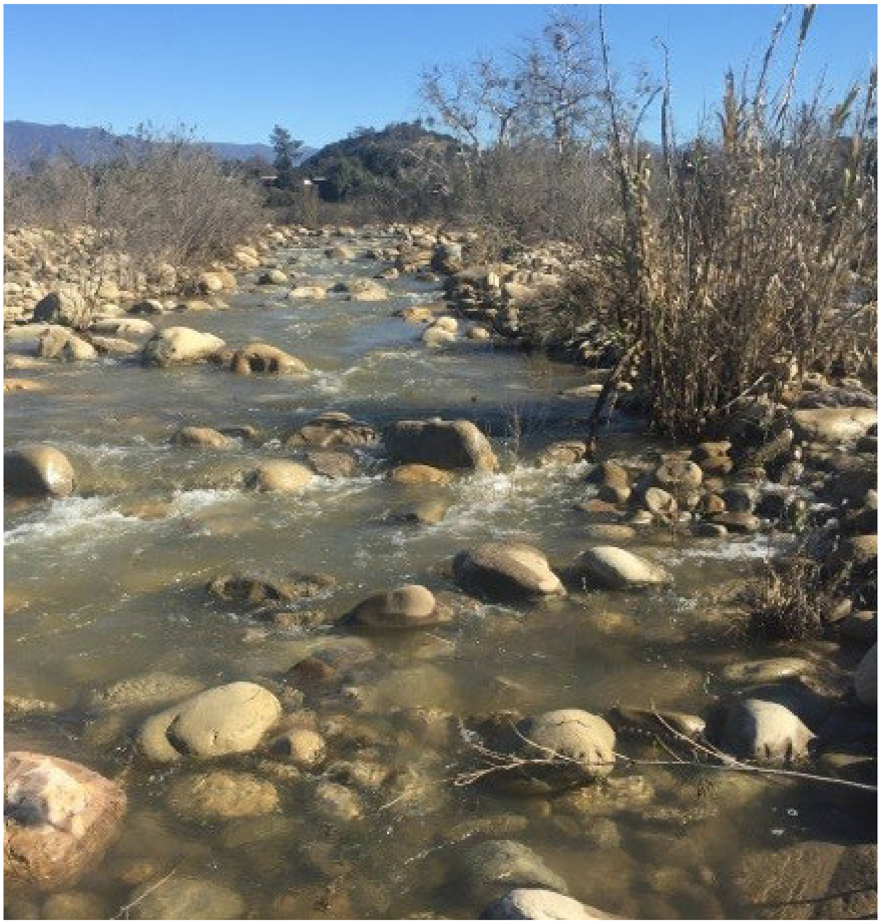
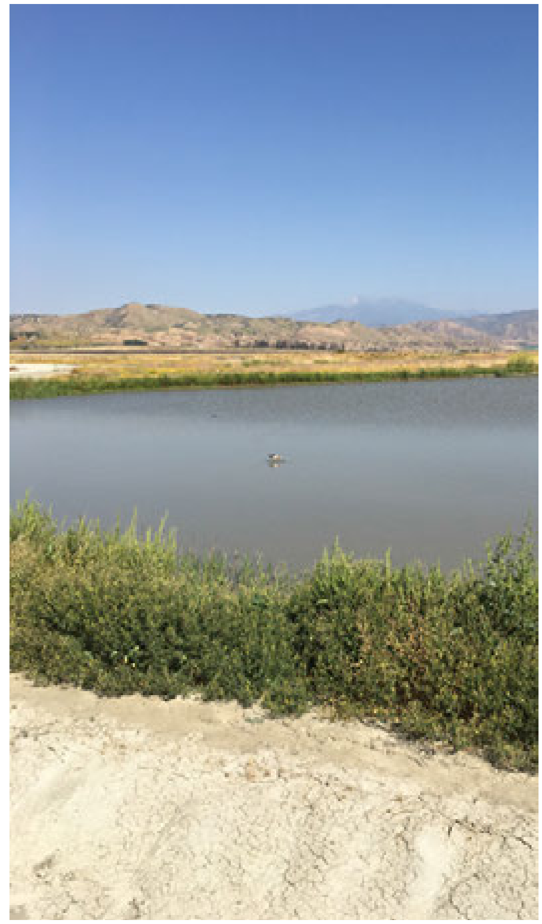
LEGAL, REGULATORY, AND POLICY CONSIDERATIONS

Apart from SGMA requirements, there are numerous laws, regulations, and policies that protect fish and wildlife. The following compilation is provided for GSAs to consider during the development and implementation of groundwater plans. Where applicable and reasonable, GSAs should consider the list below to ensure compliance with existing laws, regulation, and policies. These include but are not limited to:

1. **California Endangered Species Act (CESA), Federal Endangered Species Act (ESA)**
   GDEs and ISW in SGMA-regulated basins contribute to habitat for over 120 federal or State-listed Threatened and Endangered (T&E) species. GDEs and ISW in SGMA-regulated basins also overlap with federally-designated Critical Habitat, areas that contain features essential to the conservation of T&E species. Groundwater management decisions in basins with T&E species and/or Critical Habitat should evaluate groundwater management impacts to species and habitats of concern.[10]

2. **Lake and Streambed Alteration (LSA)**
   The Fish and Game Code requires an entity to notify the Department prior to commencing any activity that may substantially divert or obstruct the natural flow of, or substantially change or use the material from the bed, channel, or bank of any river, stream, or lake, or deposit debris, waste, or other materials where it could pass into any river, stream, or lake. An LSA Agreement is required when the activity may substantially adversely affect existing fish and wildlife resources.

3. **California Environmental Quality Act (CEQA)**
   Groundwater plans developed under SGMA are exempt from CEQA. However, project and management actions needed to achieve basin sustainability are subject to CEQA. CDFW will likely have a CEQA review and permitting nexus with groundwater project and management actions (e.g., Incidental Take Permits, Lake and Streambed Alteration Agreements, etc.). Accordingly, CDFW will expect CEQA lead agencies to thoroughly address proposed groundwater management project impacts (i.e., 'significant effects') to GDEs and ISW.

4. **Public Trust Doctrine**

Public trust resources entitled to protections under the Public Trust Doctrine include navigable surface waters and fisheries. Tributary waters, including groundwater hydrologically connected to navigable surface waters and surface waters tributary to navigable surface waters, are also subject to the Public Trust Doctrine to the extent that extractions affect or may affect public trust uses. Accordingly, groundwater plans should consider public trust protections for navigable ISW and their tributaries, and ISW that support fisheries, including the level of groundwater contribution to those waters.

5. **Clean Water Act and Porter Cologne Act**

Water quality degradation, one of the six sustainability indicators required in SGMA groundwater sustainability plans, is also governed by the Clean Water Act and Porter-Cologne Act and has a significant impact on habitat viability. GDEs and ISW are vulnerable to groundwater quality shortcomings. For example, groundwater pollutants can be taken up by phreatophytic vegetation in GDEs or flow into gaining streams. Groundwater extraction can also compound existing ISW water quality impairment designations under the Clean Water Act. For example, reduced streamflow recharge from depleted aquifers can exacerbate temperature and algae Total Maximum Daily Loads. In addition, the preservation and enhancement of fish, wildlife, and other aquatic resources are designated as beneficial uses under the Porter-Cologne Act. Groundwater extraction could cause or exacerbate temperature or other water quality conditions for those uses. Thorough groundwater plans will consider groundwater quality impacts under the Clean Water Act/Porter Cologne Act.

6. **State, Federal, Tribal Protected Lands and Waters**
   Lands and waters governed by state, federal, and tribal governments are held in the protection of the public trust, including CDFW Wildlife Areas, Ecological Reserves, and conservation easements. These lands merit specific consideration and protection in groundwater plans to ensure no adverse impacts occur to the GDEs and ISW on these lands so they can continue to meet their habitat management objectives. This policy consideration applies to groundwater allocations and groundwater fees – public lands providing valuable habitat should be considered for categorical allocations or pricing that allow the lands to continue to serve their public functions successfully.

7. **Instream Flow Requirements/Recommendations**
   The State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCBs) enforce legally-mandated instream flow requirements, such as the instream flow requirements for cannabis compliance gages[11]. CDFW and other environmental organizations develop instream flow recommendations based on field measurements, desktop analyses, and species/habitat needs. Both instream flow requirements and instream flow recommendations can inform development of sustainability criteria (e.g., minimum thresholds) in groundwater plans to help prevent the occurrence of undesirable results. Because flow requirements and/or recommendations represent thresholds beyond which adverse impacts to water rights holders and/or aquatic species are expected to occur, they should be considered in groundwater plans.

8. SWRCB Water Quality Control Plan

The SWRCB adopted a Water Quality Control Plan in December 2018 for the Bay Delta: San Joaquin River Flows and Southern Delta Water Quality, which set new regulatory requirements for instream flow. The Lower San Joaquin River flow requirements, as adopted[12], would provide a range of 30 to 50 percent of unimpaired flow from February through June in the Merced, Tuolumne, and Stanislaus Rivers. Groundwater plan water budgets and projections should account for these instream flow regulatory requirements accordingly.

9. California Water Action Plan (WAP)

The California Natural Resources Agency state-wide WAP identifies a list of actions to support reliable water supply in California for all beneficial uses and users and calls for the protection and restoration of important ecosystems. Among priority efforts is ensuring sufficient water for wetlands and waterfowl and enhancing water flows in streams statewide. These statewide priorities should be reflected in groundwater planning for GDEs and ISW.

10. California Biodiversity Initiative[13]

This initiative addressing Executive Order B-54-18 seeks to work across agencies and organizations to secure California's biodiversity benefits for the State's short- and long-term environmental and economic health. Two key groundwater-related facets of this initiative are: 1) improving understanding and protection of the State's native plants, and 2) managing lands and waters to achieve biodiversity goals. This initiative supports CDFW's interest in planning for the conservation of non-listed rare plants and species of concern, in addition to T&E species, and should be reflected in groundwater plan GDE considerations.

LEGAL, REGULATORY AND POLICY CONSIDERATIONS		
	✓	California Endangered Species Act, Endangered Species Act
	✓	Lake and Streambed Alteration
	✓	California Environmental Quality Act
	✓	Public Trust Doctrine
	✓	Clean Water Act/Porter Cologne Act
	✓	State, Federal, Tribal Protected Lands and Waters
	✓	SWRCB Water Quality Control Plan
	✓	Instream Flow Requirements/Recommendations
	✓	California Water Action Plan
	✓	California Biodiversity Initiative

Resources

CDFW RESOURCES

The following CDFW resources are publicly available to help identify, prioritize, and protect GDE and ISW habitats and the species therein in the context of groundwater planning processes. These reports, programs, plans, and tools are best used in conjunction with groundwater planning resources from other organizations and agencies (see Additional Resources).

1. **California State Wildlife Action Plan (2015 Update; SWAP)**
   SWAP identifies priorities for conserving California's aquatic and terrestrial resources and includes habitat conservation targets by geographic area. Among SWAP goals are*: maintain and enhance the integrity of ecosystems by conserving key natural processes and functions, habitat qualities, and sustainable native species population levels*; and *integrate wildlife conservation with working landscapes and environments*. Groundwater is specifically recognized as a critical component of habitat connectivity and water quality, quantity, and availability goals for enhancing ecosystems.

2. **CDFW Instream Flow Program**
   The CDFW Instream Flow Program conducts instream flow studies and establishes instream flow recommendations pursuant to PRC § 10000. Instream flow studies are carried out based on statewide stream priorities, including Water Action Plan priorities. The studies assess the amount and timing of surface water flow and collect data to recommend flow regimes required to maintain healthy aquatic resources. Groundwater planners are encouraged to cross-reference groundwater plan development (including water budgets and surface water-groundwater models) with CDFW's Instream Flow Program data and recommendations. Specifically, groundwater planners may wish to consider instream flow criteria and recommendations detailed in the program's technical reports to inform surface water depletion undesirable result definitions and monitoring approaches.

3. **California National Diversity Database (CNDDB)**
   CNDDB inventories narrative and geospatial information on the status and locations of rare plants and animals in California. The CNDDB spatial data can be downloaded as a shapefile or accessed via the Biogeographic Information and Observation System (BIOS) Data Viewer, a system designed to enable the management, visualization, and analysis of biogeographic data. This tool may inform GDE and ISW identification and prioritization for monitoring and protection. Note, CNDDB may not cover all GDEs and ISW, and as a positive detection database, it is not a replacement for on-the-ground surveys. Geographic areas with limited information on CNDDB often signify an absence of survey work. It is therefore inappropriate to imply that rare and endangered plants and animals do not occur in an area due to lack of information in the CNDDB.

4. Areas of Conservation Emphasis (ACE)
ACE contains geospatial data on native species richness, rarity, endemism, and sensitive habitats for six taxonomic groups: birds, fish, amphibians, plants, mammals, and reptiles. ACE also summarizes information on the location of four sensitive habitat types (i.e., wetlands, riparian habitat, rare upland natural communities, and high-value salmonid habitat) which may inform the identification of GDEs and ISW and integration of habitat protection into groundwater plans.

5. Vegetation Classification and Mapping Program (VegCAMP)
VegCAMP develops and maintains maps classifying vegetation and habitat in the state to support conservation and management decisions at the local, regional, and state levels. This tool may help identify and prioritize GDEs, as well as provide information regarding their vegetation composition. Note, the tool may not map all GDEs.

6. Natural Community Conservation Plans (NCCP)
NCCP identify and provide for the regional protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. Not all groundwater basins intersect an approved (n=16) or developing (n=10+) NCCP. Where groundwater basins do intersect an NCCP, the NCCP may be referenced to identify local habitat priorities and protections that may inform GDE and ISW monitoring and management.

7. Regional Conservation Investment Strategies (RCIS)
RCIS use a science-based approach to identify conservation and enhancement opportunities that, if implemented, will help California's declining and vulnerable species by protecting, creating, restoring, and reconnecting habitat. These opportunities are paired with investment strategies and mitigation credits to incentivize habitat protection. There is potential for groundwater plans to leverage crediting opportunities with project and management actions that optimize GDEs and ISW for habitat value for fish and wildlife beneficial uses and users of groundwater.

ADDITIONAL RESOURCES

The following resources may also be useful in the development of local GSPs that protect GDEs and ISW for fish and wildlife beneficial uses and users of groundwater and ISW. This list is non-exhaustive, and CDFW does not endorse all aspects of these documents; they are included for information purposes only.

1. *Center for Law, Energy & the Environment, UC Berkeley School of Law. 2018.* Navigating Groundwater-Surface Water Interactions under SGMA. A report on legal and institutional questions on groundwater-surface water interactions under SGMA.

2. *Community Water Center. 2019.* Guide to protecting Drinking Water Quality Under the Sustainable Groundwater Management Act. A factsheet to address best management practices for drinking water concerns.

3. *Department of Water Resources. 2018.* Natural Communities Commonly Associated with Groundwater Dataset. A map viewer and data-base allowing viewing and download of Vegetation and Wetland layers that are contained in the Natural Communities Commonly Associated with Groundwater dataset.

4. *Department of Water Resources. 2018.* [SGMA Data Viewer]. Online mapping tool displaying a variety of datasets related to the SGMA sustainability indicators.

5. *Environmental Defense Fund. 2018.* [Addressing Regional Surface Water Depletions in California]. A proposed approach for SGMA compliance on the avoidance of depletions of ISW that have significant and unreasonable adverse impacts on beneficial uses of surface water.

6. *Golden Gate University Center on Urban Environmental Law. 2018.* [Drafting SGMA Groundwater Plans with Fisheries in Mind]. A guidebook for using SGMA to protect fisheries.

7. *Stanford University. 2018.* [Guide to Compliance with California's SGMA]. A guide on how to avoid the "undesirable result" of "significant and unreasonable adverse impacts on beneficial uses of surface waters."

8. *The Nature Conservancy. 2014.* [Groundwater and Stream Interaction in California's Central Valley: Insights for Sustainable Groundwater Management]. A report providing technical information on the state of streams and groundwater resources in the Central Valley to illustrate the physical inter-relationship between the surface and groundwater.

9. *The Nature Conservancy. 2018.* Considering Nature Under [SGMA: Environmental User Checklist]. A checklist to help ensure that groundwater plans adequately address nature as required under SGMA.

10. *The Nature Conservancy. 2018* [Groundwater Dependent Ecosystems under SGMA]. Guidance for preparing groundwater sustainability plans with careful consideration of GDEs.

11. *The Nature Conservancy. 2018* [GDE Rooting Depth Database]. A maximum-rooting depth database provides information that can help assess whether groundwater dependent plants are accessing groundwater.

12. *The Nature Conservancy. 2019* [GDE Pulse Tool.] Compilation of 35 years of satellite imagery for every polygon in the Natural Communities Commonly Associated with Groundwater Dataset to assess changes in GDEs

13. *Union of Concerned Scientists. 2017.* [Navigating a Flood of Information]. Guidance for evaluating and integrating climate science into California groundwater planning.

Fish & Wildlife Groundwater Planning Considerations Summary

1. CDFW cares about sustainable groundwater management, because groundwater is a critical component of functional ecosystems and habitats, and because it is within CDFW's jurisdiction to conserve, protect, and manage fish, wildlife, native plants and the habitats on which they depend. [FGC § 1802, 711.7(a).] As trustee for California's fish and wildlife resources, CDFW intends to engage in groundwater planning processes (where resources are available) to represent the groundwater needs of GDEs and fish and wildlife beneficial uses and users of groundwater.

2. Groundwater plans should answer key questions about GDEs and ISW including the existence of GDEs and ISW, the determination of adverse impacts attributable to groundwater management, and the identification of appropriate management response actions that minimize or mitigate adverse impacts to GDEs and ISW.

3. GSAs may choose to evaluate and integrate into groundwater plans a range of scientific, management, and legal fish and wildlife planning considerations – complementary to the SGMA statute and regulations – to carefully account for groundwater management impacts to fish and wildlife beneficial uses and users of groundwater.

4. CDFW and other public entities have a variety of publicly available resources that can be used to help identify, prioritize, and protect GDE and ISW habitats and the species therein in the context of groundwater planning processes.

CDFW provides this document only as a consideration in groundwater planning. CDFW is neither dispensing legal advice nor warranting any outcome that could result from the use of these considerations. Following these considerations does not guarantee success of a GSP or compliance with SGMA which will be determined by the Department of Water Resources and the State Water Resources Control Board, or compliance with other applicable laws and regulations. Furthermore, except to the extent that this document directly references existing statutory or regulatory requirements, the information contained herein merely represents considerations, not requirements, that may be considered in light of the individual circumstances of each groundwater plan.

Appendix

FISH & WILDLIFE GROUNDWATER PLANNING CONSIDERATIONS TABLES

The following is a distilled, tabular compilation of fish and wildlife groundwater planning considerations intended to support the development of groundwater sustainability plans (GSPs) that protect fish and wildlife and the groundwater dependent ecosystems (GDEs) on which they depend.

Find the complete Fish and Wildlife Groundwater Planning Considerations Document here: https://www.wildlife.ca.gov/Conservation/Watersheds/Groundwater.

Scientific Considerations	
CDFW expects groundwater plans and supporting documentation to follow 'best available science' practices, including careful application of scientific concepts to help avoid adverse impacts to fish and wildlife beneficial uses and users of groundwater.	
HYDROLOGIC CONNECTIVITY	Whether terrestrial vegetation can access groundwater and whether surface water is hydrologically connected with groundwater are important determinations in the context of groundwater planning. If hydrologic connectivity exists between a terrestrial or aquatic ecosystem and groundwater, then that ecosystem is a potential GDE and must be identified in a GSP. Changes in geospatial extent and temporal groundwater interconnectivity of these ecosystems can impact their habitat value to fish and wildlife.
SURFACE WATER DEPLETIONS	Interconnected surface water (ISW) depletions attributable to groundwater extraction can occur through two different mechanisms: captured recharge and induced infiltration. Both should be considered when evaluating the possibility of depletions to ISW and establishing ISW sustainability criteria in GSPs.
FISH AND WILDLIFE SPECIES WATER NEEDS	An evaluation of GDEs and ISW depletions should identify possible impacts to fish and wildlife beneficial uses and users of groundwater and should consider a range of species water needs across life history phases including basic spatial and temporal water availability, as wells as sufficient hydrologic variability and water quality.
HABITAT VALUE	GSPs that seek to minimize impacts to GDEs and avoid ISW depletion should contemplate impacts to habitat characteristics including habitat connectivity, heterogeneity, and sensitivity to groundwater elevation changes.
MONITORING SYSTEMS	Effective monitoring methods and systems can aid in understanding groundwater management impacts to GDEs and ISW and inform subsequent action. An effective monitoring system will provide data representative of groundwater-dependent habitats throughout the alluvial basin and will be designed to capture geospatial and temporal variability at a scale meaningful to fish and wildlife beneficial uses and users of groundwater and ISW. Robust monitoring systems will be scalable; and capable of identifying early signs of adverse impacts, informing baselines, and characterizing interconnected surface waters.
DATA QUALITY	Data quality underscores all components of a groundwater plan and subsequent plan updates. Transparent groundwater plans will clearly identify data used to develop plans and include narratives on data collection methods, equipment calibration, quality assurance checks, data processing steps, and on how data was used to inform plan components.

Management Considerations

CDFW encourages groundwater planners to detail how management actions will consider fish and wildlife beneficial uses and users of groundwater and what management actions will be initiated on what timeline if adverse impacts to fish and wildlife beneficial uses and users of groundwater, GDEs, or ISW are observed.

CONSERVATIVE DECISIONS UNDER UNCERTAIN CONDITIONS	Information gaps common to groundwater management should inspire conservative groundwater management decisions that err on the side of caution when it comes to protecting fish and wildlife and their habitats.
ADAPTIVE MANAGEMENT	Decision-making with imperfect information requires groundwater managers to be agile and responsive to dynamic circumstances. GSPs should detail how groundwater monitoring and management will be able to adapt to changing resource conditions and information availability.
PRIORITIZED RESOURCE ALLOCATION	With limited resources available, groundwater planners may choose to allocate available monitoring and management resources to prioritized GDEs and ISWs. Prioritization may reflect criteria such as habitat value or vulnerability, species dependency, and/or 'indicator' GDEs or ISWs.
MULTI-BENEFIT APPROACH	Groundwater planners are encouraged to design project and management actions for multiple-benefit solutions, including habitat improvements. Evaluation of supply augmentation and demand reduction management actions may quantify or describe impacts on GDEs and ISW to justify actions that serve multiple beneficial users of groundwater.

Legal, Regulatory, and Policy Considerations

Apart from SGMA requirements, there are numerous laws, regulations, and policies that protect species and habitat and can inform development and implementation of GSPs.

CALIFORNIA ENDANGERED SPECIES ACT, ENDANGERED SPECIES ACT	GDEs and ISWs in SGMA-regulated basins contribute to habitat for over 120 federal or State-listed Threatened and Endangered (T&E) species. Basins with T&E species should evaluate groundwater management impacts to species and habitats of concern.
LAKE AND STREAMBED ALTERATION (LSA)	The Fish and Game Code requires an entity to notify the Department prior to commencing an activity that may substantially divert/obstruct the natural flow of any river/stream/lake.
CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)	SGMA project and management actions necessary to achieve basin sustainability may be subject to CEQA.
PUBLIC TRUST DOCTRINE	Public trust resources entitled to protections under the Public Trust Doctrine include navigable surface waters and fisheries. Tributary waters, including groundwater hydrologically connected to navigable surface waters and surface waters tributary to navigable surface waters, are also subject to the Public Trust Doctrine to the extent that extractions affect or may affect public trust uses.
CLEAN WATER ACT AND PORTER COLOGNE ACT	Water quality degradation, one of the six sustainability indicators required in GSPs, is also governed by the Clean Water Act and Porter Cologne Act and has a significant impact on habitat viability.
STATE, FEDERAL, TRIBAL PROTECTED LANDS AND WATERS	Lands and waters governed by state, federal, and tribal governments are held in the protection of the public trust, including CDFW Wildlife Areas, Ecological Reserves, and conservation easements. These lands merit specific consideration in GSPs.
INSTREAM FLOW REQUIREMENTS/ RECOMMENDATIONS	The State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards enforce legally-mandated instream flow requirements. CDFW and other environmental organizations develop instream flow recommendations based on field measurements, desktop analyses, and species/habitat needs. These requirements and recommendations can inform GSP sustainability criteria.
SWRCB WATER QUALITY CONTROL PLAN	The SWRCB adopted a Water Quality Control Plan in December 2018 for the Bay Delta: San Joaquin River Flows and Southern Delta Water Quality, which set new regulatory requirements for instream flow that inform future water availability.
CALIFORNIA WATER ACTION PLAN (WAP)	The California Natural Resources Agency state-wide WAP identifies a list of actions to support reliable water supply in California for all beneficial users and calls for the protection and restoration of important ecosystems.
CALIFORNIA BIODIVERSITY INITIATIVE	This initiative addressing Executive Order B-54-18 seeks to work across agencies and organizations to secure California's biodiversity benefits for the State's short- and long-term environmental and economic health.

Endnotes

1 CDFW acknowledges that groundwater knowledge and understanding is imperfect and reserves the right to update these groundwater planning considerations as additional information becomes available and knowledge of groundwater systems in relationship to habitat and species needs improves over time.

2 'Best available science' refers to the use of sufficient and credible information and data specific to the decision being made and the time frame available for making that decision. [23 CCR § 351(h).]

3 SGMA states, "the groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans including surface water users, if there is a hydrologic connection between surface and groundwater bodies." [Water Code § 10723.2(f).] SGMA also defines 'significant depletions of interconnected surface waters' as "reductions in flow or levels of surface water that is hydrologically connected to the basin such that the reduced surface water flow or levels have a significant and unreasonable adverse impact on beneficial uses of the surface water." [Water Code § 10735.2(d).] These uses of the term hydrologic connectivity in SGMA may differ from other state and federal wetland identification protocols such as the SWRCB Wetland Delineation methods.

4 The capillary fringe is the area directly above the water table that may hold water in the pores through capillary pressure, a property of surface tension that draws water upward.

5 Cook, P.G., P. Brunner, C.T. Simmons, and S. Lamontagne. 2010. What is a Disconnected Stream?

6 A gaining stream is one in which the stream channel bottom is lower than the adjacent groundwater elevation, meaning water moves from the aquifer into the channel. A losing stream is one in which the stream channel bottom is above the groundwater elevation, and water moves from the channel into the surrounding aquifer.

7 Cunningham, W. L., and C. W. Schalk. 2011. Groundwater Technical Procedures of the U.S. Geological Survey.

8 Rantz, S.E. 1982. Measurement and Computation of Streamflow: Vol. 1. Measurement of Stage and Discharge.

9 Department of Water Resources. Best Management Practices for Sustainable Management of Groundwater.

10 CDFW also seeks protection and preservation of non-T&E species, with specific consideration for Species of Special Concern that directly depend on groundwater for survival.

11 SWRCB. 2018. Cannabis Compliance Gages (Cannabis Policy, Attachment A, Section 4).

12 SWRCB. 2018. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

13 2018. California Biodiversity Initiative. California Natural Resources Agency, California Department of Food and Agricultures, Governor's Office of Planning and Research.

Attachment 2.

FISH & WILDLIFE GROUNDWATER PLANNING CONSIDERATIONS

Freshwater Wetlands

JUNE | 2019

PREFACE

In 2014, California passed the Sustainable Groundwater Management Act (SGMA) (AB1739, SB 1168, SB 1319), authorizing local groundwater sustainability agencies to develop groundwater sustainably plans for a subset of California's alluvial aquifers. This document provides considerations to assist local groundwater sustainability agencies in avoiding or minimizing adverse impacts to freshwater wetland beneficial uses and users of groundwater in local groundwater management planning and implementation. The information provided is intended to help local groundwater planners, groundwater planning proponents and consultants, and California Department of Fish and Wildlife (CDFW) staff work together to protect wetlands as a public trust resource.

WETLANDS

When acting in an advisory role, CDFW typically considers the U.S. Fish and Wildlife Service's definition of wetlands as "…lands transitional between terrestrial and aquatic systems..." that have one or more of the following attributes:

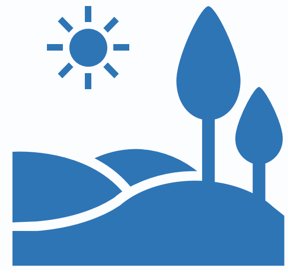
(1) at least periodically, the land supports plants that grow wholly or partially in water;
(2) the substrate is predominantly impermeable or semi-impermeable soil that allows for shallow water retention rather than rapid percolation of surface water to groundwater; and
(3) the substrate is non-soil and is saturated with water or covered by shallow water at some point during the growing season of each year.

It is estimated that California has lost more than 90% of its historical wetlands.[1]

[1] Central Valley Joint Venture Implementation Plan

ECOSYSTEM SERVICES

Wetlands may provide some or all of the following critical ecosystem services:



- purify water by trapping sediments and breaking down pollutants and bacteria;
- recharge groundwater aquifers and contribute to streamflow;
- reduce peak water flows during storm events (flood control);
- store carbon through wetland vegetation and decomposition of organic matter;
- support biodiversity through habitat provision for hundreds of species, including state and federally listed species; and
- buffer climate extremes such as drought and flood.

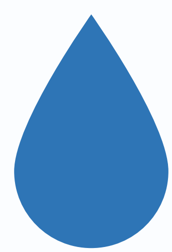
SOCIO-ECONOMIC VALUE

Wetlands may generate some or all of the following socio-economic values:

- sustain migrating waterfowl and fisheries;
- provide recreation opportunities including waterfowl hunting, bird watching, hiking, and fishing;
- remediate polluted waters by removing excess nitrogen and sediment;
- protect eroding streambanks from high velocity flows;
- support food-supply (e.g. rice fields); and
- maintain cultural and aesthetic values of the landscape, including tribal wetland resources.

WETLAND MANAGEMENT CATEGORIES

Wetlands are often categorized based on the timing of flooded habitat and the species they support. Examples of managed Central Valley freshwater wetland types and their beneficiary species are as follows:



- Seasonal wetlands | Typically flooded for 6 months from October through March | Provide habitat for migratory waterfowl and shorebirds | Most abundant wetland in California;
- Semi-permanent wetlands | Typically flooded for 10 months from October through July | Provide critical habitat for breeding waterfowl and shorebirds, and state and federally listed species (e.g. state-listed Tricolored blackbird); and
- Permanent wetlands | Flooded year-round | Provide critical habitat for molting waterfowl and state- and federally listed-species (e.g., giant garter snake).

WATER RESOURCES

Wetlands – naturally-occurring and managed – receive water from precipitation, surface water, and/or groundwater. Most wetlands have seasonal water needs, meaning they require 'flooding' (natural or managed) during specific times of the year. For example, in the Central Valley, many wetlands undergo a fall 'flood-up' wherein wetlands are inundated during the fall, ensuring saturated surface conditions for waterfowl migrating south during the winter.

Naturally occurring wetlands rely on precipitation; surface water over-bank flow during floods; and/or high groundwater tables that intersect the ground surface and cause pooling, constituting a groundwater dependent ecosystem. Managed flooding, relying on surface water diversions and groundwater extraction, is used to mimic historic natural flooding or groundwater seepage which has diminished or ceased entirely under contemporary reservoir management regimes and groundwater resource development.

POLICIES & PROTECTIONS

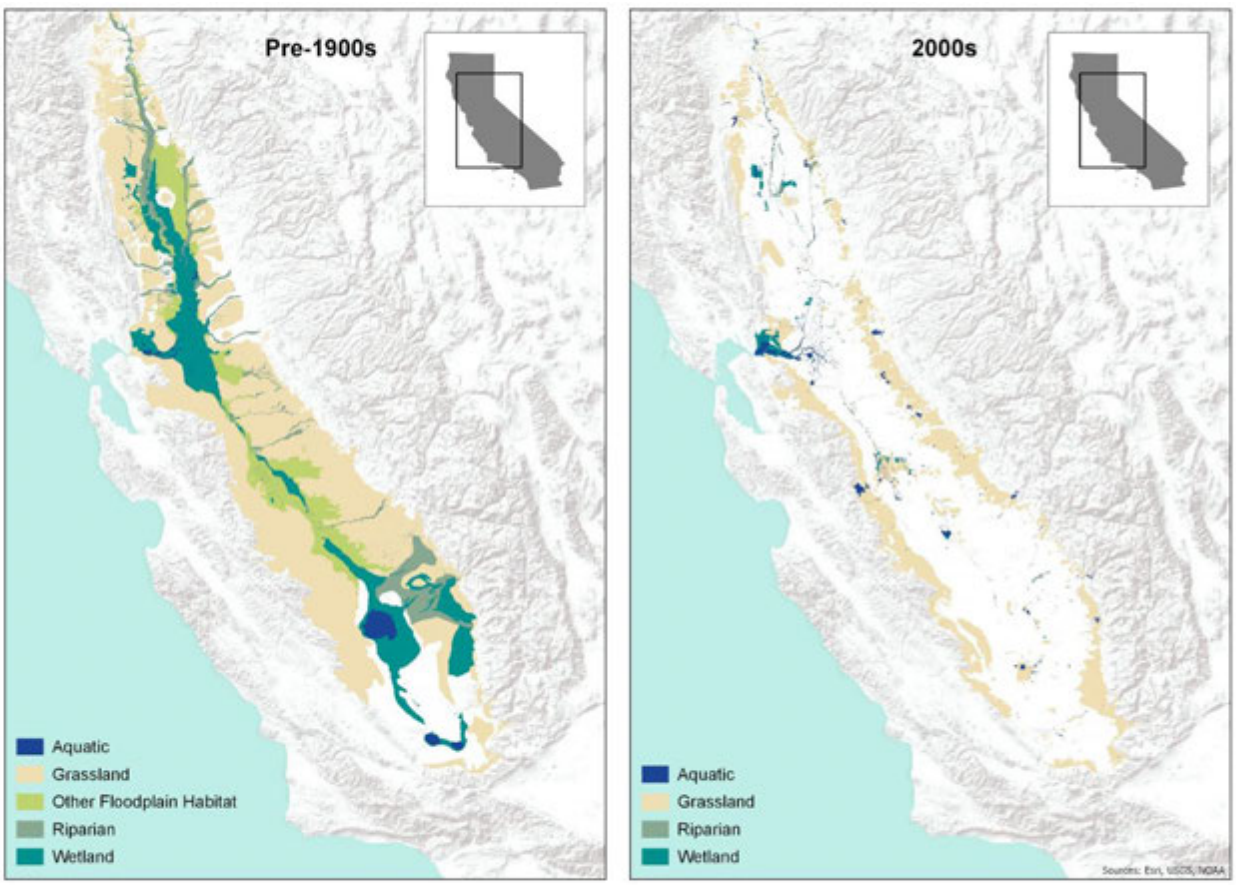
Many policies exist to protect wetlands against further loss and degradation. For example, The Wetlands Conservation Policy (Executive Order W-59-3), also known as the state's "No Net Loss" policy, was an executive order issued in 1993 providing for the coordination of state-wide activities for the preservation and protection of wetland habitats. The State Water Resources Control Board (SWRCB) also adopted a resolution to ensure that wetlands and riparian areas that historically were protected under the federal Clean Water Act remain protected under the state Porter-Cologne Water Quality Control Act (Resolution No. 2019-0015). Wetlands may also be entitled to protection under the public trust doctrine to the extent that public trust resources, including fish and wildlife, depend on them.

In support of wetland goals and in recognition of their value, various state and federal laws, partnerships, and programs are designed to protect wetlands from further decline. These include but are not limited to: Clean Water Act, Central Valley Project Improvement Act, Central Valley Joint Venture, Inland Wetland Conservation Program of the Wildlife Conservation Board, National Wildlife Refuge System – Wetlands of International Importance, State Wildlife Areas, Ramsar Convention on Wetlands, Endangered Species Act – Critical Habitat Designations, United States Fish and Wildlife Service (USFWS) and Natural Resources Conservation Service (NRCS) federal easement programs, State easement programs (e.g., Permanent Wetland Easement Program), and State incentive programs (e.g., California Waterfowl Habitat Program).

CHALLENGES

Despite existing protections, wetland habitats face a range of threats such as development, increasing operations costs, and surface water delivery constraints. A significant number of California wetlands are actively managed, relying upon human intervention to ensure the presence and maintenance of desired wetland habitat conditions. This on-going upkeep requires landowners to have adequate funding for water deliveries and maintenance activities, which can be difficult to secure.

Increased water costs and potential groundwater extraction curtailment, in part resulting from implementation of the Sustainable Groundwater Management Act (SGMA), may pose threats to the continued existence of functional wetlands. Increased costs and decreased water availability may limit landowners' ability to manage wetland habitats to meet necessary ecosystem functions. While lands themselves may be protected from development by fee title purchase or easements, the habitat values on those lands are not necessarily protected from degradation, particularly if they are dependent on managed intervention. An inability to preserve protected lands *and* manage wetlands for habitat outcomes is likely to reduce the abundance and quality of available habitat, leading to species decline.



HABITAT LOSS IN CALIFORNIA'S CENTRAL VALLEY FROM PRE-1900'S TO THE 2000'S. *MAP CREDIT: DUCKS UNLIMITED*

HISTORIC AND CURRENT (CIRCA 1995) AQUATIC/GRASSLAND/RIPARIAN + HISTORIC WETLAND DATA SOURCE: GEOGRAPHIC INFORMATION CENTER. 2003. THE CENTRAL VALLEY HISTORIC MAPPING PROJECT. CHICO (CA): CALIFORNIA STATE UNIVERSITY. AVAILABLE FROM: HTTPS://WWW.WATERBOARDS.CA.GOV/WATERRIGHTS/WATER_ISSUES/PROGRAMS/BAY_DELTA/DOCS/CMNT081712/SLDMWA/CSUCHICODPTOFGEOGRAPHYANDPLANNINGCENTRALVALLEY.PDF

CURRENT (CIRCA 2009) MANAGED WETLAND DATA SOURCE: PETRIK, K., D. FEHRINGER AND A. WEVERKO. 2013. MAPPING SEASONAL MANAGED AND SEMI-PERMANENT WETLANDS IN THE CENTRAL VALLEY OF CALIFORNIA. FINAL REPORT TO THE CENTRAL VALLEY JOINT VENTURE. DUCKS UNLIMITED, INC., RANCHO CORDOVA, CA.

SUGGESTIONS FOR CONSIDERING WETLANDS IN GROUNDWATER PLANNING AND MANAGEMENT

Wetlands are at risk of further decline. Competing water demands are likely to drive up water costs and reduce available water that might otherwise naturally return to a wetland or be applied to a managed wetland. Minimizing the financial and water supply burdens on wetland landowners supports the long-term presence and maintenance of these critical habitats. Groundwater and watershed planning processes should consider the following opportunities to ensure continued ecological and socio-economic benefits generated by wetlands:

- Identify where wetlands are hydraulically connected with the groundwater table to determine the presence of groundwater dependent ecosystems (GDEs); the identification of GDEs is required in SGMA groundwater planning [see, e.g., Water Code § 10727.4(l)].
- Account for natural and managed wetland groundwater use and recharge in water budgets as required by SGMA [Title 23 California Code of Regulations § 351(al), § 356.2(b)(4)]; account for agricultural tailwater inflows to wetlands and wetland outflows to down-stream systems in basin water budgets.
- Monitor wetland coverage over time to track trends and identify relationships to groundwater resources and management practices.
- Credit wetlands for recharge contributions and water quality improvement contributions.
- Consider categorical groundwater pricing or allotments (e.g., reduced groundwater costs for wetlands, or seasonal allotments to meet habitat needs); managed wetlands typically lack the capacity to absorb new costs in the same way as for-profit landowning entities (e.g., some wetlands are enrolled in incentive programs that have contractual obligations such as 'no-profit' clauses).
- Identify opportunities for mutual benefit project and management actions that help recover groundwater levels and that benefit wetland existence (e.g., managed aquifer recharge projects; water supply remediation; addition of semi-permanent wetlands by capturing excess waters from December through April and retaining this water until July or August); targeting multi-benefit actions can assist in identifying funding to implement groundwater management projects.
- Share information about existing wetland incentive programs to private wetlands facing increasing groundwater costs (e.g., California Waterfowl Habitat Program); note that available incentive program funding will support less than one quarter of Central Valley private wetlands through 2028, leaving 75% vulnerable to significant losses).

REFERENCES

1. EcoAtlas. Stream and Wetland Maps. https://www.ecoatlas.org/
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DISCLAIMER: CDFW provides this document only as a consideration in groundwater planning. CDFW is neither dispensing legal advice nor warranting any outcome that could result from the use of these considerations. Following these considerations does not guarantee success of a groundwater plan, compliance with SGMA (which will be determined by DWR and the SWRCB), or compliance with other applicable laws and regulations. Furthermore, except to the extent that this document directly references existing statutory or regulatory requirements, the information contained herein merely represents considerations, not requirements, that may be considered in light of the individual circumstances of each groundwater plan.

Exhibit E

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Northern Region
601 Locust Street
Redding, CA 96001
(530) 225-2300
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

June 15, 2021

Eileen Sobeck
Executive Director
State Water Resources Control Board
1001 I Street, 25th Floor
Sacramento, CA 94814
eileen.sobeck@waterboards.ca.gov

SUBJECT: Minimum Flow Recommendations for the Shasta and Scott Rivers to Inform the 2021 Drought Emergency Regulations

Dear Director Sobeck:

On May 3, 2021, the California Department of Fish and Wildlife (CDFW) transmitted a letter to the State Water Resources Control Board (SWRCB) that there is sufficient scientific information available to begin a long-term flow setting process to protect Coho and Chinook Salmon in the Scott River. On May 10, 2021, Governor Gavin Newsom extended the drought declaration to include the Klamath Basin. On June 1, 2021, the SWRCB sent notices of water unavailability to junior water rights holders in the Scott River watershed in Siskiyou County. The purpose of this letter is to build on the cooperative relationship we have established with your agency, emphasize the importance of providing flows for Coho and Chinook Salmon during this drought emergency, and request drought emergency minimum instream flows for the Scott and Shasta Rivers for the next 12 months.

Recommendations

As the Trustee Agency for California's fish, wildlife, and native plant resources (See, e.g., Fish and Game Code sec 1802) we are providing drought emergency minimum flow recommendations by month for each River as measured at the relevant gages (Table 1). These flow recommendations were developed in consultation with the National Marine Fisheries Service (NMFS) and are not intended to set the stage for long-term management considerations, nor should they be construed to provide adequate protections for salmonids over extended periods of time. They only provide drought emergency minimum flow recommendations for all life stages of salmon during the current drought emergency. These drought emergency minimum flows are intended to enable salmonids in these rivers to survive this dire situation.

Table 1. Drought Emergency minimum flow requirements for the Shasta and Scott Rivers

River (gage)	Daily Minimum Emergency Flow Requirements (cfs)											
	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Shasta (Yreka) USGS 11517500	50	50	125	150	150	135	135	135	70	*50*	*50*	50
Scott (Fort Jones) USGS 11519500	30	*33*	40	*60*	*150*	200	200	200	150	150	125	50

Italicized numbers represent deviations from referenced standards when subject matter experts considered other environmental variables. Implementation of these bare minimum flows may be lifted if CDFW and NMFS subject matter experts agree that reference minimum emergency flows are more than may be necessary to benefit relevant life stages (e.g., migration has ended early).

The Scott River recommendations are strongly influenced by the Klamath National Forest (KNF) adjudicated right to stream flow in the Scott River measured at the USGS gage at Fort Jones. The KNF flow amounts are deemed necessary through the Scott River decree "*to provide minimum subsistence-level fishery conditions including spawning, egg incubation, rearing, downstream migration and summer survival of anadromous fish and can be experienced only in critically dry years without resulting in depletion of fisheries resources*". The Shasta River recommendations are informed by McBain and Trush (2014), and our understanding of available base flows and historic water use. The recommendations deviate from referenced values only when we considered other factors such as the current emergency drought conditions, field notes, and the professional judgment of CDFW and NMFS subject matter experts. A brief background for each river follows:

<u>The Scott River</u>

The Scott River was the focus of the CDFW's May 3, 2021 letter in part because a lack of adequate flows in November and December nearly resulted in a Coho Salmon migration disaster in 2020. We believe that ultimately in mid-December, Coho Salmon managed to access a portion of the available spawning habitat following a long-delayed surface water connection. We will not know until Spring 2022 if that reproductive effort was successful. Our primary concern was that between the Fort Jones gage (USGS 11519500) and Shackleford Creek into mid-December 2020, approximately 1,700 adult Coho Salmon were staging in the mainstem Scott River without access to spawning tributaries.

In Attachment 2 of the May 3, 2021 letter, we also noted that Scott River Chinook Salmon are declining at a faster rate than the Klamath Basin as a whole. The later critical migration period for adult Chinook Salmon migration into the upper Scott River is from October 16-31. Extensive and prolonged groundwater extraction throughout the irrigation season, as well as surface water diversion for stock water generally beginning October 1 in the Scott Valley, further exacerbates low flow barriers during this critical migration period. Since 1980, when the Scott River decree was established, changes have occurred that result in lower base flows than in previous decades when similar amounts of annual discharge were available. These statements are scientifically supported by Attachment 2 (and associated figures/tables). Table 3 of Attachment 2 displays mean September flows at the Fort Jones gage for five water year types separated into two time periods – 1942 to 1979 and 1980 to 2020. For example, prior to 1980 there were four "critically dry" water years and the average September flows during these years was 33.1 cubic feet per second (cfs). After 1980 there have been 11 "critically dry" water years, and the average September flow during these years was 9.7 cfs.

2020 gage information further supports our recommendations in the Scott River that are below the KNF water rights. In November 2020, flows at the Fort Jones gage ranged from 7 to 37 cfs. Shackleford Creek connected to the mainstem Scott River for a few days in mid-November only when flows peaked at 19-37 cfs. Coho Salmon accessed French Creek sometime between December 17 and December 21 when flows ranged between 86 and 131 cfs at the gage, which exceeds the 60 cfs that appears to provide minimal access to tributaries (Yokel 2014). Coho Salmon were able to access Sugar Creek and presumably the upstream Scott River Forks through the “tailings” around January 4 and 5, 2021 when the flows exceeded 149 cfs.

<u>The Shasta River</u>

We cannot overstate the relevance of the Big Springs Complex, Mainstem Shasta River, and other key tributaries that support roughly 10 to 30 percent of Klamath Basin Chinook Salmon population over the last decade (CDFW 2020). This system is also key to supporting spawning and rearing habitat for Klamath Basin Coho Salmon. In the last two years, outmigration conditions for Chinook and Coho Salmon in the Shasta River have been critically impaired. May/June 2021flows have been as low as 3.5 cfs at the Montague gage (USGS 11517000) and 6 cfs at the Yreka gage (USGS 11517500). This represents a new low in the historical record for the Shasta River during this time frame. Worth noting is the correlation of low flows with lethal water temperatures that have occasionally exceeded 25 degrees Celsius.
Based on current conditions, we think it will be nearly impossible to achieve needed flows to support Chinook and Coho Salmon during this emergency

drought without significant improvements to water use practices. For the best available science regarding drought emergency minimum flows, we are referencing McBain and Trush (2014). They used regional regression models, standard setting methods, riffle-crest measurements, 1 and 2-dimensional hydraulic modeling, habitat mapping, and photo documentation to summarize Instream Flow Needs (IFN) at USGS gage 115117500 in table 22 (page 105). Recommended minimum flows for dry conditions resulting from that effort range from 50 to 150 cfs.

Item 6 of the May 10 drought proclamation states "*To the extent voluntary actions are not sufficient, the Water Board, in coordination with the Department of Fish and Wildlife, shall consider emergency regulations to establish minimum drought instream flows*". We support meeting drought emergency minimum flow requirements through voluntary actions. In fact, some landowners have already contributed voluntary flows upon agency request. However, if voluntary actions are not implemented immediately or are not projected to be successful in achieving the drought emergency minimum flows, then curtailment of surface water diversions and ground water withdrawals will be required. We must also continue to address unlawful water diversions, illegal cannabis, and other unreasonable uses.

Action needs to start immediately to minimize delays in surface water connection. We are prepared to meet with you to review the enclosed scientific information that informs our recommendations. If you have any questions regarding this letter, please contact Environmental Program Manager Joe Croteau at joe.croteau@wildlife.ca.gov.

Sincerely,

DocuSigned by:
Tina Bartlett
1D82ADE7303A474...

Tina Bartlett
Regional Manager
Northern Region

ECs page 6

Enclosures

CDFG 1974_Stream Flow Needs for Anadromous Salmonids in the Scott River Basin

Division of Water Rights 1975_Hydrogeologic Conditions Scott Valley

CDFG 1976_ Internal Memo Re: Scott River Adjudication

SWRCB 1976_Proposed Principles for Allocating Water to Various Claimants

McBain and Trush, 2014. Shasta River Canyon Instream Flow Needs Assessment. 221 pg.

Yokel 2014_Scott River Adult Coho Spawning Ground Surveys

Yurok 2015_ An Evaluation of the Anadromous Fish Interim Instream Flow Need for the Lower Scott River, in Siskiyou County, California Phase I, Final Report

2020 Scott Juvenile Salmon Outmigration Study_FINAL

2020 Scott River Salmon Studies Annual Report_FINAL

2020 Shasta Juvenile Salmon Outmigration Study_FINAL

2020 Shasta River Salmon Studies Annual Report_FINAL

May 3, 2021 Attachment 1 - 2017 Flow Report

May 3, 2021 Attachment 2 - Scott River CDFW Memo_FINAL

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California Department of Fish and Wildlife. 2020. Shasta River Salmon Monitoring Report. Prepared for Coastal Monitoring Program. 29 p.

Yokel, D. 2014. Scott River adult Coho spawning ground surveys 2013-2014 Season. Siskiyou Resource Conservation District, Etna, California. Prepared for: United States Fish and Wildlife Service; Agreement #12-CS-11050500-037. 27 p.

ec:

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Exhibit F

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
Vol. 44, No. 4 AMERICAN WATER RESOURCES ASSOCIATION August 2008

RELATIVE EFFECTS OF CLIMATE AND WATER USE ON BASE-FLOW TRENDS IN THE LOWER KLAMATH BASIN[1]

Robert W. Van Kirk and Seth W. Naman[2]

ABSTRACT: Since the 1940s, snow water equivalent (SWE) has decreased throughout the Pacific Northwest, while water use has increased. Climate has been proposed as the primary cause of base-flow decline in the Scott River, an important coho salmon rearing tributary in the Klamath Basin. We took a comparative-basin approach to estimating the relative contributions of climatic and non-climatic factors to this decline. We used permutation tests to compare discharge in 5 streams and 16 snow courses between "historic" (1942-1976) and "modern" (1977-2005) time periods, defined by cool and warm phases, respectively, of the Pacific Decadal Oscillation. April 1 SWE decreased significantly at most snow courses lower than 1,800 m in elevation and increased slightly at higher elevations. Correspondingly, base flow decreased significantly in the two streams with the lowest latitude-adjusted elevation and increased slightly in two higher-elevation streams. Base-flow decline in the Scott River, the only study stream heavily utilized for irrigation, was larger than that in all other streams and larger than predicted by elevation. Based on comparison with a neighboring stream draining wilderness, we estimate that 39% of the observed 10 Mm^3 decline in July 1-October 22 discharge in the Scott River is explained by regional-scale climatic factors. The remainder of the decline is attributable to local factors, which include an increase in irrigation withdrawal from 48 to 103 Mm^3/year since the 1950s.

(KEY TERMS: surface water hydrology; climate variability/change; rivers/streams; Klamath River; salmon; permutation tests.)

Van Kirk, Robert W. and Seth W. Naman, 2008. Relative Effects of Climate and Water Use on Base-Flow Trends in the Lower Klamath Basin. *Journal of the American Water Resources Association* (JAWRA) 44(4):1035-1052. DOI: 10.1111/j.1752-1688.2008.00212.x

INTRODUCTION

Snowmelt is an important contributor to discharge in nearly all major rivers of the western United States (U.S.). Analyses of hydrometeorological data from this region show that climate warming has decreased the percentage of precipitation falling as snow and accelerated snowpack melt, resulting in earlier peak runoff and lower base flows (Hamlet *et al.*, 2005; Mote *et al.*, 2005; Regonda *et al.*, 2005; Stewart *et al.*, 2005; Mote, 2006). These trends may have begun nearly a century ago but are well documented to have occurred over the past 60 years (Hamlet *et al.*, 2005; Mote, 2006). Climate patterns in the Pacific Northwest over this time period have been affected both by long-term, systematic warming and by decadal-scale oscillations (Hamlet *et al.*, 2005;

[1]Paper No. JAWRA-07-0074-P of the *Journal of the American Water Resources Association* (JAWRA). Received June 12, 2007; accepted December 12, 2007. **Discussions are open until February 1, 2009**.

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Regonda *et al.*, 2005; Stewart *et al.*, 2005). In particular, the Pacific Decadal Oscillation (PDO) cycled through a cool phase (increased snowpack and streamflow) from the mid-1940s to 1976 and through a warm phase (decreased snowpack and streamflow) from 1977 through at least the late 1990s (Minobe, 1997; Mote, 2006). Regardless of the degree to which climatic trends since the 1940s reflect short-term *vs.* long-term processes, base flow in Pacific Northwest rain-snow systems is strongly dependent on timing and amount of snowmelt, which is reflected by April 1 snow water equivalent (SWE) (Gleick and Chalecki, 1999; Leung and Wigmosta, 1999; McCabe and Wolock, 1999). Trends in April 1 SWE appear to be driven primarily by temperature, which, along the Pacific Coast, is a function of elevation and latitude (Knowles and Cayan, 2004; Mote, 2006), and secondarily by precipitation (Hamlet *et al.*, 2005; Mote *et al.*, 2005; Stewart *et al.*, 2005).

Concurrent with the observed declines in April 1 SWE over the past 60 years, water use in the Pacific Northwest has increased substantially. Total water withdrawal in California, Idaho, Oregon, and Washington increased 82% between 1950 and 2000, with irrigation accounting for nearly half of this increase (MacKichan, 1951; Hutson *et al.*, 2004). Accordingly, declines in streamflow over the past half century could be caused by a combination of continental-scale climatic factors and watershed-scale increases in water use rather than by climatic factors alone. Although climate models diverge with respect to future trends in precipitation over this region, there is widespread agreement that the trend toward lower SWE and earlier snowmelt will continue (Leung and Wimosta, 1999; McCabe and Wolock, 1999; Miller *et al.*, 2003a; Snyder *et al.*, 2004; Barnett *et al.*, 2005; Zhu *et al.*, 2005; Vicuna *et al.*, 2007). Thus, availability of water resources under future climate scenarios is expected to be most limited during the late summer (Gleick and Chalecki, 1999; Miles *et al.*, 2000). Development and implementation of appropriate water management strategies to deal with these shortages will require distinction between the component of late-summer flow decrease attributable to large-scale climatic factors and that attributable to local-scale changes in water use. Management actions implemented at the watershed or basin scale have the potential to reverse declines in streamflow that have been caused by increased water use but will not reverse those caused by continental-scale climatic factors.

The lower Klamath Basin in northern California (Figure 1) provides an important example of the need to distinguish the effects of climate on observed declines in base flow from those of water use. The Klamath River and its tributaries support populations of anadromous fish species with economic, ecological, and cultural importance. Of these, coho salmon (*Oncorhynchus kisutch*, Southern Oregon/Northern California Coasts Evolutionarily Significant Unit) are listed as threatened under the U.S. Endangered Species Act (Good *et al.*, 2005). In addition,

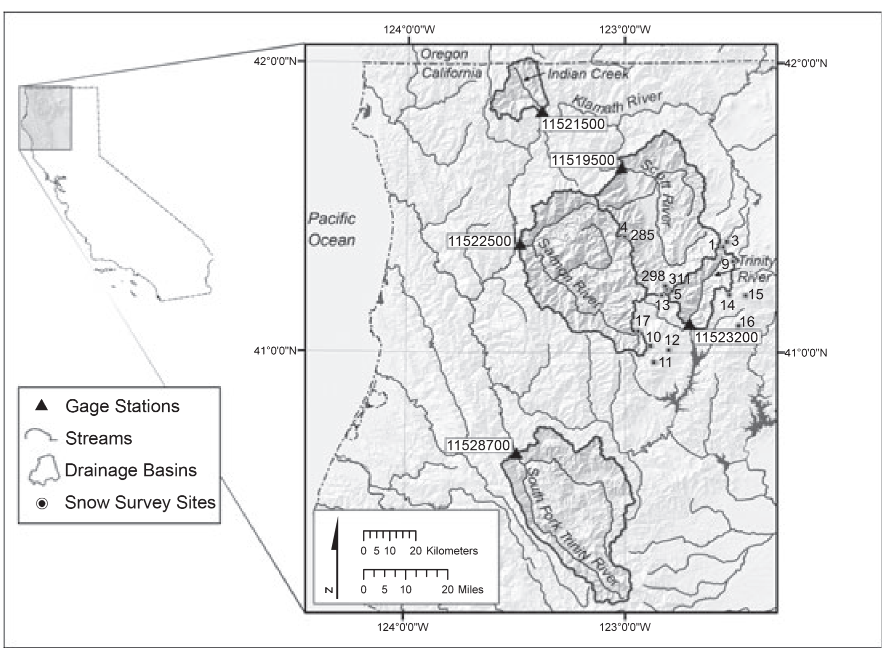

FIGURE 1. Map of Lower Klamath Basin, California, Showing Study Watersheds, Stream Gages, and Snow Courses Used in This Study. Snow course and stream gage numbers correspond to those listed in Tables 1 and 2.

steelhead trout (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*) in the lower Klamath Basin are of special concern or are at risk of extinction (Nehlsen *et al.*, 1991). Habitat degradation, over-exploitation, and reductions in water quality and quantity have been implicated in declines of these species (Nehlsen *et al.*, 1991; Brown *et al.*, 1994; Good *et al.*, 2005). In particular, low late-summer and early fall streamflow in several tributaries is a major factor limiting survival of juvenile coho salmon (NRC, 2003; CDFG, 2004). Increasing late-summer tributary flow is a major objective of coho salmon recovery efforts, particularly in the Scott River (Figure 1), the most important coho salmon spawning and rearing stream in the basin (Brown *et al.*, 1994; NRC, 2003; CDFG, 2004). If reduction in Scott River base-flow has been caused primarily by climatic factors, as has been proposed by Drake *et al.* (2000), then flow objectives for coho salmon recovery may not be attainable through local management, and the success of other recovery objectives (e.g., habitat restoration) may be limited by continued low base flows. On the other hand, if reduction in base flow is due in substantial part to changes in amount, timing and source of water withdrawal, then at least that particular component of flow reduction caused by water-use factors could be mitigated through local management actions.

Research Approach and Objectives

The goal of this study is to distinguish the relative effects of regional-scale climatic factors from those of local-scale factors on trends in late-summer and early fall flows in lower Klamath tributaries, with particular emphasis on the Scott River. We aim to provide water and fisheries managers with information they need to develop realistic and attainable base-flow objectives for fisheries recovery. Ideally, such a study would analyze water-use data, including location and timing of withdrawals, source of water withdrawn (ground *vs.* surface), and rate of consumptive use. Furthermore, in agricultural settings, it is desirable to analyze the type of crops irrigated, method of irrigation application, amount of return flow, and pathways (ground *vs.* surface) by which return flow enters stream channels. Unfortunately, almost no data of these types are available for the watersheds of the lower Klamath Basin, including that of the Scott River, where a large amount of irrigated agriculture occurs. Thus, as an expeditious, first-order attempt to distinguish between effects of climate *vs.* water use on base flow declines, we use statistical analysis of existing SWE and streamflow data from across the basin. Results of this study can then be used to prioritize future data collection and modeling efforts focused more specifically on mechanisms that could explain the observed statistical trends and on the predicted effects of possible management strategies.

We begin with the operating hypothesis that declines in base flow that have been observed in the Scott River are caused primarily by climate trends, as expected based on the large body of climate literature cited above and on the results of Drake *et al.* (2000), the only published study we could find that has addressed this problem. According to this hypothesis, trends in base flow observed in the Scott River should be consistent with those observed in other streams in the lower Klamath Basin, across which climate is relatively uniform. Further, we expect to observe differences in base-flow trends among these streams because of variation in elevation and latitude, which directly influence SWE. Secondary differences in streamflow trends among streams in the basin can then be attributed to local, watershed-scale factors such as land and water use. Although applied here to a specific basin, our methodology has applicability to any river system in which there are at least a few gaged streams unregulated by storage reservoirs. We use permutation tests for our statistical hypothesis tests, but this is not a methodological study intended to compare the results and applicability of these types of tests to those of other types of statistical tests. However, because permutation tests are not widely applied in water resources research, we provide sufficient detail in statistical methods so that they can be adopted by researchers in other basins.

The objectives of this paper are to (1) quantify basin-scale trends in streamflow and SWE in the lower Klamath Basin, (2) analyze the dependence of base flow and SWE trends on elevation and latitude, (3) compare relative change in base flow among different streams in the basin using a paired-basin approach, and (4) use paired-basin correlation analysis to estimate the component of decline in Scott River base-flow that is attributable to regional-scale climatic factors. The difference between this component and the total decline in base flow is attributable to local-scale factors, which we discuss. We also compare our results with those of Drake *et al.* (2000) and discuss implications for fisheries management.

STUDY AREA

We define the lower Klamath Basin as the drainage of Klamath River downstream of the

Oregon-California state line (Figure 1). This coincides approximately with the location of Irongate Dam, which blocks upstream migration of anadromous fish, as well as the point at which the river exits the low-relief, volcanic geology of the Cascade Mountains and enters the high-relief, geologically complex Klamath Mountain and Coast Range provinces. This point is also roughly at the transition between the ocean-influenced climate to the west and the arid, inter-mountain climate to the east.

Elevations in the study area range from sea level to 2,500 m. Annual precipitation ranges from 50 cm in the eastern valleys to over 200 cm at higher elevations. Nearly all precipitation falls from October through April. Precipitation occurs almost exclusively as rain at elevations below 500 m and almost exclusively as snow above 2,000 m. Snowpack generally accumulates throughout the mid-winter to late-winter at elevations exceeding 1,500 m. High relief and impermeable bedrock geology contribute to rapid runoff of both rainfall and snowmelt from upland areas, and ground-water storage is generally limited to relatively small alluvial aquifers immediately adjacent to major streams. Correspondingly, stream hydrographs in the study area are of the rain/snow type (Poff, 1996), characterized by rapidly increasing discharge at the onset of the rainy season, a broad peak lasting most of the winter and spring, and recession beginning in June, once maximum snowmelt has occurred (Figure 2). Base flow, which is generally 1.5 orders of magnitude lower than peak flow, occurs during late summer and early fall. Variability in this pattern across catchments is driven by the relative contribution of rain and snowmelt to runoff, which, in turn, is determined primarily by elevation and latitude, and to a lesser degree by distance from the coast and local topographic features.

To focus on changes in streamflow related to climate change, we limited our analysis to streams that have a continuous record of discharge dating back at least 40 years from the present and are unaffected by storage reservoirs. Only five streams in the lower Klamath Basin met these criteria: the Scott, Salmon, Trinity (upstream of reservoirs), and South Fork Trinity rivers and Indian Creek (Figure 1, Table 1).

All five of the study watersheds are sparsely populated, although population is increasing in some locales, particularly in the South Fork Trinity watershed. Uplands are mountainous areas managed by the U.S. Forest Service. Substantial timber harvest has occurred in all five watersheds, although it has been more limited in the Salmon and Trinity watersheds because of large amounts of federally designated wilderness. Rugged terrain and a preponderance of federal land limit most human activities to narrow river corridors in the Indian, Salmon, and Trinity watersheds. Additionally,

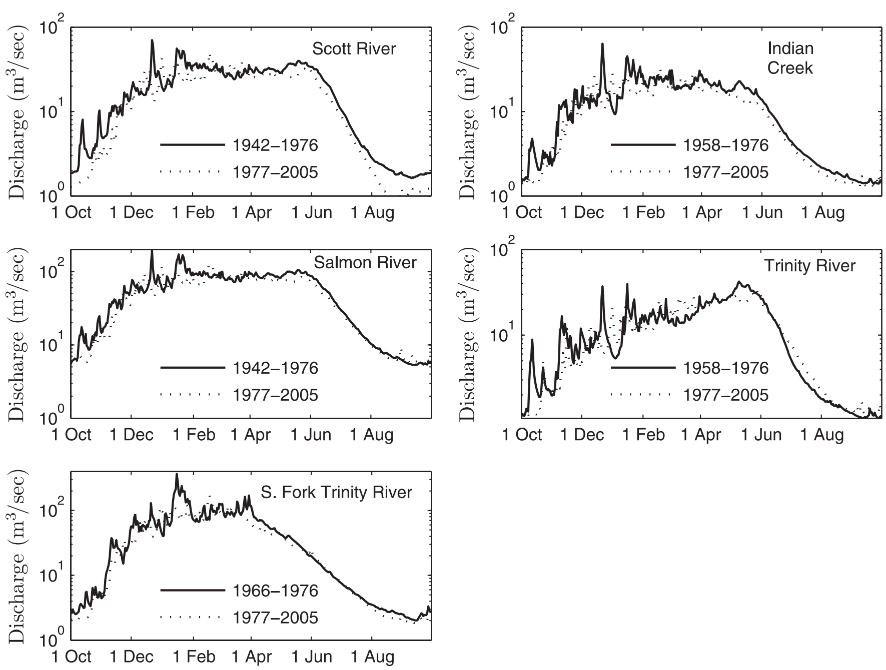

FIGURE 2. Mean Historic-Period and Modern-Period Hydrographs for the Five Study Streams. All streams display a rain-snow hydrologic regime with base flow period during late summer. Discharge is shown on a logarithmic scale to facilitate visual comparison of modern and historic periods at low discharge values. However, statistical comparison of annual and late-summer discharge between periods was performed on untransformed data.

TABLE 1. Study Basin Descriptions and Flow Statistics.

	Scott River	Indian Creek	Salmon River	South Fork Trinity River	Trinity River
USGS stream gage	11519500	11521500	1522500	11528700	11523200
Drainage area (km^2)	1,691	311	1,945	1,979	386
Mean basin elevation (m)	1,688	1,220	1,386	1,378	1,734
Latitude of basin centroid (°N)	41.479	41.904	41.293	40.468	41.228
Earliest year analyzed	1942	1958	1942	1966	1958
Mean annual historic-period discharge (Mm^3)	605.7	403.1	1,744	1,420	385
Mean annual modern-period discharge (Mm^3)	514	345.3	1,517	1,175	361.1
p-value: historic and modern annual discharges equal	0.127	0.116	0.113	0.163	0.294
Mean late summer historic-period discharge (Mm^3)	10.96	9.193	37.04	14.77	7.273
Mean late summer modern-period discharge (Mm^3)	6.541	8.274	37.47	12.08	8.024
p-value: historic and modern late summer discharges equal	<0.001	0.055	0.629	0.049	0.799

Notes: Flow data are from the USGS National Water Information System, http://www.waterdata.usgs.gov/nwis, *accessed* December 2006. Historic period ends in 1976; modern period is 1977 through 2005; p-values are reported for the one-sided alternative hypothesis that modern-period discharge is less than historic-period discharge.

topography prevents substantial agricultural development. The South Fork Trinity watershed supports some agriculture, primarily fruit and vegetable farms, vineyards, and cattle grazing operations. Because agricultural development in the South Fork Trinity watershed is relatively small in scale, few if any data on irrigation withdrawals are available.

Only the Scott watershed contains large areas of private, non-mountainous land that support large-scale agriculture; about 120 km^2 of pasture, grain, and alfalfa are irrigated in the Scott watershed. A typical western-U.S. system of water rights based on the doctrine of prior appropriation governs withdrawal and delivery of surface water for irrigation in the Scott Valley (California Superior Court, 1950, 1958, 1980). Under this type of water rights system, surface water diverted from streams is delivered to water users in order of decreed water right priority date (date on which the claim to put the water to beneficial use was first made; these are typically dates in the mid to late 19th Century in California). Early in the irrigation season, when streamflows are high, all users receive their full allocation of water. As streamflow declines throughout the irrigation season, those users with junior (i.e., more recent) priority dates must cease diversion to leave the available water to users with more senior rights. By the end of a typical irrigation season, only users with the most senior rights continue to divert surface water. The California Department of Water Resources (CDWR) collects some data on irrigation use in the Scott Valley. However, CDWR does not provide watermaster service to account for distribution of decreed surface rights in all areas of the Scott watershed, and withdrawal and distribution of ground water is unregulated.

METHODS

Streamflow and SWE data were available in our study area from the mid-1940s to the present. Given our working hypothesis regarding climate effects and the natural division of this time period into two distinct phases of the PDO (cool from mid-1940s to 1976, warm from 1977 on), we used a two-step comparison approach to analysis of temporal trends (Helsel and Hirsch, 1992). Because streamflow data for the Scott River were first collected in water year 1942, we defined the "historic" period as 1942-1976 and the "modern" period as 1977-2005. We then analyzed differences in SWE and streamflow between these two time periods. We used permutation tests (Ramsey and Schafer, 2002; Good, 2005; see Appendix A) to perform all statistical hypothesis tests. We performed these tests at the $\alpha = 0.05$ significance level.

All of the hypothesis tests involved comparing values of a particular SWE or discharge variable between the historic and modern periods. Although use of permutation tests does not require the data to meet any distributional assumptions, it does require independence of observations (Good, 2005). Thus, we first corrected the data for dependence caused by first-order serial autocorrelation using the correction as

$$x_t = u_t - ru_{t-1}, \tag{1}$$

where x_t is the corrected value of the variable for year t, u_t is the uncorrected value for year t, and r is first-order serial autocorrelation coefficient (i.e., the Pearson correlation coefficient between u_t and u_{t-1} (Neter *et al.*, 1989; Ramsey and Schafer, 2002). We then calculated the test statistic as

$$T = \frac{\bar{x}_1 - \bar{x}_2}{\text{SE}}, \qquad (2)$$

where $\bar{x}_1$ is the mean of the corrected daily discharge values over Group 1, $\bar{x}_2$ is the mean over Group 2, and

$$\text{SE} = s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}, \qquad (3)$$

where s is the pooled standard deviation, n_1 is the number of years in Group 1 and n_2 is the number of years in Group 2. Groups 1 and 2 refer to the complementary subsets into which the data are divided according to a given permutation (see Appendix A). To calculate the value of the test statistic obtained from the data as they occurred in the observed permutation, Group 1 is taken to be the collection of data observed over the modern period of years, and Group 2 is that observed over the historic period, that is,

$$T_{\text{observed}} = \frac{\bar{x}_{\text{modern}} - \bar{x}_{\text{historic}}}{\text{SE}} \qquad (4)$$

Although (Equation 4) is the test statistic of the standard two-sample t-test, we use it instead in permutation tests and as the response variable in regressions. Thus, we refer to it as a generic "T"-statistic.

As we wanted to focus our analysis on the period of days during the base flow period over which declines in discharge in the Scott River have been most apparent, we defined the "late summer" period of base flow based on analysis of the Scott River data at the daily scale instead of defining this period based on visual examination of hydrographs or on a convenient calendar designation (e.g., August and September). We first $\log_{10}$-transformed daily discharge for each individual day between June 1 and November 30. The transformation was performed not to meet the assumptions of the hypothesis test but rather to prevent rare but extreme daily flow events from exerting excessive influence over group mean. We then compared the mean of the transformed discharge between historic and modern periods of years with a permutation test on the T-statistic (see Appendix A). We performed these tests with a two-sided alternative. This analysis showed that the mean of $\log_{10}$-transformed daily discharge (equivalently, the geometric mean) differed significantly between the historic and modern periods on every day of the period August 2 through October 5. We thus defined "late summer" to be this period of consecutive days.

Streamflow and SWE Trends

We tested for differences in total late-summer discharge between historic and modern periods at all five stream gages. For streams on which gaging began after 1942, we defined the historic period to begin with the first year in the period of record (Table 1). Because of the smoothing inherent in averaging daily discharge over the 65-day late-summer period, we did not transform the raw discharge data. These tests were performed with the one-sided alternative that late-summer discharge during the modern period was less than that during the historic period, in accordance with what would be expected based on climate change. We also performed this analysis on annual water-year discharge at each stream gage and on April 1 SWE at all 16 snow courses in the study area for which at least 40 years of data were available (Figure 1, Table 2). For these tests, we also used a one-sided alternative, for consistency with the late-summer for analysis.

Dependence of Base Flow and SWE Trends on Elevation and Latitude

To quantify dependence of change in SWE and streamflow on elevation, we performed permutation regression analysis (see Appendix A) of the observed T-statistic (Equation 4) as a function of elevation. In this case, T_{observed} serves as a dimensionless measure of change in SWE or streamflow between historic and modern periods and thus allows direct comparison of the regression line for streamflow to that for SWE. To incorporate the effect of latitude, we used Mote's (2006) estimate that winter isotherms along the Pacific Coast of North America increase southward at a rate of 137 m in elevation per degree of latitude. We referenced latitude to that of Indian Creek, the furthest north of the study watersheds, and defined latitude-adjusted elevation of a given snow course or study watershed to be

$$E_{\text{adjusted}} = E - 137(L_{\text{Indian}} - L), \qquad (5)$$

where E is the actual elevation of the snow course or watershed (mean over the watershed), E_{adjusted} is the adjusted elevation, L_{Indian} is the watershed-centroid latitude of the Indian Creek watershed, and L is the latitude of the snow course or watershed centroid. Centroids and mean elevations of the drainage basins were computed in a Geographic Information System from Digital Elevation Models. For the SWE analysis, we regressed dimensionless change in April 1 SWE

TABLE 2. Snow Course Descriptions and April 1 Snow Water Equivalent (SWE) Statistics.

Course Number	Elevation (m)	Latitude (°N)	Earliest Year of Record	Mean Historic-Period April 1 SWE (cm)	Mean Modern-Period April 1 SWE (cm)	*p*-Value: Historic and Modern April 1 SWE Equal
17	1,554	41.077	1946	40.3	30.2	0.021
14	1,646	41.150	1947	84.7	90.2	0.666
285	1,676	41.397	1951	104.2	68.2	0.001
15	1,722	41.197	1947	66.2	52.0	0.022
298	1,737	41.233	1956	49.4	44.5	0.224
3	1,783	41.382	1942	37.0	30.0	0.059
4	1,798	41.400	1951	95.0	52.1	<0.001
16	1,838	41.093	1942	55.5	51.5	0.261
13	1,875	41.200	1949	91.1	91.1	0.482
311	1,890	41.225	1949	71.1	72.5	0.568
12	1,951	41.008	1947	127.8	126.7	0.434
11	1,981	40.967	1947	95.2	101.2	0.704
5	2,012	41.217	1946	80.8	81.4	0.524
1	2,042	41.367	1942	95.3	88.4	0.218
10	2,042	41.023	1946	111.7	112.7	0.542
9	2,195	41.318	1946	84.2	86.9	0.634

Notes: Table is sorted by elevation for ease of interpretation. Data are from the California Department of Water Resources snow course database, http://www.cdec.water.ca.gov/misc/SnowCourses.html, *accessed* May 2007. Historic period is earliest year of record through 1976; modern period is 1977 through 2005; *p*-values are reported for the one-sided alternative hypothesis that modern-period SWE is less than historic-period SWE.

against latitude-adjusted snow course elevation. We performed an analogous regression for change in late-summer discharge against latitude-adjusted mean watershed elevation for the five study streams.

Comparison of Relative Base-Flow Decline Among Study Streams

To compare base-flow trends among the five study streams, we used a before after control-impact-pairs analysis (Stewart-Oaten *et al.*, 1986). For each of the 10 (${}^5C_2 = \frac{5!}{2!3!} = 10$) unique pairwise combinations (a,b) of the five study streams and for each year in the intersection of the periods-of-record of the two streams, we computed the ratio $\frac{Q_a}{Q_b}$, where Q_a is the total late-summer discharge in stream a for the given year and Q_b is the total late-summer discharge in stream b. To prevent small values in the denominator from producing extremely large values of the ratio, we chose stream b to be the stream in each pair with the larger mean late-summer discharge during the modern period. We then compared the mean of these annual ratios $\frac{Q_a}{Q_b}$ between modern and historic periods using the permutation method. We used two-sided alternatives because the purpose of the paired-basin tests was to assess differences in streamflow response among the study streams, and if factors other than climate change affected this response, we would not know *a priori* which stream in a given pair should have the lower relative streamflow during the modern period.

Component of Scott River Base-Flow Decline Attributable to Climate

We estimated the component of base-flow decrease in the Scott River due to climate by comparing daily flow in the Scott River with that of a reference stream. Based on geographic proximity and lack of substantial changes in anthropogenic effects on water resources over the past half-century, either the Salmon or Trinity could serve as the reference stream for this estimate. Although the Trinity watershed is closer in elevation to that of the Scott, we chose the Salmon as the reference watershed because it is much closer in size to that of the Scott (Table 1) and because the hydrograph of the Salmon River is more similar to that of the Scott than to any of the other study streams (Figures 2 and 3). Furthermore, because the latitude-adjusted elevation of the Salmon River watershed is lower than that of the Scott River, comparison with the Salmon River provides an overestimate of the effect of climate and hence an underestimate of the effect of local-scale factors on Scott River base-flow. We used the line of organic correlation (Helsel and Hirsch, 1992) to determine the linear relationship between daily Scott River discharge and daily Salmon River discharge. Because the relationship was used for prediction and not for hypothesis

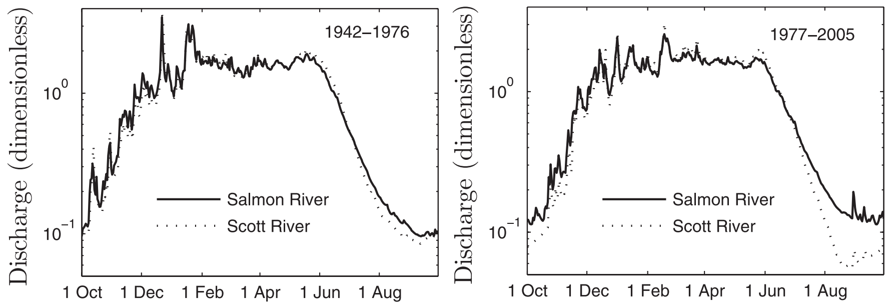

FIGURE 3. Period-of-Record Mean Dimensionless Hydrographs for the Salmon and Scott Rivers, Historic and Modern Periods. Dimensionless discharge is daily discharge divided by mean period-of-record discharge. Note that the hydrographs were nearly identical during the historic period but that during the modern period, Scott River discharge was much lower than Salmon River discharge from early July through late October.

testing, we did not correct daily values for serial autocorrelation. In this analysis we used all daily flow values from July 1 through October 22 during each of the calendar years in the historic period. This period of days was chosen because it was the time period over which the relationship between Scott and Salmon river hydrographs differed most between the historic and modern periods (Figure 3). We applied the organic linear relationship to modern-period Salmon River daily discharge values to estimate what discharge would have been in the Scott River during the modern period if response of flows in the Scott River to regional climate change had been the same as that of flows in the Salmon River. Because the line had a negative intercept, predicted discharge on a small percentage of days was slightly negative, and discharge on these days was set to zero. The difference between this estimated modern-period discharge and the observed modern-period discharge was our estimate of the component of Scott River summer discharge decrease due factors other than climate. For comparison, we also determined the line of organic correlation relating Scott and Salmon river discharge over the modern period.

RESULTS

Streamflow and SWE Trends

Mean daily hydrographs showed relatively small differences between historic and modern periods, with the exception of substantially lower modern-period discharge during late summer and early fall in the Scott River (Figure 2). Mean annual discharge in all five study streams was lower during the modern period, but none of the differences were significant (Table 1). The Scott River showed by far the greatest decrease in late summer discharge between the two time periods (40.3% decrease, $p < 0.001$), followed by the South Fork Trinity (18.2% decrease, $p = 0.049$) and Indian Creek (10.0% decrease, $p = 0.055$). Late-summer discharge increased slightly in the Salmon (1.2% increase, $p = 0.629$) and Trinity (10.3% increase, $p = 0.799$) rivers between historic and modern periods.

Mean April 1 SWE was lower in the modern period at all seven snow courses below 1,800 m, and these differences were significant at four of these courses and marginally significant at a fifth (Table 2). Mean April 1 SWE was higher in the modern period at five of the nine courses with elevations above 1,800 m, but none of these differences were significant.

Dependence of Base Flow and SWE Trends on Elevation and Latitude

Change in April 1 SWE between historic and modern periods showed a significant, positive dependence on latitude-adjusted snow-course elevation (Figure 4). There was no significant dependence of change in late summer streamflow on latitude-adjusted drainage-basin elevation among the five study watersheds, but this dependence was significant when the Scott River was removed from the analysis (Figure 4). The slopes of the SWE and the significant (i.e., Scott River not included) flow regression lines were similar (0.00427/m for change in SWE, and 0.00539/m for change in late summer flow). Under the null hypothesis that the SWE and significant flow regressions are independent of each other, permutation analysis showed that the probability of obtaining a linear relationship between change in SWE and elevation as significant as that observed and a relative difference between the slope of the two lines this small is $p = 0.00203$ (see Appendix A). This provides strong evidence that the similarity in slopes of these two

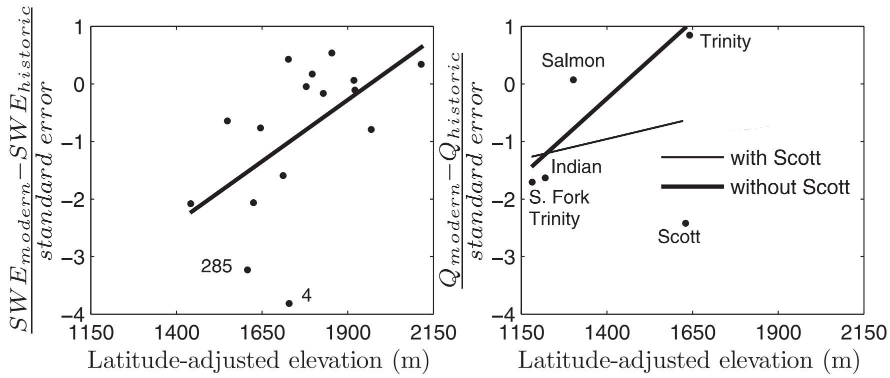

FIGURE 4. Change in April 1 Snow Water Equivalent (SWE; left) and Late-Summer Flow (right) Between the Historic and Modern Periods as a Function of Latitude-Adjusted Elevation. Decrease in both parameters is measured by the dimensionless T-statistic (Equation 4). Snow course Numbers 4 and 285 are identified in the left panel. Change in April 1 SWE showed a significant dependence on elevation ($y = 0.00427x - 8.39$, $p = 0.028$). Change in late-summer flow showed no significant dependence on elevation with all data included ($y = 0.00141x - 2.39$, $p = 0.700$) but showed significant dependence on elevation when the Scott River was removed from the analysis ($y = 0.00539x - 7.80$, $p = 0.042$).

regression lines cannot be caused by chance alone, that is, that the dependence of change in streamflow on elevation is linked with that of change in SWE, as expected based on the underlying hydrologic processes.

Comparison of Relative Base-Flow Decline Among Study Streams

Late-summer flow in the Scott River declined between historic and modern periods relative to all four of the other study streams, and all of the differences in discharge ratio involving the Scott River were significant (Table 3). Decline in base flow in the Scott River was greatest relative to the Trinity River, followed by that relative to the Salmon River, Indian Creek, and the South Fork Trinity River, respectively. Late-summer flow in the South Fork Trinity declined relative to all study streams except the Scott, and these differences were all significant. Late-summer flow in Indian Creek declined relative to the Trinity and Salmon rivers, but only the decline relative to the Trinity was significant. As mentioned above, late-summer discharge in the Salmon and Trinity rivers increased slightly between the historic and modern periods, and the paired-basin test showed that the increase observed in the Trinity River was significantly greater relative to that in the Salmon River.

Component of Scott River Base-Flow Decline Attributable to Climate

Scott River daily discharge from July 1 to October 22 was much lower relative to Salmon River discharge during the modern period than during the

TABLE 3. Paired-Basin Tests of the Null Hypothesis That the Ratio of Late Summer (August 2 through October 5) Discharge Is Equal Between Modern and Historic Periods.

Pair	Mean Ratio of Late-Summer Discharge (historic)	Mean Ratio of Late-Summer Discharge (modern)	Stream With Lower Relative Late Summer Discharge in Modern Period	*p*-Value: Historic and Modern Ratios Equal
Scott/Trinity	1.65	0.602	Scott	<0.001
Scott/Salmon	0.136	0.063	Scott	0.001
Scott/Indian	0.961	0.589	Scott	0.003
Scott/South Fork Trinity	0.599	0.400	Scott	0.010
Trinity/South Fork Trinity	0.397	0.590	South Fork Trinity	0.007
South Fork Trinity/Salmon	0.334	0.272	South Fork Trinity	0.035
Indian/ South Fork Trinity	0.590	0.747	South Fork Trinity	0.018
Trinity/Indian	0.803	0.973	Indian	0.001
Indian/Salmon	0.237	0.223	Indian	0.174
Trinity/Salmon	0.172	0.193	Salmon	0.045

Notes: Mean ratios of late-summer discharge are shown here; means of late summer discharge for each basin are given in Table 1; *p*-values are reported for the two-sided alternative hypothesis.

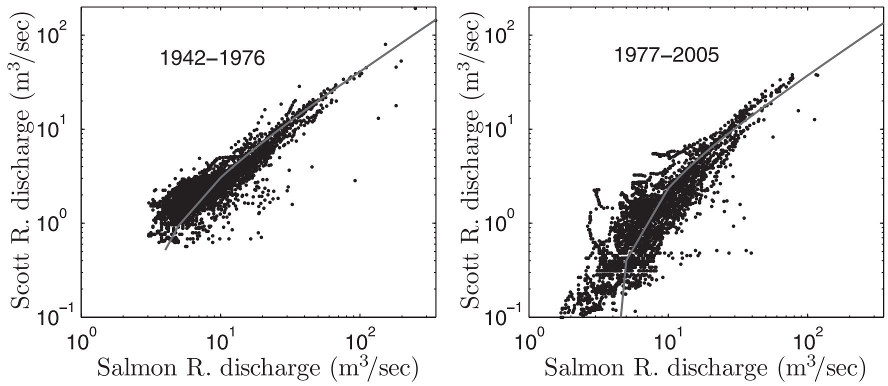

Figure 5. Scatterplots and Lines of Organic Correlation Relating Scott River Daily Discharge (y) and Salmon River Daily Discharge (x) for July 1 Through October 22, Historic and Modern Periods. Lines of organic correlation are $y = 0.422x - 1.17$ for the historic period and $y = 0.398x - 1.62$ for the modern period. Discharge is plotted on logarithmic scales to show detail at low discharge values; however, the lines of organic correlation and all analyses were performed on the untransformed data. Note that daily discharge in the Scott River never fell below 0.566 m^3/s during the historic period but fell below this value on 28.6% of all days between July 1 and October 22 during the modern period.

historic period (Figures 3 and 5). Furthermore, whereas the magnitudes of daily discharge in the Salmon River showed little difference between the historic and modern periods, daily discharge in the Scott River showed a large decrease in mean (from 3.23 to 2.15 m^3/s). During the historic period, discharge in the Scott River was less than 1 m^3/s on 4.3% of all days from July 1 through October 22, whereas during the modern period, flows were less than 1 m^3/s on 46.2% of these days. Applying the historic-period organic linear relationship to modern-period Salmon River daily discharge produced an estimate of Scott River daily flow under the influence of regional-scale climate trends alone (Figure 6). The estimated mean hydrograph differed very little from the observed historic-period hydrograph from July 1 through early August, but estimated modern-period discharge was lower over most of August, September, and October. Observed July 1 through October 22 discharge in the Scott River averaged 31.8 Mm^3/year over the historic period and 21.3 Mm^3/year over the modern period. Our estimate of July 1 through October 22 discharge under the influence of regional-scale climate trends alone averaged 27.8 Mm^3/year over the modern period. Thus, the component of decrease in Scott River discharge caused by factors other than regional-scale climate is estimated at 6.5 Mm^3/year, 61% of the observed decrease.

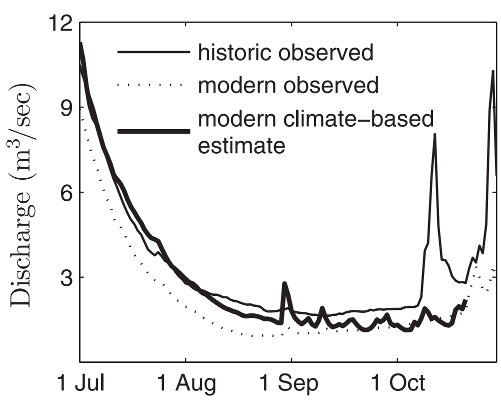

FIGURE 6. Mean July Through October Hydrographs for the Scott River, Showing Observed Historic-Period and Modern-Period Discharge and Estimated Modern-Period Discharge Based on Correlation With the Salmon River (climate-based estimate). Estimated modern-period flows show little deviation from historic-period flows during July and early August but are lower than historic-period flows from mid-August through late October.

DISCUSSION

Streamflow and SWE Trends and Dependence on Elevation and Latitude

Base flow and April 1 SWE in the lower Klamath Basin follow general trends toward lower April 1 SWE and lower base flows observed throughout the Pacific Northwest over the past 60 years (Hamlet *et al.*, 2005; Mote *et al.*, 2005; Regonda *et al.*, 2005; Stewart *et al.*, 2005; Mote, 2006). Models indicate that global warming may increase precipitation over the Pacific Northwest (Leung and Wigmosta, 1999; McCabe and Wolock, 1999; Salathé, 2006) so that at the highest elevations, April 1 SWE may actually increase because of increased winter-time precipitation, despite the trend toward higher temperatures. In the lower Klamath Basin, SWE has decreased significantly at lower-elevation snow courses but has increased slightly at several higher-elevation courses (Table 2). Thus, our results are consistent with regional-scale analyses and reflect trends in both temperature and precipitation. The patterns of base-flow change between the historic and modern periods in the South Fork Trinity, Indian, Salmon and Trinity watersheds are exactly as predicted by SWE-elevation-latitude relationships. The within-basin analysis (Table 1), the paired-basin analysis (Table 3), and the regression analysis (Figure 4) all showed that when compared with that of the historic period, late-summer discharge in the modern period in each stream, both independently and relative to the other streams, followed the order predicted by latitude-corrected elevation and by the SWE patterns. Base flow decreased in the two watersheds with the lowest latitude-adjusted elevation (South Fork Trinity River and Indian Creek), and the decrease was greatest in the South Fork Trinity, which has the lowest latitude-adjusted elevation of any of the study streams. Base flow increased in the Trinity and Salmon rivers, and the increase was greatest in the Trinity River, which has the highest latitude-adjusted elevation of any of the study streams. The increases in late-summer flow observed in the Salmon and Trinity watersheds have occurred despite moderate decreases in total annual flow in these streams, suggesting effects from finer-scale patterns in temperature and precipitation that we did not analyze.

Base-Flow Decline in the Scott River Relative to the Other Streams

Base-flow trends in the Scott River clearly do not follow those of the other four streams. The latitude-corrected elevation of the Scott River watershed is only 31.5 m less than that of the Trinity River watershed (Figure 4), but base flows in the Scott River showed by far a greater decrease between historic and modern periods than those in any of the other four watersheds. The paired-basin analyses (Table 3), regression relationships (Figure 4), and Salmon River comparison (Figures 3 and 5) provide strong evidence that base flow in the Scott River has responded to regional-scale climate in a much different way than the other four streams and/or that factors other than climate have contributed to changes observed in Scott River base-flow since the late 1970s.

Certainly, some of the trends in Scott River base-flow are caused by the same climatic factors that have affected the other study streams. Decreases in mean annual discharge between historic and modern periods were 6.2% in the Trinity River, 13.0% in the Salmon River, 14.3% in Indian Creek, 15.1% in the Scott River, and 17.0% in the South Fork Trinity River (Table 1). The *p*-values for the significance of these declines were remarkably similar for all but the Trinity River (Table 1). Furthermore, the paired-basin analysis showed no significant trends in total annual discharge among the study streams. Differences in response of the Scott River relative to the other streams appear to be limited only to base flow trends because at the annual scale, response of the Scott River to climatic differences between the two time periods was indistinguishable from those of the other study streams.

Factors Affecting Scott River Base-Flow

Geographic factors may be partially responsible for the large apparent difference in base-flow response between the Scott River and the other study streams. Although not the furthest east of the study basins, the Scott watershed does lie partially within a precipitation shadow formed by the large region of high-elevation terrain to the west of the watershed, contributing to a drier, more continental climate than that of the other four study watersheds. The Scott watershed has by far the smallest basin yield (discharge per unit watershed area, Table 1), an indication of both lower precipitation and higher evapotranspiration, the latter of which includes a large amount of irrigation not present in the other watersheds. The elevation dependence exhibited by base-flow change in the other streams predicts an increase in base flow in the Scott River between historic and modern periods (Figure 4). However, the comparison with the Salmon River predicts a decrease, albeit one only about 40% as large as that observed. The two snow courses with the largest decreases in April 1 SWE were Courses 4 and 285, located on the western side of the Scott watershed (Table 2, Figures 1 and 4). Although these are two of the lower-elevation snow courses in the study area, their decline is disproportionate with their elevation (Figure 4). The large decreases in April 1 SWE at these courses could be caused by local geography (e.g., the precipitation shadow), but a snow survey technician who has conducted measurements at these courses noted that forest vegetation has encroached on the courses, reducing accumulation of snowpack on the courses themselves (Power, 2001; J. Power, personal communication). Furthermore, none of the other courses in the Scott basin (Numbers 5, 298, and 311) show patterns inconsistent with the rest of the courses, and SWE has increased slightly at Courses 5 and 311 (Table 2).

Additional data provide evidence that part of the observed decrease in Scott River base-flow since the

1970s is likely caused by an increase in withdrawal of water for irrigation in the Scott Valley. Although data on water use in the Scott Valley are sparse and difficult to obtain, those that we were able to acquire show that irrigation withdrawals in the Scott Valley increased by 115% between 1953 and the period over which modern data are available (1988-2001; Figure 7). We were unable to locate data from the 1960s and 1970s to determine when the majority of the increase occurred, but across the western U.S. as a whole, the largest increase in irrigation withdrawal between 1950 and 2000 occurred in the 1970s (Hutson *et al.*, 2004). This increase in irrigation withdrawal accompanied an 89% increase in irrigated land area (Figure 7). In 1953, 77 cm of irrigation was applied over the growing season, and Mack (1958) reported that application rates in the 1940s averaged about 76 cm per year. Average application rate over the period 1988-2001 was 88 cm per year, a 15% increase over historic values. The limited data available show no change in crop types since the 1950s; irrigation has been applied primarily to alfalfa, grain, and pasture through both the historic and modern periods. Climatic factors could have influenced the increase in irrigation application rate; a warmer climate could result in a longer growing season and in higher evapotranspiration rates. However, the 15% increase in application rate is small compared the observed increases of 89% in irrigated land area and 115% in irrigation withdrawal between the historic and modern periods.

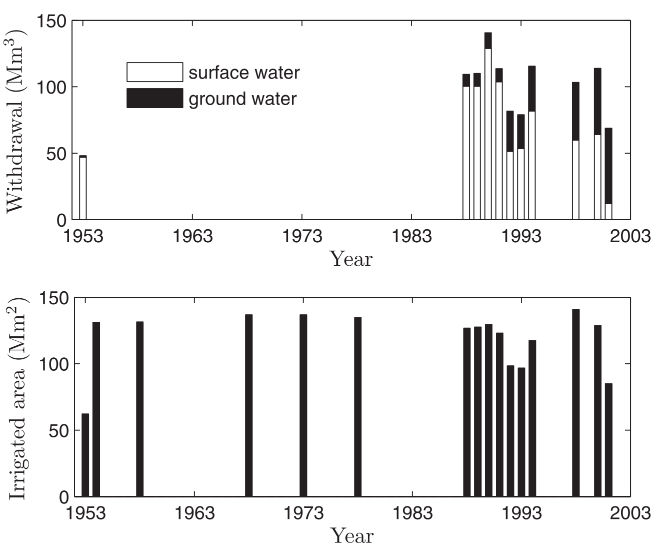

FIGURE 7. Annual Irrigation Withdrawal (top) and Irrigated Land Area (bottom) in the Scott River Basin From 1953 to 2001. Note that ground water made up less than 3% of total withdrawals in 1953 and more than 80% in 2001. Total annual withdrawal increased from 48 Mm^3 in 1953 to an average of 103 Mm^3 over the period 1988-2001, in close proportion to increase in irrigated area (62 Mm^3 in 1953, average of 117 Mm^2 over 1988-2001). Data for 1953 are from Mack (1958). All other data were provided by the California Department of Water Resources upon request.

A second important trend in irrigation practices in the Scott Valley is that most irrigation in the Scott Valley is currently applied with sprinklers, and conveyance occurs in a pipe network. Recharge of ground water resulting from former flood irrigation practices has been largely eliminated, as has been observed in other locations around the western U.S. (Johnson *et al.*, 1999; Venn *et al.*, 2004). Mack (1958) estimated that during water year 1953, recharge to the alluvial aquifers in the Scott Valley was provided by precipitation (about 25 Mm^3), tributary inflow (unspecified amount), and irrigation seepage (about 21 Mm^3). Thus, in 1953, of the 48 Mm^3 withdrawn for irrigation, only about 27 Mm^3 (56%) was used consumptively. This efficiency is typical of flood irrigation systems with ditch conveyance (Battikhi and Abu-Hammad, 1994; Venn *et al.*, 2004). Conversion from flood to sprinkler irrigation has been reported to increase efficiencies to about 70% (Venn *et al.*, 2004), implying that while withdrawal of irrigation water in the Scott Valley has increased 115% since the 1950s, consumptive use may have increased by as much as 167%. Venn *et al.* (2004) reported that after conversion from flood to sprinkler irrigation in an alluvial valley in Wyoming, streamflow decreased significantly in the late summer and early fall because of decreased recharge of ground water, and this same mechanism could be acting in the Scott Valley as well.

A third important change is that ground water replaced surface water as the dominant source of irrigation water between 1990 and 2000 (Figure 7), reflecting trends observed across the western U.S. (Hutson *et al.*, 2004). Even if recharge from precipitation and tributary inflow have remained unchanged since the 1950s, change in irrigation conveyance and application methods and increased pumping of ground water in the Scott Valley could have resulted in decline of aquifer water levels. These alluvial aquifers discharge to the Scott River and its tributaries (Mack, 1958), and thus decline in aquifer levels could result in lowered base flows in the Scott River. In the upper Snake River basin of Idaho, where ground water-surface water interactions in an irrigation system have been extensively studied, conversion from flood to sprinkler irrigation and increase in pumping of ground water have resulted in significant declines discharge from the aquifer into the Snake River (Johnson *et al.*, 1999; Miller *et al.*, 2003b). Because of lag times inherent in ground water responses, withdrawal of ground water in the middle of the irrigation season can affect stream base-flow into the late summer and early fall. Furthermore, ground water provides a source of irrigation water late in the season when streamflow is low and availability of surface water is limited. Thus, transition from an irrigation system based primarily on diversion of surface water from streams to one with a large capacity to pump ground water allows more water to be used late in the irrigation season. Finally, because ground-water pumping in the Scott Valley is unregulated, actual withdrawal amounts could differ from those reported on an annual basis by CDWR, and there is a general lack of data that is sufficient in spatial and temporal extent to perform the mechanistic modeling of interactions between ground and surface water that would be necessary to quantify the effect that changes in irrigation practices have had on streamflow in the Scott River.

Comparison With Drake et al. (2000)

Our estimate that 39% of the decrease in Scott River base-flow is due to climatic factors is contrary to that of Drake *et al.* (2000), who concluded that 78% of the decrease is due to decline in April 1 SWE. The disparity in these conclusions is easily explained by analysis methods. First, Drake *et al.* (2000) analyzed hydrologic data from the Scott River watershed alone, whereas our study employed a comparative approach using other watersheds in the basin. Secondly, they did not use any variables related to water use, which clearly show substantial changes over the same time period during which base flows have decreased (Figure 7). Finally, Drake *et al.* (2000) based their conclusion on decrease in April 1 SWE at Snow Courses 4 and 285 and a single term representing this SWE decrease in a multiple regression equation explaining September discharge in the Scott River. Their regression equation was

$$Q = (2.5 + 1.18 \times \text{annualprecip.} + 8.6 \times \text{Augustprecip.} - 6.7 \times \text{Julyprecip.} + 0.48 \times \text{Course 285 SWE} + 0.25 \times \text{Course 5 SWE})^2, \quad (5)$$

where Q is September discharge, annual and monthly precipitation are as recorded on the Scott Valley floor, and April 1 values were used for the SWE terms. Because SWE at Snow Courses 4 and 285 were highly correlated, Snow Course 285 was chosen to represent these courses in the regression equation. Snow Course 5 was used to represent SWE at Courses 5 and 298, two highly correlated courses at which April SWE exhibited little temporal trend. The regression analysis did not include SWE at the other snow course in the Scott River watershed (Course 311) nor at courses near the Scott River drainage basin divide in adjacent watersheds (Courses 1 and 13; Figure 1). April 1 SWE at these courses showed no significant decrease between historic and modern periods (Table 2). The estimate that 78% of the decline in Scott River base-flow is due to climate was based on the r^2-value of 0.78 for the regression Equation (5).

Based on mean values for the explanatory variables in the regression equation, the annual precipitation term is six times greater in magnitude than the August precipitation term and over 10 times greater in magnitude than the July precipitation term. Thus, July and August precipitation contribute relatively little to September discharge. The annual precipitation term is about 1.5 times greater than the Snow Course 285 term and about three times greater than the Snow Course 5 term. Mean annual precipitation at the Ft. Jones weather station, located near the Scott River gage, was 55.9 cm during the historic period and 54.8 cm during the modern period. April 1 SWE at Course 5 averaged 80.8 cm during the historic period and 81.4 cm during the modern period. These two variables show almost no change between historic and modern periods, and the sum of their respective terms in the regression equation is over twice as large as the Snow Course 285 term. Therefore, the conclusion of Drake *et al.* (2000) is based on a single term that accounts for less than one-third of the total magnitude of the variable terms in the regression equation.

Implications for Fisheries

Based on our estimate of the component of Scott River base-flow decrease attributable to changes in water use, returning irrigation to historic-period patterns in the Scott River would, in theory, increase July 1-October 22 discharge by an average of 0.65 m^3/s. This estimate includes continued irrigation withdrawal at the pre-1970s rate of about 50 Mm^3, albeit with as much as 21 Mm^3 of this returning to the aquifer and streams via canal seepage. It also accounts for decrease in streamflow caused by regional-scale climate trends. Under current conditions, streamflow in the Scott River can drop below 0.283 m^3/s in the late summer and early fall of dry years. At this discharge, some reaches of the river become a series of stagnant and disconnected pools that are inhospitable to many aquatic species. An additional 0.65 m^3/s could create a viable corridor for movement of aquatic species, decrease fluctuations in water temperature (particularly daily maxima), and maintain the functionality of cold water seeps and tributary mouths upon which salmonids rely (Cederholm *et al.*, 1988; Sandercock, 1991; Stanford and Ward, 1992). Bartholow (2005) observed a warming trend of 0.5°C/decade in Klamath River water temperatures over the same period of years we have analyzed, suggesting that provision of cold-water refugia for aquatic life will become even more critical as climate warming continues. Although it is not likely that irrigation sources, withdrawal amounts, and application methods in the Scott River watershed will revert back to those of the 1960s, our results at least provide evidence that observed declines in base flow have not been caused by climate trends alone and hence could be reversed to the benefit of salmon and other aquatic life through changes in water management. However, management of water resources in the Scott Valley to meet the needs of both agriculture and fish will require consistent and accurate watermaster service for the entire valley, quantification of ground-water withdrawals and their effects on surface water, and water-use data that are easily obtainable. A major research need in the Scott Valley relevant to water management and aquatic species conservation is a comprehensive study of interactions between ground water and surface water that includes mechanistic modeling of effects of ground-water withdrawal on streamflow throughout the valley.

CONCLUSIONS

We statistically analyzed streamflow in five lower Klamath Basin streams that are unregulated by storage reservoirs as well as April 1 SWE at all 16 snow courses in the basin with long periods of record. We compared streamflow and April 1 SWE between historic (1942-1976) and modern (1977-2005) periods, which were defined based on two distinct phases of the PDO. The historic period was a cold phase, which has been associated with high snowpack and high streamflows throughout the Pacific Northwest, and the modern period was a warm phase, which has been associated with lower snowpacks and streamflows region-wide. April 1 SWE decreased significantly between historic and modern periods at low-elevation snow courses in the lower Klamath Basin. No significant trends were apparent at higher elevations. Correspondingly, base flow decreased significantly in the two study streams with the lowest latitude-adjusted elevation and increased slightly in two of the higher-elevation study streams. With the Scott River excluded from the analysis, the dependence of base-flow change on adjusted elevation follows the same trend as that of SWE. Despite a latitude-adjusted elevation only 1.8% lower than the highest-elevation watershed in the study, the Scott River has experienced a much larger reduction in base flow than the other study streams. Geographic differences may account for some of the discrepancy in base flow trends between the Scott River and the other four watersheds. However, irrigation withdrawal in the Scott watershed has increased from about 48 Mm^3 per year to over 100 Mm^3 since the 1950s, and the amount of ground water withdrawn for irrigation has increased from about 1 Mm^3 per year to about 50 Mm^3. We estimate that 39% of the observed 10 Mm^3 decline in July 1-October 22 discharge in the Scott River has been caused by regional-scale climatic factors and that the remaining 61% is attributable to local factors, which include increases in irrigation withdrawal and consumptive use. Even after accounting for climatic factors, returning water use to pre-1970s patterns of withdrawal sources and quantities, conveyance mechanisms, and application methods in the Scott River watershed could benefit salmon and other aquatic biota by increasing July 1-October 22 streamflow by an average of 0.65 m^3/s.

If our study watersheds are representative of others in the lower Klamath Basin, climate-induced decreases in late-summer streamflow in low-elevation watersheds will, at best, complicate the recovery of anadromous salmonids and may, at worst, hinder their persistence. Sound water management and recovery efforts such as habitat and watershed restoration will be required to help offset the effects of climate warming on river ecology, particularly because both decreased base flows and increased water temperatures occur simultaneously during periods of warm climate. Because streams at lower elevations are more susceptible to decreases in base flow caused by decreases in April 1 SWE, local-scale human-induced changes associated with water and land use could have a greater affect on streamflow and water temperature in these streams than in higher-elevation streams experiencing the same continental-scale warming. The South Fork Trinity River is of particular concern. It harbors one of the few remaining stocks of wild spring Chinook salmon in the entire Klamath Basin, and the latitude and elevation of the drainage put it at particular risk of climate-induced changes that adversely affect Chinook salmon and other species. Furthermore, development and largely unquantified water use on the South Fork Trinity River and important fish bearing tributaries such as Hayfork Creek exacerbate the problem. We recommend additional gaging on streams that are susceptible to the effects of human use, such as Hayfork

Creek, and on "control" streams that drain wilderness areas, such as Wooley Creek in the Salmon River watershed and the North Fork Trinity River, to monitor future trends in water use and climate in the lower Klamath Basin.

APPENDIX A: PERMUTATION TESTS

Standard statistical hypothesis tests are commonly used to analyze time-series data collected at precipitation and streamflow gages (e.g., Helsel and Hirsch, 1992; McCuen, 2003). Most of these tests, whether parametric or non-parametric, are based on the assumption that the data were obtained through random sampling of infinite populations. However, this assumption is generally not met by data sets collected at precipitation and stream gages. First, these types of data are not randomly selected. The locations of stream and precipitation gages are almost never randomly chosen, and the recording of data at regular intervals such as days, months, or years does not constitute random selection. Second, the data rarely constitute a sample but rather comprise the entire population. For example, if we analyze difference in annual discharge between two time periods and have discharge values for every year in both time periods, then we have the entire population at hand. There is no sampling, and hence no infinite population to which inference can be drawn. Permutation tests, often called randomization tests in experimental contexts, are appropriate statistical tests to use for analysis of these and other types of non-sampled data (Ramsey and Schafer, 2002). We refer the reader to the comprehensive texts by Edgington (1995) and Good (2005) for a full treatment of theory and methodology and here present only a brief treatment of the two permutation tests used in this paper.

The basic concept behind permutation tests is best illustrated by the example of testing for differences in mean between two groups. Consider the comparison of late-summer discharge in the Scott River between the two time periods. Once the time-series data are corrected for serial autocorrelation, the observations constitute independent, annual values for each of the 64 years between 1942 and 2005, inclusive, and hence satisfy the assumptions of permutation tests. We then measure the magnitude of difference in the mean for each of the two time periods 1942-1976 and 1997-2005, relative to variability, using the test statistic (Equation 4). This division of 64 years into the historic and modern period is only one of the $\frac{64!}{35!29!} \approx 1.39 \times 10^{18}$ distinct ways in which this set of 64 annual values can be divided into two groups of size 35 and 29. Each of these distinct ways is called a permutation, and each has associated with it a particular value of the test statistic (Equation 2). The distribution of these test statistics is called the permutation distribution. The *p*-value of the permutation test is the probability that we could have selected a permutation at random for which the value of the test statistic was at least as extreme (using either one or two tails, as appropriate to the alternative hypothesis) as that of the observed grouping (i.e., division of the time period into 1942-1976 and 1977-2005 time periods).

In practice, when the number of permutations is on the order of 10^4 or less, one computes the test statistic for every possible permutation and obtains the exact *p*-value of the test. This procedure is inherently non-parametric and requires no assumptions about the distribution of the original data or the number of observations, even if one uses a test statistic such as (Equation 2) that can be used in the context of a parametric test. When the number of permutations is large, there are two choices for conducting the test. One is to randomly select a large number of permutations from among those possible and use this sample to represent the entire set of permutations (see Supplementary Material). The other is to use a standard parametric test statistic (such as the *T*-statistic) from an analogous sample-based hypothesis test. It has been shown that for the permutation versions of most of these basic tests, the permutation distribution approaches the sampling distribution of the test statistic asymptotically as the number of permutations becomes infinite, regardless of the distribution of the original data (Edgington, 1995; Good, 2005). In our example of 1.39×10^{18} permutations, the permutation distribution of (Equation 2) is in fact a *t*-distribution (Figure A1). Hence, we can calculate the *p*-value of the test by comparison of the test statistic with the standard *t*-distribution without having to generate any permutations. In this case, the *p*-value of the permutation test for difference in mean coincides with that of the two-sample *t*-test but the interpretation is different. In the permutation test, the *p*-value is the probability of having obtained a difference in *population* mean at least as extreme as that observed in a randomly selected division of the data into two *populations* of sizes 35 and 29. In the two-sample *t*-test, the *p*-value is the probability of having obtained a difference in *sample* mean at least extreme as that observed based on random selection of a *sample* of size 35 from one population and a *sample* of size 29 from a second, independent population, under the null hypothesis that the population means are the same. Thus, even though we might get the "right answer" in terms of the *p*-value with naïve use of a two-sample *t*-test, our inference would be

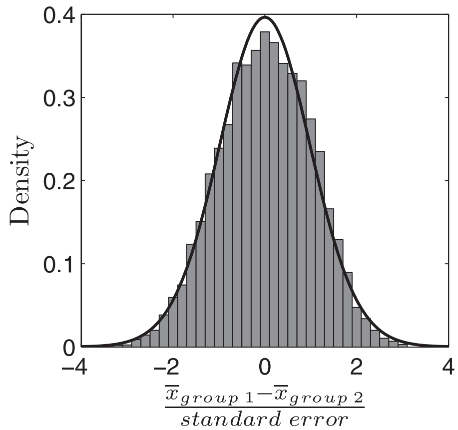

FIGURE A1. Permutation Distribution of the T-Statistic (Equation 1) for the Difference Between Historic-Period and Modern-Period Late Summer Discharge in the Scott River (Table 1). The histogram shows T-statistics from 10,000 randomly selected permutations (from among the 1.39×10^{18} possible), and the curve is the Student's t-distribution that would be used for the analogous t-test based on random samples from populations with unequal variances. The t-distribution has 39 degrees of freedom, as calculated using Satterthwaite's approximation (Ramsey and Schafer, 2002). In this case, the permutation and sampling distributions of the test statistic are identical.

inappropriate because our data do not constitute samples from infinite populations.

In the permutation version of linear regression, the permutations consist of all possible ways of pairing the observations of the dependent variable, y, with those of the independent variable, x. There are $n!$ such permutations possible with a set of n ordered pairs. We perform the permutation test on the standard regression test statistic given by the ratio of regression mean square to error mean square. The observed statistic is that obtained from the data points as they were reported, and that value is compared against the values obtained from all of the other permutations. When the number of permutations is large, the permutation distribution of this test statistic is an $F_{1,n\text{-}2}$-distribution, identical to the sampling distribution of this test statistic. The SWE regressions used data pairs from 16 stations, so the number of permutations is $16! \approx 2.09 \times 10^{13}$, and use of the standard F-distribution is appropriate for computing the p-value of the permutation test. However, the number of permutations in the streamflow regressions was very small, so the standard F-distribution is not a good approximation to the permutation distribution. In the regression with the Scott River removed ($n = 4$), the value of the test statistic obtained from the observed pairing of dependent and independent variables was 7.58, the largest among the 24 permutations. Thus, the p-value for this test is 1/24 = 0.0417 (Table A1). Regression analysis of these same four data points based on random

Table A1. Cumulative Distribution of the Test Statistic $\frac{\text{MSR}}{\text{MSE}}$ for the Regression of Change in Streamflow *vs.* Adjusted Basin Elevation With Scott River Removed (Figure 4).

Test Statistic Value	Permutation Probability	Sampling Probability
7.5800	0.0417	0.1105
7.3102	0.0833	0.1139
2.6847	0.1250	0.2430
2.2445	0.1667	0.2728
2.1459	0.2083	0.2806
2.0749	0.2500	0.2864
1.9534	0.2917	0.2971
1.8136	0.3333	0.3104
1.2981	0.3750	0.3726
1.2497	0.4167	0.3799
1.0196	0.4583	0.4189
0.9162	0.5000	0.4395
0.9001	0.5417	0.4429
0.8407	0.5833	0.4560
0.5477	0.6250	0.5363
0.5388	0.6667	0.5393
0.4449	0.7083	0.5734
0.4289	0.7500	0.5798
0.3393	0.7917	0.6191
0.2621	0.8333	0.6596
0.2047	0.8750	0.6953
0.1894	0.9167	0.7059
0.0677	0.9583	0.8191
0.0622	1.0000	0.8263

Note: The test statistic values are those from each of the 24 possible permutations. The permutation probability is the probability of observing a test statistic at least as large from the permutation distribution, and the sampling probability is the probability of observing a test statistic at least as large from the sampling distribution, namely an $F_{1,2}$-distribution. The F-distribution underestimates probabilities for small values of the test statistic and overestimates them for the larger values.

sampling produces a p-value of 0.110 (Table A1). If the four study streams had been randomly selected from a large number of streams (on the order of 40 streams or more), then the probability is 0.110 of having observed a linear relationship at least this strong in a *sample* of four (x,y) pairs, under the null hypothesis that there was no linear relationship between x and y in the whole population. However, because these four streams were not selected at random (they were selected because they were streams that happened to have long periods of flow records), it is inappropriate to draw inferences to a large population from this set of four. Using permutation testing, the probability is 0.0417 of having observed a linear relationship this strong by chance assignment of the x and y values into (x,y) pairs, and we conclude that among this *population* of four study streams, there is a significant dependence of y on x.

To compare the slopes of the SWE and streamflow regressions (Figure 4), we first computed slopes m_i for each of the possible 24 permutations of the streamflow data and slopes m_j for each permutation in a random sample of 1,000 permutations from among the 16! possible for the SWE data (see Supplementary Material). We then calculated the symmetric relative difference between the slopes given by

$$\frac{|m_i - m_j|}{0.5(|m_i| + |m_j|)} \tag{6}$$

for all possible combinations i, j as i ranged over the 24 streamflow permutations and j ranged over the 1,000 randomly selected SWE permutations. The observed relative difference was smaller than 92.61% of these differences. However, we are interested in differences in slopes not for all possible pairs of regression lines but only for those that are statistically significant to begin with. If the dependence of change in streamflow on adjusted elevation is independent of that of SWE on adjusted elevation, then the probability of randomly selecting a regression pair with a difference in slopes as small as the observed difference *and* randomly selecting a permutation of the SWE data showing as strong a linear relationship as that observed is the product of the two individual probabilities. The probability of the former event is 1 − 0.9261 = 0.0739, and the probability of the latter is 0.0275. Thus, the desired probability is 0.00203. We conclude that it is extremely unlikely to have observed regression relationships this similar by chance alone if the dependence of change in streamflow on elevation is independent of that of change in SWE on elevation.

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SUPPLEMENTARY MATERIAL

Supplementary materials mentioned in the text (computer code to conduct permutation tests) are available as part of the online paper from: http://www.blackwell-synergy.com.

Please note: Neither AWRA nor Blackwell Publishing is responsible for the content or functionality of any supplementary materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

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Exhibit G

Groundwater Conditions in Scott Valley, California

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ACRONYMS

CDEC- California Data Exchange Center

DEM – Digital Elevation Models

DRG – Digital Raster Graphics

DWR – California Department of Water Resources

FGDC – Federal Geographic Data Committee

GIS – Geographic Information Systems

NRCS – National Resource Conservation Service

NWIS – National Water Information Service

Siskiyou RCD – Siskiyou Resource Conservation District

SWRCB- California State Water Resources Control Board

SSPA – S. S. Papadopulos & Associates, Inc.

USGS – U.S. Geological Survey

1.0 INTRODUCTION

This report describes groundwater conditions in the Scott Valley (Figure 1.1), located in Siskiyou County, California, and the development of a groundwater model representing the alluvial aquifer that can be used to investigate groundwater/surface-water interactions. The goal of this work is to improve understanding of the relationship between land and water use on flow conditions in the Scott River.

The groundwater model is applied to examine groundwater conditions given recent levels of groundwater use, and under an alternative water use condition representing partial build-out of the existing groundwater capacity. The partial build-out case, in comparison to the recent condition case, provides a mechanism for examining the impacts of groundwater pumping on the aquifer and on the Scott River. Many other scenarios can be evaluated through specification of alternative conditions to the model input packages. For example, scenarios may be structured to examine how the location and timing of groundwater diversion and use, or how managed recharge, might enhance late season flows of the Scott River.

This work is based on extensive data presently available in the public record, including over 1,000 well logs, soil and geologic data, groundwater elevations, well tests, high-resolution land surface elevation data, crop and riparian vegetation mapping, climatological data and stream gage records. The groundwater model provides a reasonable representation of existing conditions and is a useful tool for examining broad questions related to groundwater use in the Scott Valley. The groundwater model may be updated and refined as additional information is obtained. Focused data investigations may be particularly useful for improved assessment of specific scenarios or improved understanding of localized conditions.

2.0 SUMMARY OF AVAILABLE DATA

As part of this study, existing studies, reports and data sets were compiled and reviewed. These are summarized below.

2.1 Geologic Setting

The Scott Valley is underlain by younger alluvium, including stream channel, floodplain and alluvial fan deposits (Figure 2.1, from USGS, 2005). The water-bearing characteristics of the alluvial deposits are well-characterized by Mack (1958), and are discussed further in Section 3.0. Older alluvium is present along some of the valley margin; upland areas surrounding the valley are comprised of schist and various intrusive rocks (Figure 2.1).

The USDA NRCS SSURGO national soil inventory identifies several soil types within the valley and tributary areas (Figure 2.2). Diyou and Settlemeyer Loam dominate in the valley area; and, Stoner Gravelly Sandy Loam dominates in the tributary areas.

Water well driller's reports for 1,089 wells within eleven townships including the Scott Valley and interconnected tributary areas were obtained from the DWR under a confidentiality agreement for purposes of evaluating hydrogeologic conditions within the valley. These reports provide the driller's description of subsurface materials encountered during drilling, the well depth, and information on well yield, if available.

2.2 Groundwater Elevations

Depth-to-water data was obtained for wells in the Scott Valley from two primary databases: the USGS/NWIS and DWR/CDEC. Table 2.1 identifies wells in the Scott Valley for which data were found in the NWIS or CDEC databases noted above, and shows the well depth, construction date, use and surface elevation. Data obtained from NWIS consists of 84 depth-to-water measurements for 120 wells lying within the Scott Valley. Many of the listed wells have only one depth-to-water measurement taken during a regional inventory performed in 1953 by the USGS (Mack, 1958). One well has a series of 25 measurements over approximately a 15-year period. Of these wells, 22 were monitored approximately weekly from mid-July to mid-October in 1953; these data are not reflected in NWIS but are provided in Mack (1958), Table 9. Data in the CDEC database consists of depth-to-water data for 9 wells, from the early 1950s (1 well), the mid-1960s (4 wells), the mid-1990s (1 well), and the early 2000s (3 wells). These wells provide a long-term record of groundwater levels ranging over a period from one to five decades.

The wells for which multiple depth-to-water measurements are available are identified on Table 2.2 and shown on Figure 2.3. Hydrographs for these wells are provided in Appendix A.

Other data will be evaluated, as possible, during later phases of this study. Monthly depth-to-groundwater measurements have been collected as part of the Scott Valley Community Groundwater Measuring Program, established by the Scott River Watershed Council and with subsequent involvement of the Natural Resource Conservation Service, the Siskiyou RCD and the Klamath Forest Service. These data, including approximately 42 wells enrolled voluntarily by landowners, have been sampled since early 2006, and are being evaluated as part of the Siskiyou County Groundwater Study (Harter and Hines, 2008). These monthly data were requested at the initiation of this study in June of 2011. A representative of the Siskiyou RCD responded that the data would not be made available to this study at that point in time. Should the Siskiyou RCD share these data at a later date, the information will be reviewed to supplement understanding of spatial groundwater conditions over these recent years.

2.3 Specific Capacity

Specific capacity, an indicator of the aquifer's ability to transmit water (discussed further in Section 3.0), can be calculated from a well's pumping rate and the drawdown observed over a short pumping period, typically over a period of an hour to a few hours. Values for specific capacity calculated from data on well logs are tabulated on Table 2.3.

2.4 Streamflow

The USGS and DWR maintain gaging stations within the Scott Valley that provide information regarding river and tributary flows. Figure 2.4 shows surface water features and gages within the Scott Valley. Gaging stations are identified on Table 2.4.

2.5 Agricultural Water Use and Distribution

Figure 2.4 shows the spatial distribution of agricultural lands and major crop classes from the 2000 Siskiyou County Land Use Survey prepared by the DWR. Pasture and alfalfa are the primary crop classes, comprising over 90% of the irrigated lands. Also included in the DWR survey is information at the parcel scale on water source (groundwater, surface water or both) and irrigation method. The 2010 DWR land use survey data were not yet available at the time of this assessment.

The DWR estimates annual irrigated crop acreages, crop evapotranspiration, evapotranspiration of applied water, effective precipitation and applied water for 20 crop categories for sub-watershed areas identified as Detailed Analysis Units (DAU). These estimates reflect reference evapotranspiration, crop coefficients, soil characteristics, rooting depths and the quantity and timing of precipitation and are published for selected years by the DWR (http://www.water.ca.gov/landwateruse/anaglwu.cfm#). Table 2.5 provides DWR estimates for the year 2000 for applied water, the consumed fraction and evapotranspiration of applied water. The difference between applied water and the portion of this consumed or lost through evapotranspiration by plants or soil is also shown on Table 2.5 as *excess applied water*. Excess applied water is typically returned to the surface water system as tailwater or to groundwater by deep percolation.

Water sources for irrigated lands include surface water, groundwater or both surface water and groundwater. The Scott Valley Adjudication Decree (1980) identifies adjudicated points of diversion, associated acreages and allotments. These are summarized on Table 2.6. Major ditches diverting natural flows of the Scott River include: the Farmer's Ditch at Diversion No. 183, serving 1,236 acres in the southeast area of the Valley; and the Scott Valley Irrigation District (SVID) Ditch, serving 5,131 acres along the eastside of the Valley from Diversion No. 223 (between French and Etna Creek). The Scott Valley Irrigation District (SVID) Ditch served 1,630 acres from Diversion No. 576 at the northern end of the Valley, downstream of the confluence with Moffett Creek in the past; this ditch is presently unused. Under the adjudication, wells serving 12,975 acres are identified, including lands served by groundwater only or combined groundwater and surface water. Other points of diversion include direct diversions from creeks, springs and collection reservoirs generally located on the west or northwest sides of the valley, and from ditches or pipelines conveying water from these sources; diversions from Moffett Creek, and diversions from the eastside gulches to lands located above the Scott Valley Irrigation District Ditch. The DWR (Table 2.5) estimates that approximately 31,800 acres were irrigated in the Scott Valley in the year 2000.

Estimated canal losses are reported by DWR (1991) based on canal flow measurements. Farmer's Canal was reported to have minimal losses; the SVID Canal was reported to lose 7.4 cfs in the first 40,000 feet of the ditch in June 1990 (measurements by DWR in June 1990 with diversion averaging 38 cfs); and, 7 cfs in the lower 36,000 feet of the ditch (measurements by SCS, date unspecified).

2.6 Riparian Vegetation Water Use

Figure 2.5 shows the extent of wetland vegetation as mapped by the FWS National Wetland Inventory, consisting of approximately 7,100 acres of Emergent, Forested/Shrub, Riverine and Freshwater Pond wetlands. Table 2.7 identifies wetland classes in the Scott Valley. Some portion of this acreage coincides with areas designated by DWR in 2000 as cropland (Section 4.6).

2.7 Groundwater Wells

Over 1,000 well logs obtained from the DWR were reviewed to identify numbers of domestic, public, stock and irrigation wells; and to characterize their spatial distribution and depth of completion. Because well logs and data provided by the DWR only are located with respect to township, range and section, without precise coordinates or location by quarter or quarter-quarter section, a mechanism for filtering wells that are not within the alluvial aquifer was applied, as some sections include adjacent bedrock areas. For this purpose, 243 wells that encountered bedrock within 50 feet of land surface were excluded as either minor producers or beyond the primary alluvial aquifer area. A few wells were also excluded that were located outside of the study area. Of the remaining wells, the following were identified: 550 domestic, 169 irrigation, 2 public supply and 8 stock wells. Table 2.8 shows the number and well depth range for domestic wells by section; and, Table 2.9 shows the number and well depth range for irrigation wells by section. Table 2.10 summarizes the number of wells drilled by date ranges.

2.8 Land Surface and Channel Elevation

Light Detection and Ranging (LiDAR) data were collected by Watershed Sciences in November of 2010 to characterize land surface elevations at a fine resolution. This survey covered most of the Scott Valley (121,160 acres), with the exception of some upland tributary areas on the east side including Hamlin, Hurd, Heartstrand and Upper McConaughy Gulches. The Scott Valley LiDAR survey resulted in an accuracy with error of less than 0.1 foot (<0.03 meter RMSE) compared to ground-based RTK surveys. Bare earth or last return values are used in calculating land surface elevations. In areas beyond that of the LiDAR survey, the LiDAR-based elevations are supplemented with USGS 10-meter National Elevation Data (NED/DEM) coverages obtained from the USDA NRCS Geospatial Gateway.

3.0 HYDROGEOLOGIC CONDITIONS

3.1 Hydrogeologic Setting

In the 1950s, the U.S. Geological Survey undertook a comprehensive study of geology and groundwater conditions in the Scott Valley (Mack, 1958). This study, which included an inventory of existing wells, a review of driller's logs and well yields, and monitoring of depth to groundwater and water quality, provides a reasonably clear understanding of the hydrogeologic setting of the Scott Valley. Mack describes water bearing deposits in the Scott Valley as consisting of stream channel, flood-plain and alluvial-fan deposits within the valley area and along valley margins. Bedrock penetrated by wells in the upland or valley margin areas provides small amounts of water, in some cases sufficient for domestic use, but generally not significant in terms of the overall basin water supply. Data obtained since the Mack study provide opportunity to further refine the understanding of hydrogeologic conditions; these data consist of driller's logs, groundwater elevations and well yields for additional wells.

The alluvial material constituting the valley fill aquifer consists of a combination of clay, sand and gravel which appear to range from well-sorted to poorly-sorted in driller's logs provided by Mack and as reflected on DWR well logs for wells drilled subsequent to Mack's study. Mack describes the flood plain alluvium underlying the east side of the valley between Etna and Ft. Jones as being the most permeable; also of note are alluvial fan deposits on the west side, which contain both coarse channel deposits and layers of fine sediments. Numerous springs and wetlands are located along the valley margin on the west side between Etna and Greenview at or near the base of the fans; these discharge areas indicate the interception of the water table with the land surface or, in cases of springs or flowing wells, suggest that the interspersed fine-grained layers are sufficient to create localized confining conditions.

The California State Water Resources Control Board prepared a report on hydrogeologic conditions (SWRCB, 1975) in the Scott Valley to support the Scott River water rights adjudication. As part of this study, well logs were reviewed and cross-sections prepared denoting the alluvial materials as described by drillers, and, an area of highly permeable floodplain deposits was delineated (Figure 3.1).

California's Groundwater Bulletin 118 (2004) summarizes conditions of the Scott River Valley Groundwater Basin, based largely on information developed by Mack (1958) and SWRCB (1975). The average irrigation well yield is reported as 794 gpm based on 27 well completion reports. As part of this study, well completion reports available through 2010 were reviewed. Based on 204 irrigation well completion reports, 116 of which report yield, the average irrigation well yield is 524 gpm; the median yield is 250 gpm.

Harter and Hines (2008) further summarize the geologic setting, also largely as understood by Mack, but reflecting review of additional water level and well log data; and, provide comprehensive background on the Scott Valley's physical setting, including climate, temperature, precipitation; soils; and, watershed characteristics.

Figure 3.1 shows the well depth for specific wells where identified in the NWIS and CDEC databases (Table 2.1) and shows the range of well depths within each section as tabulated by the DWR based on driller's logs on file with the DWR. Most valley wells do not fully penetrate the alluvial fill, therefore, in composite, the alluvial fill is generally as deep as or deeper than the maximum depth shown. In some cases, the wells have reached bedrock, providing spatial control on the depth of the valley alluvium. These data are discussed further in Section 4.2.

3.2 Aquifer Properties

The report on hydrogeologic conditions prepared by the California State Water Resource Control Board (SWRCB,1975) provides estimates of hydraulic conductivity (permeability) based on specific capacity for wells in various regions of the valley. Specific capacity can be influenced by the length of the pumping period, aquifer storage properties and well efficiency. The method and adjustments employed by the SWRCB to convert from specific capacity to permeability are not identified in the 1975 report. Nevertheless, specific capacity provides insight into the transmissive properties of the aquifer. SWRCB concluded that the floodplain deposits have a hydraulic conductivity of about 134 ft/day (1,000 gpd/ft^2) and describes fan deposits or other alluvial sediments as "non-floodplain" deposits where the hydraulic conductivity was inferred to be less than about 40 ft/day (300 gpd/ft^2).

As part of this study, the evaluation of specific capacity was extended to the present, including all well test data reported on well logs filed with the DWR. Specific capacity, calculated for over 90 wells from test data provided on driller's logs, is shown on Table 2.3. Values range from less than one gpm/foot to over 100 gpm/foot. These data are generally consistent with the SWRCB's description of high transmissivity with the valley floodplain, and within the area outlined by SWRCB (1975) as the area of interconnected groundwater, although some data suggest that the aquifer is significantly less transmissive in the area south of Etna Creek and west of the Scott River. Also as described by SWRCB, specific capacity is generally lower in areas beyond the floodplain; however, some exceptions are noted.

Well yield, as reported on driller's logs, also was examined as a general indication of aquifer transmissivity. The spatial distribution of well yield suggests that areas of high or moderate transmissivity may be present beyond the area delineated by SWRCB, including the Moffett Creek alluvium, some parts of the area identified as "discharge zone" by Mack (1958), and in some areas of the Scott River floodplain in the southern and northern reaches of the Scott River. Lower well yields in the Oro Fino Valley, along valley margins and on the west mountain fans are consistent with generally lower specific capacity values in those areas.

3.3 Groundwater Elevations and Trends

Groundwater measurements have been made as part of several monitoring programs. In composite, these data provide a reasonably good understanding of the groundwater conditions in the Scott Valley. Mack (1958) and the DWR (1990, as represented in the 1991 Flow Augmentation Study) have developed groundwater elevation contour maps depicting the general configuration of the water table within the valley. Based on measurements at 38 wells, the DWR 1990 map shows the water table sloping from upland areas towards the Scott River and towards the downgradient (north) end of the Scott Valley, sloping at approximately 0.0015 foot/foot in the valley area. Mack similarly maps groundwater elevations, reflects a similar pattern, and observes a hydraulic gradient of about 7.5 feet per mile, which is comparable that observed in 1990 by the DWR. These data reflect a system which receives recharge from the surrounding mountainous areas, as well as recharge from stream and creek beds, and from the conveyance and application of irrigation water within the valley. The Scott River is the dominant discharge feature within the valley, and drains both run-off and intercepted groundwater from the valley when the hydraulic gradient is towards the river, as is reflected by these water table maps. However, there may be times of the year when particular river reaches lose water to groundwater, in lieu of gains, depending on the combination of local groundwater conditions, stream stage and the stream bed channel elevation.

Figure 3.2 shows the depth to water for wells monitored in October 1953. Groundwater levels are very shallow in the valley bottom, generally less than 10 feet to water. As would be expected, the depth to water increases towards the valley margins, generally reflecting the higher land surface elevations. While this same general condition might be expected today, inspection of hydrographs of the five wells monitored over a period of many decades (Appendix A) indicates that late summer or fall groundwater elevations have experienced declines over the decades. The long-term monitored wells (Table 2.2) are:

- **42/09-02A2:** This shallow well is located less than a mile east of the Scott River in the central area of the Scott Valley. The well appears sensitive to precipitation and appears also influenced by local factors. While the noise in the hydrograph may obscure trends, a number of years in the latter half of the record reflect elevations lower than seen in the earlier period.

- **42/09-27N1**: This is a shallow well located east of Etna, near Etna Creek and about a mile west of the Scott River. More recent dry season water levels are about 4 feet lower than in previous decades.

- **43/09-23F1**: This unused well is located just north of the airport, and about one half mile west of the Scott River. Low water levels in the past decade have been approximately 2 feet lower than those generally observed prior to 1980.

- **43/09-24F1**: This irrigation well is 204 feet deep and is located about a mile east of the Scott River. Water levels are erratic with some measurements apparently influenced by pumping. However, a decline of a few feet over recent decades is suggested by the seasonal lows where pumping influence is not suspected.

- **44/09-28P1**: This unused well is 65 feet deep, located near Scott River Road along Tyler Gulch at the downstream end of the Scott Valley. Late summer/fall water levels appeared to have declined from the mid 1960s to the present; recent low water levels appear to be 5 to 10 feet below the low water levels seen in the late 1960s.

Harter and Hines (2008) examined the groundwater trends at these same wells and concluded: "the minimum groundwater level measurements observed have shown a decline in almost all cases, when taking into account fluctuations due to differences in precipitation. This trend in declining minimum levels of groundwater measured in these wells corresponds to a period when an increase in the number of groundwater wells installed within Scott Valley has been observed. Surface flows have likely been impacted by this decrease in groundwater levels during critical times." Figure 3.3 provides a cumulative mass plot of precipitation from 1950 to the present at Ft. Jones. While some multi-year periods have experienced lower precipitation and precipitation likely influences short-term groundwater fluctuations and trends, a sustained decline in precipitation that would explain the apparent declines in low season groundwater elevations is not apparent. Van Kirk and Naman (2008a, b) analyzed snow water equivalent (SWE) data and a decline in base flow of the Scott River, considering also data and trends for other tributaries of the Klamath Basin. Noting that SWE decreased corresponding to cool and warm phases of the Pacific Decadal Oscillation for the periods 1942-1976 and 1977-2005, respectively, they concluded that 39% of the decline in late summer discharge of the Scott River is explained by regional scale climatic factors, with the remainder (about 23 cfs of the 37 cfs late summer decline) attributable to local or watershed factors such as changes in consumptive use.

A tally of wells drilled (based on DWR logs complied in June 2011 and Mack, 1958), and filtered to exclude those falling outside of the alluvial valley, indicates that whereas about 80 wells existed in the mid-1950s, about 400 existed by 1980, over 600 existed by 2000. Since 2000, an additional 168 well have been drilled (Table 2.10). While some of the drilling may simply replace older wells, nevertheless, more wells are in use today than in previous decades. The withdrawal of groundwater from wells has the potential to not only impact groundwater elevations but also to impact surface water flows, discussed further in Section 4.0.

Another factor which may have influenced declining low-season groundwater elevations is the reduction in irrigation-related recharge to the valley. Irrigation efficiency was reported to be about 55 % in the mid-fifties (Mack, 1958, based on Horn and others, 1954). In 2000, an irrigation efficiency of approximately 73% was achieved (Table 2.5, DWR, 2000). If the same amount of water is diverted and applied, improved irrigation efficiency may increase the quantity of water consumptively used and reduce the quantity of water that returns to groundwater through deep percolation and/or directly to surface water as tailwater. However, if diversions and applied water are reduced commensurate with the increased efficiency, then changes in efficiency would have little effect on the basin water budget, although changes in local hydrologic conditions may occur. Other factors also may have influenced agricultural consumptive use and return flow, and their trends, over the past 50 years. These factors include the timing of available surface water, the occurrence of shortage (fewer cuttings) and the availability of groundwater as a supplemental water supply, particularly later in the season. Harter and Hines (2008) note: "Considering the changes in crops, acreage and the factors above, the amount of water likely used by crops has increased from 1958 to 2000 by between 15 percent (10,000 more acre feet) and 30 percent (20,000 acre feet) depending on the date when surface irrigation stops, i.e. July 15, Aug 1 or Aug 15."

If crop yields have increased over time, either through an extended season or through more effective irrigation methods, consumptive water use would similarly have increased. Increased consumptive use has the potential to impact groundwater elevations, through a reduction of the percolation of excess applied water to the shallow aquifer and as a result of increased groundwater pumping. Watershed and river channel conditions may also impact groundwater elevations and associated surface water flows. Groundwater conditions, trends, and influencing factors can be further examined with the groundwater model, the development of which is described in the next section.

4.0 GROUNDWATER MODEL DEVELOPMENT

4.1 Model Code and Approach

The Scott Valley Groundwater Model uses a modified version of MODFLOW2000 (Harbaugh et. al., 2000) which incorporates the ET-RIP Package (Baird and Maddock, 2005; Maddock and Baird 2003) with capabilities for enhanced representation of riparian plant communities. In this phase of model development, exchanges between rivers or creeks and groundwater are represented using the River Package. This package does not explicitly model surface water flow; rather, it represents user-specified surface water conditions for model stress periods, i.e., seasonally specified stream stage and channel width, and tracks groundwater-surface water exchanges accordingly. The model simulates groundwater elevations within the aquifer and stream gain/loss associated with simulated groundwater conditions; for example, the model can simulate changes in groundwater elevations and stream gain/loss due to changes in recharge conditions, pumping, irrigation efficiency, stream channel conditions, or other model inputs.

4.2 Model Structure

The Scott Valley Groundwater Model is structured to represent groundwater flow and surface water interactions in the alluvial aquifer of the Scott Valley. Figure 4.1 shows the location of the groundwater model domain (active model area) and the streams, drains and canals that are explicitly represented in the model. The alluvial aquifer is bounded on all sides by bedrock of upland mountainous areas. Bedrock has limited capacity to transmit water and is excluded from the active model area. However, mountain-front recharge from bedrock to the alluvial aquifer is included as a boundary condition. The vertical extent of the alluvial aquifer was characterized from examination of well logs and geologic cross-sections. Model details are further described below.

4.2.1 Model Grid

The model grid is composed of 553 rows and 280 columns, with cell size uniformly equal to 200 by 200 feet. The model grid is oriented north-south, with principal flow towards the basin outlet generally oriented along columns south of Ft. Jones, and oriented along rows northwest of Ft. Jones. The model origin (lower left corner) is located 500,564.86E and 4,576,828.15N, UTM Zone 10N NAD83 horizontal datum (meter).

4.2.2 Model Elevations and Layer Thickness

Land surface elevations are assigned to each model cell based on LiDAR elevation data, supplemented by10-meter DEMs on the east side of the valley where LiDAR was not available (Figure 4.2). The bottom of the model represents the bottom of the alluvial aquifer. Two model layers are defined. Analyses conducted to delineate the model layer elevations and thicknesses are described below.

4.2.2.1 Delineation of Alluvial Aquifer

The lateral boundaries of the alluvial aquifer are readily apparent from inspection of geologic and topographic maps, generally corresponding to the bounding upland bedrock areas. Over 1,000 well logs were inspected to identify the thickness of alluvium. Because the wells are located only by section on well logs and within the database provided by the DWR, this analysis was directed towards identifying, for each section, the maximum observed alluvial thickness (Table 4.1). Where bedrock is encountered in wells, the depth to bedrock often corresponds to the bottom of the alluvial aquifer. However, some well logs reflect a significant thickness of clay or cemented material above bedrock. In these cases, the bottom of the alluvial aquifer is identified as the lowermost elevation at which alluvial material with reasonable capacity to store or transmit water, including gravels, sands and/or silts, are identified on well logs. For sections in which no well penetrates to bedrock, the maximum well depth was identified and the alluvial thickness is characterized as "greater than" this value (also shown on Table 4.1). The values shown on Table 4.1 formed the basis for the alluvial aquifer thickness represented in the groundwater model, shown on Figure 4.3. Active model cells along the model boundary were assigned a minimum alluvial thickness of 50 feet.

The alluvial aquifer thickness assigned to each cell was subtracted from the average land surface elevation to determine the elevation at the bottom of the alluvial aquifer as represented in the groundwater model. Figure 4.4 shows the elevation of the modeled alluvial aquifer bottom. The bottom slopes down from adjacent upland areas, reaching greatest depths in the central area of the Scott Valley.

4.2.2.2 Layer Thickness

Two model layers are designated in the Scott Valley Groundwater Model. Layer 1 represents the uppermost saturated portion of the aquifer, including the horizon commonly referred to as the "water table". In this layer, water storage is characterized by *specific yield*, a storage parameter largely reflecting the occurrence of gravity drainage (or pore space filling) at the top of the saturated zone. Layer 2 constitutes deeper sediments in the main valley and within the more prominent tributary aquifers where a thickness of sediments greater than 25 feet is present below the bottom of Layer 1. In this layer, water storage is characterized by a *storage coefficient*, a storage parameter reflecting the release of stored water that results from matrix and fluid compaction.

Layer 1 is present throughout the model domain, as shown on Figure 4.1. The bottom elevation of Layer 1 is set at 50 feet below the riverbed elevation along the Scott River, and at 50 feet below the streambed elevation along major tributaries. In the central valley, the bottom elevation is maintained at the same elevation across model rows within valley floor, then, gradually sloped upwards towards the western basin margins. In Quartz Valley, Oro Fino Valley and the Moffett Creek area, the bottom elevation is generally maintained across rows or columns (depending on orientation of the valley) and corresponds to the row/column riverbed elevation, with some smoothing to handle transitions to neighboring zones or other local spatial conditions. The bottom elevation of Layer 1 is shown on Figure 4.5. Layer 1 encompasses the entire alluvial thickness in several upland gulch areas, as well as in upland alluvial areas of tributary "arms" including those defined by Etna Creek, Kidder Creek, Mill and Shackleford Creeks and most of the Oro Fino Valley. The saturated thickness of Layer 1 is approximately 50 feet along much of the Scott River. The thickness of Layer 1 increases towards the basin boundaries in varying amounts, depending on topography, subsurface and recharge conditions.

Layer 2 extends from the bottom of Layer 1 (Figure 4.5) to the bottom of the alluvial aquifer (Figure 4.4). In the central valley area, Layer 2 ranges from 80 to 210 feet in thickness. Layer 2 is thin towards valley margins and is absent in most of the upland gulches and valleys. The areal extent of Layer 2 is shown on Figure 4.1.

4.3 Hydraulic Properties

4.3.1 Hydraulic Conductivity

Initial values for horizontal hydraulic conductivity are based on data and analyses described in Section 3, including specific capacity computed from well tests (Table 2.3) and literature-based values (Mack, 1958; DWR, 1975). Hydraulic conductivity values were initially associated with sub-regions corresponding to Mack's (1958) storage units, tributary watersheds and the DWR (1975) report on hydrogeologic conditions. These sub-regions are shown on Figure 4.6. Because the available data are based on short-term pumping tests and tend to reflect localized conditions, the initial hydraulic conductivity values are also evaluated in a basin-wide context and adjusted in model calibration. Resulting model horizontal conductivity values within sub-regions are summarized on Table 4.2. The ratio of horizontal to vertical hydraulic conductivity is specified as 200:1 between layers 1 and 2.

4.3.2 Storage Terms

The uppermost sediments within the Scott Valley alluvial aquifer are under water table (unconfined) conditions; therefore, the storage term in Layer 1 is assigned a value for specific yield, whereby water is stored or released from storage via the process of gravity drainage. The specific yield for Layer 1 was set by sub-regions based on estimates developed by Mack (1958), ranging from 7 to 15%[1]; values are shown on Table 4.2. The top of Layer 2 of the model is situated below the water table; accordingly, a specific storage value of 1×10^{-5} is specified for preliminary model runs; this value is multiplied by layer thickness within MODFLOW to obtain a storage coefficient for Layer 2.

4.4 Pumping

Groundwater withdrawals for domestic, municipal and irrigation use are distributed into the model using the MODFLOW Well Package.

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[1] For computational efficiency in model development, the hydraulic parameters are not varied as a function of saturated thickness. As implemented in MODFLOW, this requires specification of a dummy "specific storage" which functions as a "multiplier" to achieve the intended value for specific yield. The dummy specific storage value is selected such that when multiplied by layer thickness, the desired specific yield is obtained.

4.4.1 Domestic and Municipal Pumping

Groundwater withdrawal for domestic use is estimated at a total value of 136 acre-feet per year for 544 wells, assuming an average withdrawal of ¼ acre-foot per year per well (Section 2.7). In areas where the wells are widely dispersed, the impacts of these withdrawals will have little impact on modeled conditions. However, areas in which wells are clustered have the potential for a noticeable combined impact, and these are represented in the model. To this end, sections containing more than 10 wells were identified. In these sections, the estimated combined domestic pumping is distributed within the section and represented in the Well Package. The greatest concentration of domestic wells is located within the upper Kidder Creek drainage and in the general area between Greenview and Cheeseville (186 wells). Additional domestic well clusters represented in the model include the Etna area with 39 wells, Heartstrand Gulch with 16 wells, and the Ft. Jones/Moffett area with 31 wells. Pumping from the domestic well clusters is assigned to Layer 2 except in basin margin areas where only Layer 1 is represented. Municipal pumping by the Town of Ft. Jones is represented at the location of WW-2 in T43N/09W-02. Pumpage from this well is estimated at 50 acre-feet per year.

4.4.2 Groundwater Pumping for Irrigation

Groundwater use for irrigation is based on DWR Agricultural Water Use tables for DAU 3, an area used in DWR land and water use analyses, roughly corresponding in area to the Scott Valley watershed above the USGS gage near Ft. Jones. Detailed monthly reports were obtained from the DWR for the years 2000 and 2002 to 2005. The monthly reports tabulate irrigated acreage, evaporation of applied water (ETAW), the consumed fraction, unit applied water, applied water, evapotranspiration (ET) and effective precipitation (EP) for alfalfa, corn, grain, meadow pasture, other field and other truck crop categories. These quantities are separately identified based on water source, that is, surface water and groundwater. Supply-limited acreages of alfalfa and meadow pasture are also included as alfalfa-X and meadow pasture-X. The data table for the year 2000 is provided in Appendix C.

Groundwater pumped for irrigation use is represented in the groundwater model for two cases representing different points in the historic period with differing capacity for groundwater extraction. One case represents “recent conditions”; a second case represents "partial build-out" of groundwater capacity. While pumping and water use vary somewhat from year to year, depending on cropped acreage, crop distribution, weather and water supply conditions, these two cases are taken as representative of two distinct development conditions and provide a basis for examining hydrologic conditions and relationships within the alluvial aquifer. These cases are identified for illustrative purposes and can be modified or refined in future scenario evaluations.

4.4.2.1 Recent Condition

For the recent condition, irrigation pumpage is taken as the monthly quantity of applied irrigation groundwater for major crop categories (alfalfa, corn, grain and meadow pasture/pasture) as tabulated by the DWR for the year 2000 (Appendix C). These values are summarized on Table 4.3a by model season for the four major crop categories. The total quantity of groundwater withdrawal for irrigation under this condition is about 40,530 acre-feet per year for lands within DAU3 (Scott Valley). Applied as a unit withdrawal per irrigated acre for each crop category, the irrigation pumpage is spatially distributed into irrigated lands within the groundwater model in proportion to the percent coverage of each crop category within each model cell[2]. In this process, the distribution of crops is based on the GIS crop coverage from the 2000 DWR land use survey (*00SK*, http://www.water.ca.gov/landwateruse/lusrvymain.cfm, accessed 5/27/2011). The fact that lands planted with different crops tend to use surface water and groundwater in different proportions is preserved by this method. While actual cropped acreage and water sources will differ to some degree from the 2000 DWR land use survey in any particular year, this survey is believed adequate to capture the general nature of spatial cropping patterns in the valley.

4.4.2.2 Partial Build-Out Condition

The partial build-out condition differs from the recent condition in that groundwater capacity is specified at 60% of the 2000 condition. This case is not intended to represent a specific historic year; rather, it is structured to provide a point of comparison

[2] The modeled quantity of groundwater withdrawal is not exactly equal to the total applied groundwater for DAU3 due to the fact that some DAU3 irrigated areas are located outside of the active model grid. However, because most of the DAU3 irrigated lands located outside of the model grid are pasture, and groundwater is not a significant percentage of the water source to pasture, the difference between modeled groundwater irrigation withdrawals and DWR's estimated groundwater irrigation withdrawals for DAU3 is relatively small.

that will provide insight on impacts of incremental levels of groundwater pumping. While structured as a hypothetical, this pumping condition would have occurred at some point in the past. Based on drilling dates of the well logs available to this study, this condition would likely have occurred in or around the early 1980s. In addition to varying pumped groundwater for irrigation, this case correspondingly reduces the recharge from excess applied groundwater (see Section 4.5, below) that would have been associated with reduced pumping levels. Changes in cropping patterns or efficiency are not incorporated into this groundwater usage condition.

A review of monthly records of applied groundwater suggests that a 60% reduction in well capacity would potentially limit the application of irrigation water from wells in the months of June through September, but have little impact on groundwater usage in May. In the “partial build-out” case, the amount of applied groundwater is limited to 60% of the maximum monthly value from the “recent condition” values for each crop category. The resulting quantities of applied groundwater by season, for each crop category, are shown on Table 4.3b. The corresponding total groundwater withdrawal for irrigation in DAU3 under this condition is about 27,960 acre-feet per year. As for the “recent condition”, the groundwater withdrawal for irrigation is spatially distributed into irrigated lands within the model grid in proportion to the percent coverage of each crop category within each model cell.

4.5 Recharge

Recharge to the groundwater system includes mountain-front recharge, recharge from percolation of applied irrigation water, and recharge due to seepage from canals and farm laterals.

4.5.1 Mountain-Front Recharge

Mountain-front recharge (subsurface flow into the valley along the mountain front) is distributed along model boundaries (Figure 4.7) using the Well Package, at values identified on Table 4.4. Mountain-front recharge is estimated using a water balance approach for 13 watersheds tributary to the Scott River. This method involves computing available water in the upland watersheds as a function of evapotranspiration and precipitation over the mountainous areas. These quantities are developed over an 800-

meter gridded area using climate data developed by the PRISM Group, Oregon State University for the 1971 to 2000 period, with elevation and slope data from digital elevation models. Gaged stream records were reviewed to develop a preliminary allocation of available water between runoff and mountain-front recharge. This method, further described in Appendix D, provides a preliminary, physically-based, range of values for the distribution of recharge into the groundwater model along the valley margins. Mountain-front recharge was adjusted in model calibration; the resulting estimates are shown on Table 4.4. These estimates may be refined in future study phases if additional information becomes available. Additionally, subsurface inflow associated with the Scott River is included in an amount of 346 acre-feet per year, based on flux calculated by Darcy's Law at the cross-section where the valley is intersected by the southern model boundary.

4.5.2 Canal Seepage

Recharge through canal seepage during the irrigation season is estimated from limited field observations, as discussed in Section 2. Canal seepage is handled through the Well Package, as it is not expected to vary substantially as a function of water table elevations. Based on field observations (DWR, 1991), seepage is represented as 1 cfs per mile for the SVID Ditch below Young's Dam. The Farmer's Ditch, diverting at approximately Sugar Creek, is reported to have minimal to no seepage losses (DWR, 1991). However, some areas of seepage from this canal are inferred from the presence of vegetation and grassy or seep areas along the canal. Seepage from this ditch is represented at 0.5 cfs per mile.

4.5.3 Irrigation Season Recharge through Deep Percolation of Applied Water on Irrigated Lands

Recharge via infiltration from irrigated lands, or, on-farm deep percolation, is calculated using monthly, crop-specific, agricultural water use tables developed by the DWR (Appendix C). The on-farm deep percolation is simulated in the groundwater model as recharge using MODFLOW's Recharge Package, with distribution according to the number of acres of each crop type within each model cell.

On-farm deep percolation is taken as the difference between the total applied water and total evapotranspiration of applied water (ETAW), where the total represents the combination of applied surface water and groundwater. These values are computed monthly from the DWR table for DAU3 (Scott Valley) for 2000, then, grouped to correspond to the seasonal periods represented in the groundwater model. Resulting seasonal values for on-farm deep percolation are shown on Table 4.5a for the "recent condition" and on Table 4.5b for the "partial build-out condition". As noted earlier, for the partial build-out condition, the only change simulated is a reduction in groundwater capacity. In this case, the change in groundwater pumping of about 12,550 acre-feet per year is associated with a change in recharge of applied irrigation water of about 2,750 acre-feet per year, reflecting a consumed fraction of 78% for groundwater. That is to say, approximately 22% of the pumped groundwater returns to the aquifer or stream system; therefore, pumping 12,550 acre-feet per year would have a net impact of approximately 9,800 acre-feet per year given the agricultural water use assumptions reflected in the farm water budget (Appendix C). As noted for the pumping distribution, modeled quantities are based on unit rates per crop class acreage as mapped to each model cell[3].

4.5.4 Non-Irrigation Season Recharge

Recharge during the non-irrigation season is represented using MODFLOW's Recharge Package. During the non-irrigation season, available water, after satisfying evapotranspiration demand, is estimated to be about 10 inches (from water balance methods as described in Appendix D). This amount will partition between run-off and infiltration. Infiltration is estimated as 3 inches over the non-irrigation season (October through April) in the valley, including cropped and non-cropped land; this quantity is included in the Recharge Package.

4.6 Evapotranspiration

The ET-RIP Package is used to represent water use by riparian vegetation. Table 2.7 identifies the wetland groups and corresponding National Wetland Inventory (NWI) classification codes; Figure 2.5 shows the distribution of the wetland groups including emergent wetland, forested/shrub/wetland, pond and riverine for the Scott Valley. The ET-RIP package supports specification of percent cell coverage by each plant group, and assignment of a time-dependent ET curve for each plant group. The percent cell coverage

[3] Deep percolation associated with all irrigated acreage in DAU3 is summarized on Table 4.5, including approximately 2,500 acres of pasture that lie beyond the model boundary Model input, developed from the unit values shown on Table 4.5, excludes deep percolation associated with acreage that falls outside the model boundary.

for the wetland classes shown on Figure 2.5 are mapped into each cell of the the Scott Valley Groundwater Model. Of approximately 7,100 NWI mapped wetland acres, 6,776 acres fall within the model boundaries. A comparison of NWI mapped wetlands with DWR mapped crop acreage within the Scott Valley indicates that 4,341 acres of the NWI mapped wetlands classes coincide with mapped crop acres. For these lands, the crop classification is applied as the primary land use in the groundwater model, effectively reducing the number of wetland acres falling within the model grid from 6,776 to 2,438 acres.

Analyses conducted by the U.S. Bureau of Reclamation (2003) of ET demand by wetland classes, including northern climate salt grass, willows, cottonwoods, rushes/sedges and tules/cattails in the Upper Klamath Basin, illustrate a relatively close correspondence on a seasonal scale to the ET curve for alfalfa for that location. Assuming a similar relationship for the Scott Valley, the monthly evapotranspiration demand for alfalfa in the Scott Valley is used to approximate wetland ET demand, at an annual value of 2.21 feet, distributed as 0.68 feet in the May-June season and 1.53 feet in the July-September season. As structured, the ET-RIP Package can readily be updated to reflect class-specific rates if this information becomes available. The ET-RIP Package also offers the option of implementing a depth-specific evapotranspiration rate, which may be useful in some future model applications.

4.7 Gains/Losses to the Scott River

Gains and losses to the Scott River and major tributaries (Figure 4.1), including Shackleford Creek, Mill Creek, Oro Fino Creek, Kidder Creek, Patterson Creek, Moffett Creek, Big Slough, Etna Creek and French Creek are calculated within MODFLOW as a function of aquifer head, the specified stage within the river or stream, and a river conductance term. For ease in comparing simulated gains/losses to observed gains/losses, the modeled river cells have been grouped into reaches, as shown on Figure 4.8 and identified on Table 4.6.

The MODFLOW River Package is used to specify creek and river conditions that allow for the computation of groundwater-stream interactions. River bottom elevations are specified for each model cell crossed by a creek or river. LiDAR data were used in developing the river bottom elevations in a process involving identification of topographic lows, followed by a smoothing and reasonable adjustment. Stage for river segments is specified according to time-dependent flow conditions, representative of conditions to be simulated in a given scenario. River conductance is a lumped term reflecting the hydraulic conductivity of river bed material and the approximate river width. Grain size composition, reflected by D50 values reported by Sommarstrom et al. (1990) and subsequent studies, were considered in identifying a range for initial values.

Three prominent drainage channels are represented in the model: Big Slough, East Slough and West Slough. For purposes of this study, Big Slough is identified as including both the upper section, between Patterson and Kidder Creeks, and its continuation into the north-south trending reach of lower Kidder Creek. Big Slough is represented in the River Package, discussed above. Two other prominent drainage channels, identified for purposes of this study as East and West Slough, are represented in the Drain Package. The West Slough intercepts shallow groundwater, tailwater and runoff from an area west of the river in the upper valley, and flows into the Scott River at the French Creek confluence. The East Slough similarly intercepts shallow groundwater and/or surface water. It originates between the Eastside Road and the Scott River, about a mile north of Eller Lane, and intercepts the Scott River about a half mile north of Scarface Road. These channels intercept some of the shallow groundwater in areas of high water table, augmenting the drainage of low lying valley areas and returning flows to the Scott River.

4.8 Model Calibration

Initial model files were prepared based on data inputs as described in the previous sections. During model calibration, model parameters were adjusted to achieve a reasonable match to observed conditions, while maintaining consistency with information reflected in well logs, including lithology, well yield and specific capacity.

Data available for model calibration include groundwater elevations collected from a set of wells over a period of decades and periodic elevations collected at a larger number of wells, as described in Section 3.3. Valley-wide elevation surveys were undertaken in the mid-1950s (Mack, 1958) and again in August 1990 (DWR, 1991). Published information from these survey events provides a means of judging the general correspondence of simulated to observed groundwater levels. Wells with long-term hydrographs that continue to the present suggest that under recent conditions, late summer/early fall groundwater elevations may be up to a few feet lower than early values in some locations (Section 3.3 and Appendix A); and, winter/early spring groundwater elevations appear to have experienced minimal long-term declines. The multi-decadal records were used to evaluate the reasonableness of the model simulations with respect to long-term trends and seasonal fluctuations; and, these records provided guidance in extrapolating from past, valley-wide monitoring events to subsequent conditions on a valley-wide scale. Model results are discussed in Sections 5.0 and 6.0.

5.0 STEADY-STATE OSCILLATORY MODEL, PARTIAL BUILD-OUT

The steady-state oscillatory model (SSO model) provides a means of simulating seasonally-variable groundwater conditions corresponding to user-specified water use and water supply conditions, typically selected as representative of historical or existing conditions. The SSO model provides initial heads for subsequent transient runs that may look at seasonal or annual variation in greater detail or that may be used as a point of comparison for scenario analysis. The SSO model consists of an initial steady-state stress period followed by transient stress periods. Oscillations, composed of annual cycles of seasonal stresses, are repeated until there is minimal net change in storage over the course of two consecutive years. Aside from its value as a starting point for transient simulations, the SSO model is useful in characterizing the groundwater environment and surface water interactions under long-term average conditions and evaluating the general reasonableness of the model.

Two SSO model simulations were developed with alternate water use conditions; one simulating partial build-out conditions, and one simulating recent conditions. The SSO model of partial build-out conditions, described below, supported an initial calibration process and served to initialize a subsequent transient run. The SSO model of recent conditions and a transient simulation to evaluate the timing of stream depletion impacts associated with groundwater withdrawals are discussed in Section 6.0.

5.1 Seasonal Input for the SSO Models

The SSO models consist of a one-year, four-stress period transient simulation that is repeated for a 25-year period. Two seasonal stress periods are defined for the non-irrigation months and two periods are defined for the irrigation months. The non-irrigation periods are identified as Period A, spanning October through November, post-irrigation months with limited recharge and relatively low river flow; and, Period B, spanning December through April, months in which precipitation and run-off significantly increase river and tributary flows. The irrigation periods are identified as Period C, spanning May through June, a period with continuing high river and stream flows and good surface water availability for irrigation; and, Period D, July through September, characterized by low river flow, greater likelihood of dry stream reaches or creeks, decreasing availability of surface water supplies for irrigation, and increased amounts of groundwater pumping. The average flow of the Scott River at the USGS gage near Ft. Jones over the years 1971 to 2000 for the seasonal periods A through D was 212, 1,038, 902 and 96 cfs, respectively, with an average annual flow of 642 cfs (Appendix B).

Water supply conditions for the SSO model are taken from the 1971 to 2000 period. Stream stage is based on the long-term average flow per season, as noted above. Mountain-front recharge is based on conditions reflected in PRISM climate data for the period 1971 to 2000 (Appendix D).

Water use in the valley is dominated by irrigated agriculture; as such, assumptions for groundwater pumping and recharge from on-farm deep percolation are specified according to scenario, partial build-out or recent conditions. The partial build-out condition is described in Section 4.4.2.2 and 4.5.3 wherein groundwater capacity is limited to 60% of the recent condition (year 2000) values.

5.2 SSO Model Results, Partial Build-Out Condition

Simulated groundwater contours for the SSO model, partial build-out condition, are shown on Figure 5.1[4], for the end of the irrigation season. Spatial groundwater elevations were reviewed for overall reasonableness when compared to groundwater elevation maps from the historic period (Mack, 1958; DWR, 1991). A review of time-trend data at selected wells (Appendix A) indicates that over the multi-decadal historical period, groundwater declines tend to be on the order of a few feet; that is, declines in groundwater elevations are small enough to not greatly impact a comparison of this type. Model adjustments were made as part of an initial calibration process to attain general consistency of simulated to observed conditions, with respect to the magnitude, direction and slope of the water table.

Figure 5.2 shows simulated and observed heads over a 10-year period at five locations with monitoring records available for the 1980s. The simulated heads are influenced by seasonally variable water use and recharge rates over the 10-year period, resulting in higher water levels in winter/spring than in late summer/fall. Year-to-year

[4] Simulated groundwater elevations are mapped for the portions of the model area where LiDAR elevation data were available; simulated results in areas beyond the LiDAR survey extent are subject to greater uncertainty.

fluctuations are not represented in this simulation, nor are localized pumping impacts that cause additional inter-annual variability and "noise" in the observed water levels. The comparison provides a means of examining the reasonableness of the model, as the SSO output should bear reasonable resemblance to what is understood to be average hydrologic conditions in the basin for the partial build-out condition. Due to imprecision in well measuring point elevations, topographic variation across grid cells, the resolution of model stress periods and local pumping influences, the goal of this comparison is to obtain a reasonable, overall, correspondence to spatial conditions and trends rather than a precise match. Shallow wells located very close to the model boundaries (42/09-02A2 and 44/09-28P1) were given less weight in this exercise, as localized conditions on model edges can be difficult to capture in a basin-scale model. In addition to consideration of well responses, the model calibration was guided by depth-to-water maps; the spatial distribution of specific capacity and well yield; and, lithology reported on well logs.

Figure 5.3 compares simulated groundwater elevations at the end of the irrigation season to groundwater elevations measured in the fall of 1953 at fifty-six wells. Because the amount of pumping represented in the partial build-out simulation is greater than that occurring during 1953, the correspondence is expected to result in simulated values, on average, lower than observed values. While the difference is expected to vary depending on location, the available data (Appendix A) suggest that the difference is relatively low; thus, the comparison should be informative for checking reasonableness of the model. The average residual, or difference in simulated and observed elevations, is approximately 7 feet; that is, the simulated values on average are somewhat lower than the observed values, as expected. The simulated results are generally consistent with elevations and trends reflected in available data[5], particularly within the interior of the basin. Larger deviations are noted in areas of higher elevation, typically, along the model edges. The upland valley margin areas may be more sensitive to increased pumping over time, and a greater residual may reflect differences in pumping conditions. On the other hand, the valley margin areas are subject to greater uncertainty due to several factors, including, accuracy of reported,

[5] Water elevations were measured in the late-1980s by the DWR (1991) at 38 wells, and formed the basis for a published groundwater contour map representing that period of time, as noted above. Efforts were made to obtain the underlying data for use in the comparison. However, the data could not be located by the DWR staff in Red Bluff, nor are the data recorded in the NWIS or CDEC databases. If these data should be located, they will be considered in future model updates/refinements.

map-interpolated well elevations in areas of higher relief; the greater concentration of shallow or dug wells; and, the sensitivity of water levels along thin valley margins to localized lithology and recharge conditions. Despite these uncertainties, the valley margin points-of-comparison are retained as they provide potentially useful information that can be further explored at later time, if relevant to specific model applications.

Simulated to observed comparisons, as displayed on Figures 5.1, 5.2 and 5.3, were evaluated during the course of preliminary model calibration, along with other information including depth-to-water maps; the spatial distribution of specific capacity and well yield; and, lithology reported on well logs. Seasonal fluctuations at well locations with shorter term records (Appendix A) were also examined for general consistency with model-simulated seasonal fluctuations. During this process, model parameters including hydraulic conductivity, stream conductance, and mountain-front recharge were adjusted to achieve a reasonable representation of observed conditions, as reflected in available data.

Table 5.1 provides a summary of the annual groundwater budget obtained from the SSO model output. Under the simulated partial build-out conditions, on average, the Scott River receives inflow from groundwater amounting to about 33 cfs. This amount is variable in time and spatially. Greater inflows are simulated between Young's Dam and Eller Lane, although significant inflow also occurs as the valley narrows towards Ft. Jones and again as it narrows above the USGS gage. During winter months, several reaches are simulated as recharging water to the aquifer, as a result of increased river stage during the wetter periods. Several of the tributary creeks also intercept groundwater (stream gains), particularly at lower elevations; although Kidder, Patterson and Etna Creeks recharge water to the aquifer during winter/early spring. The Big Slough functions as a drain, intercepting on average about 9 cfs from groundwater, in addition to collecting run-off draining from Kidder and Patterson Creeks. The simulated water balance represents the average of simulated seasonal conditions. While actual values may vary from year to year, and simulated values may be refined if additional data become available, these values provide a general indication of expected pattern and trends under the partial build-out condition.

6.0 EVALUATION OF GROUNDWATER PUMPING IMPACTS

Two simulations were developed to provide insight on the impacts of groundwater withdrawals on the stream system. These include a SSO model of the recent condition, generally reflecting water use as characterized by DWR for the year 2000; and, a transient simulation, which also models the recent condition but initiates with the partial build-out condition. Results of the transient simulation are used to characterize the timing of stream depletion impacts associated with an incremental increase in groundwater pumping beyond the partial build-out levels. For both the SSO model and the transient model, the recent condition is as described in Section 4.4.2.1 and 4.5.3, and consists of a net increase in groundwater use of approximately 9,800 acre-feet per year as compared to the partial build-out condition. This net increase reflects an increase in groundwater pumping of about 12,550 acre-feet per year, offset by an increase in recharge from applied irrigation water of about 2,750 acre-feet per year.

6.1 SSO Model Results, Recent Condition

The SSO model of the recent condition was structured as that described for the partial build-out condition in Section 5.1, with the exception of irrigation pumping and deep percolation, which are set at levels as noted above. As for the partial build-out condition, the underlying assumptions for recharge and seasonal stream flow are based on long-term average conditions for the period 1971-2000.

Table 6.1 provides a summary of the annual groundwater budget obtained from the SSO model output for this simulation. This table shows the long-term distribution of impacts of increased groundwater pumping/increased irrigation recharge on stream gains/losses. While most streams continue to gain on an average annual basis as previously described for the partial build-out system, the magnitude of gains decreases. Similarly, reductions in inflow to gaining tributaries occur; and, increased seepage losses are seen in losing reaches. These changes, whether decreases in river gains, or increases in seepage losses, result in a net reduction to surface water flow from that which would occur under the partial build-out condition. These differences are examined more fully with the transient model, described below.

6.2 Transient Simulation, Change from Partial Build-Out to Recent Condition

A transient simulation was developed to examine the impacts of a change in groundwater pumping on groundwater elevations and on groundwater-stream interactions. The 25-year partial build-out SSO model provides the initial condition for the 25-year transient model, which initiates with 5 years of "partial-buildout" conditions (described in Section 4.4.2.2), and then transitions with a single-step increase[6] in pumping levels. Water use assumptions for the final 20 years of the transient simulation reflect the "recent condition" as described in Section 4.4.2.1 and 4.5.3, that is, a net increase in groundwater use of approximately 9,800 acre-feet per year. This net increase reflects an increase in groundwater pumping of about 12,550 acre-feet per year, offset by an increase in recharge from applied irrigation water of about 2,750 acre-feet per year.

The transient simulation illustrates the progression of groundwater impacts to the aquifer and stream system from the additional increment of groundwater pumping beyond the partial build-out levels. With some limitations, the results can be scaled to approximate impacts for other magnitudes of increase or decrease in groundwater pumping, assuming a similar spatial layout of wells. For example, a change of half the simulated change (i.e., decrease or increase of 4,900 acre-feet per year from the simulated increase of about 9,800 acre-feet per year) would modify the results by a similar proportion from those shown with this simulation; however, large changes from those simulated would merit examination in an alternate scenario.

Figure 6.1 maps the change in groundwater elevations as compared to the initial (partial build-out) heads after a period of 20 years, at the conclusion of the irrigation season. Overall, groundwater elevation changes resulting from the simulated increase in pumping from partial build-out to recent levels are relatively small. With the exception of valley margins where the alluvial material thins and is typically less transmissive, greatest simulated differences (end of the irrigation season), generally fall in the range of one to four feet. The simulated difference shown on Figure 6.1 is the incremental change due to the increase in pumping that would gradually develop over the period of years between the

[6] The change from partial build-out to recent conditions is simulated as a step-increase to support characterization of a stream depletion curve that can be used to assess stream depletion impacts under a variety of pumping schedules and amounts; for example, the results can be used to prepare a curve of gradual depletion impacts due to incremental changes over a period of years.

partial build-out and recent condition. This gradual decline would be superimposed on seasonal or annual fluctuations that otherwise occur.

Figure 6.2 shows the simulated change as it progresses seasonally for a 10-year period due to the step-change increase in pumping at selected well locations with long-term records. Minimum differences occur at the end of the non-irrigation/recharge season, with declines within a range of about 0.5 to 1.5 feet. Declines of this magnitude would be difficult to detect, particularly with the pumping increase occurring gradually over a decade or more, and considering inter-annual climate fluctuations. Declines during late summer months are more pronounced, largely because of the timing of irrigation pumping. Simulated, incremental, summer declines range from under 2 feet to about 4 feet at the locations shown. Declines increase over the first few years following the step-change in pumping, and then reach an oscillatory steady-state condition, with minimal change from year to year. In the historical period, assuming that a transition occurred from the partial build-out to the recent condition over a period of one or two decades, the change would have been more gradual, but the end result, essentially as shown. As noted before, these pumping-induced declines would be superimposed on seasonal or annual fluctuations that otherwise occur.

The range of incremental declines simulated, and as shown on Figure 6.1 and 6.2, are within a range expected based on review of long-term trends reflected in the data available to this study. Additional data exist for wells monitored in recent years under a voluntary monitoring program. A request to review and consider these data for this study was declined by the Siskiyou RCB in June 2011. If these data are made available to this study at a later date, they will be considered in model updates/refinements.

Figure 6.3 shows average annual stream depletion to the Scott River and tributaries in acre-feet per year, and as a percentage of the net pumping increase, resulting from the step-change from partial build-out to recent water use conditions. Most of the simulated depletion results from reduced groundwater inflow to the streams (reduced “gains”). This depletion relationship can be used to examine lagged impacts of a gradual increase in pumping or other pumping schedules with the same spatial distribution of groundwater use. Conversely, the stream depletion relationship can be viewed as a stream accretion relationship by reversing signs, if impacts of increasing recharge are to be considered[7].

Figure 6.4 shows the stream depletion in late summer (Period D, July through September) as reduction in Scott River flow and tributaries that feed the Scott River above the USGS gage due to the simulated change. Higher stream depletion impacts occur during the summer than during the winter/early spring period, reflecting the seasonal occurrence of irrigation pumping. The simulated net increase in pumping between the partial build-out condition (approximately, 1980s) and the recent condition (2000) indicates a corresponding stream depletion impact of approximately 16 cfs during the late summer season, July through September. The stream depletion is a change that would be superimposed on surface water flows resulting from the combination of other inflows and outflows, including run-off, ambient stream gains/losses, surface diversion and return flow. The stream depletion impact resulting from changes in groundwater use prior to the partial build-out condition, i.e., from the 1950s to the 1980s is not quantified as part of this exercise.

[7] If the spatial distribution of enhanced recharge is to be localized or otherwise different than the assumed pumping distribution, then, a scenario-specific accretion curve should be developed rather than using the depletion curve shown on Figure 6.3.

7.0 DISCUSSION AND FUTURE DIRECTIONS

A preliminary groundwater model of the Scott Valley has been prepared, suitable for general characterization of valley-wide groundwater conditions and groundwater/surface water interactions. Simulations reflecting two distinct water use conditions have been made. A simulation of water use under partial build-out of well capacity sets groundwater pumping at an amount reflecting 60% of the well capacity available in the year 2000, and adjusts irrigation recharge accordingly. A simulation of water use under a more recent condition sets groundwater pumping at the amounts estimated and summarized by the DWR for the year 2000. Pumping and irrigation-related recharge are pro-rated based on crop classes and spatially assigned to the model in accordance with mapped GIS coverages. Other sources of recharge, including mountain-front recharge and winter stream flows, are based on average conditions for the period 1971 to 2000. The groundwater model, as presently configured, tracks changes to groundwater elevations and surface water/groundwater interactions through four distinct seasons, although monthly or other time intervals could be incorporated in future scenarios.

The models were applied to identify differences in groundwater elevations and to quantify stream depletion impacts associated with the net change in groundwater use between the partial build-out and recent water use condition, within the context of average water supply/climate inputs. Simulation results are generally consistent with observed water-level data. Long-term groundwater elevations declines are minimal in winter, and greater in late summer, on the order of a few feet, depending on location. Groundwater declines are limited in the valley area due to the presence of groundwater connected streams; however, the streams can be and have been impacted by increased levels of groundwater pumping. The models have been applied to generate a stream depletion relationship, which shows that, on average, increases in groundwater pumping are entirely conveyed to equivalent reductions in streamflow within approximately five years, with the bulk of the impact occurring in the first year or two. This relationship has been developed for the existing distribution of irrigated lands and crop classes; alternate stream depletion relationships can be determined for pumping from specific areas within the valley.

Similarly, stream accretion curves can be developed corresponding to enhanced recharge or groundwater storage scenarios.

The simulations assume average water supply/climate conditions. While the results are generally applicable to wet or dry years, some questions may warrant more specific examination of wet or dry conditions, particularly where river drying or extensive flooding is anticipated. These changes can be incorporated into specific scenario analysis.

The models may be applied to evaluate scenarios that might offset stream depletion impacts. Scenarios might involve recharge ponds, modification of pumping locations or schedules, alternate irrigation application methods or other approaches for increasing aquifer recharge. In some cases, model refinement may be appropriate, particularly if new data is generated, offering opportunity to fine tune the model in areas relevant to management alternatives. Finally, the release and sharing of all existing water elevation data is encouraged, along with any anecdotal information relating to hydrologic conditions that water users have observed.

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Figures

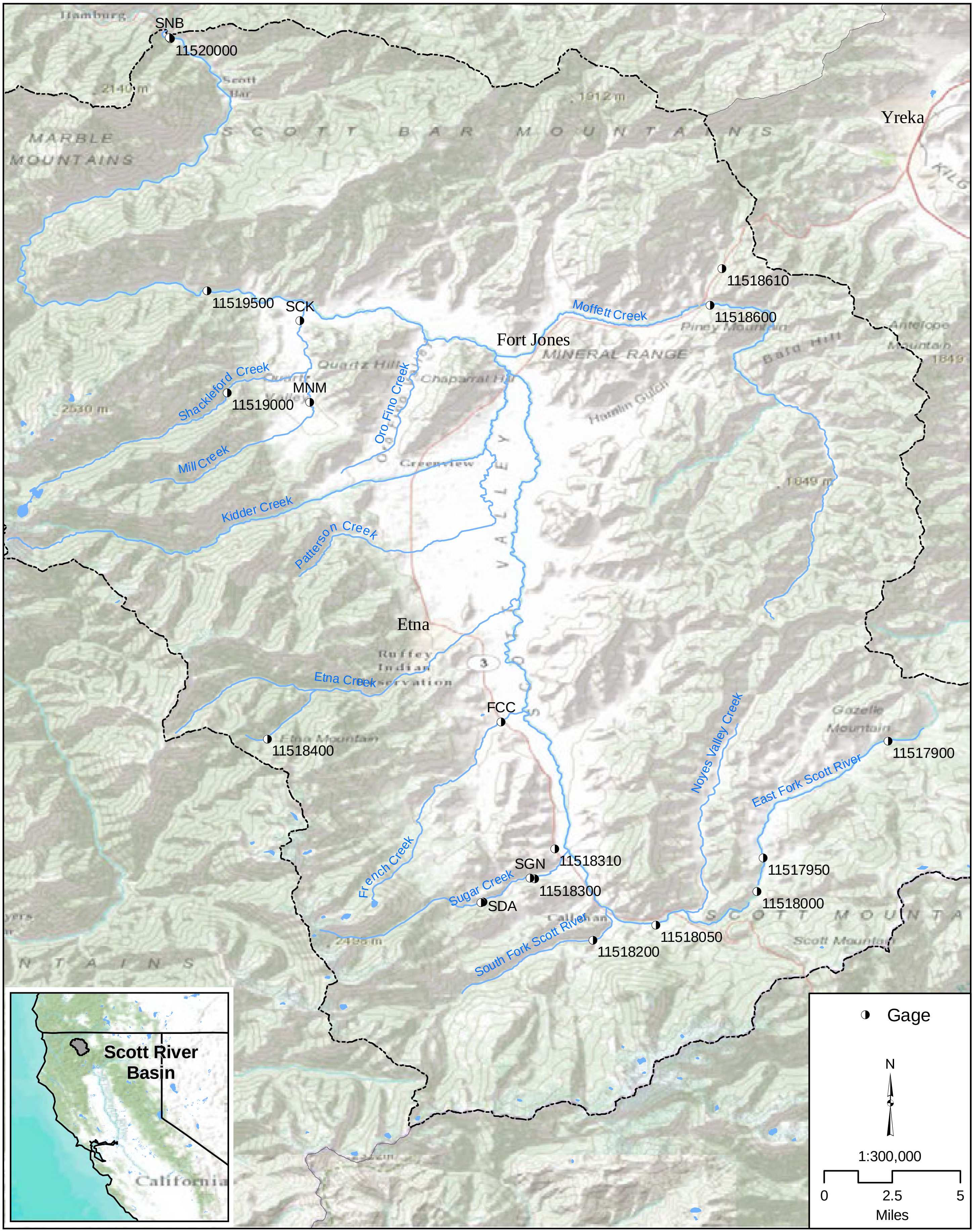

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Figure 1.1 Scott River Sub-Basin

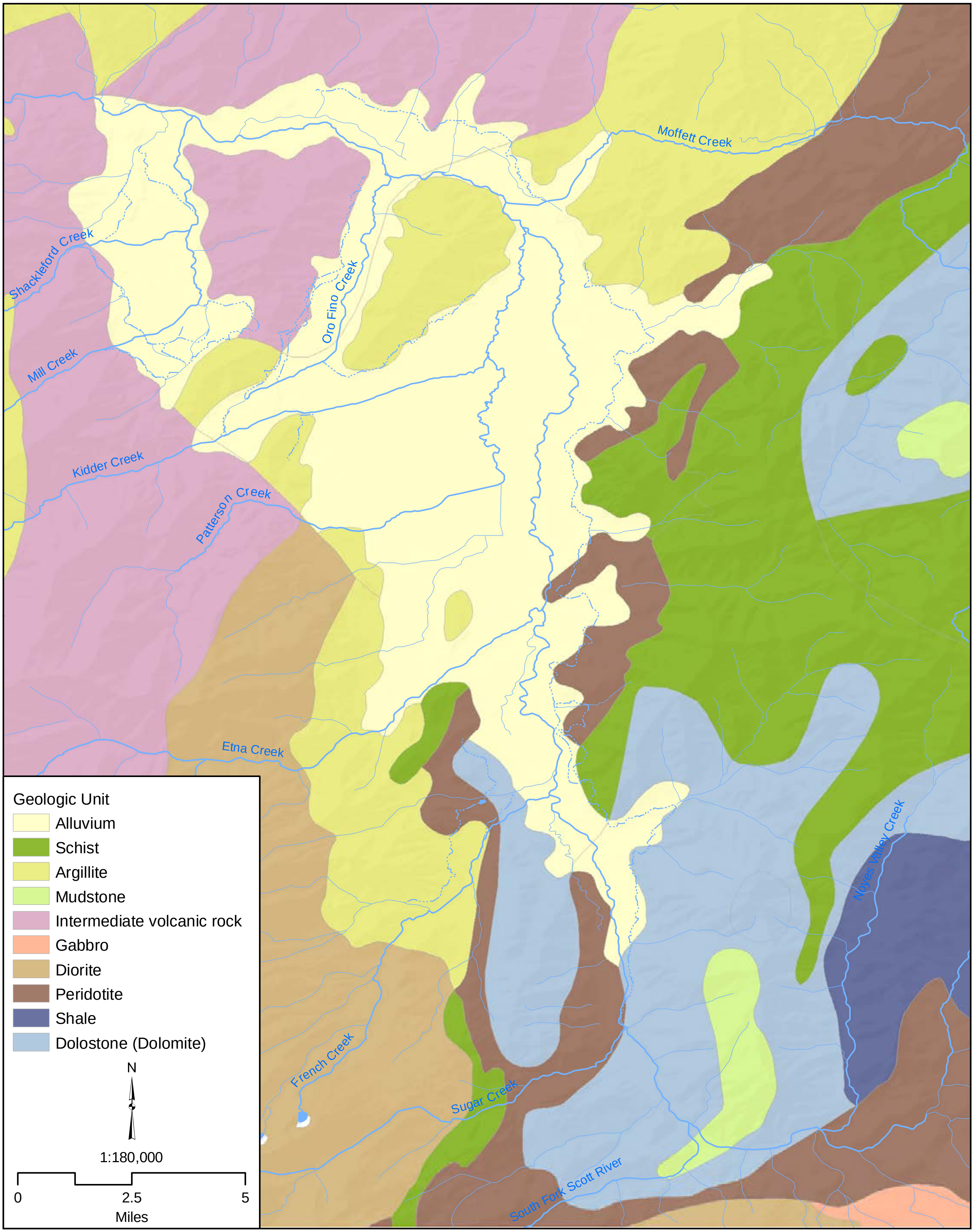

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Figure 2.1 Geologic Units

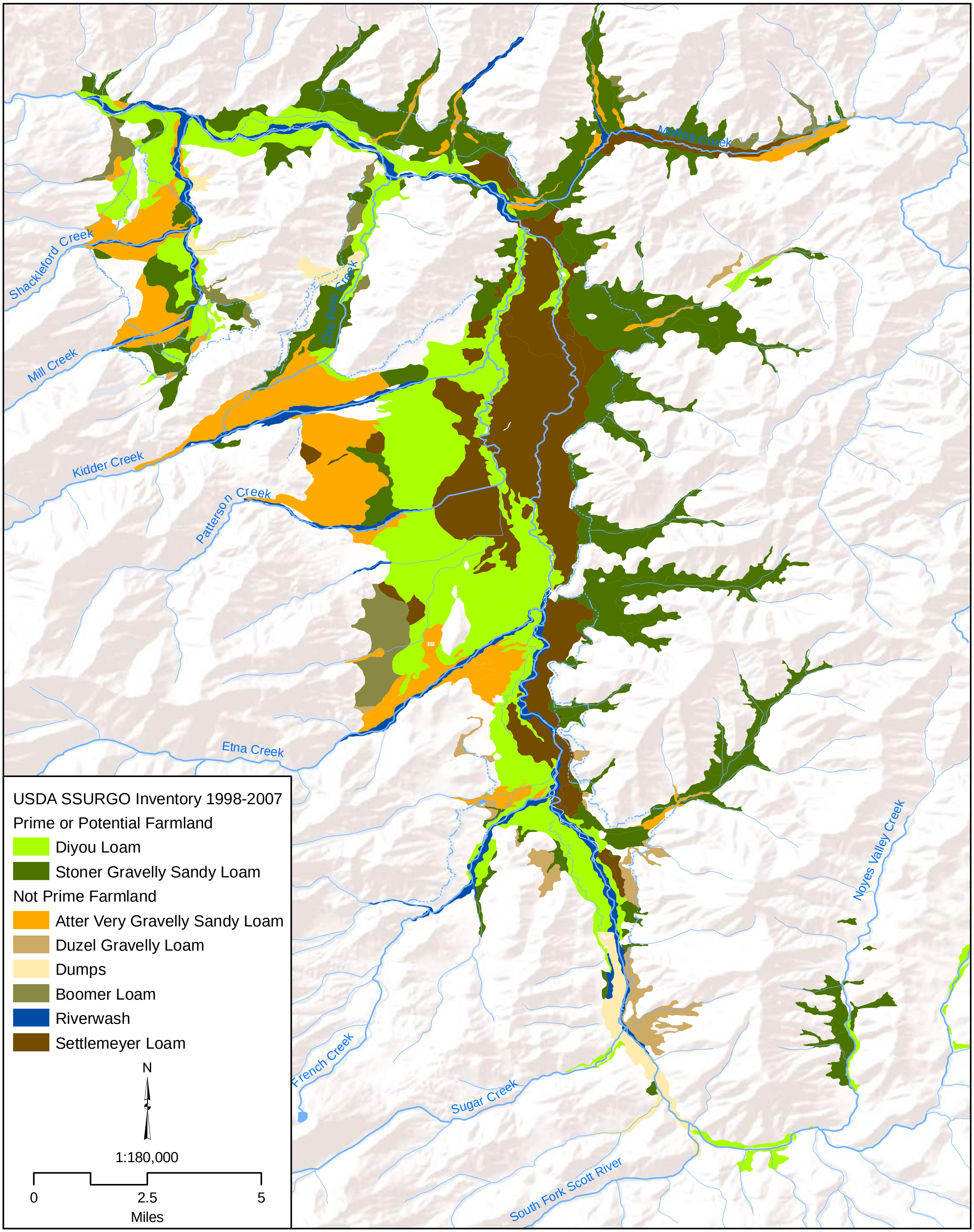

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Figure 2.2 Soils

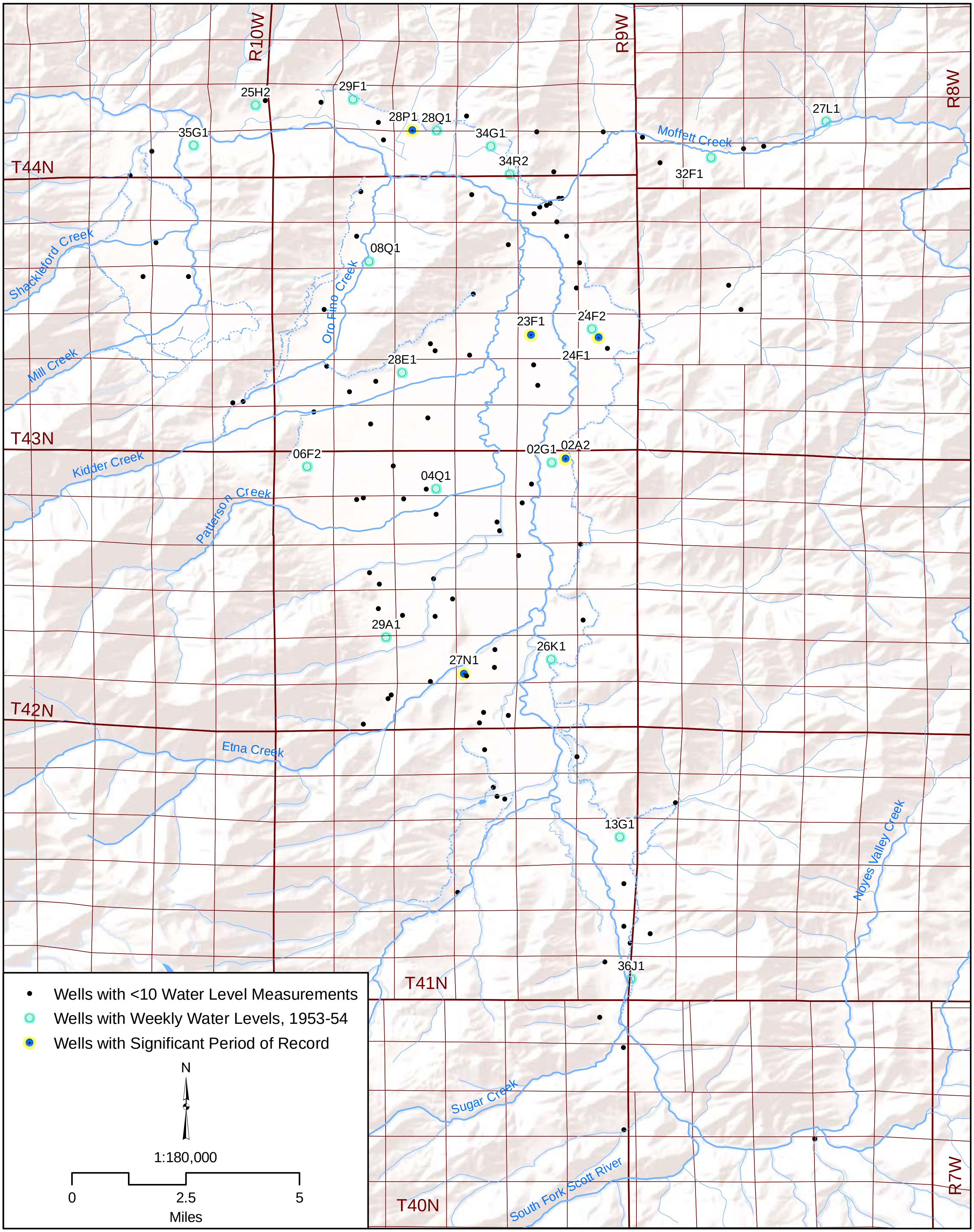

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Figure 2.3 Wells with Groundwater Elevation Measurements

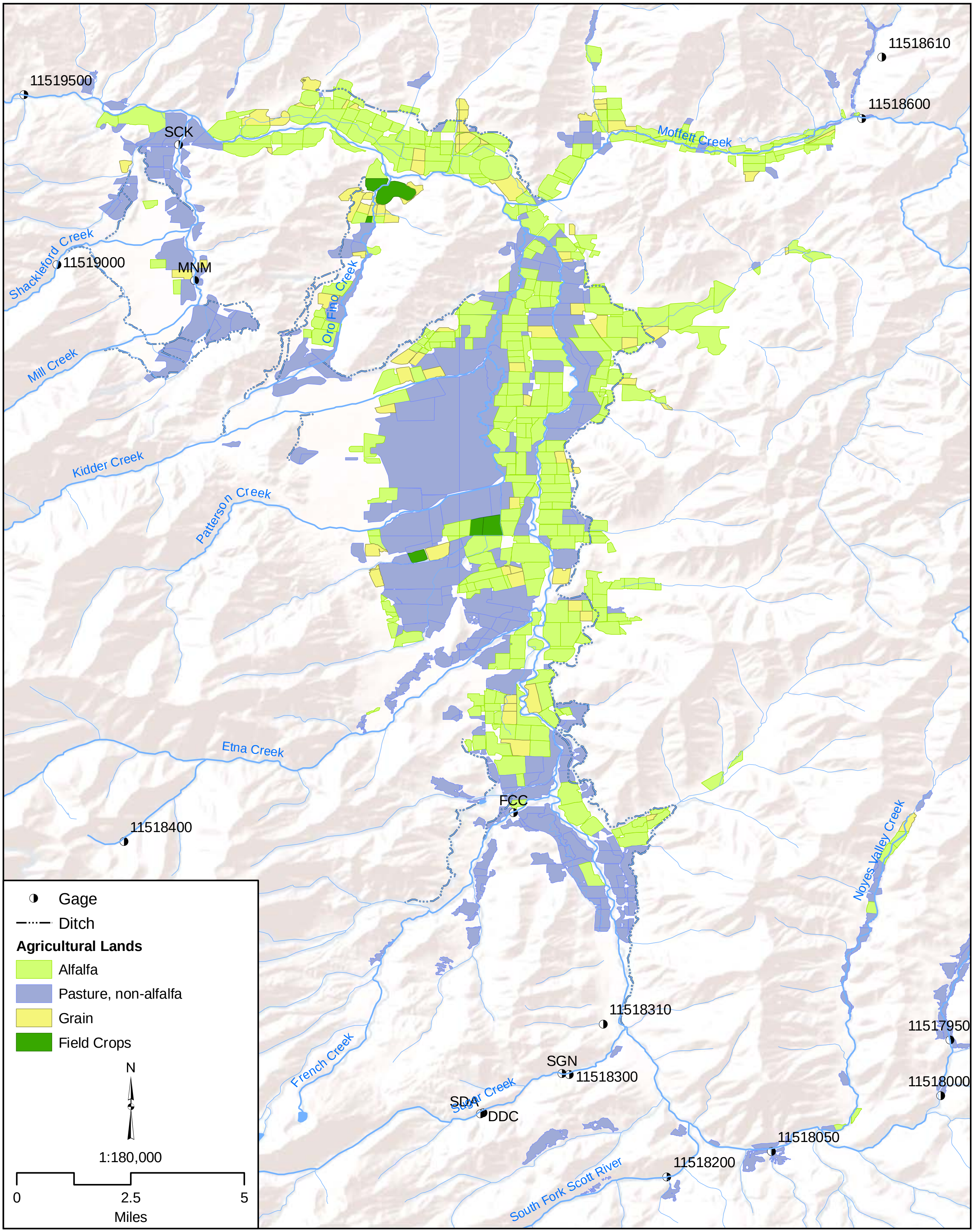

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Figure 2.4 Agricultural Lands and Selected Canals

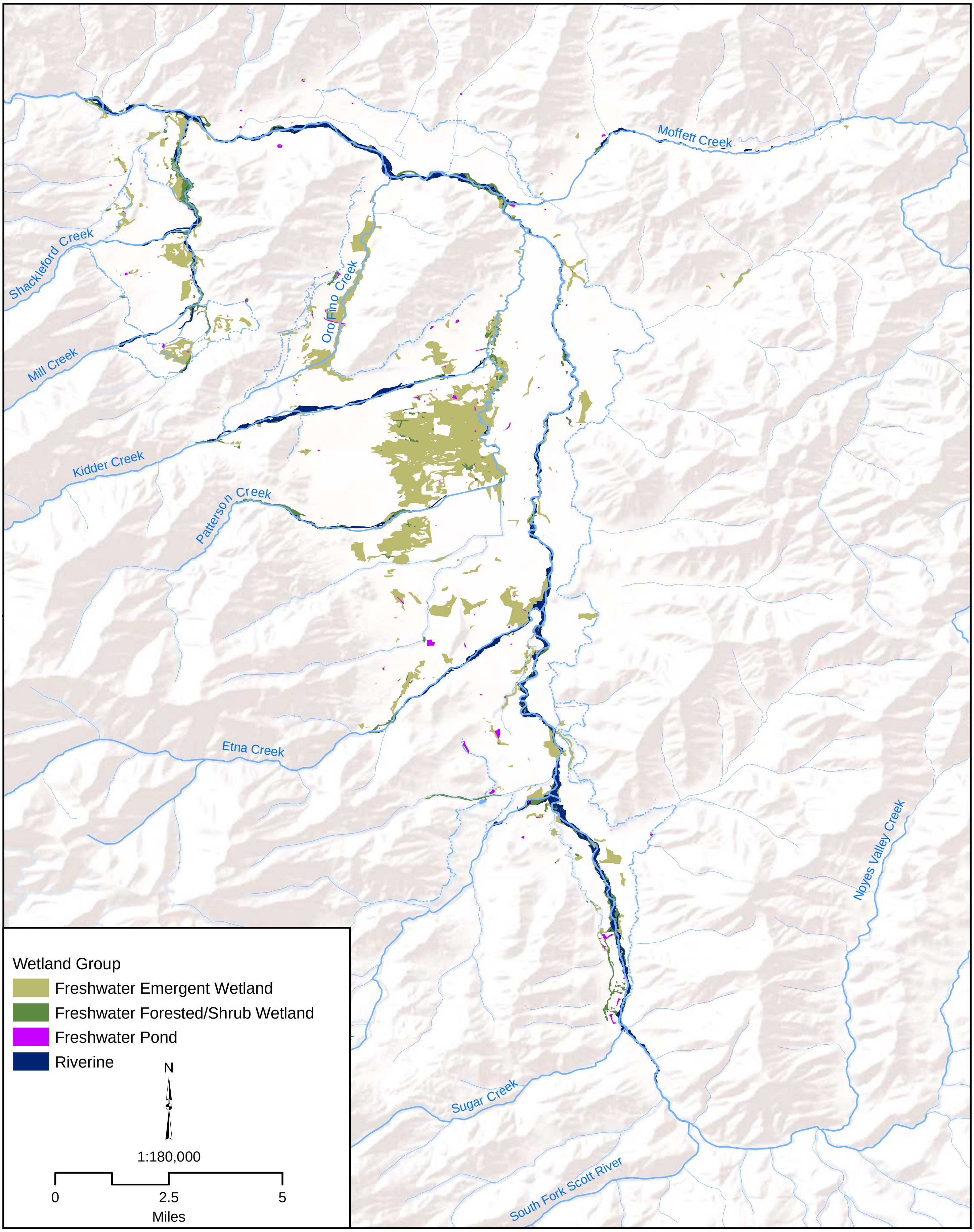

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Figure 2.5 Wetland Groups

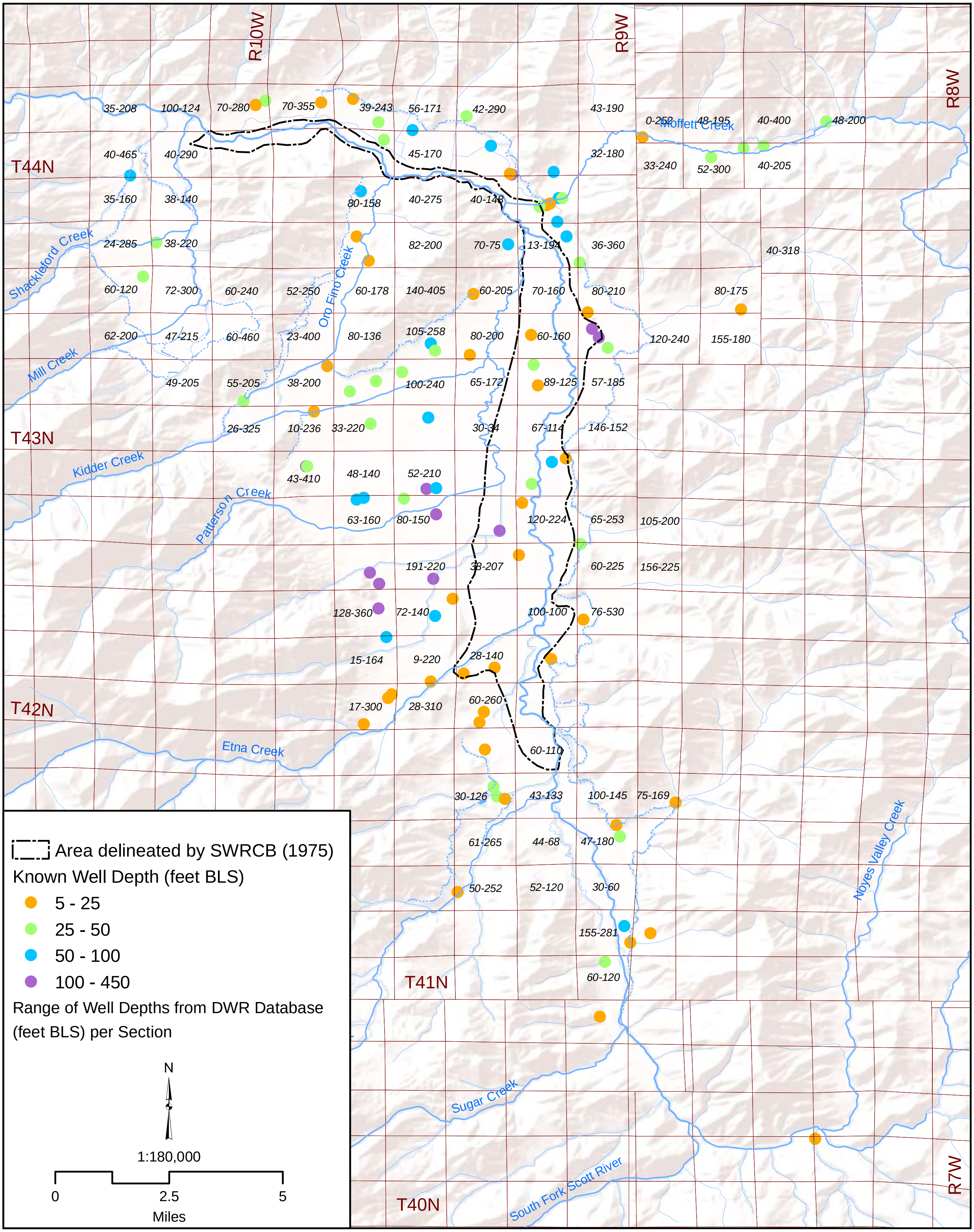

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Figure 3.1 Well Depth

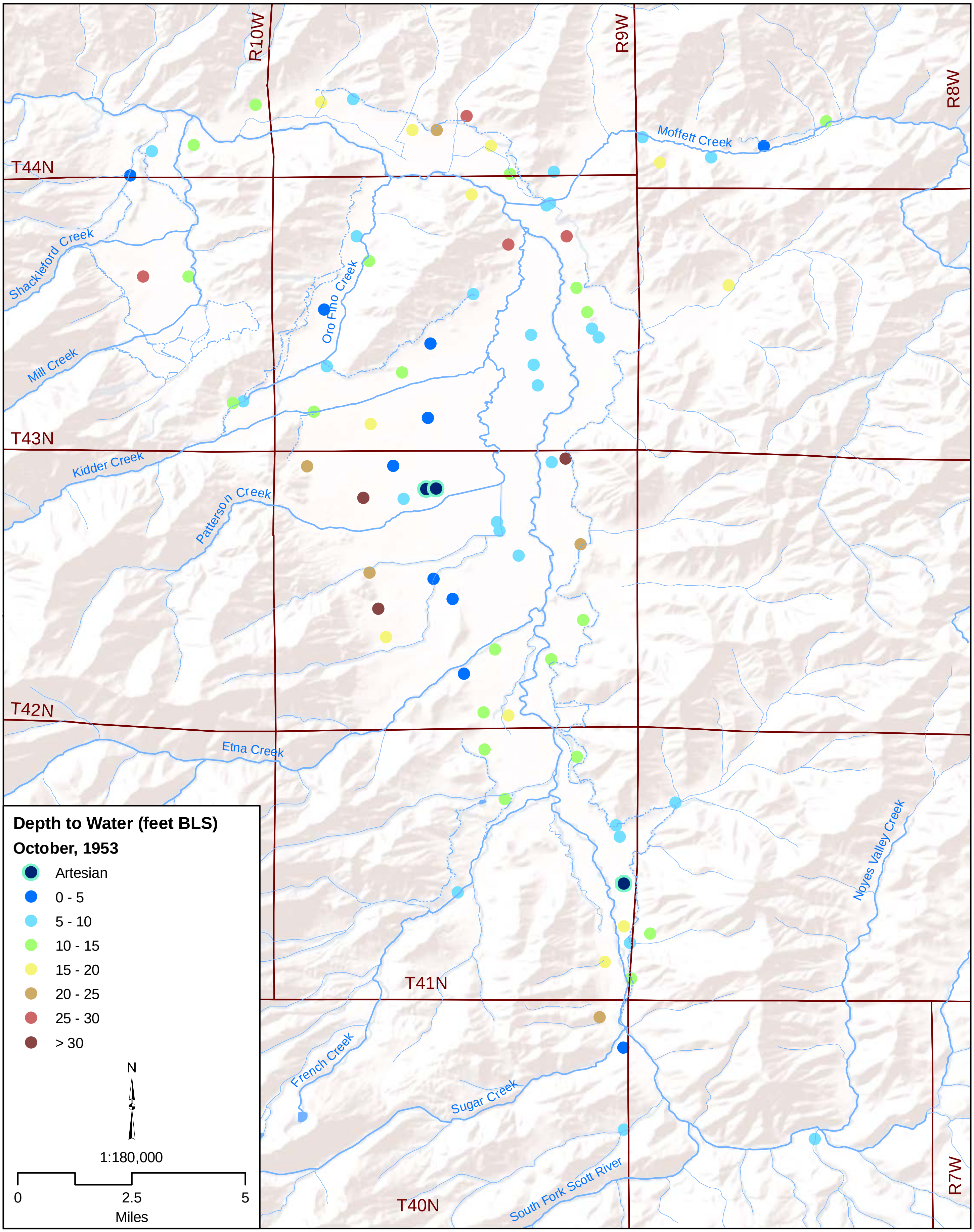

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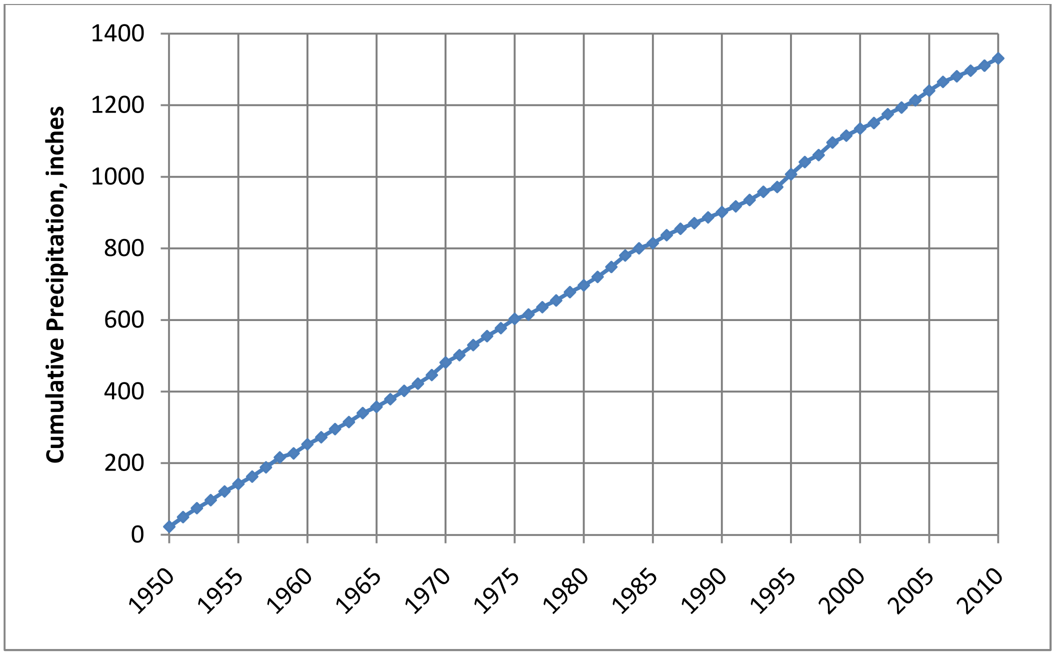
Figure 3.2 Depth To Water



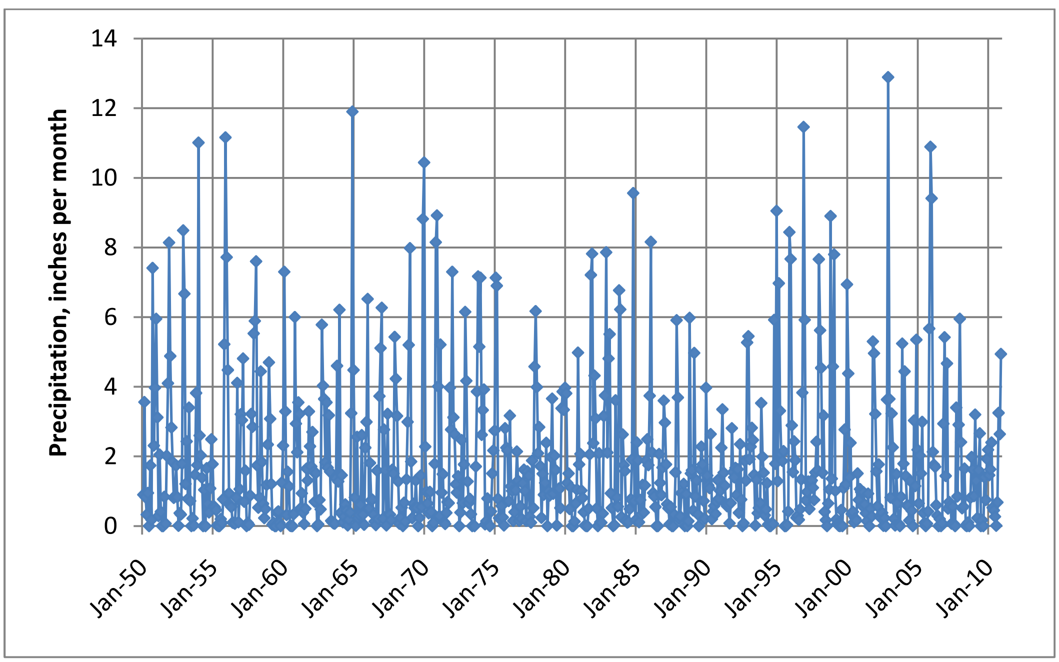


Figure 3.3. Cumulative Mass Plot, Precipitation at Ft. Jones, 1950 to 2010

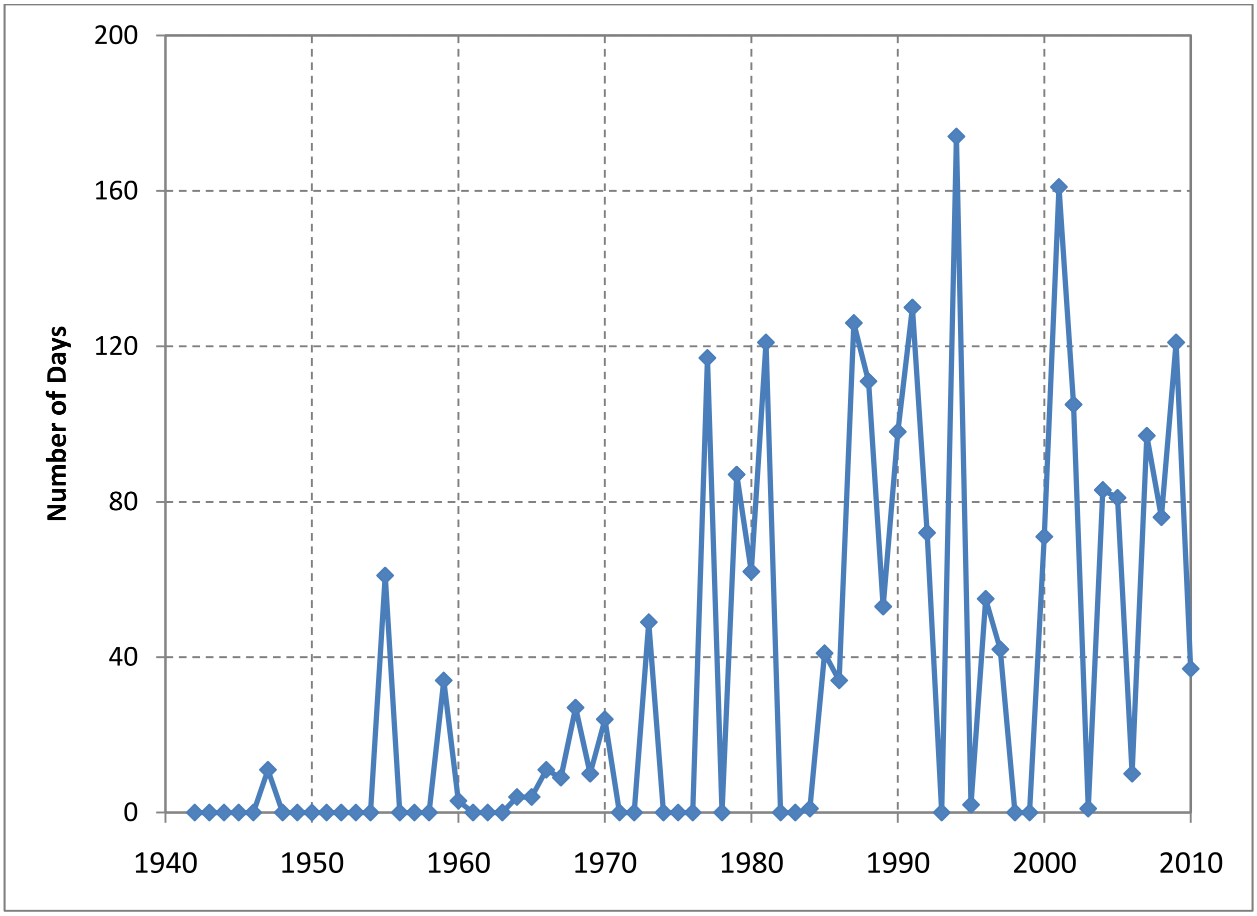


Figure 3.4. Number of Days with Flow at Ft. Jones below 40 cfs

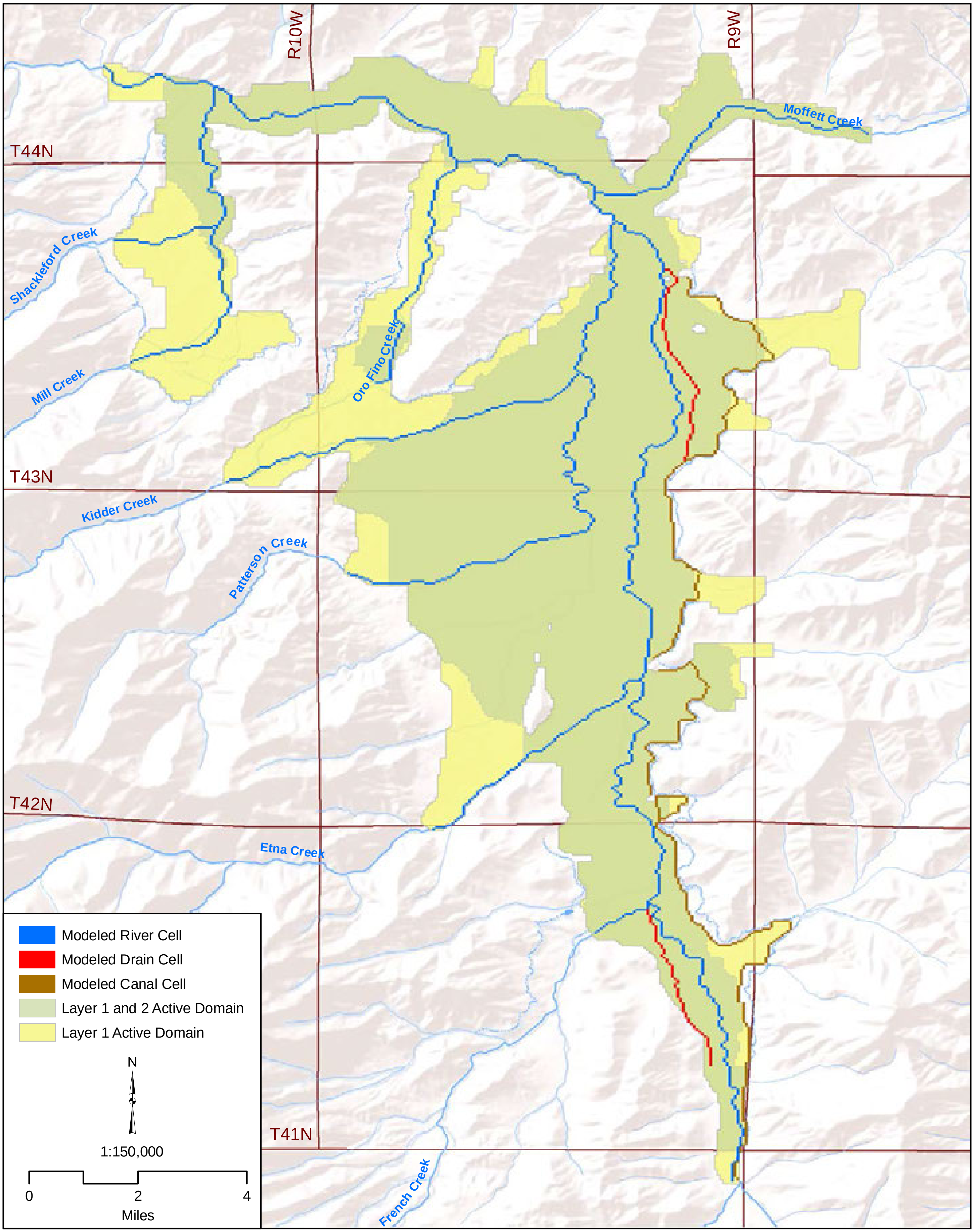


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Figure 4.1 Groundwater Model Features

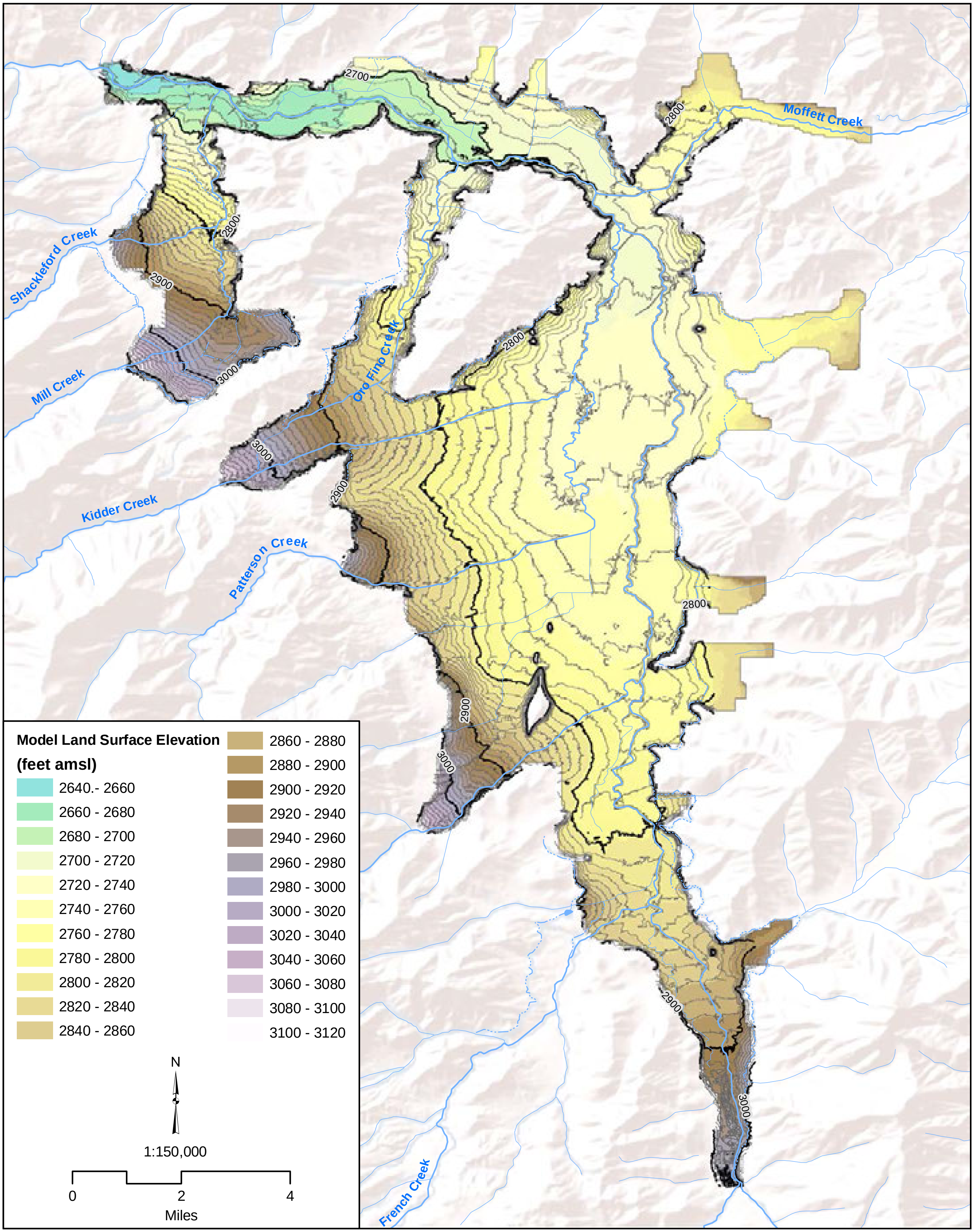

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Figure 4.2 Land Surface Elevation

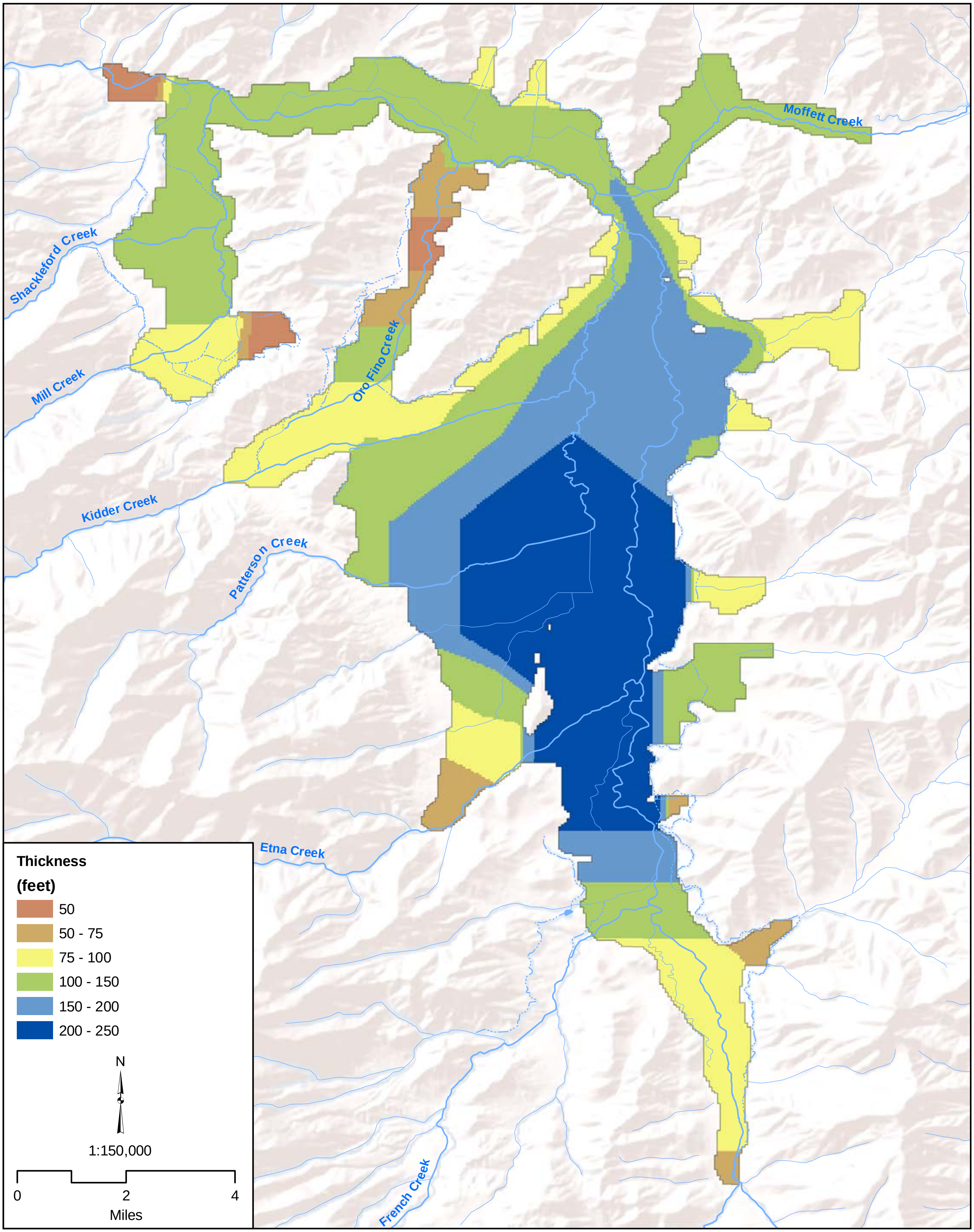

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Figure 4.3 Alluvial Aquifer Thickness Represented in the Groundwater Model

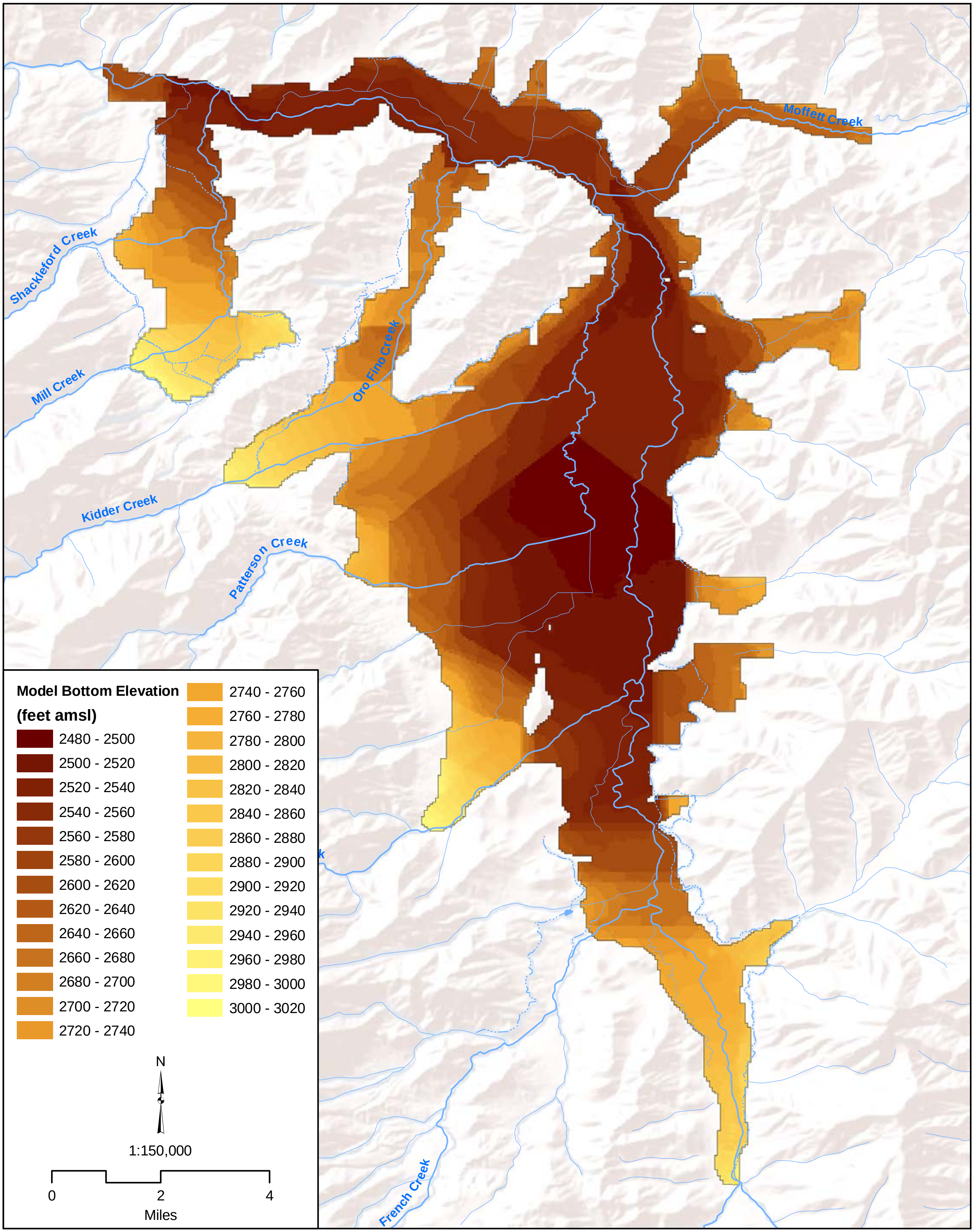

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Figure 4.4 Model Bottom Elevation

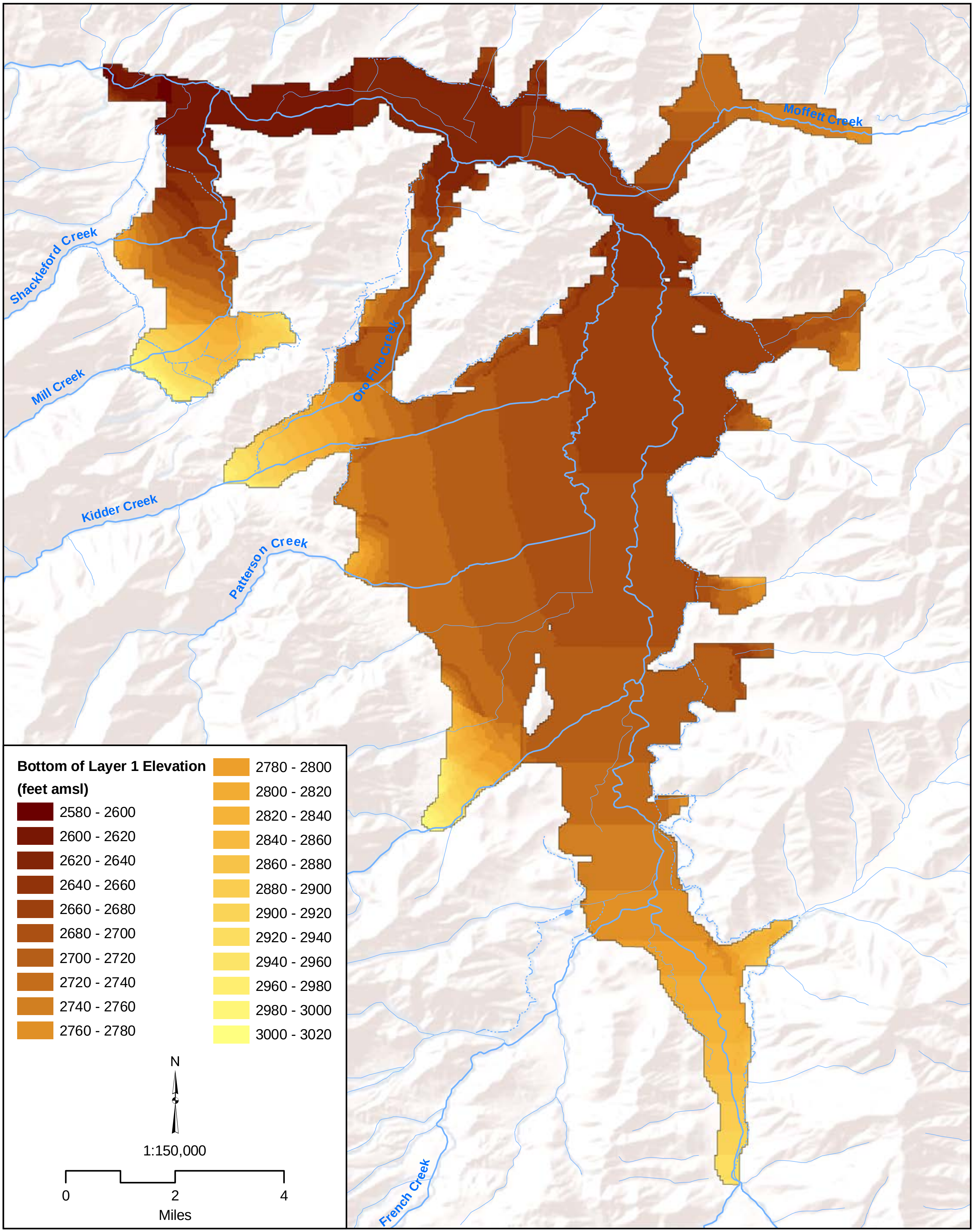

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Figure 4.5 Layer 1 Bottom Elevation

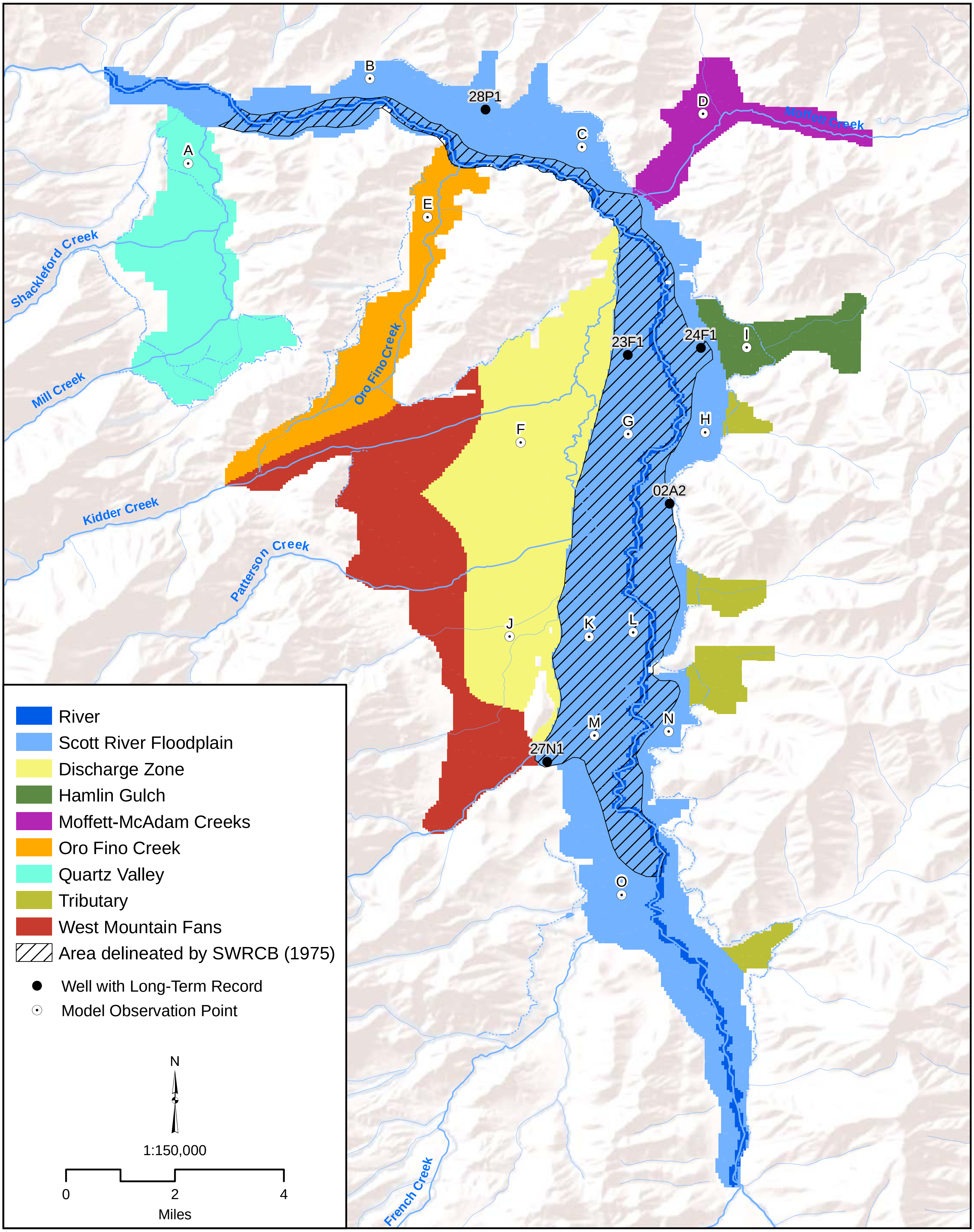

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Figure 4.6 Groundwater Model Sub-Regions and Selected Observation Locations

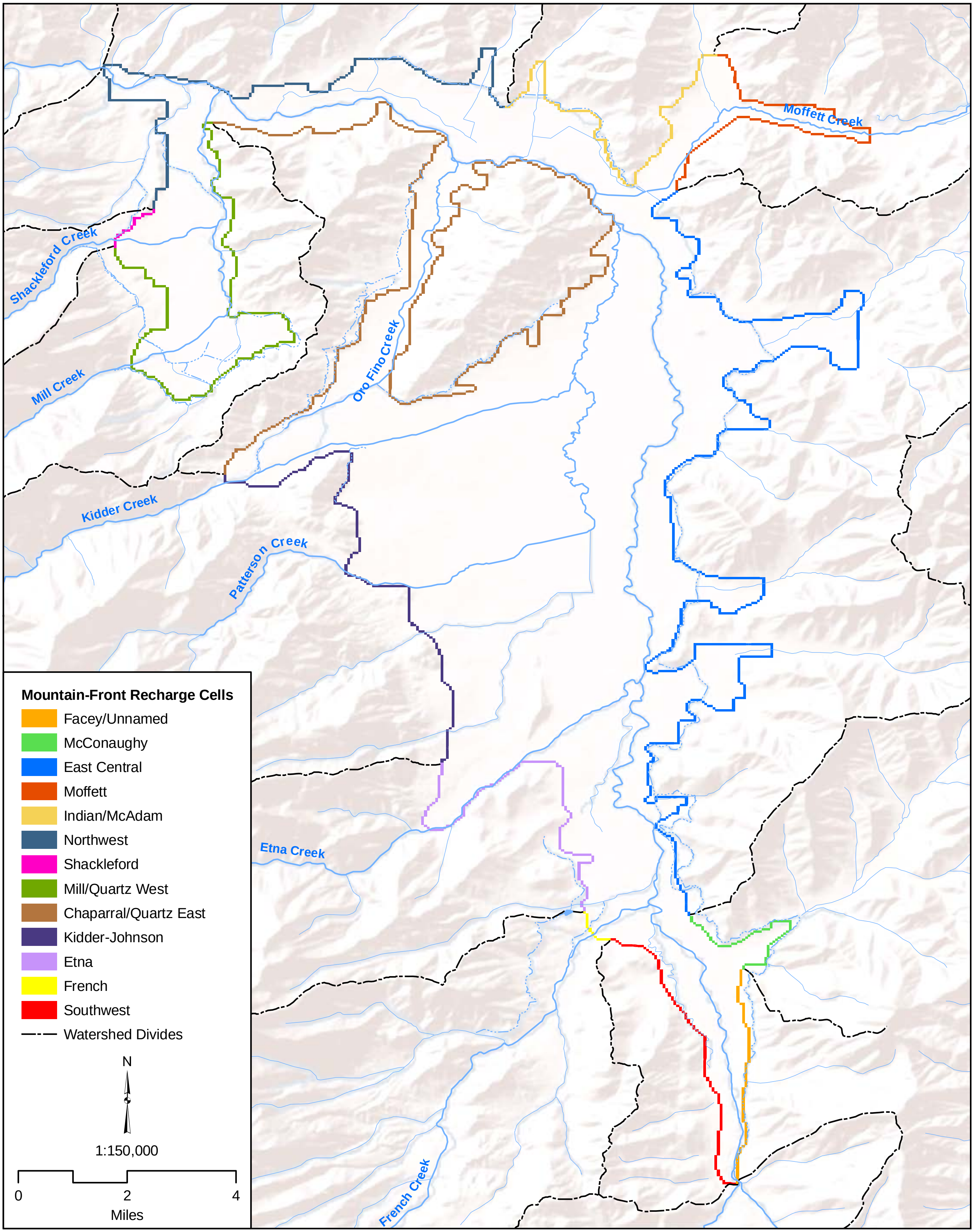

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Figure 4.7 Mountain-Front Recharge Cells

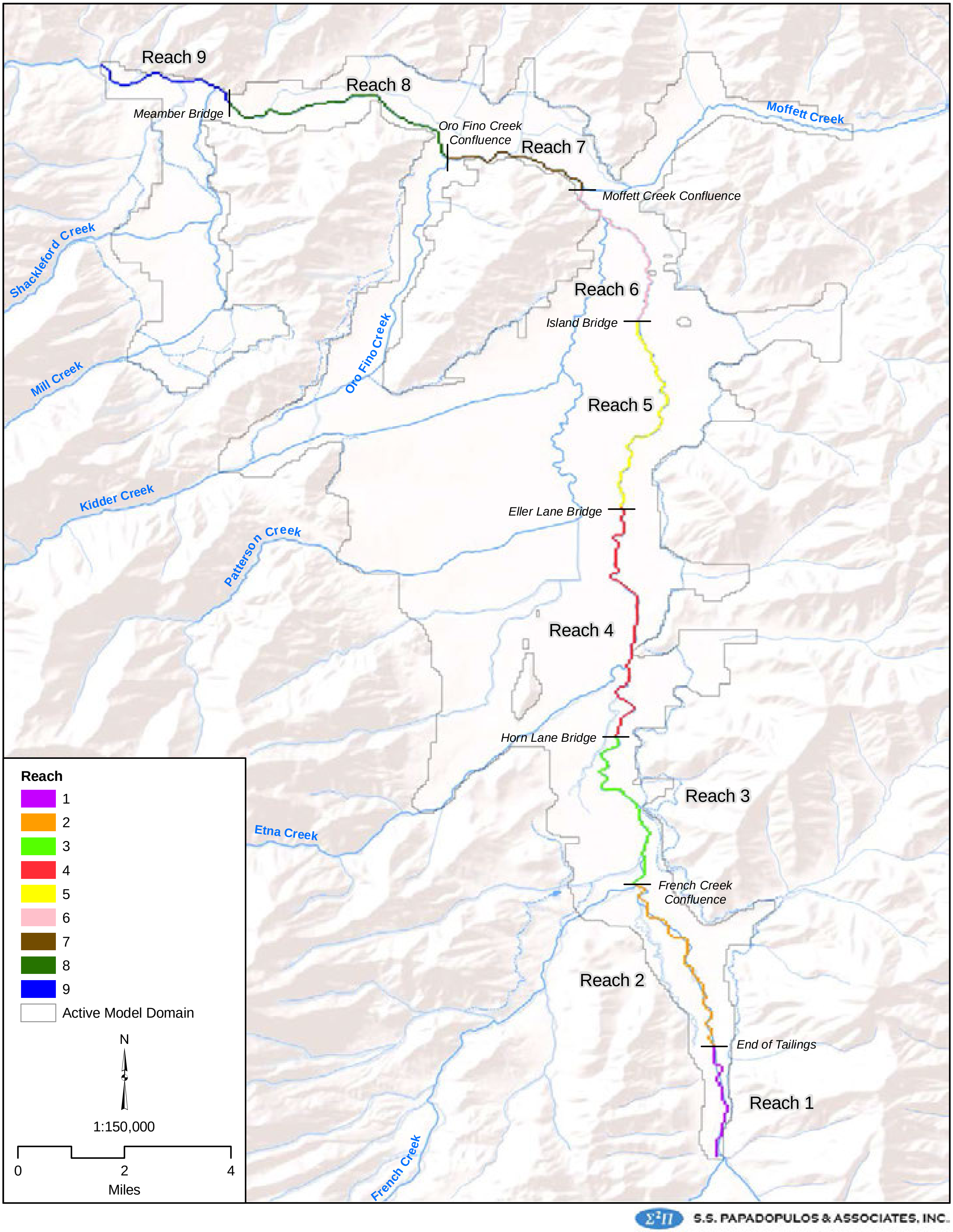


Figure 4.8 Modeled Reaches, Scott River

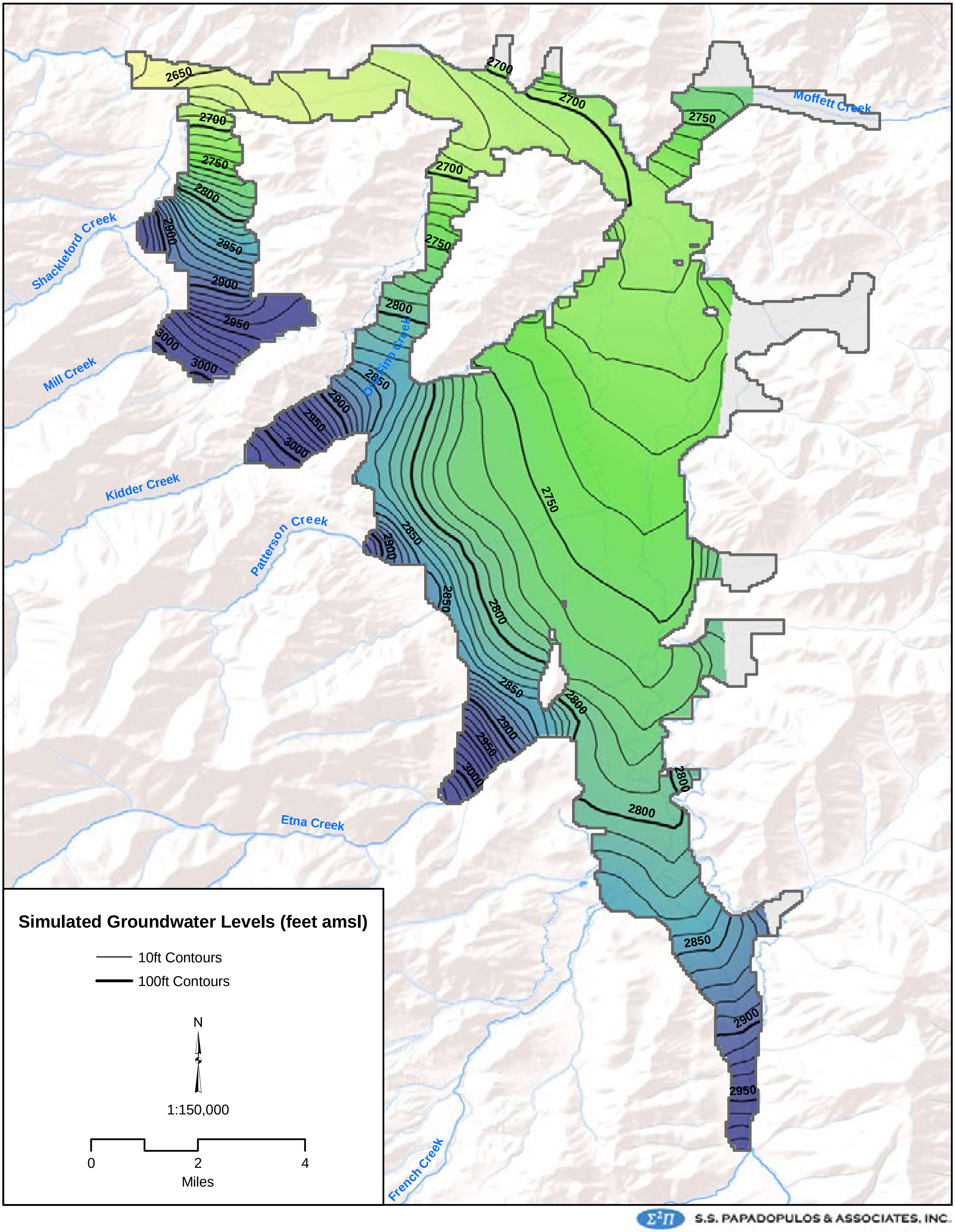


Figure 5.1 Simulated Groundwater Contours at End of Irrigation Season, Partial Build-Out

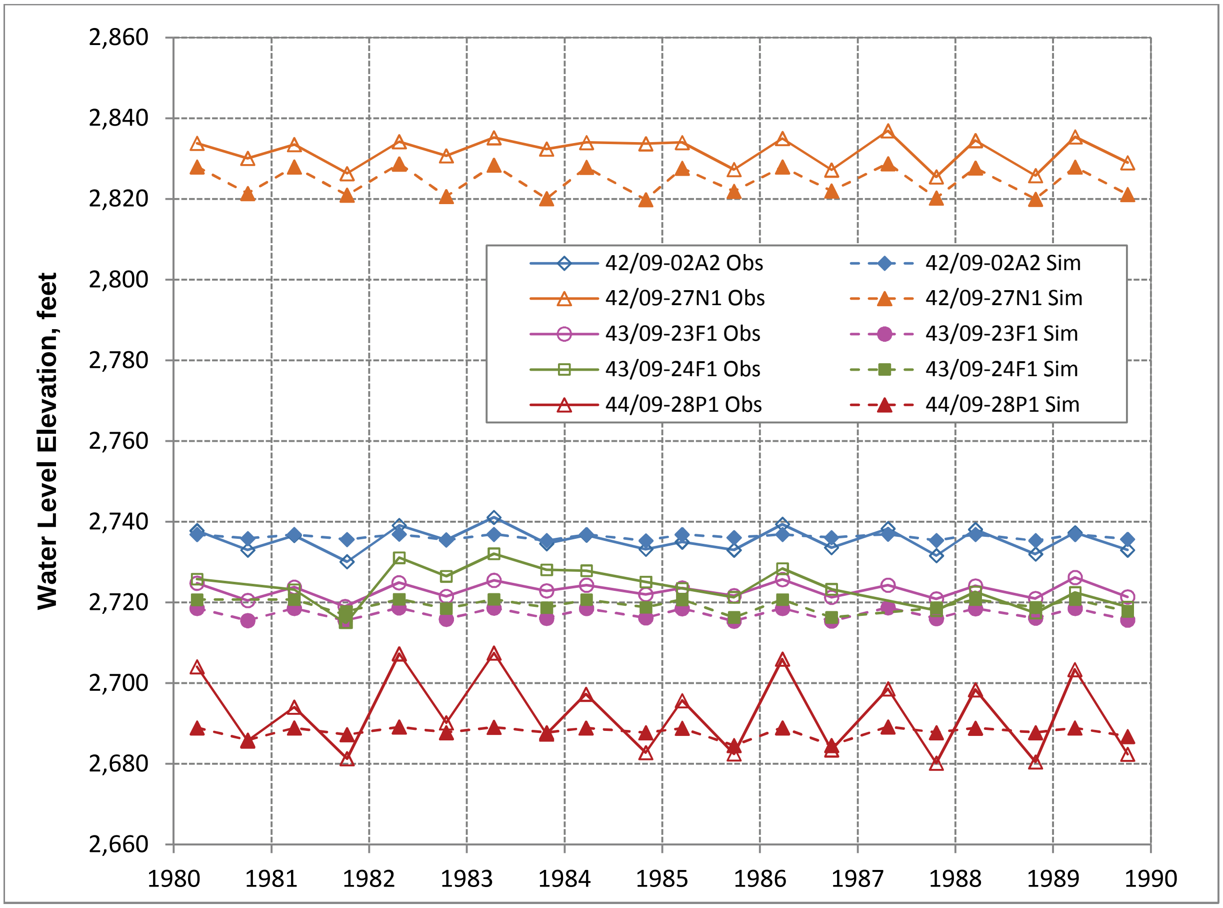


Figure 5.2 Simulated and Observed Groundwater Elevations at Selected Locations, Partial Build-Out

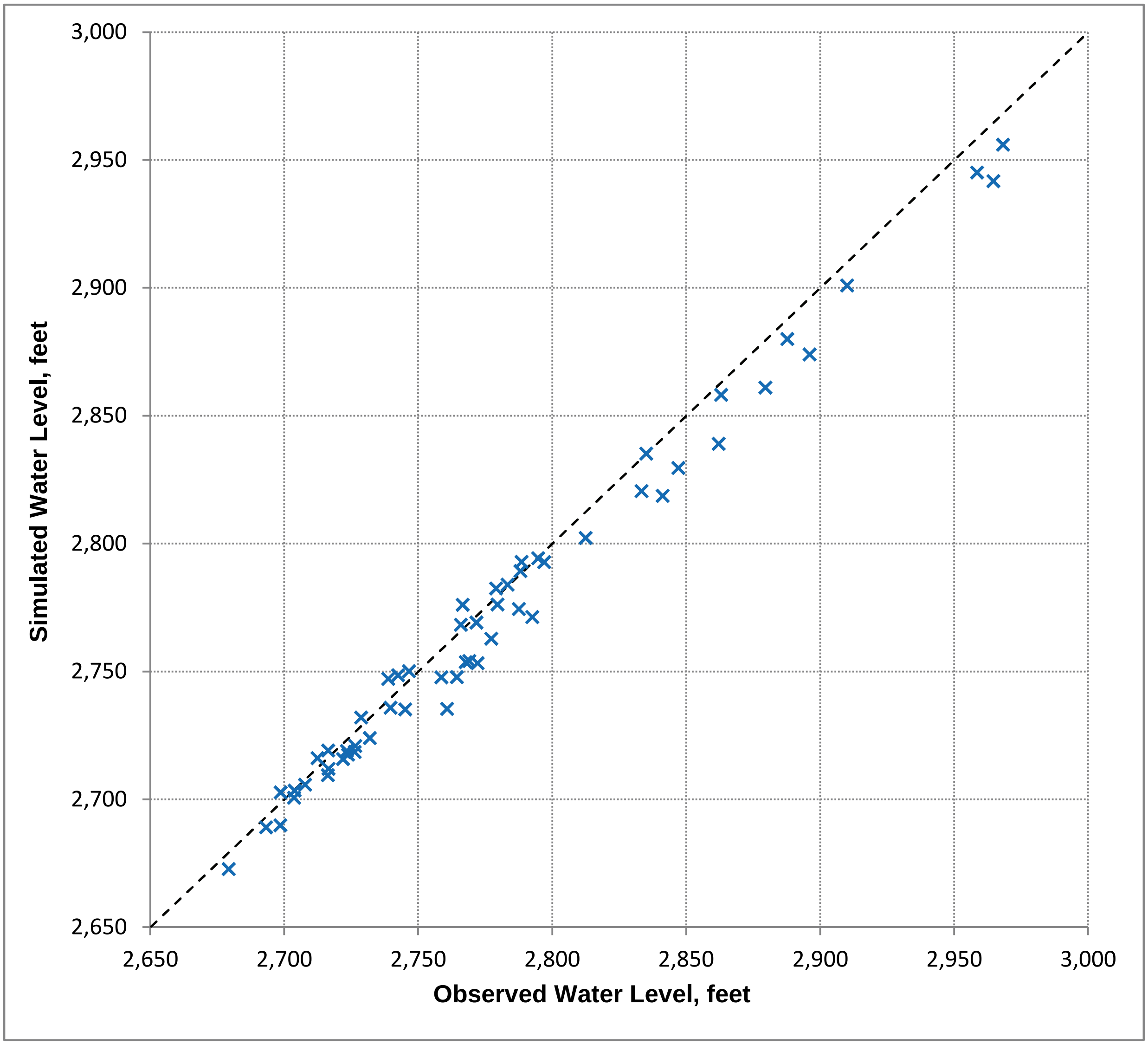
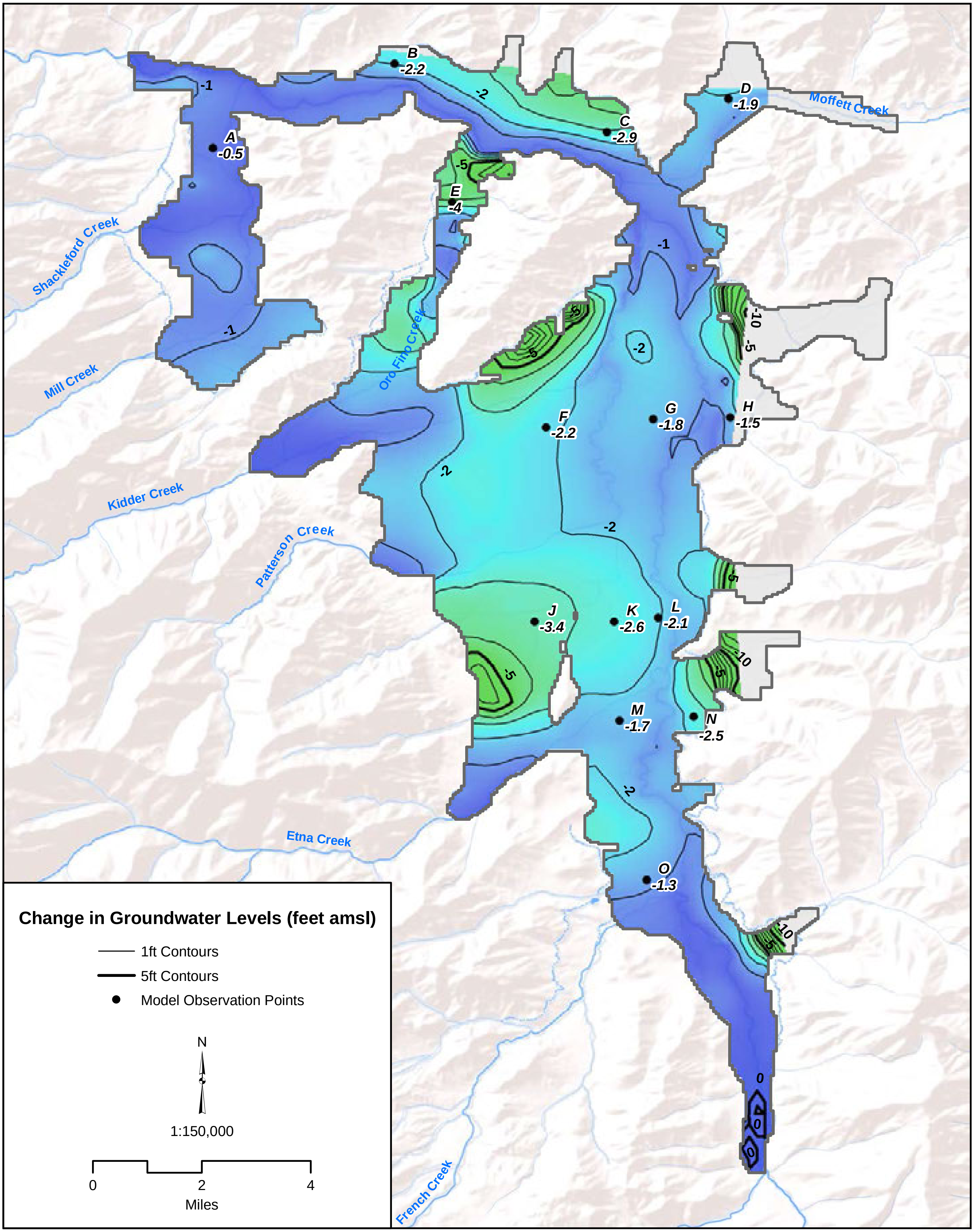


Figure 5.3 General Comparison of Simulated and Observed Groundwater Elevations



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6.1 Change in Simulated October Groundwater Levels due to Change in Pumping from Partial Build-Out to Recent Condition

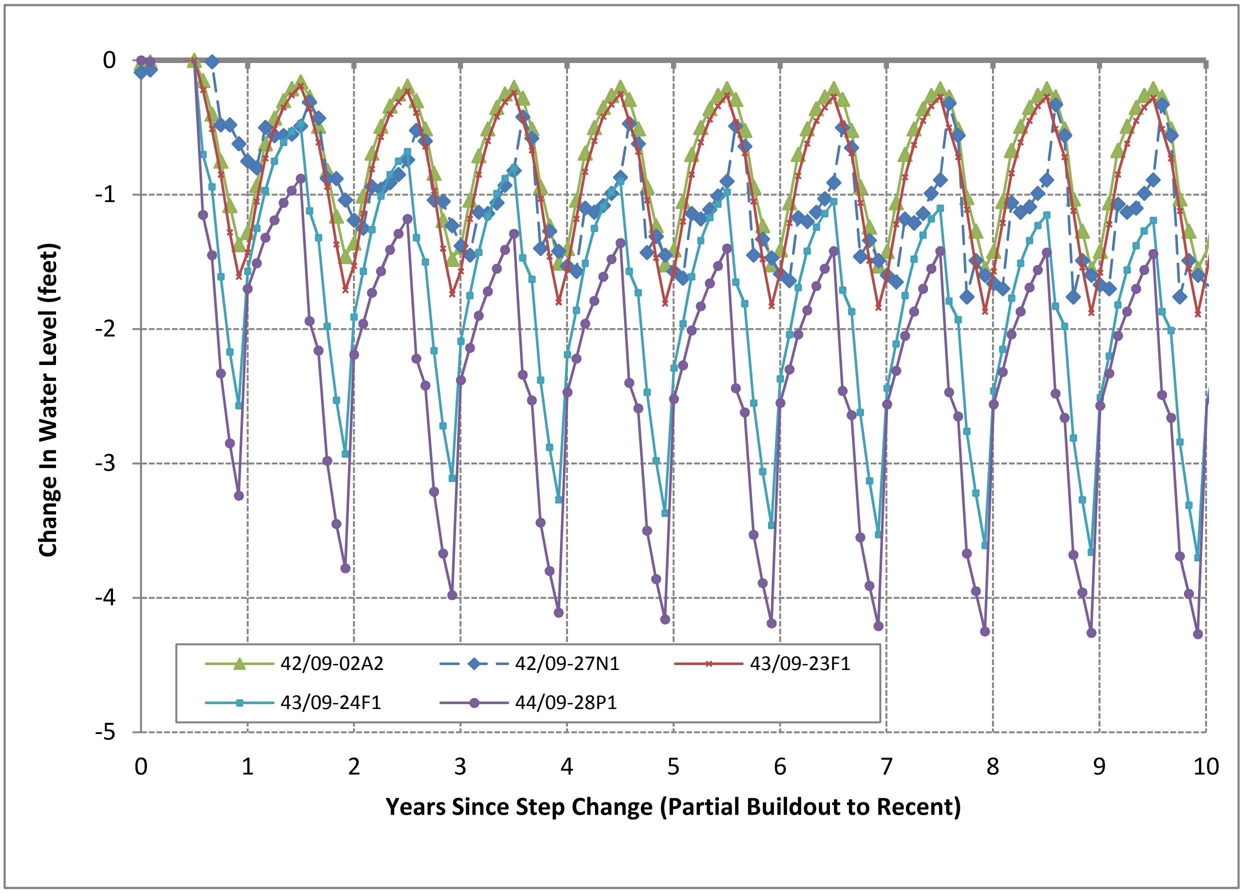
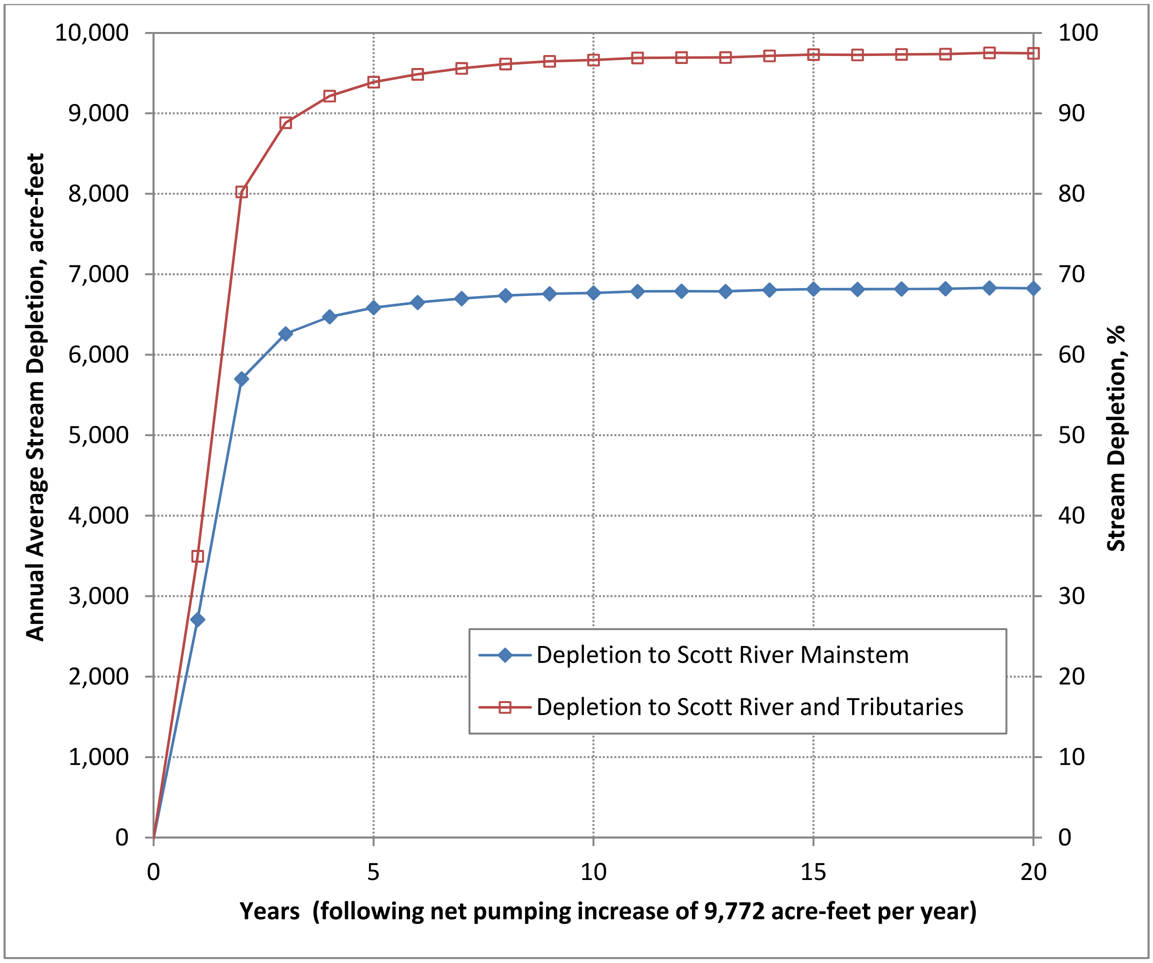
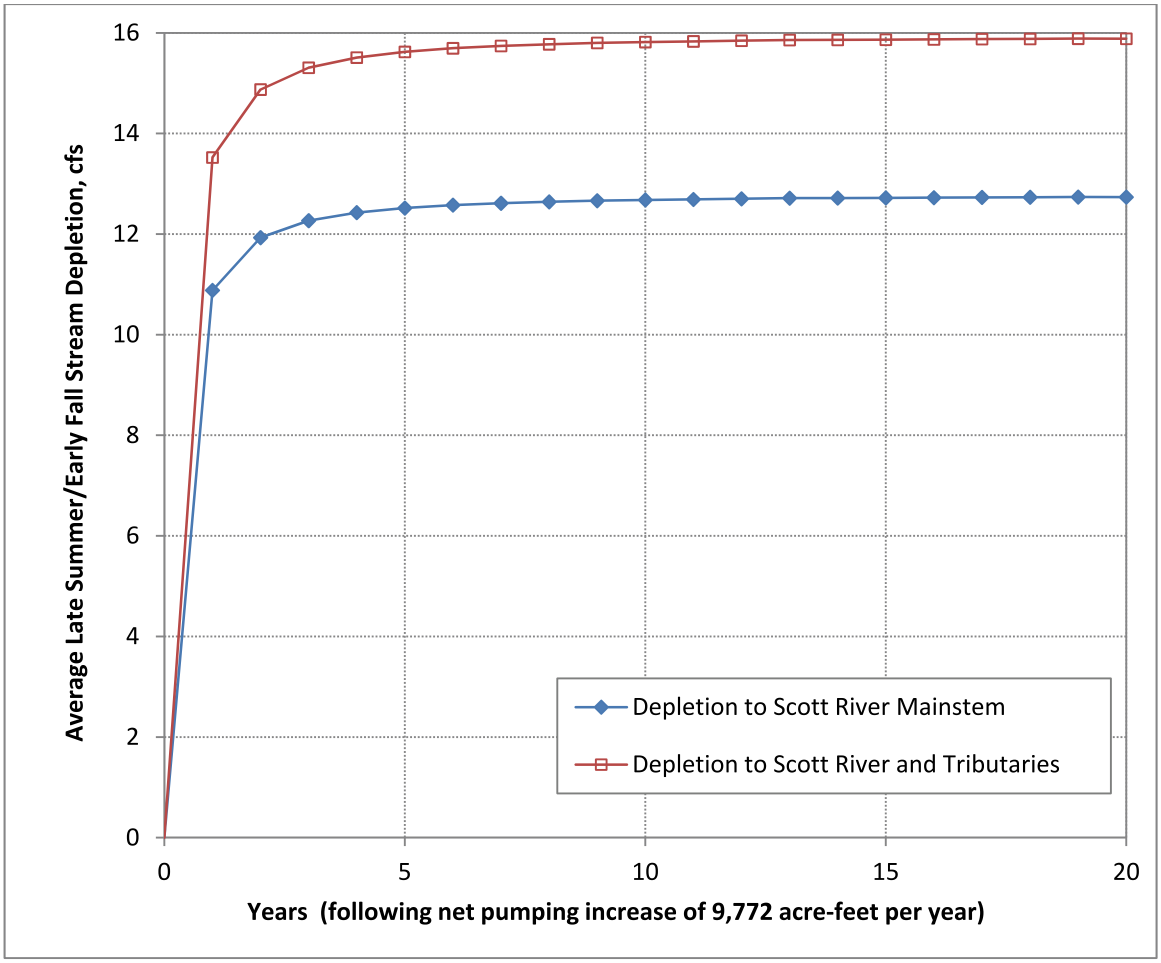


Figure 6.2 Change in Simulated Groundwater Elevations at Selected Locations due to Step-Change in Pumping from Partial Build-Out to Recent Condition



Note: The net increase in pumping is simulated as occurring as a single step; the resulting curve can be used to identify lagged depletion impacts from a gradual change in pumping

Figure 6.3 Average Annual Stream Depletion to Scott River and Tributaries from Increased Groundwater Use, Partial Build-Out to Recent Pumping Levels



Note: The net increase in pumping is simulated as occurring as a single step; the resulting curve can be used to identify lagged depletion impacts from a gradual change in pumping

Figure 6.4 Late Summer/Early Fall Stream Depletion to Scott River and Tributaries from Increased Groundwater Use, Partial Build-Out to Recent Condition

Tables

Table 2.1
Wells with One or More Depth to Water Measurements

Short Well Name	State Well Number	USGS Site Number	Construction Date	Well Depth	Use	Elevation, feet, NGVD29
40/09-01G1	040N009W01G001M	412048122494901		20		3,019
40/09-12A1	040N009W12A001M	412013122492201				3,050
40/09-13R1	040N009W13R001M	411839122492101	1937			3,183
40/08-14N1	040N008W14N001M	411828122454201		16		3,256
41/09-02J1	041N009W02J001M	412547122501501				2,828
41/09-03L1	041N009W03L001M	412555122520101	1949	25		2,827
41/08-07J1	041N008W07J001M	412454122482201	1900	22		2,951
41/09-10G1	041N009W10G001M	412512122515101	1949	30		2,880
41/09-10J1	041N009W10J001M	412501122514701		50		2,872
41/09-10J2	041N009W10J002M	412458122513801	1938	25		2,859
41/09-13B1	041N009W13B001M	412428122493001	1930	18		2,889
41/09-13G1	041N009W13G001M	412415122492601	1900	32		2,889
41/09-22M1	041N009W22M001M	412311122523201	1952	15		2,958
41/09-24H1	041N009W24H001M	412321122492101				2,896
41/09-25H1	041N009W25H001M	412232122492101	1949	65		2,928
41/09-25R1	041N009W25R001M	412213122491401		14		2,697
41/08-30L1	041N008W30L001M	412224122485101	1923	18		3,089
41/09-36B1	041N009W36B001M	412151122494301		28		2,980
41/09-36J1	041N009W36J001M	412132122491301				2,973
42/09-02A2	042N009W02A002M	413129122502801		22	Domestic	2,746
42/09-02G1	042N009W02G001M	413125122504401	1948	76		2,750
42/09-02N1	042N009W02N001M	413100122510701	1952	28		2,741
42/09-04P1	042N009W04P001M	413054122530801	1951	156		2,769
42/09-04Q1	042N009W04Q001M	413055122525701	1936	60		2,767
42/09-05H1	042N009W05H001M	413121122534601				2,783
42/09-06F1	042N009W06F001M	413120122552601		111		2,852
42/09-06F2	042N009W06F002M	413120122552501	1953	26		2,852
42/09-08C1	042N009W08C001M	413044122542001	1950			2,831
42/09-08C3	042N009W08C003M	413042122542801		66		2,836
42/09-09D1	042N009W09D001M	413043122533401	1948	32		2,805
42/09-09G1	042N009W09G001M	413025122525701	1950	450		2,750
42/09-10K1	042N009W10K001M	413016122514701	1952			2,744
42/09-10Q1	042N009W10Q001M	413006122514401	1953	120		2,748
42/09-11D1	042N009W11D001M	413038122511801	1951	22		2,746
42/09-13D1	042N009W13D001M	412951122501101	1925	35		2,773
42/09-14E1	042N009W14E001M	412938122512201	1942	20		2,756
42/09-16Q1	042N009W16Q001M	412911122530001	1951	150		2,769
42/09-17K1	042N009W17K001M	412918122541301	1952	200		2,863
42/09-17Q1	042N009W17Q001M	412905122540201	1952			2,843
42/09-20G1	042N009W20G001M	412837122540301	1925	145		2,946
42/09-21A1	042N009W21A001M	412848122523801	1924	10		2,780

Table 2.1
Wells with One or More Depth to Water Measurements, continued

Short Well Name	State Well Number	USGS Site Number	Construction Date	Well Depth	Use	Elevation, feet, NGVD29
42/09-21K1	042N009W21K001M	412828122525801	1940	100		2,800
42/09-21M1	042N009W21M001M	412829122533501				2,867
42/09-24M1	042N009W24M001M	412824122500801		20		2,784
42/09-26K1	042N009W26K001M	412739122504501	1860	20		2,779
42/09-27G1	042N009W27G001M	412750122514901	1948			2,794
42/09-27K1	042N009W27K001M	412729122515001	1940	23		2,800
42/09-27N1	042N009W27N001M	412722122522501	1933	19	Unused	2,840
42/09-27N2	42N09W27N002M				Domestic	
42/09-29A1	042N009W29A001M	412804122535401	1950	65		2,917
42/09-32H1	042N009W32H001M	412654122535201	1951	25		2,955
42/09-32H2	042N009W32H002M	412658122534801	1951	25		2,953
42/09-32P1	042N009W32P001M	412624122542001	1863	5		3,080
42/09-33B1	042N009W33B001M	412713122530301	1952	18		2,910
42/09-34L1	042N009W34L001M	412638122520201		20		2,803
42/09-34P1	042N009W34P001M	412626122520701	1910	18		2,804
42/09-35Q1	042N009W35Q001M	412634122513401	1860			2,806
43/09-02G1	043N009W02G001M	413628122503601	1924	65		2,760
43/09-02G2	043N009W02G002M	413628122503201	1931	45		2,727
43/09-02K1	043N009W02K001M	413620122505001		25		2,725
43/09-02K2	043N009W02K002M	413622122504601		19		2,725
43/09-02L1	043N009W02L001M	413618122505801	1950	42		2,728
43/09-02P2	43N09W02P002M				Domestic	
43/09-02Q1	043N009W02Q001M	413601122503801	1949	56		2,723
43/09-02Q2	43N09W02Q002M				Domestic	
43/09-03F1	043N009W03F001M	413632122521601				2,724
43/09-05F1	043N009W05F001M	413636122542301	1947	65		2,737
43/09-08F1	043N009W08F001M	413544122542801		19		2,753
43/09-08Q1	043N009W08Q001M	413516122541401	1948	25		2,773
43/09-10J2	043N009W10J002M	413535122513401	1949	72		2,743
43/10-11E1	043N010W11E001M	413537122581801	1962	40		2,845
43/09-11H2	043N009W11H002M	413544122502701	1946	51		2,736
43/09-12N1	043N009W12N001M	413514122501201	1913	42		2,750
43/09-13E1	043N009W13E001M	413445122501601				2,724
43/09-13N2	043N009W13N002M	413417122500301		18		2,735
43/10-14B1	043N010W14B001M	413458122574101				2,875
43/10-15A1	043N010W15A001M	413458122583301	1945	35		2,914
43/09-15L1	043N009W15L001M	413438122521401	1934	23		2,785
43/08-17F1	043N008W17F001M	413448122472101				2,853
43/08-17Q1	043N008W17Q001M	413420122470701	1905	20		2,845
43/09-18R1	043N009W18R001M	413420122550501	1951			2,801
43/09-21K1	043N009W21K001M	413341122530301	1940	100		2,762

Table 2.1
Wells with One or More Depth to Water Measurements, continued

Short Well Name	State Well Number	USGS Site Number	Construction Date	Well Depth	Use	Elevation, feet, NGVD29
43/09-21Q1	043N009W21Q001M	413333122525801		32		2,761
43/09-22P1	043N009W22P001M	413328122521801		6		2,735
43/09-23F1	043N009W23F001M	413351122510801	1952		Unused	2,728
43/09-24F1	043N009W24F001M	413348122495001	1953	204	Irrigation	2,735
43/09-24F2	043N009W24F002M	413358122495801	1953	146		2,734
43/09-24Q1	043N009W24Q001M	413336122494001	1900	40		2,740
43/10-25P1	043N010W25P001M	413235122563801	1951	30		2,974
43/10-25P2	043N010W25P002M	413233122565001				2,980
43/09-26C2	043N009W26C002M	413317122510501	1952	27		2,732
43/09-26L1	043N009W26L001M	413253122510001	1943	24		2,737
43/09-28E1	043N009W28E001M	413308122533601	1950	41		2,784
43/09-29G2	043N009W29G002M	413258122540601	1958	42		2,800
43/09-29M1	043N009W29M001M	413246122543601	1936	27		2,829
43/09-30A1	043N009W30A001M	413315122550201	1915	16		2,842
43/09-31B1	043N009W31B001M	413223122551701	1948	20		2,873
43/09-32G1	043N009W32G001M	413209122541201	1924	30		2,806
43/09-33G1	043N009W33G001M	413216122530601	1941	100		2,766
44/08-08A1	044N008W08AS01M	414000122470001				4,745
44/09-12K1	044N009W12K001M	414000122490001	1988	80		2,989
44/10-25H1	044N010W25H001M	413820122561301	1952	32		2,703
44/10-25H2	044N010W25H002M	413815122562401	1949	17		2,694
44/09-25R1	44N09W25R001M				Domestic	
44/08-27L1	044N008W27L001M	413756122452901		30		2,908
44/09-27M1	044N009W27M001M	413802122522201	1900	45		2,743
44/09-28P1	044N009W28P001M	413746122532401	1949	65	Unused	2,711
44/09-28Q1	044N009W28Q001M	413746122525601	1949			2,721
44/09-29F1	044N009W29F001M	413822122543201	1920	19		2,704
44/09-29Q1	044N009W29Q001M	413755122540301	1948	36		2,710
44/09-30G1	044N009W30G001M	413818122550901	1917	25		2,695
44/08-30P1	044N008W30P001M	413738122490001	1945	15		2,789
44/08-31G1	044N008W31G001M	413709122484001				2,893
44/09-32A1	044N009W32A001M	413735122535701	1949	30		2,702
44/08-32F1	044N008W32F001M	413715122474101	1935	27		2,825
44/08-33C1	044N008W33C001M	413728122464101	1953	35		2,848
44/08-33D1	044N008W33D001M	413725122470401	1950	40		2,831
44/09-34G1	044N009W34G001M	413728122515401	1952	97		2,721
44/10-34H1	044N010W34H001M	413722122582301				2,707
44/10-34Q1	044N010W34Q001M	413654122584801		90		2,824
44/09-34R1	044N009W34R001M	413655122513001	1951	120		2,720
44/09-34R2	044N009W34R002M	413656122513201	1860	20		2,717
44/10-35G1	044N010W35G001M	413729122573501				2,683
44/09-35Q1	044N009W35Q001M	413658122504201	1945	70		2,735

Table 2.2
Wells with Multiple Depth to Water Measurements

Short Well Name	DWR State Well Number	USGS Site Number	Well Use	Number of Records	Period of Record	
Long-term, multi-year records						
42/09-02A2	42N09W02A002M	413129122502801	Domestic	94	Aug-1953	Aug-2004
42/09-27N1	42N09W27N001M	412722122522501	Unused	83	May-1953	Mar-2001
42/09-27N2	42N09W27N002M	-	Domestic	44	Oct-1994	Apr-2011
43/09-02P2	43N09W02P002M	-	Domestic	16	Mar-2004	Apr-2011
43/09-02Q2	43N09W02Q002M	-	Domestic	16	Sep-2003	Apr-2011
43/09-23F1	43N09W23F001M	413351122510801	Unused	119	May-1953	Apr-2011
43/09-24F1	43N09W24F001M	413348122495001	Irrigation	112	Mar-1953	Apr-2011
44/09-25R1	44N09W25R001M	-	Domestic	27	Jul-2002	Apr-2011
44/09-28P1	44N09W28P001M	413746122532401	Unused	94	Oct-1953	Apr-2009
Short-term, greater than 3 records						
41/09-13G1	-	412415122492601	Domestic	15	Jul-1953	Oct-1953
41/09-36J1	-	412132122491301	Domestic	14	Jul-1953	Oct-1953
42/09-02A2	42N09W02A002M	413129122502801	Domestic	9	Aug-1953	Oct-1953
42/09-02G1	-	413125122504401	Irrigation	15	Jul-1953	Oct-1953
42/09-04Q1	-	413055122525701	Domestic	6	Jul-1953	Oct-1953
42/09-06F2	-	413120122552501	Unused	10	Aug-1953	Oct-1953
42/09-26K1	-	412739122504501	Unused	14	Jul-1953	Oct-1953
42/09-27N1	42N09W27N001M	412722122522501	Unused	15	Jul-1953	Oct-1953
42/09-29A1	-	412804122535401	Domestic	15	Jul-1953	Oct-1953
43/09-08Q1	-	413516122541401	Domestic	14	Jul-1953	Oct-1953
43/09-23F1	43N09W23F001M	413351122510801	Unused	14	Jul-1953	Oct-1953
43/09-24F1	43N09W24F001M	413348122495001	Irrigation	14	Jul-1953	Oct-1953
43/09-24F2	-	413358122495801	Irrigation	15	Jul-1953	Oct-1953
43/09-28E1	-	413308122533601	Stock	15	Jul-1953	Oct-1953
44/08-27L1	-	413756122452901	Domestic	15	Jul-1953	Oct-1953
44/08-32F1	-	413715122474101	Domestic	9	Aug-1953	Oct-1953
44/09-28Q1	-	413746122525601	Domestic, Stock	15	Jul-1953	Oct-1953
44/09-29F1	-	413822122543201	Unused	14	Jul-1953	Oct-1953
44/09-34G1	-	413728122515401	Unused	12	Aug-1953	Oct-1953
44/09-34R2	-	413656122513201	Unused	14	Jul-1953	Oct-1953
44/10-25H2	-	413815122562401	Domestic	15	Jul-1953	Oct-1953
44/10-35G1	-	413729122573501	Domestic	14	Jul-1953	Oct-1953

Table 2.3
Well Test Data and Calculated Specific Capacity

Well	Completed Well Depth, feet	Discharge, gpm	Drawdown, feet	Specific Capacity, gpm/foot	DWR File
41/08-07	157	6	120	0.1	64784
41/09-11	65	150	8	19	61391
41/09-11	85	500	55	9	66135
41/09-11	85	500	55	9	66136
41/09-11	133	141	92	2	62895
42/08-07	103	20	60	0.3	60393
42/08-18	156	250	71	4	62890
42/09-02	120	1,500	12	125	65841
42/09-02	180	1,700	2	850	89635
42/09-04	111	48	10	5	59484
42/09-04	92	8	45	0.2	61785
42/09-06	100	20	20	1	64780
42/09-06	117	15	20	1	64783
42/09-08	63	60	20	3	63980
42/09-09	81	80	15	5	58384
42/09-10	171	3,000	144	21	63975
42/09-11	224	2,000	83	24	83455
42/09-12	170	186	64	3	62084
42/09-13	60	27	1	27	58399
42/09-13	60	760	39	19	59899
42/09-13	93	400	74	5	59902
42/09-16	191	100	185	1	58575
42/09-16	220	4,000	60	67	58577
42/09-17	85	130	70	2	58595
42/09-17	170	500	120	4	64543
42/09-17	105	400	25	16	64766
42/09-23	100	1,200	8	150	66111
42/09-24	190	3	190	0.02	64792
42/09-26	210	1,600	100	16	66164
42/09-27	60	20	40	1	64709
42/09-28	170	15	170	0.1	64788
42/09-29	100	20	60	0.3	61403
42/09-32	270	23	80	0.3	62913
42/09-33	66	150	35	4	59198
42/09-34	67	400	46	9	59878
42/09-34	100	115	14	8	64725

From California Department of Water Resources Well Completion Records

Table 2.3
Well Test Data and Calculated Specific Capacity, continued

Well	Completed Well Depth, feet	Discharge, gpm	Drawdown, feet	Specific Capacity, gpm/foot	DWR File
43/08-17	130	400	40	10	83801
43/09-02	80	40	1	40	62908
43/09-02	159	550	61.2	9	64279
43/09-04	85	8	53	0.2	61617
43/09-05	115	7	85	0.1	61616
43/09-05	158	250	140	2	64546
43/09-10	70	800	30	27	59766
43/09-11	80	40	62	1	59679
43/09-11	120	600	60	10	64746
43/09-12	110	20	110	0.2	64793
43/09-13	180	700	111	6	83454
43/09-14	101	120	2	60	61408
43/09-14	70	400	21	19	61604
43/09-14	160	1,500	50	30	83495
43/09-15	200	100	100	1	62984
43/09-15	105	350	65	5	64504
43/09-18	175	50	140	0.4	86648
43/09-24	220	300	210	1	60406
43/09-25	100	60	5	12	63959
43/09-25	185	1,000	160	6	64762
43/09-26	125	1,750	110	16	60405
43/09-27	172	900	150	6	64761
43/09-28	100	600	70	9	64734
43/09-30	200	80	170	0.5	66169
43/09-32	75	29	1	29	62906
43/09-35	67	550	11	50	59410
43/09-35	114	160	80	2	61827
43/09-36	146	1,600	60	27	80086
43/10-02	72	50	5	10	60357
43/10-11	165	400	85	5	64520
43/10-13	83	20	48	0.4	59407
43/10-13	190	30	100	0.3	64702
43/10-14	203	350	98	4	59411
43/10-15	60	24	10	2	59404
43/10-15	60	24	18	1	59406
43/10-22	62	6	6	1	62069

From California Department of Water Resources Well Completion Records

Table 2.3
Well Test Data and Calculated Specific Capacity, continued

Well	Completed Well Depth, feet	Discharge, gpm	Drawdown, feet	Specific Capacity, gpm/foot	DWR File
43/10-22	73	10	4	3	62070
43/10-22	67	9	7	1	62071
43/10-22	64	10	3	3	62072
43/10-36	100	60	20	3	62980
44/08-29	65	600	57	11	59413
44/08-30	76	45	55	1	59409
44/09-25	80	300	56	5	59412
44/09-25	80	3	61	0.05	61625
44/09-27	67	100	1	100	61627
44/09-28	100	460	15	31	58265
44/09-28	165	20	165	0.1	64703
44/09-28	171	250	110	2	66124
44/09-28	171	250	110	2	66125
44/09-29	243	400	40	10	59622
44/09-29	73	7	68	0.1	61615
44/09-30	100	5	63	0.1	61407
44/09-32	100	1,500	25	60	65856
44/09-33	104	120	4	30	58336
44/09-36	80	25	75	0.3	64785
44/09-36	180	1,200	100	12	65358
44/10-34	69	18	52	0.3	58344
44/10-34	113	25	20	1	64781

From California Department of Water Resources Well Completion Records

Table 2.4
Summary of Stream Gages and Flow Data

CDEC Station ID	USGS Station ID	DWR Station ID	Station Name	Elevation, feet	Operator	Period of Record (Discharge)		Number of Measurements
SNB	11520000	F25040	Scott River near Scott Bar	1,560	USGS	10/1/1911	9/30/1913	731
					CA DWR	10/01/2004	9/30/2007	619
SFJ	11519500		Scott River near Fort Jones	2,624	USGS	10/1/1941	Present	25,365
SCK	11519000	F25484	Shackleford Creek near Mugginsville	2,690	USGS	10/1/1956	9/30/1960	1,461
					CA DWR	6/24/2004	9/1/2010	1,621
-	11518600		Moffett Creek near Fort Jones	-	USGS	10/1/1958	9/30/1967	3,287
-	11518610		Soap Creek Tributary near Fort Jones	-	USGS	1961	1973	11
MNM		F25480	Mill Creek near Mugginsville	2,840	CA DWR	11/10/2004	9/29/2005	322
-	11518400		Etna Creek above Lunch Creek near Etna	-	USGS	2/10/1961	4/27/1973	13
FCC	-	F25650	French Creek at HWY 3 near Callahan	2,840	CA DWR	6/24/2004	9/30/2009	1,774
-	11518310		Cedar Gulch near Callahan	-	USGS	2/1/1966	9/30/1973	2,799
SGN	11518300	F25890	Sugar Creek near Callahan	3,130	USGS	9/1/1957	9/30/1960	1,126
					CA DWR	10/01/2009	9/30/2010	363
DDC	-		Darbee Ditch near Callahan	3,400	CA DWR	9/20/2010	Present	375
SDA			Sugar Creek below Darbee Ditch near Callahan	3,400	CA DWR	5/12/2010	Present	471
-	11518200	F28100	South Fork Scott River near Callahan	3,270	USGS	10/1/1958	9/30/1960	731
					CA DWR	6/29/2002	Present	1,911
-	11518050	F26050	East Fork Scott River near Callahan	3,120	USGS	10/1/1959	9/30/1974	5,479
					CA DWR	6/28/2002	9/30/2010	2,066
-	11518000		East Fork Scott River near Callahan	-	USGS	10/1/1910	9/30/1911	365
-	11517950		East Fork Scott River above Kangaroo Creek near Callahan	-	USGS	9/1/1970	7/6/1973	1,040
-	11517900		East Fork Scott River below Houston Creek near Callahan	-	USGS	8/30/1970	7/6/1973	1,042

Table 2.5
Land and Water Use Data, 2000

	Grain	Corn	Alfalfa	Pasture	Total	Acreage Weighted Average, acre-feet/acre
Irrigated Crop Area (acres)	2,000	300	13,000	16,500	31,800	--
Applied Water (acre-feet/acre)	1.56	1.92	2.78	3.13	--	2.88
Consumed Fraction (percent)	0.77	0.73	0.79	0.67	--	0.73
Evapotranspiration of Applied Water (acre-feet/acre)	1.2	1.4	2.2	2.1	--	2.08
Excess Applied Water (acre-feet/acre)	0.36	0.52	0.58	1.03	--	0.80

Source: DWR, Land and Water Use, DAU 003 (Scott Valley), <www.water.ca.gov/landwateruse/docs/annualdata/2000/ag_dau_2000.xls>

Table 2.6
Irrigated Acreage and Allotments under Scott River Decree

Sub-Area	Schedule[1]	Area Served, acres	Priority 1 Allotment, cfs	Total Amount[2], cfs
Upper Tributaries, East Fork, Scott River	B1	146	5.20	6.32
Rail Creek and Tributaries	B2	368	6.58	10.33
Middle Tributaries, East Fork, Scott River	B3	279	3.36	8.91
Lower Tributaries, East Fork, Scott River	B4	626	6.72	21.29
East Fork, Scott River above Rail Creek	B5	779	0.16	35.67
East Fork, Scott River - Rail Creek to Gouse Creek	B6	420	0.17	19.44
East Fork, Scott River - Grouse Creek to Confluence with South Fork, Scott River	B7	119	0.08	7.77
Tributaries of South Fork, Scott River	B8	108	8.29	9.58
South Fork, Scott River	B9	99	6.07	8.05
Wildcat Creek and Tributaries	B10	290	1.73	7.49
Sugar Creek and Tributaries	B11	525	1.28	25.58
Messner Gulch, Cedar Gulch, Facey Gulch (aka Luddy Gulch), and other Tributaries of Scott River	B12	293	1.64	4.70
McConaughy Gulch and Tributaries	B13	220	3.57	3.57
Wolford Slough and Tributaries	B14	282	5.65	6.62
Clark Creek	B15	710	2.50	15.06
Tributaries of Etna Creek	B16	124	2.09	2.29
Upper Etna Creek including the Etna Mill Ditch	B17	732	2.41	13.72
Lower Etna Creek Downstream from the Etna Mill Ditch	B18	1,250	6.52	36.40
Shell Gulch, Hurds Gulch, Hamlin Gulch and their Tributaries	B19	292	1.53	4.19
Johnson Creek and Tributaries	B20	1,148	2.50	18.70
Crystal Creek	B21	884	2.10	11.30
Patterson Creek (West)	B22	3,251	5.62	35.48
Big Slough and Tributaries	B23	2,398	17.62	37.82
Tributaries of Kidder Creek	B24	326	2.17	6.53
Upper Kidder Creek	B25	4,514	17.91	91.93
Lower Kidder Creek	B26	3,352	32.66	53.04
Upper Moffett Creek and Tributaries	B27	797	9.37	12.10
Duzel Creek and Tributaries	B28	169	1.27	2.76
Lower Moffett Creek	B29	1,491	18.92	26.26
Soap Creek and Tributaries	B30	71	1.20	1.42
Tributaries of Lower Moffett Creek	B31	180	3.36	3.36
McAdam Creek and Tributaries	B32	761	0.05	14.68
Indian Creek and Tributaries	B33	641	0.15	12.58
Oro Fino Creek and Tributaries	B34	1,457	0.12	21.74
Rattlesnake Creek and Tributaries	B35	105	0.08	6.14
Tyler Gulch and Tributaries	B36	53	0.06	0.96
Patterson Creek (North) and Tributaries	B37	106	0.03	2.03
Sniktaw Creek and Tributaries	B38	552	1.38	10.68
Lower Scott River Tributaries	B39	33	0.14	0.68
Graveyard Gulch, Meamber Creek and Meamber Gulch	B40	179	2.86	2.90

Table 2.6
Irrigated Acreage and Allotments under Scott River Decree, continued

Sub-Area	Schedule[1]	Area Served, acres	Priority 1 Allotment, cfs	Total Amount[2], cfs
Scott River from the Confluence of East Fork and South Fork to the Lower End of the Dredger Tailings	D1	1,654	6.16	49.25
Scott River from Lower End of Dredger Tailings to the Scott Valley Irrigation District Ditch Diversion No. 223	D2	7,946	26.44	128.16
Scott River from the Scott Valley Irrigation District Diversion No. 223 to Diversion No. 576	D3	4,463	4.27	71.56
Scott River from Diversion No. 576 to USGS Gaging Station	D4	1,115	9.89	20.58
Scott River from USGS Gaging Station to Confluence with Klamath River	D5	145	2.79	4.67
Subtotal, Independent Tributary Streams[3]	B1 - B40	30,130	185	620
Subtotal, Natural Flow of the Scott River[3]	D1 - D5	15,323	50	274
Total Surface Water [3]	**B1 - B40, D1 - D5**	**45,453**	**235**	**894**
Groundwater Interconnected with the Scott River[4]	**C**	**12,975**	**--**	**--**

Notes:

1. Schedule refers to Scott River Adjudication Decree (1980)
2. Total Allotment includes all priority classes and surplus
3. Irrigation to some acreage is permitted from more than one diversion point and may be included on multiple schedules; accordingly, this tally may include some “double-counting” and does not represent total acreage served by irrigation; rather, totals represent the sum of acreages potentially irrigated by the identified systems.
4. Groundwater acreage overlaps with acreage served by surface water for 4,649 acres.

Table 2.7
Riparian Wetland Classes in Scott Valley

System	Wetland Group	NWI Classification Code	Class	Water Regime	Special Modifier	Acres
Palustrine	Freshwater Emergent Wetland	PEMA	Emergent	Temporary Flooded	-	415.6
		PEMAh			Diked/Impounded	1.1
		PEMB		Saturated	-	2.8
		PEMC		Seasonally Flooded	-	3,997.3
		PEMCh			Diked/Impounded	21.5
		PEMCx			Excavated	7.4
		PEMF		Semi-permanently Flooded	-	3.9
		PEMFh			Diked/Impounded	0.2
		PEMFx			Excavated	0.8
	Total					**4,450.7**
	Freshwater Forested/ Shrub Wetland	PFOA	Forested	Temporary Flooded	-	2.4
		PFOC		Seasonally Flooded	-	249.3
		PSSA	Scrub/Shrub	Temporary Flooded	-	19.6
		PSSC		Seasonally Flooded	-	526.7
		PSSCx			Excavated	10.8
	Total					**808.9**
	Freshwater Pond	PABF	Aquatic Bed	Semi-permanently Flooded	-	12.2
		PABFh			Diked/Impounded	5.9
		PABFx			Excavated	33.9
		PABG		Intermittently Exposed (to drought)	-	5.2
		PABGh			Diked/Impounded	2.9
		PABGx			Excavated	16.7
		PABHh		Permanently Flooded	Diked/Impounded	0.9
		PABHx			Excavated	0.5
		PABKh		Artificially Flooded	Diked/Impounded	9.3
		PUBFh	Unconsolidated Shore	Semi-permanently Flooded	-	0.3
		PUBFx			-	2.0
		PUBHh		Permanently Flooded	-	9.4
		PUBHx			-	6.3
		PUSC		Seasonally Flooded	-	2.7
		PUSCh			-	1.0
		PUSCx			-	3.8
	Total					**113.1**
Riverine	Riverine	R2ABH	Lower Perennial	Aquatic Bed	Permanently Flooded	1.9
		R2UBH		Unconsolidated Bottom	Permanently Flooded	441.4
		R2USA		Unconsolidated Shore	Temporary Flooded	188.5
		R2USC			Seasonally Flooded	733.0
		R3USC	Upper Perennial		Seasonally Flooded	9.3
		R4USA	Intermittent		Temporary Flooded	92.7
		R4USC			Seasonally Flooded	255.2
		R4USCx			Seasonally Flooded, Excavated	5.8
	Total					**1,727.8**

NOTES:

Palustrine Special Modifier Codes : h = Diked/Impounded, x = Excavated
Riverine Special Modifier Codes : A = Temporarily Flooded, C = Seasonally Flooded, Cx = Seasonally Flooded & Excavated, H = Permanently Flooded

Table 2.8
Inventory of Domestic Wells

Location	Number of Wells	Minimum Depth, feet	Maximum Depth, feet	Median Depth, feet
41/08-07	4	120	169	150
41/08-30	1	115	115	115
41/09-02	1	60	60	60
41/09-03	3	100	196	100
41/09-10	2	110	126	118
41/09-13	4	47	185	60
41/09-14	1	68	68	68
41/09-15	4	64	265	128
41/09-36	2	65	110	88
42/08-07	3	105	184	123
42/09-02	1	50	50	50
42/09-04	2	52	220	136
42/09-05	32	48	140	103
42/09-06	53	50	405	150
42/09-07	1	95	95	95
42/09-08	5	63	160	100
42/09-09	2	80	81	81
42/09-12	3	65	140	132
42/09-13	1	240	240	240
42/09-15	2	125	153	139
42/09-17	3	56	320	105
42/09-20	1	405	405	405
42/09-21	1	72	72	72
42/09-24	16	76	190	105
42/09-25	1	205	205	205
42/09-26	3	30	50	50
42/09-27	5	28	100	70
42/09-28	12	20	220	75
42/09-29	9	90	164	135
42/09-32	27	29	300	65
42/09-33	1	187	187	187
42/09-34	2	60	80	70
43/08-17	2	80	109	95
43/08-18	1	387	387	387
43/08-20	1	180	180	180
43/09-02	13	40	135	80
43/09-03	5	40	100	72
43/09-04	1	85	85	85
43/09-05	1	115	115	115
43/09-08	1	40	40	40
43/09-09	1	105	105	105
43/09-10	1	76	76	76
43/09-11	7	64	200	80
43/09-12	6	60	120	88
43/09-13	4	80	210	95

Notes:

1. Excludes wells that encountered bedrock at depths less than 50 feet
2. Excludes wells with unknown depth

Table 2.8
Inventory of Domestic Wells, continued

Location	Number of Wells	Minimum Depth, feet	Maximum Depth, feet	Median Depth, feet
43/09-14	1	100	100	100
43/09-15	6	106	200	124
43/09-16	3	140	255	170
43/09-17	3	60	160	158
43/09-18	3	55	180	130
43/09-19	1	23	23	23
43/09-20	1	80	80	80
43/09-21	1	258	258	258
43/09-23	3	100	130	100
43/09-25	1	57	57	57
43/09-26	3	89	100	90
43/09-28	2	189	240	215
43/09-29	31	32	160	60
43/09-30	4	38	200	71
43/09-31	27	50	281	100
43/09-32	16	33	220	75
43/09-34	2	30	34	32
43/09-35	1	80	80	80
43/10-02	9	38	100	50
43/10-03	7	35	160	45
43/10-10	8	24	300	142
43/10-11	8	38	100	57
43/10-13	6	60	190	103
43/10-14	5	75	105	100
43/10-15	5	60	120	80
43/10-22	8	62	205	87
43/10-24	2	60	75	68
43/10-25	10	60	160	100
43/10-26	3	49	205	100
43/10-36	17	26	325	90
44/08-29	4	48	155	74
44/08-30	2	76	300	188
44/08-31	4	52	205	110
44/08-32	7	52	124	82
44/09-25	7	68	140	80
44/09-27	3	62	290	67
44/09-28	3	56	165	75
44/09-29	5	73	243	108
44/09-30	10	70	355	119
44/09-33	1	126	126	126
44/09-36	18	34	106	80
44/10-25	7	70	203	100
44/10-34	20	40	465	115
44/10-35	4	40	100	76

Notes:

1. Excludes wells that encountered bedrock at depths less than 50 feet
2. Excludes wells with unknown depth

Table 2.9
Inventory of Irrigation Wells

Location	Number of Wells	Minimum Depth, feet	Maximum Depth, feet	Median Depth, feet
41/08-18	1	75	75	75
41/09-02	2	97	110	104
41/09-03	1	110	110	110
41/09-11	6	43	133	85
42/08-18	1	156	156	156
42/09-02	3	120	180	150
42/09-04	2	60	111	86
42/09-05	3	100	107	104
42/09-08	1	115	115	115
42/09-09	2	120	150	135
42/09-10	1	171	171	171
42/09-11	3	120	235	200
42/09-12	1	170	170	170
42/09-13	3	60	100	65
42/09-14	1	142	142	142
42/09-15	3	104	207	150
42/09-16	2	191	220	206
42/09-17	1	180	180	180
42/09-21	2	125	141	133
42/09-23	1	110	110	110
42/09-24	2	150	275	213
42/09-26	3	140	240	210
42/09-28	5	14	108	30
42/09-32	2	47	92	70
42/09-33	2	66	70	68
42/09-34	9	67	260	118
43/08-17	3	102	130	102
43/08-20	2	165	185	175
43/09-02	5	91	100	100
43/09-03	1	55	55	55
43/09-04	3	193	275	255
43/09-05	2	90	158	124
43/09-10	1	70	70	70
43/09-11	8	20	145	101
43/09-12	1	36	36	36
43/09-13	2	170	185	178
43/09-14	5	71	160	101
43/09-15	1	105	105	105
43/09-17	2	63	63	63
43/09-19	1	400	400	400
43/09-21	2	105	146	126
43/09-22	2	80	200	140
43/09-23	3	60	160	120
43/09-24	3	120	250	195
43/09-25	5	80	185	140

Notes:

1. Excludes wells that encountered bedrock at depths less than 50 feet
2. Excludes wells with unknown depth

Table 2.9
Inventory of Irrigation Wells, continued

Location	Number of Wells	Minimum Depth, feet	Maximum Depth, feet	Median Depth, feet
43/09-26	1	125	125	125
43/09-27	2	81	172	127
43/09-28	3	100	215	138
43/09-29	2	80	220	150
43/09-30	1	67	67	67
43/09-31	2	100	100	100
43/09-32	1	126	126	126
43/09-35	2	69	115	92
43/09-36	2	146	152	149
43/10-10	1	120	120	120
43/10-11	3	60	220	165
43/10-14	3	110	203	126
43/10-23	1	47	47	47
44/08-29	1	66	66	66
44/08-30	2	60	85	73
44/08-31	1	84	84	84
44/08-32	2	100	110	105
44/09-25	1	65	65	65
44/09-27	1	89	89	89
44/09-28	4	57	171	136
44/09-29	1	105	105	105
44/09-30	3	100	147	112
44/09-32	1	100	100	100
44/09-33	3	104	170	135
44/09-34	1	123	123	123
44/09-36	5	32	180	68
44/10-26	1	100	100	100
44/10-27	1	35	35	35

Notes:

1. Excludes wells that encountered bedrock at depths less than 50 feet
2. Excludes wells with unknown depth

Table 2.10
Number of Wells Drilled, 1950 through 2010

Period	Wells Drilled during Period	Cumulative Wells Drilled	Irrigation Wells Drilled during Period	Cumulative Irrigation Wells
Prior to 1954	78	78	6	6
1955 - 1959	3	81	0	6
1960 - 1964	7	88	3	9
1965 - 1969	64	152	15	24
1970 - 1974	70	222	19	43
1975 - 1979	184	406	56	99
1980 - 1984	31	437	4	103
1985 - 1989	16	453	1	104
1990 - 1994	97	550	11	115
1995 - 1999	72	622	15	130
2000 - 2004	115	737	25	155
2005 - 2009	48	785	14	169
2010	5	790	3	172

Notes:

1. Wells prior to 1954 from Mack, 1958, Table 8, including those with unknown completion dates
2. Wells 1955-2010 from CaDWR well logs, excluding wells encountering bedrock at depths less than 50 feet
3. DWR wells exclude a total of 17 wells with unknown completion dates, 3 of which are irrigation wells
4. Inventory reflects wells with use specified as domestic, irrigation, public supply or stock

Table 4.1
Maximum Alluvial Thickness, by Section

Township	Range	Section	Number of Wells	Maximum Alluvial Thickness, feet
41N	08W	7	6	75
41N	08W	18	1	60
41N	08W	30	7	55
41N	09W	2	3	90
41N	09W	3	7	80
41N	09W	10	9	65
41N	09W	11	6	131
41N	09W	14	2	67
41N	09W	15	8	>265
41N	09W	36	5	90
42N	08W	18	1	148
42N	09W	2	5	>180
42N	09W	4	5	>220
42N	09W	5	37	>140
42N	09W	6	56	165
42N	09W	7	1	>95
42N	09W	8	8	>160
42N	09W	9	4	>150
42N	09W	10	1	166
42N	09W	11	3	>200
42N	09W	12	5	109
42N	09W	14	1	>142
42N	09W	15	7	>240
42N	09W	16	2	>220
42N	09W	17	6	>180
42N	09W	21	3	>141
42N	09W	23	2	>110
42N	09W	24	21	170
42N	09W	25	1	123
42N	09W	26	7	>240
42N	09W	27	6	>140
42N	09W	28	34	100
42N	09W	33	10	100
42N	09W	34	14	236
43N	08W	17	9	>130

Note: Sections included with wells reporting over 50 feet of alluvium.

Table 4.1
Maximum Alluvial Thickness, by Section, continued

Township	Range	Section	Number of Wells	Maximum Alluvial Thickness, feet
43N	08W	18	1	152
43N	08W	19	2	>120
43N	08W	20	3	100
43N	09W	2	25	>210
43N	09W	3	7	90
43N	09W	4	6	190
43N	09W	5	3	153
43N	09W	9	4	90
43N	09W	10	2	>76
43N	09W	11	19	128
43N	09W	12	11	>120
43N	09W	13	8	98
43N	09W	14	6	>160
43N	09W	15	12	140
43N	09W	17	7	75
43N	09W	18	11	95
43N	09W	19	4	140
43N	09W	20	3	70
43N	09W	21	6	>143
43N	09W	22	3	>200
43N	09W	23	6	>160
43N	09W	24	4	181
43N	09W	25	7	165
43N	09W	26	4	>125
43N	09W	27	3	>172
43N	09W	28	6	145
43N	09W	29	48	130
43N	09W	30	7	182
43N	09W	31	31	>185
43N	09W	32	20	180
43N	09W	35	3	>80
43N	09W	36	2	>152
43N	10W	2	13	>140
43N	10W	10	10	>146
43N	10W	11	12	200

Note: Sections included with wells reporting over 50 feet of alluvium.

Table 4.1
Maximum Alluvial Thickness, by Section, continued

Township	Range	Section	Number of Wells	Maximum Alluvial Thickness, feet
43N	10W	14	11	126
43N	10W	22	9	>205
43N	10W	23	3	175
43N	10W	24	6	60
43N	10W	25	14	90
43N	10W	26	4	>100
43N	10W	36	22	>128
44N	08W	29	6	85
44N	08W	30	6	70
44N	08W	31	14	>205
44N	08W	32	9	>124
44N	09W	25	13	136
44N	09W	27	5	>89
44N	09W	28	11	170
44N	09W	29	9	148
44N	09W	30	27	141
44N	09W	32	1	>100
44N	09W	33	5	130
44N	09W	34	1	>123
44N	09W	36	30	140
44N	10W	25	15	>100
44N	10W	26	4	92
44N	10W	35	8	>100

Note: Sections included with wells reporting over 50 feet of alluvium.

Table 4.2
Modeled Hydraulic Conductivity and Specific Yield

Sub-Region	Mean Hydraulic Conductivity, feet/day		Specific Yield, Layer 1
	Layer 1	Layer 2	
River	175	N/A	0.20
Scott River Floodplain			
Within area delineated by SWRCB	141	142	0.15
Outside area delineated by SWRCB	37	38	0.15
Discharge Zone	47	47	0.05
Hamlin Gulch	19	19	0.07
Moffett-McAdam Creeks	42	42	0.15
Oro Fino Creek	14	14	0.07
Quartz Valley	19	22	0.07
Tributary	13	21	0.07
West Mountain Fans	11	11	0.07

Table 4.3a
Groundwater Use for Irrigation, Recent Condition

Season	Alfalfa	Corn	Grain	Pasture	Total
	feet per acre per season (unless otherwise noted)				
May-June	0.87	0.26	0.55	1.07	-
July-September	1.96	1.70	0.98	1.83	-
Annual	**2.83**	**1.97**	**1.53**	**2.91**	**-**
Groundwater Acres	**11,206**	**292**	**1,807**	**1,878**	**15,183**
Annual, acre-feet	**31,721**	**574**	**2,767**	**5,469**	**40,531**

Note: Values represent applied groundwater as reported for DAU3 by the DWR for the year 2000.

Table 4.3b
Groundwater Use for Irrigation, Partial Build-Out

Season	Alfalfa	Corn	Grain	Pasture	Total
	feet per acre per season (unless otherwise noted)				
May-June	0.60	0.26	0.54	0.78	-
July-September	1.32	1.07	0.68	1.32	-
Annual	**1.91**	**1.33**	**1.22**	**2.10**	**-**
Groundwater Acres	**11,206**	**292**	**1,807**	**1,878**	**15,183**
Annual, acre-feet	**21,433**	**389**	**2,205**	**3,936**	**27,963**

Table 4.4
Estimated Mountain-Front Recharge

Zone Number	Zone Name	Area of Contributing Watershed, acres	Estimated Recharge, acre-feet per year	Number of Bounding Grid Cells
1	Facey/Unnamed	2,960	504	105
2	McConaughy	13,137	572	74
3	East Central	26,027	5,981	723
4	Moffett	59,675	2,514	169
5	Indian/McAdam	29,600	1,696	181
6	Northwest	20,172	1,578	301
7	Shackleford	12,374	1,354	27
8	Mill/Quartz West	11,201	2,038	293
9	Chaparral/Quartz East	9,432	1,236	659
10	Kidder-Johnson	29,883	6,065	226
11	Etna	19,925	4,859	171
12	French	21,097	3,197	18
13	Southwest	3,594	138	131
Sum		**259,079**	**31,732**	**3,078**

Table 4.5a
On-Farm Deep Percolation, Recent Condition

Season	Alfalfa	Corn	Grain	Pasture	Total
	feet per acre per season (unless otherwise noted)				
May-June	0.20	0.07	0.13	0.40	-
July-September	0.44	0.47	0.23	0.66	-
Total, feet	**0.64**	**0.54**	**0.35**	**1.06**	**-**
Irrigated Acres	**13,035**	**312**	**1,970**	**16,453**	**31,770**
Total, acre-feet	**8,326**	**169**	**691**	**17,465**	**26,651**

Note: Values represent difference between total applied water (surface water and groundwater) and evaporation of applied water, as reported for DAU3 by the CADWR for the year 2000.

Table 4.5b
On-Farm Deep Percolation, Partial Build-Out

Season	Alfalfa	Corn	Grain	Pasture	Total
	feet per acre per season (unless otherwise noted)				
May-June	0.15	0.07	0.12	0.39	-
July-September	0.32	0.34	0.16	0.65	-
Total, feet	0.47	0.41	0.29	1.04	-
Irrigated Acres	**13,035**	**312**	**1,970**	**16,453**	**31,770**
Total, acre-feet	**6,063**	**128**	**567**	**17,134**	**23,893**

Note: Values reflect the same quantities of applied surface water as for the recent condition, with lower quantities of applied groundwater as shown on Table 4.3b.

Table 4.6
Modeled Reaches, Scott River

Reach Number	Description	Number of Cells
1	Upstream end of model domain to the downstream end of the tailings (Tailings)	56
2	Tailings to French Creek	90
3	French Creek to Horn Lane Bridge	82
4	Horn Lane Bridge to Eller Bridge	119
5	Eller Bridge to Island Bridge	96
6	Island Bridge to Moffett Creek	73
7	Moffett Creek to Oro Fino Creek	56
8	Oro Fino Creek to Shackleford Creek	95
9	Shackelford Creek to End of Valley	55

Table 5.1
Simulated Annual Groundwater Budget, Partial Build-Out

	Groundwater Inflow	Groundwater Outflow
	acre-feet	
Net River/Creek Gains (-)/Losses (+)	**-**	**-37,624**
Scott River	-	-23,907
Shackleford Creek	-	-1,026
Mill Creek	-	-2,235
Oro Fino Creek	-	-662
Kidder Creek	1,403	-
Patterson Creek	24	-
Etna Creek	-	-522
French Creek	-	-830
Moffett Creek	-	-1,040
East Valley Slough	-	-1,095
West Valley Slough	-	-973
Big Slough	-	-6,761
On-Farm Percolation/Precipitation Infiltration	**32,219**	**-**
Evapotranspiration	**-**	**-5,387**
Mountain-Front Recharge, Canal Seepage	**38,819**	**-**
Groundwater Extraction from Wells	**-**	**-28,008**

Notes:

1. Signs: (-) represents flux out of groundwater model domain, (+) represents flux into groundwater model domain.
2. Budget represents the final year of the 4-season 25-year SSO simulation.
3. Values shown are net for year. River and creek gains/losses may vary substantially over different seasons and within sub-reaches.

Table 6.1
Simulated Annual Groundwater Budget, Recent Condition

	Groundwater Inflow	Groundwater Outflow
	acre-feet	
Net River/Creek Gains (-)/Losses (+)	**-**	**-27,876**
Scott River	-	-17,077
Shackleford Creek	-	-954
Mill Creek	-	-2,140
Oro Fino Creek	-	-338
Kidder Creek	1,688	-
Patterson Creek	173	-
Etna Creek	-	-343
French Creek	-	-777
Moffett Creek	-	-557
East Valley Slough	-	-771
West Valley Slough	-	-915
Big Slough	-	-5,865
On-Farm Percolation/Precipitation Infiltration	**34,972**	**-**
Evapotranspiration	**-**	**-5,387**
Mountain-Front Recharge, Canal Seepage	**38,819**	**-**
Groundwater Extraction from Wells	**-**	**-40,533**

Notes:

1. Signs: (-) represents flux out of groundwater model domain, (+) represents flux into groundwater model domain.
2. Budget represents the final year of the 4-season 25-year SSO simulation.
3. Values shown are net for year. River and creek gains/losses may vary substantially over different seasons and within sub-reaches.

Appendices

Appendix A

Groundwater Hydrographs

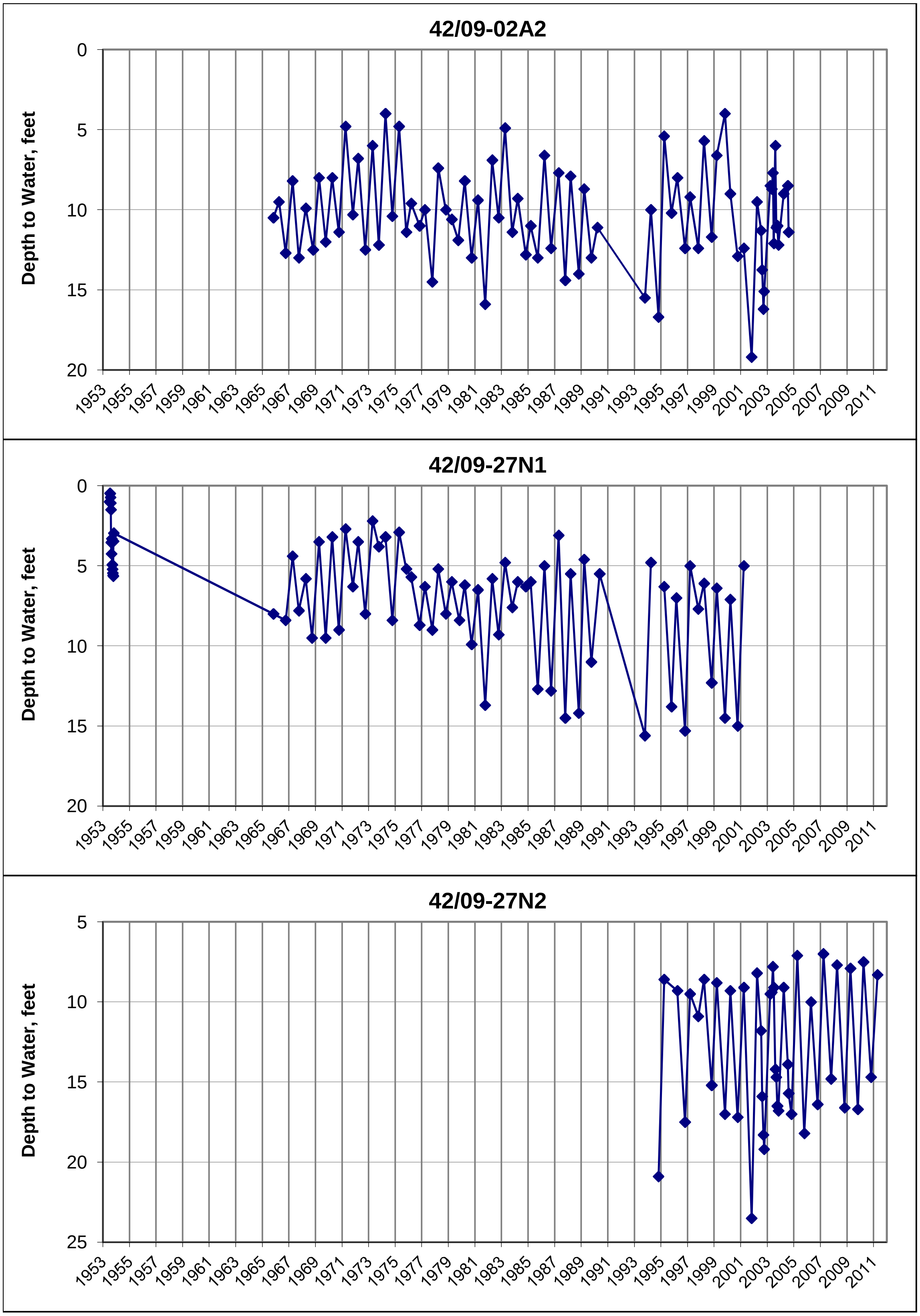


Figure A-1. Scott Valley Long-term Hydrographs

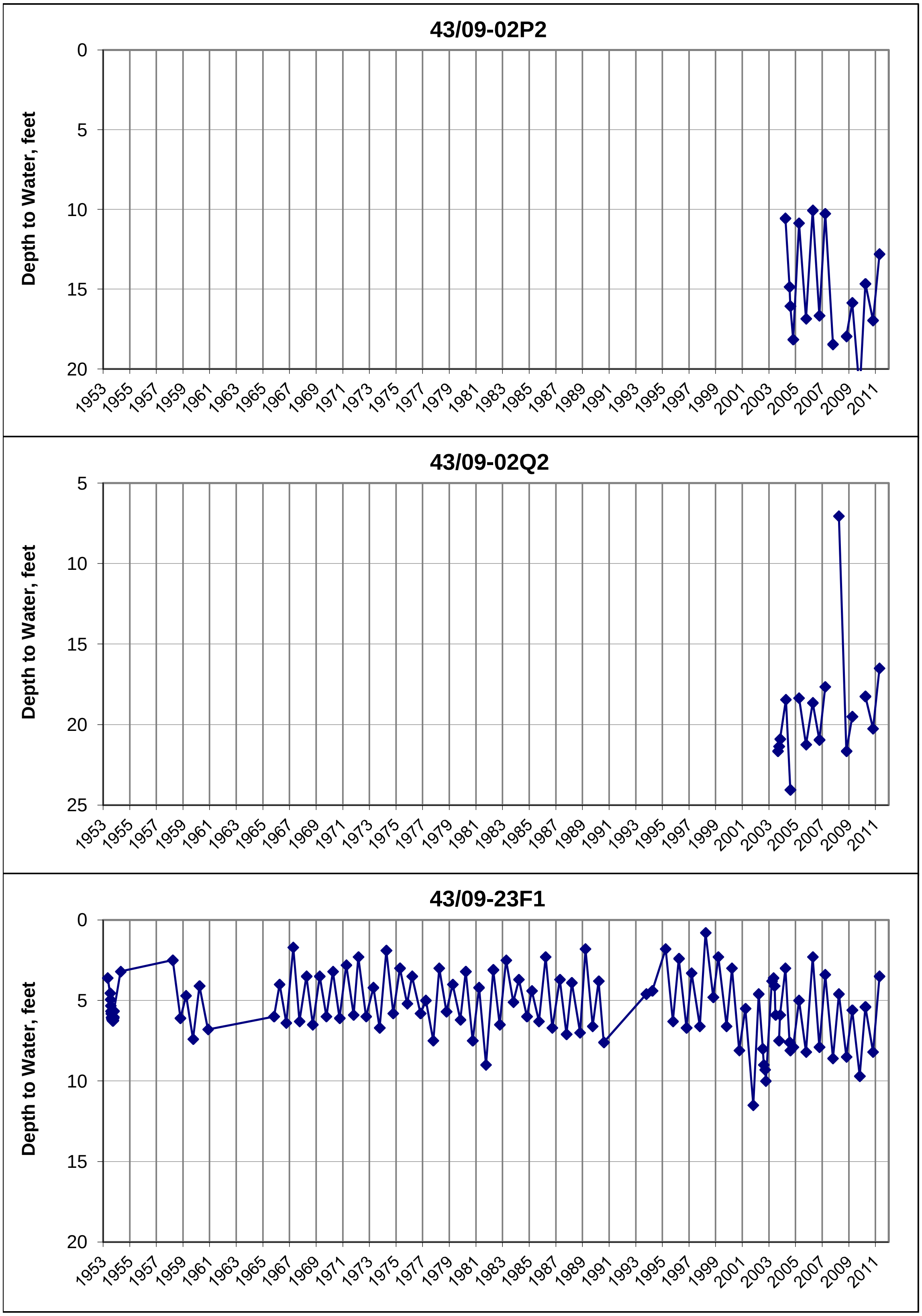


Figure A-1. Scott Valley Long-term Hydrographs, continued

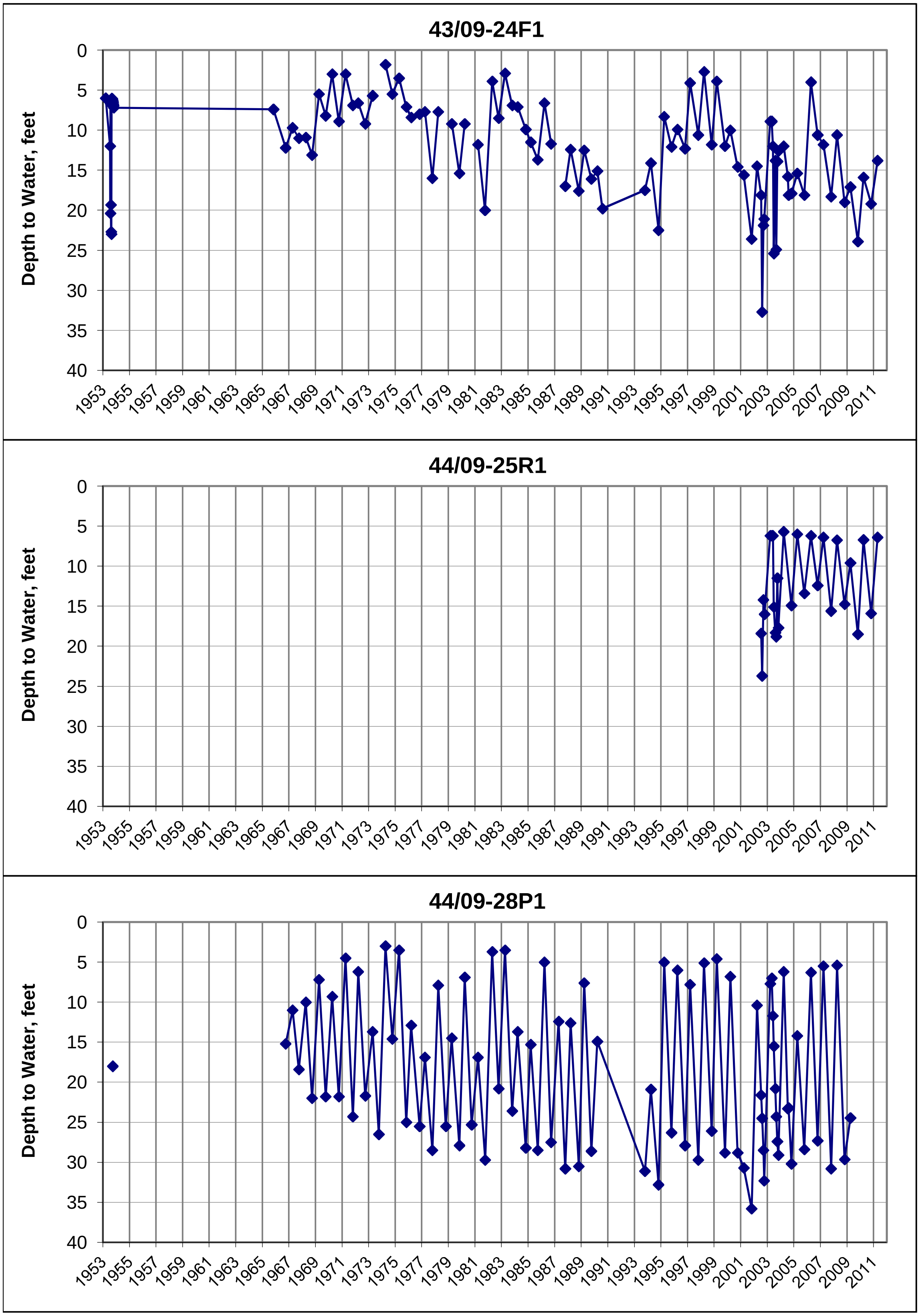


Figure A-1. Scott Valley Long-term Hydrographs, continued

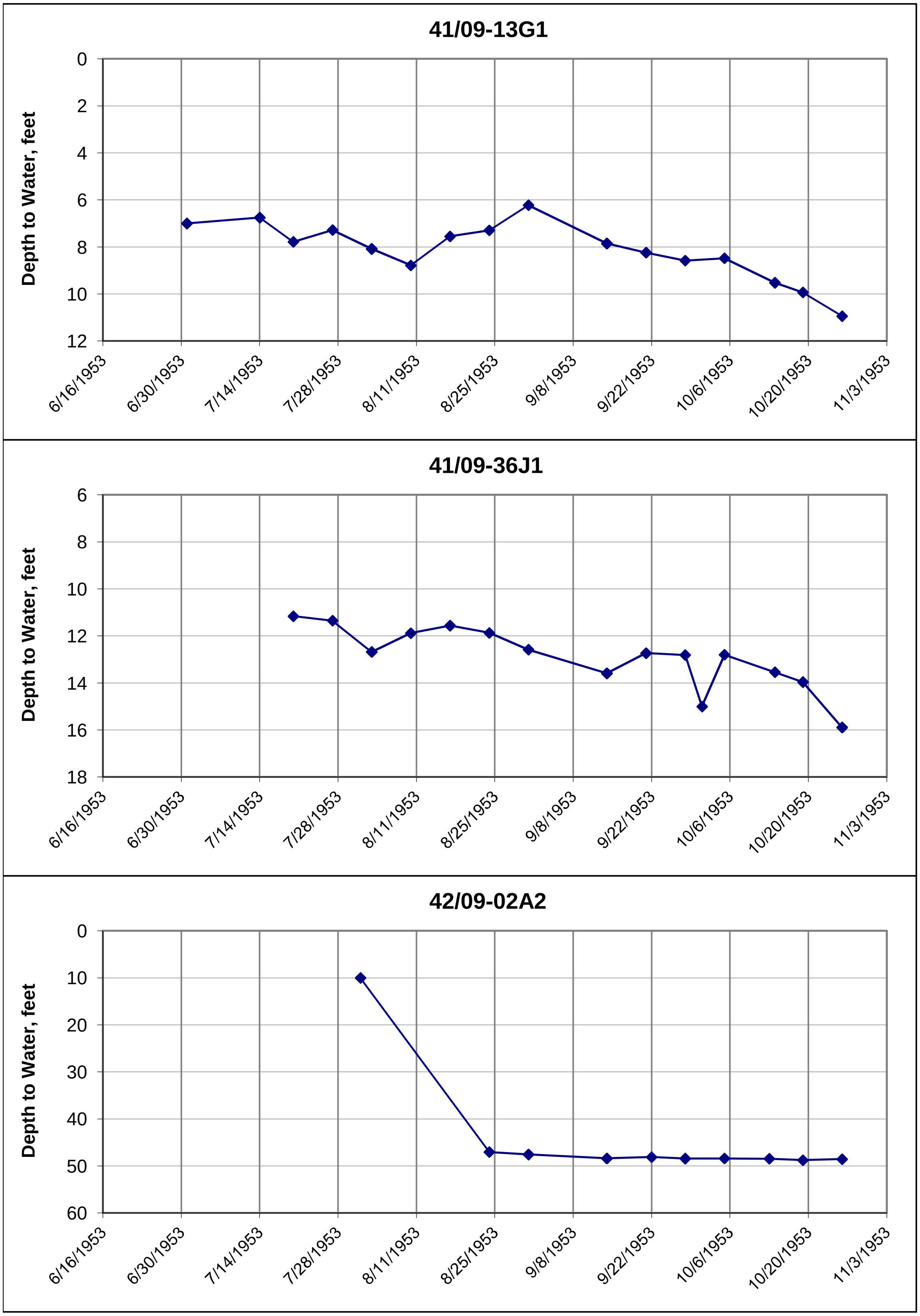


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records)

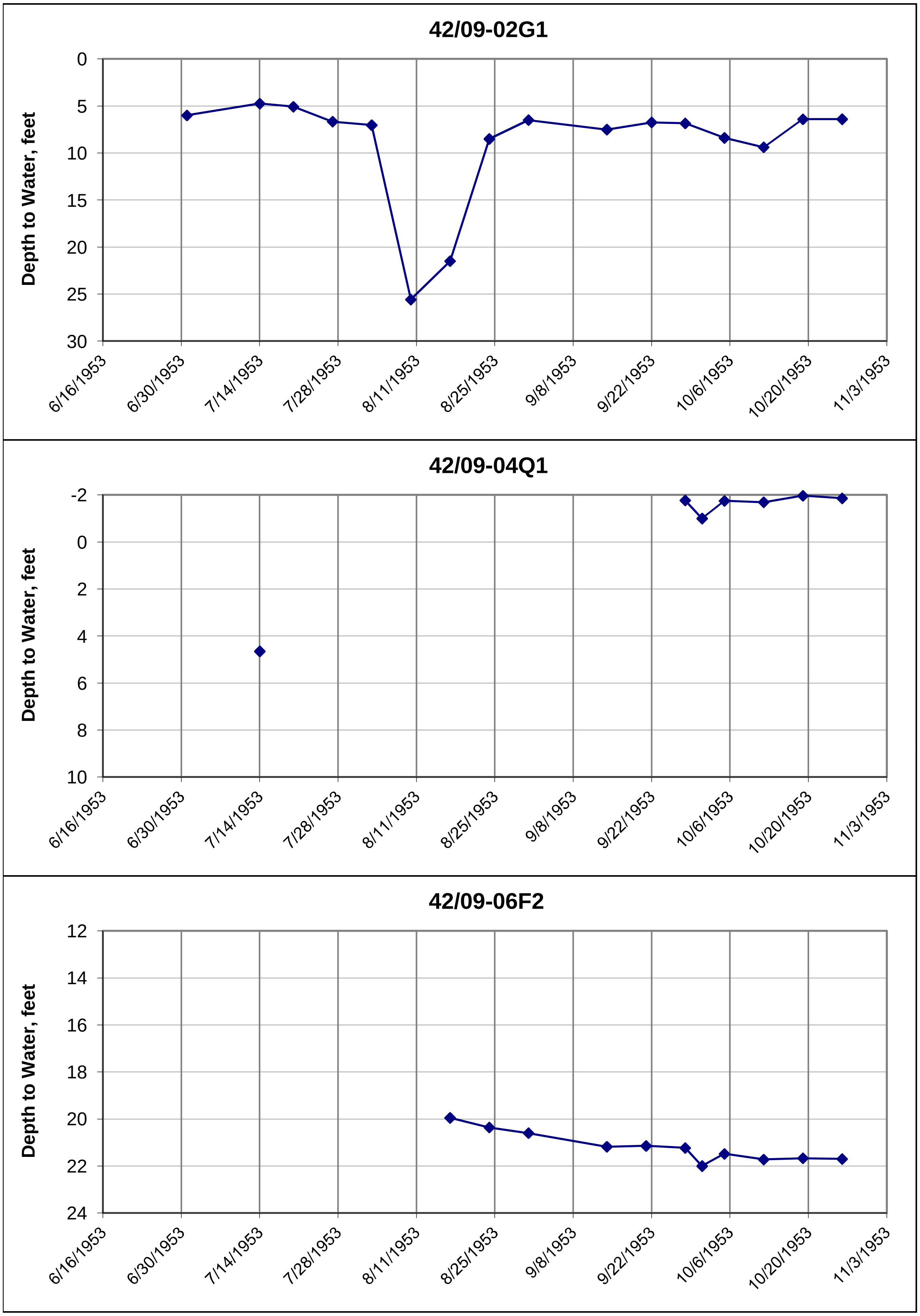
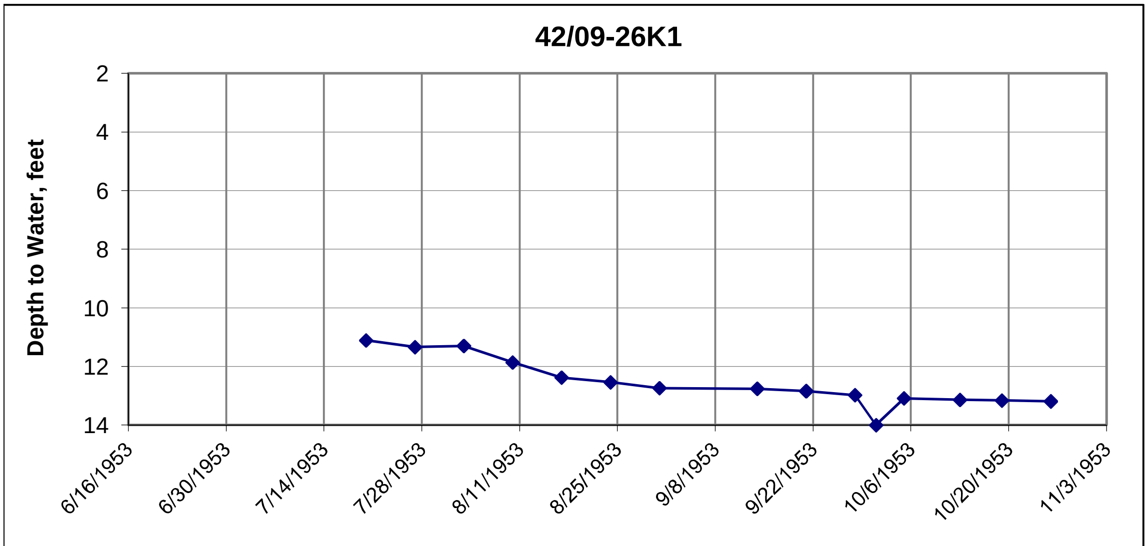
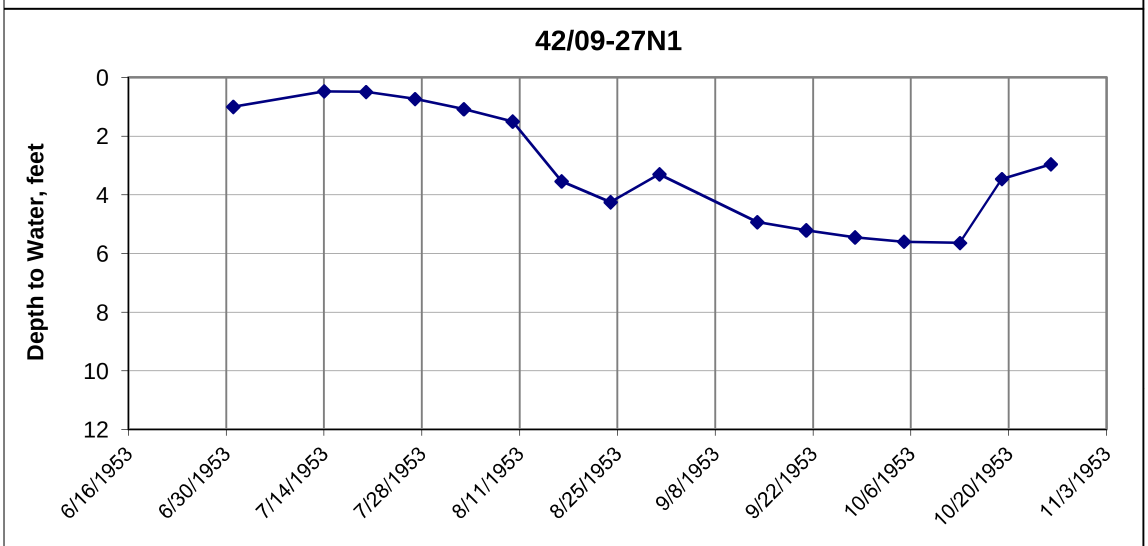


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records), continued





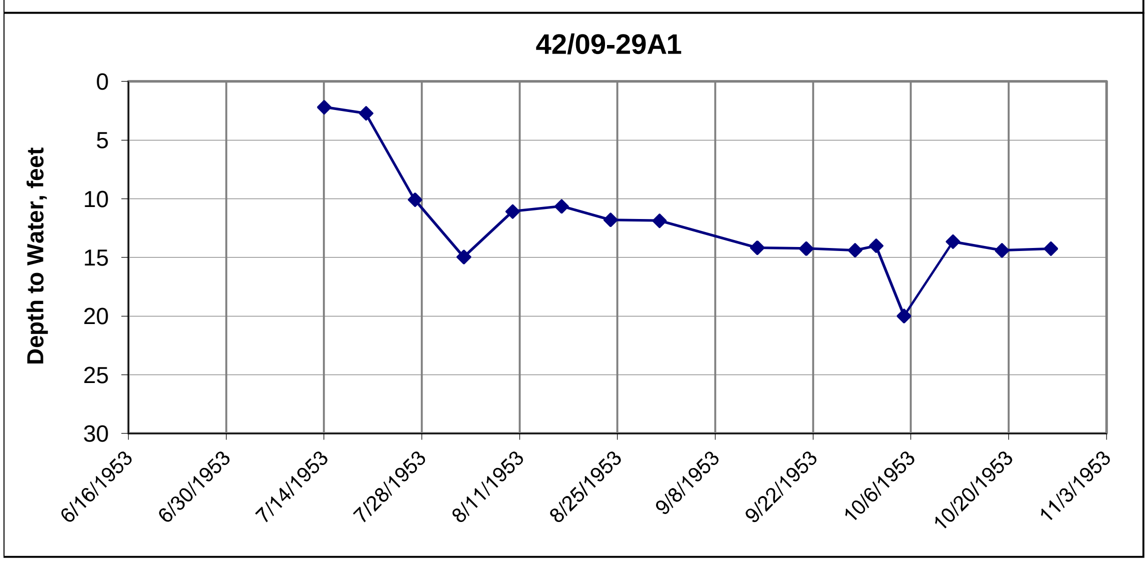


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records), continued

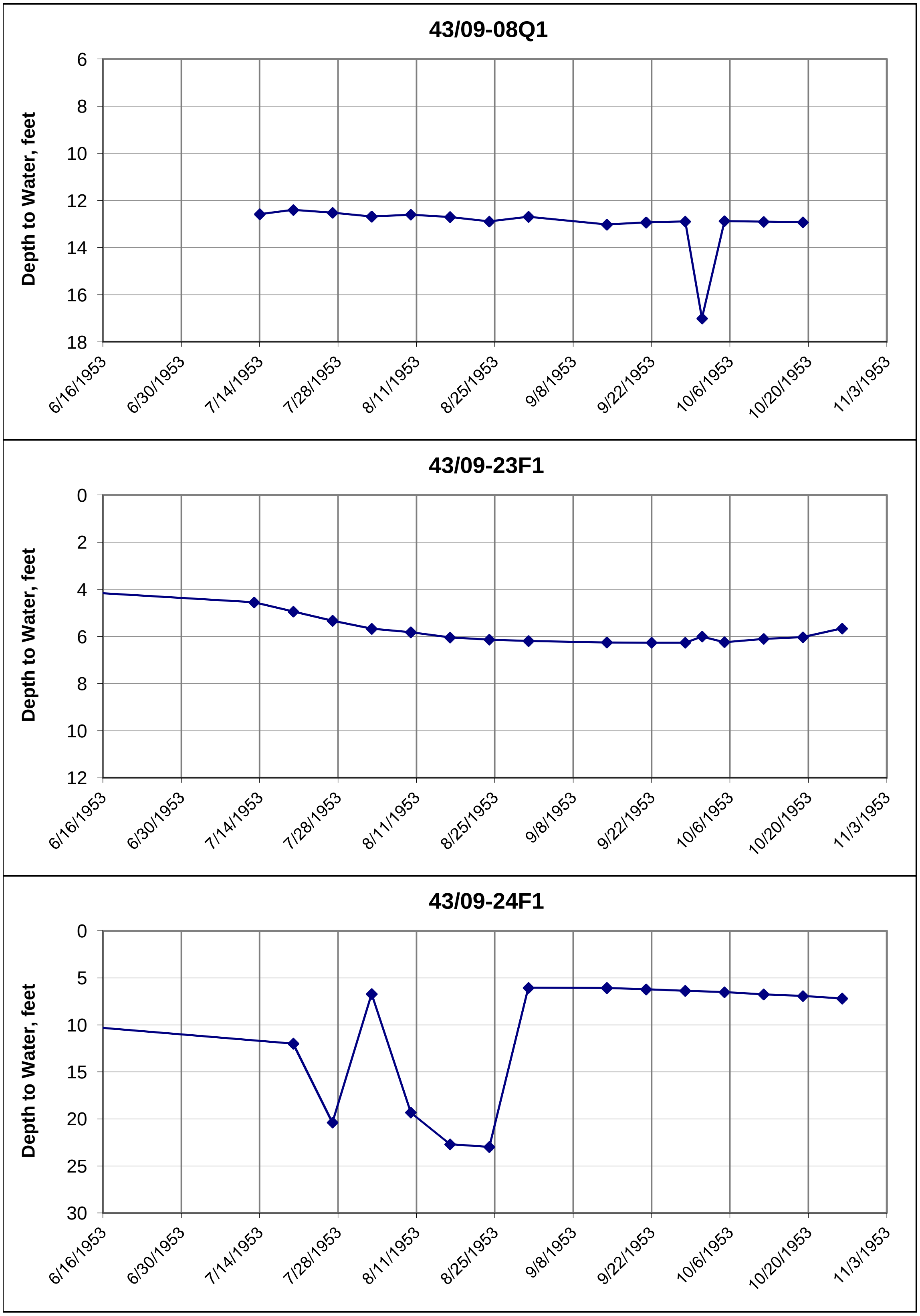
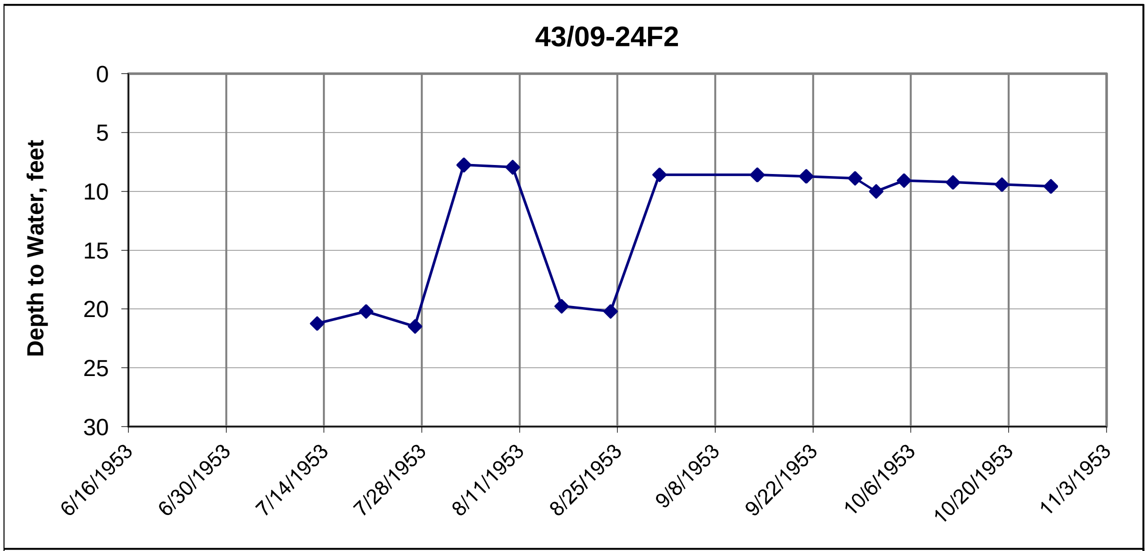
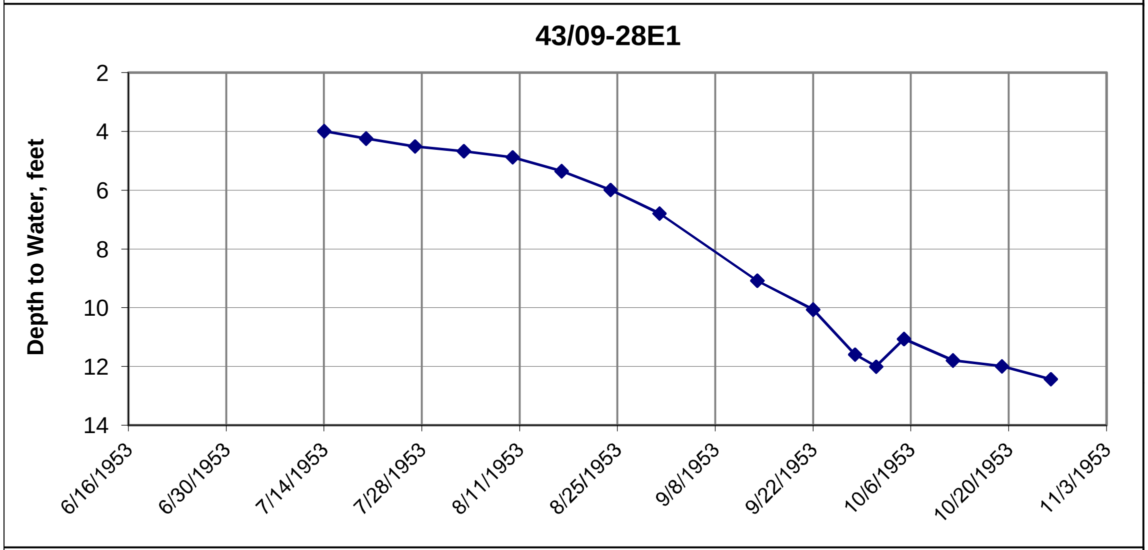


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records), continued





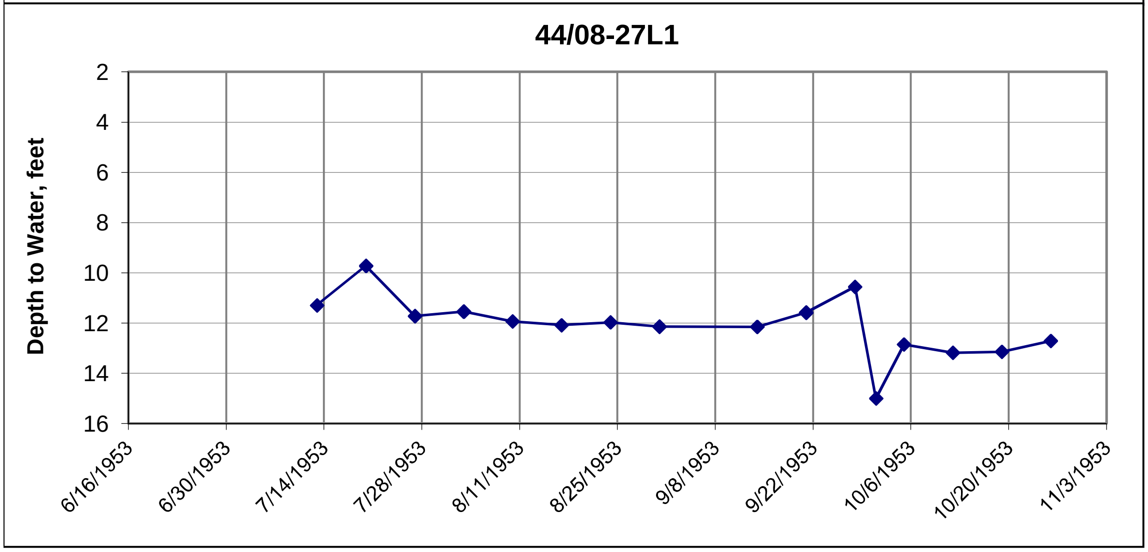


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records), continued

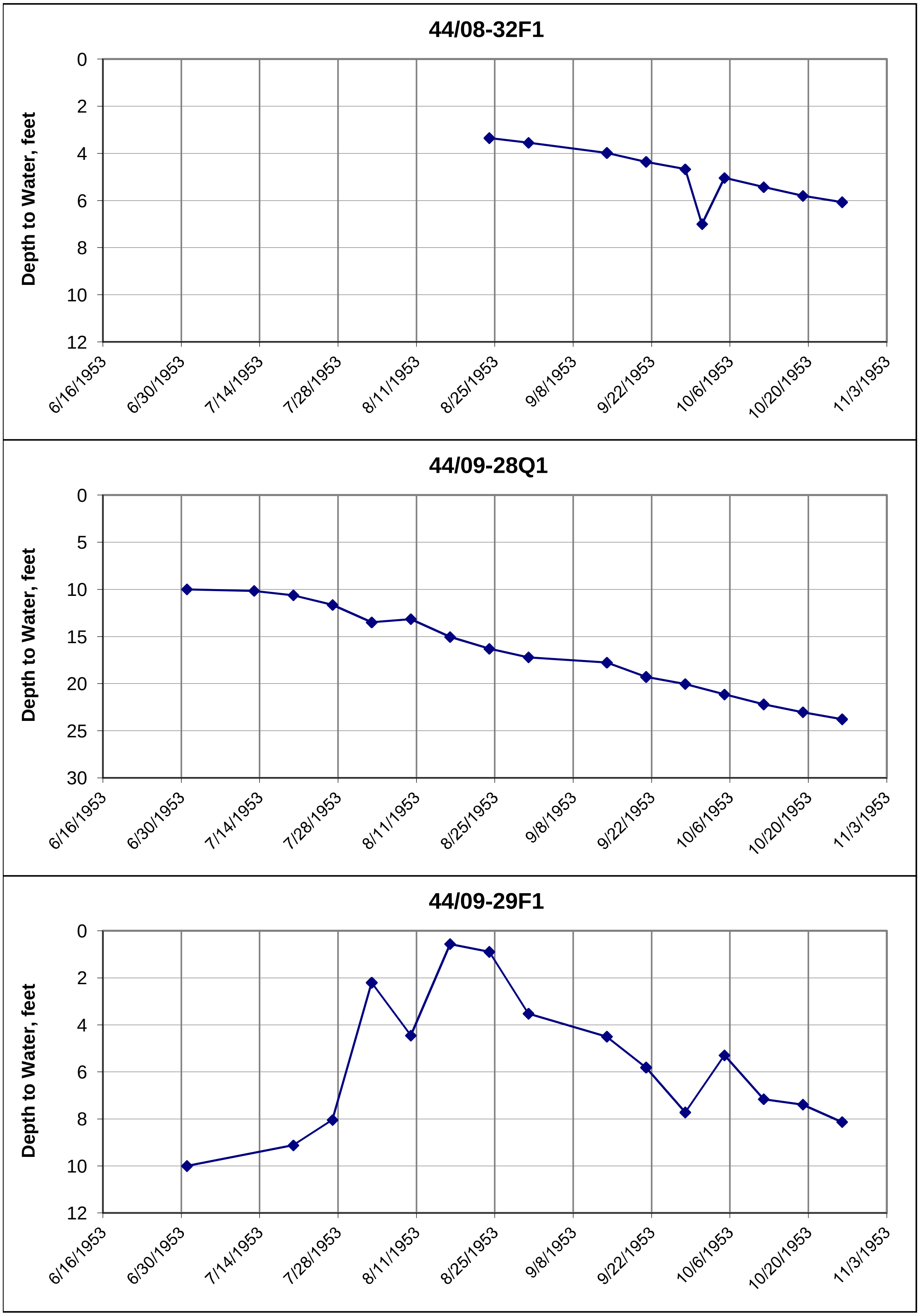


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records), continued

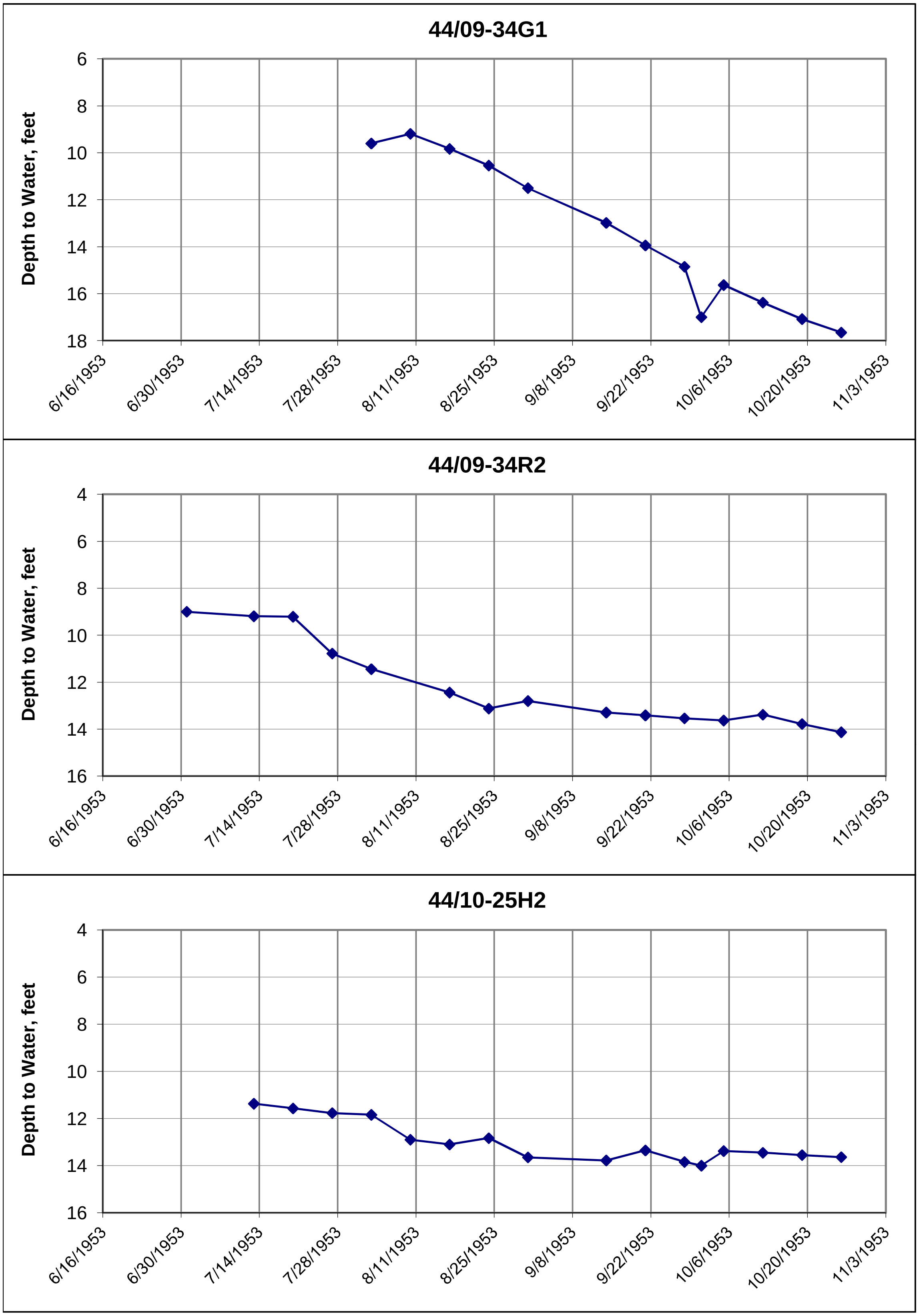


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records), continued

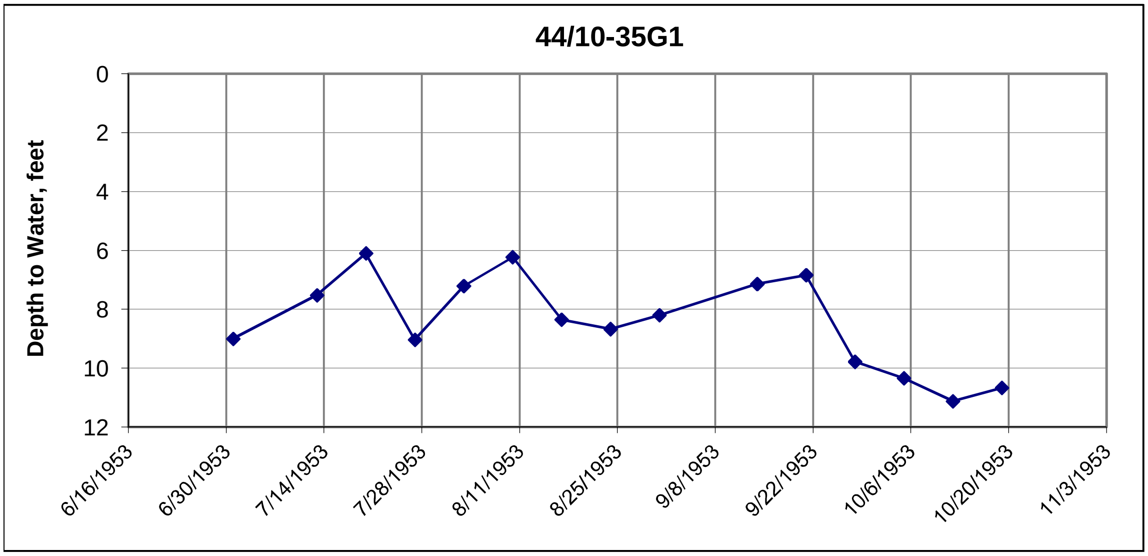


Figure A.2. Scott Valley Short-term Hydrographs (greater than 3 records), continued

Appendix B

Gaged Flow Summaries

Table B-1
Average Daily Flow, Scott River near Ft. Jones
USGS Station 11519500

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
1941	--	--	--	--	--	--	--	--	--	80	150	1,500	**--**	**--**
1942	1,156	1,480	609	785	1,275	1,058	294	90	68	67	616	1,429	**744**	**712**
1943	1,787	1,405	1,216	1,531	900	675	234	93	65	80	167	137	**691**	**835**
1944	161	248	401	390	636	332	115	75	49	46	153	233	**237**	**233**
1945	361	1,019	401	674	1,226	543	133	70	52	81	293	1,085	**495**	**409**
1946	1,254	588	794	1,100	1,359	669	189	94	64	69	329	292	**567**	**631**
1947	203	534	617	639	524	273	81	52	41	144	156	115	**282**	**305**
1948	1,238	366	314	695	1,201	1,235	222	88	76	90	140	296	**497**	**488**
1949	164	382	624	1,138	1,308	445	103	60	44	48	86	94	**375**	**400**
1950	521	634	1,132	1,119	1,131	667	145	71	53	706	1,036	2,048	**772**	**475**
1951	1,084	2,419	777	1,286	1,046	520	162	73	57	83	250	1,051	**734**	**935**
1952	726	2,118	1,219	2,217	2,270	1,580	521	167	104	88	99	394	**959**	**1,025**
1953	3,221	1,422	834	1,211	1,492	1,711	753	148	108	117	663	641	**1,027**	**957**
1954	1,141	1,716	1,493	1,614	1,333	590	184	97	89	91	220	225	**733**	**807**
1955	194	198	203	256	653	428	88	43	32	39	237	3,261	**469**	**219**
1956	3,120	1,509	1,485	1,761	1,880	1,202	318	103	80	144	276	362	**1,020**	**1,250**
1957	251	1,002	1,742	1,050	1,279	629	138	75	57	383	696	876	**681**	**584**
1958	1,570	4,793	1,515	1,565	2,426	1,483	407	133	97	100	183	174	**1,204**	**1,329**
1959	913	708	631	936	659	312	81	42	40	53	54	62	**374**	**398**
1960	97	953	937	818	841	682	103	61	48	59	224	486	**442**	**392**
1961	295	1,531	881	892	930	890	131	58	63	70	135	423	**525**	**536**
1962	279	711	541	1,136	793	486	128	64	56	941	756	1,747	**636**	**402**
1963	457	2,539	622	1,506	1,663	537	155	68	62	99	735	426	**739**	**921**
1964	810	651	493	567	650	574	123	59	49	54	129	5,003	**764**	**436**
1965	2,228	1,361	798	1,403	1,036	592	145	78	71	71	232	218	**686**	**1,075**
1966	758	383	796	1,460	1,152	458	101	48	47	61	374	803	**537**	**477**
1967	875	947	828	602	1,724	1,211	287	67	53	95	107	153	**579**	**653**
1968	497	2,056	954	574	556	295	64	44	43	51	210	463	**484**	**453**
1969	1,283	1,080	972	1,561	2,308	1,209	191	60	61	99	119	1,115	**838**	**787**
1970	4,186	1,460	1,061	584	920	596	108	51	48	64	1,016	1,295	**949**	**862**
1971	2,714	1,276	1,659	1,347	1,867	1,235	363	91	87	112	262	377	**949**	**1,084**
1972	1,405	1,024	2,825	945	971	728	136	63	69	84	126	571	**746**	**743**
1973	820	539	441	564	982	285	66	28	29	147	1,628	2,139	**639**	**378**
1974	4,417	1,264	2,128	2,174	1,854	1,595	381	113	70	74	121	196	**1,199**	**1,493**
1975	399	993	2,201	1,289	2,127	1,801	370	100	80	167	524	613	**889**	**813**
1976	380	430	605	607	945	322	90	73	62	79	87	84	**314**	**402**
1977	81	99	83	55	121	156	34	10	11	18	342	1,648	**221**	**75**
1978	1,814	1,302	1,272	1,017	936	727	264	65	139	94	103	148	**657**	**795**
1979	405	357	725	576	1,104	206	52	23	22	123	467	670	**394**	**318**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-1, Continued
Average Daily Flow, Scott River near Ft. Jones
USGS Station 11519500

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
1980	2,171	1,494	969	975	805	501	118	38	32	45	74	509	**644**	**697**
1981	440	986	539	488	398	135	23	7	8	21	1,077	3,246	**614**	**304**
1982	1,132	3,092	1,497	1,346	1,518	991	300	68	57	163	311	1,369	**987**	**1,195**
1983	1,359	2,226	2,747	1,703	2,379	1,720	769	269	228	195	960	2,086	**1,387**	**1,270**
1984	1,257	946	1,079	980	1,363	691	183	51	52	99	881	543	**677**	**820**
1985	331	549	439	1,138	655	374	67	31	39	66	100	188	**331**	**429**
1986	736	3,164	2,121	964	787	537	87	34	44	91	129	146	**737**	**736**
1987	257	559	861	843	681	152	40	13	14	20	38	750	**352**	**315**
1988	518	517	462	417	436	467	61	15	12	27	368	293	**300**	**310**
1989	308	323	1,695	1,477	917	367	74	21	32	140	137	159	**471**	**492**
1990	613	278	566	536	439	405	61	14	12	31	55	66	**256**	**280**
1991	120	233	381	296	473	256	41	13	11	18	43	140	**169**	**165**
1992	123	388	389	810	374	78	48	8	26	64	80	166	**213**	**204**
1993	515	647	1,931	1,252	1,938	1,365	219	57	48	61	76	154	**688**	**690**
1994	236	231	346	318	455	114	13	6	5	10	11	53	**150**	**168**
1995	1,719	2,029	2,285	1,549	1,803	1,352	506	92	49	66	86	1,075	**1,051**	**955**
1996	1,293	2,725	1,449	1,498	1,547	588	145	32	28	58	1,150	2,832	**1,112**	**878**
1997	3,709	1,134	800	894	633	252	74	28	37	82	178	235	**671**	**967**
1998	1,520	1,668	2,566	1,412	1,728	1,794	663	119	68	105	639	881	**1,097**	**1,003**
1999	1,120	1,610	1,552	1,295	1,664	1,244	243	71	58	71	180	237	**779**	**874**
2000	913	1,100	1,166	1,423	1,124	633	127	19	24	49	81	98	**563**	**585**
2001	99	127	386	276	401	50	8	6	4	4	60	384	**150**	**132**
2002	1,077	644	570	1,018	707	395	64	15	12	17	81	1,165	**480**	**412**
2003	2,051	1,106	1,200	1,199	1,502	1,047	181	88	49	67	111	379	**748**	**807**
2004	546	1,082	1,185	1,050	969	412	73	13	14	48	92	559	**504**	**492**
2005	554	492	549	649	1,453	656	134	22	16	35	224	2,965	**646**	**435**
2006	3,236	2,343	1,101	1,360	2,344	1,155	193	52	47	64	252	937	**1,090**	**1,255**
2007	696	524	1,074	634	539	142	38	8	7	104	113	270	**346**	**410**
2008	382	497	749	657	1,459	568	101	23	17	37	140	129	**396**	**411**
2009	235	287	613	497	929	309	36	11	7	18	48	74	**255**	**269**
2010	498	437	529	863	1,123	1,617	292	40	36	126	352	1,040	**580**	**465**
2011	1,017	540	696	--	--	--	--	--	--	--	--	--	**--**	**--**
Period of Record Average	**1,058**	**1,107**	**1,019**	**1,007**	**1,154**	**715**	**180**	**59**	**50**	**101**	**309**	**800**	**630**	**631**
Average, 1971-2000	**1,094**	**1,106**	**1,259**	**1,006**	**1,101**	**702**	**187**	**52**	**48**	**79**	**344**	**722**	**642**	**648**
Average, 1990-2010	**1,012**	**932**	**1,018**	**928**	**1,124**	**687**	**155**	**35**	**27**	**54**	**193**	**659**	**569**	**565**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-2
Average Daily Flow, Shackleford Creek near Mugginsville
CA DWR Station F25484

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
2004	--	--	--	--	--	--	--	--	--	4	8	54	**--**	**--**
2005	50	62	80	122	166	62	10	4	1	2	42	65	**55**	**52**
2006	--	--	--	--	--	103	18	7	4	4	39	108	**--**	**--**
2007	106	73	153	91	78	28	7	3	1	11	23	47	**52**	**58**
2008	53	54	107	105	180	91	16	1	1	3	24	25	**55**	**57**
2009	45	41	82	72	105	36	4	2	2	1	4	16	**34**	**37**
2010	85	73	72	95	111	106	25	4	3	--	--	--	**--**	**50**
Period of Record Average	**68**	**60**	**99**	**97**	**128**	**71**	**13**	**3**	**2**	**4**	**23**	**52**	**49**	**51**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-3
Average Daily Flow, Mill Creek near Mugginsville
CA DWR Station F25480

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
2004	--	--	--	--	--	--	--	--	--	--	3	12	--	--
2005	11	17	22	30	44	17	7	5	5	--	--	--	--	--
Period of Record Average	**11**	**17**	**22**	**30**	**44**	**17**	**7**	**5**	**5**	--	**3**	**12**	--	--

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-4
Average Daily Flow, Moffett Creek near Ft. Jones
USGS Station 11518600

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
1958	--	--	--	--	--	--	--	--	--	2	3	3	**--**	**--**
1959	7	13	14	7	4	1	1	0	1	1	2	2	**5**	**5**
1960	1	19	32	15	5	2	1	0	1	3	4	20	**9**	**7**
1961	9	46	30	20	10	4	2	1	1	1	2	4	**11**	**12**
1962	5	19	17	14	7	3	1	1	1	5	11	50	**11**	**6**
1963	12	84	19	50	39	17	6	2	1	2	5	5	**20**	**25**
1964	29	27	22	23	10	4	2	0	0	0	1	80	**17**	**11**
1965	142	70	29	40	24	8	4	2	2	1	2	2	**27**	**34**
1966	27	13	29	27	6	3	0	0	0	0	2	20	**11**	**9**
1967	36	46	43	40	44	17	5	1	1	--	--	--	**--**	**21**
Period of Record Average	**30**	**37**	**26**	**26**	**16**	**7**	**2**	**1**	**1**	**2**	**3**	**21**	**14**	**14**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-5
Average Daily Flow, French Creek at HWY 3 near Callahan
CA DWR Station F25650

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
2004	--	--	--	--	--	--	--	--	--	5	11	43	**--**	**--**
2005	29	27	25	23	86	36	6	0	0	3	41	98	**31**	**24**
2006	126	96	56	60	117	61	7	2	1	3	24	51	**50**	**56**
2007	55	36	68	47	51	16	3	2	2	16	19	26	**28**	**30**
2008	32	34	42	34	87	49	6	1	0	3	19	16	**27**	**29**
2009	28	22	34	35	86	24	1	0	1	--	--	--	**--**	**23**
Period of Record Average	**54**	**43**	**45**	**40**	**85**	**37**	**5**	**1**	**1**	**6**	**23**	**47**	**34**	**32**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-6
Average Daily Flow, Sugar Creek near Callahan
CA DWR Station F25890

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
2009	--	--	--	--	--	--	--	--	--	3	5	6	**--**	**--**
2010	19	10	15	24	36	52	18	2	2	--	--	--	**--**	**16**
Period of Record Average	**19**	**10**	**15**	**24**	**36**	**52**	**18**	**2**	**2**	**3**	**5**	**6**	**--**	**16**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-7
Average Daily Flow, South Scott River near Callahan
CA DWR Station F28100

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
2002	--	--	--	--	--	42	16	5	3	7	24	55	**--**	**--**
2003	139	110	129	159	186	196	53	26	14	--	--	--	**--**	**91**
2004	--	--	--	--	--	--	--	--	--	--	23	58	**--**	**--**
2005	66	60	77	103	260	161	43	9	4	--	--	--	**--**	**--**
2007	--	--	--	108	110	35	10	6	5	28	28	39	**--**	**--**
2008	41	37	70	121	289	172	22	7	4	13	50	24	**71**	**71**
2009	46	52	116	155	238	76	11	5	4	15	16	18	**63**	**66**
2010	52	39	64	114	240	--	54	13	7	--	--	--	**--**	**58**
Period of Record Average	**69**	**60**	**91**	**127**	**220**	**114**	**30**	**10**	**6**	**16**	**28**	**39**	**67**	**72**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-8
Average Daily Flow, East Fork Scott River near Callahan
CA DWR Station F26050

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
2002	--	--	--	--	--	24	10	4	3	5	15	64	**--**	**--**
2003	242	142	154	236	324	161	35	22	9	--	--	--	**--**	**118**
2004	--	--	--	--	--	--	--	--	--	--	22	73	**--**	**--**
2005	89	103	128	141	262	147	44	8	6	--	--	--	**--**	**--**
2006	--	--	--	--	--	--	--	--	--	10	19	55	**--**	**--**
2007	42	79	150	104	91	19	5	3	3	16	14	30	**46**	**48**
2008	53	69	99	123	219	80	13	5	4	8	42	15	**61**	**60**
2009	19	39	113	124	166	57	10	4	3	19	16	22	**49**	**50**
2010	97	119	156	200	283	307	89	13	8	--	--	--	**--**	**111**
Period of Record Average	**90**	**92**	**134**	**155**	**224**	**113**	**29**	**8**	**5**	**12**	**21**	**43**	**52**	**77**

Note: Values shown are average daily flows, cfs, over period indicated.

Table B-9
Average Daily Flow, Shackleford Creek near Mugginsville
USGS Station 11519000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Water Year Average
1956	--	--	--	--	--	--	--	--	--	19	37	44	**--**	**--**
1957	18	63	101	80	122	74	19	11	9	31	62	52	**53**	**50**
1958	60	159	58	85	187	161	50	15	11	7	35	23	**71**	**78**
1959	83	37	48	90	81	54	13	8	8	5	5	4	**36**	**41**
1960	6	38	75	81	116	115	20	13	7	--	--	--	**--**	**40**
Period of Record Average	**42**	**74**	**70**	**84**	**127**	**101**	**26**	**11**	**9**	**16**	**35**	**31**	**54**	**52**

Note: Values shown are average daily flows, cfs, over period indicated.

Appendix C

Monthly Agricultural Water Use, 2000, for DAU 003

Monthly Ag Water Use by DAU County

Crops

	Area (Acres)			Unit ETAW (ft)	ETAW (Acre-feet)			Consumed Fraction			Unit Applied Water (feet)			Applied Water (Acre-feet)			Unit ET (ft)	ET (Acre-feet)			Unit EP (ft)	EP (Acre-feet)		
	SW	GW	Total		SW	GW	Total	SW	GW	Tot	SW	GW	Tot	SW	GW	Total		SW	GW	Total		SW	GW	Total

2000 Water Year

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Alfalfa

Oct 99	1,420	11,191	12,611	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.1	179	1,408	1,587	0.1	179	1,408	1,587
Nov 99	1,420	11,191	12,611	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	1,420	11,191	12,611	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	1,420	11,191	12,611	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	1,420	11,191	12,611	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	1,420	11,191	12,611	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	1,420	11,191	12,611	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	1,420	11,191	12,611	0.1	173	1,362	1,535	0.73	0.78	0.77	0.2	0.2	0.2	237	1,746	1,983	0.4	620	4,887	5,507	0.3	447	3,525	3,972
Jun 00	1,420	11,191	12,611	0.6	789	6,220	7,009	0.73	0.78	0.77	0.8	0.7	0.7	1,081	7,975	9,056	0.6	827	6,519	7,346	0.0	38	299	337
Jul 00	1,420	11,191	12,611	0.6	811	6,388	7,199	0.73	0.78	0.77	0.8	0.7	0.7	1,110	8,190	9,300	0.6	859	6,771	7,630	0.0	48	383	431
Aug 00	1,420	11,191	12,611	0.6	812	6,398	7,210	0.73	0.78	0.77	0.8	0.7	0.7	1,112	8,202	9,314	0.6	812	6,398	7,210	0.0	0	0	0
Sep 00	1,420	11,191	12,611	0.4	553	4,356	4,909	0.73	0.78	0.77	0.5	0.5	0.5	757	5,584	6,341	0.4	553	4,356	4,909	0.0	0	0	0
Total	1,420	11,191	12,611	2.2	3,138	24,724	27,862	0.73	0.78	0.77	3.0	2.8	2.9	4,297	31,697	35,994	2.7	3,850	30,339	34,189	0.5	712	5,615	6,327

Alfalfa-X

Oct 99	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Nov 99	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	409	15	424	0.1	50	2	52	0.74	0.92	0.74	0.2	0.1	0.2	68	2	70	0.4	179	7	186	0.3	129	5	134
Jun 00	409	15	424	0.6	227	8	235	0.73	0.76	0.73	0.8	0.7	0.8	311	11	322	0.6	238	9	247	0.0	11	1	12
Jul 00	409	15	424	0.6	233	9	242	0.73	0.78	0.73	0.8	0.7	0.8	320	11	331	0.6	247	9	256	0.0	14	0	14
Aug 00	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Sep 00	409	15	424	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Total	409	15	424	1.2	510	19	529	0.73	0.78	0.73	1.7	1.6	1.7	699	24	723	1.6	664	25	689	0.4	154	6	160

Corn

Oct 99	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Nov 99	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	20	292	312	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	1	14	15	0.0	1	14	15
Jun 00	20	292	312	0.2	4	56	60	0.64	0.73	0.72	0.3	0.3	0.3	6	77	83	0.3	7	99	106	0.1	3	43	46
Jul 00	20	292	312	0.6	12	169	181	0.68	0.73	0.73	0.9	0.8	0.8	17	232	249	0.7	14	202	216	0.1	2	33	35

Monthly Ag Water Use by DAU County

Crops

2000 Water Year

003 - Siskiyou

Corn

	Area (Acres) SW	Area (Acres) GW	Area (Acres) Total	Unit ETAW (ft)	ETAW (Acre-feet) SW	ETAW (Acre-feet) GW	ETAW (Acre-feet) Total	Consumed Fraction SW	Consumed Fraction GW	Consumed Fraction Tot	Unit Applied Water (feet) SW	Unit Applied Water (feet) GW	Unit Applied Water (feet) Tot	Applied Water (Acre-feet) SW	Applied Water (Acre-feet) GW	Applied Water (Acre-feet) Total	Unit ET (ft)	ET (Acre-feet) SW	ET (Acre-feet) GW	ET (Acre-feet) Total	Unit EP (ft)	EP (Acre-feet) SW	EP (Acre-feet) GW	EP (Acre-feet) Total
Aug 00	20	292	312	0.6	12	172	184	0.69	0.73	0.73	0.9	0.8	0.8	17	236	253	0.7	14	202	216	0.1	2	30	32
Sep 00	20	292	312	0.1	1	21	22	0.71	0.71	0.71	0.1	0.1	0.1	2	29	31	0.2	3	49	52	0.1	2	28	30
Total	20	292	312	1.4	29	418	447	0.68	0.73	0.73	2.1	2.0	2.0	42	574	616	1.9	39	566	605	0.5	10	148	158

Grain

	Area (Acres) SW	Area (Acres) GW	Area (Acres) Total	Unit ETAW (ft)	ETAW (Acre-feet) SW	ETAW (Acre-feet) GW	ETAW (Acre-feet) Total	Consumed Fraction SW	Consumed Fraction GW	Consumed Fraction Tot	Unit Applied Water (feet) SW	Unit Applied Water (feet) GW	Unit Applied Water (feet) Tot	Applied Water (Acre-feet) SW	Applied Water (Acre-feet) GW	Applied Water (Acre-feet) Total	Unit ET (ft)	ET (Acre-feet) SW	ET (Acre-feet) GW	ET (Acre-feet) Total	Unit EP (ft)	EP (Acre-feet) SW	EP (Acre-feet) GW	EP (Acre-feet) Total
Oct 99	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Nov 99	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	163	1,807	1,970	0.1	11	119	130	0.72	0.78	0.77	0.1	0.1	0.1	15	153	168	0.1	24	270	294	0.1	13	151	164
Jun 00	163	1,807	1,970	0.4	59	654	713	0.70	0.78	0.77	0.5	0.5	0.5	84	838	922	0.5	82	914	996	0.1	23	260	283
Jul 00	163	1,807	1,970	0.6	97	1,077	1,174	0.70	0.78	0.77	0.9	0.8	0.8	139	1,380	1,519	0.7	115	1,280	1,395	0.1	18	203	221
Aug 00	163	1,807	1,970	0.2	28	309	337	0.70	0.78	0.77	0.2	0.2	0.2	40	396	436	0.4	61	679	740	0.2	33	370	403
Sep 00	163	1,807	1,970	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Total	163	1,807	1,970	1.2	195	2,159	2,354	0.70	0.78	0.77	1.7	1.5	1.5	278	2,767	3,045	1.7	282	3,143	3,425	0.5	87	984	1,071

Meadow Pasture

	Area (Acres) SW	Area (Acres) GW	Area (Acres) Total	Unit ETAW (ft)	ETAW (Acre-feet) SW	ETAW (Acre-feet) GW	ETAW (Acre-feet) Total	Consumed Fraction SW	Consumed Fraction GW	Consumed Fraction Tot	Unit Applied Water (feet) SW	Unit Applied Water (feet) GW	Unit Applied Water (feet) Tot	Applied Water (Acre-feet) SW	Applied Water (Acre-feet) GW	Applied Water (Acre-feet) Total	Unit ET (ft)	ET (Acre-feet) SW	ET (Acre-feet) GW	ET (Acre-feet) Total	Unit EP (ft)	EP (Acre-feet) SW	EP (Acre-feet) GW	EP (Acre-feet) Total
Oct 99	7,964	0	7,964	0.0	193	0	193	0.63	0.00	0.63	0.0	0.0	0.0	306	0	306	0.1	843	0	843	0.1	650	0	650
Nov 99	7,964	0	7,964	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	7,964	0	7,964	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	7,964	0	7,964	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	7,964	0	7,964	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	7,964	0	7,964	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	7,964	0	7,964	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.2	1,931	0	1,931	0.2	1,931	0	1,931
May 00	7,964	0	7,964	0.2	1,958	0	1,958	0.63	0.00	0.63	0.4	0.0	0.4	3,108	0	3,108	0.4	2,854	0	2,854	0.1	896	0	896
Jun 00	7,964	0	7,964	0.5	4,101	0	4,101	0.63	0.00	0.63	0.8	0.0	0.8	6,511	0	6,511	0.5	4,261	0	4,261	0.0	160	0	160
Jul 00	7,964	0	7,964	0.5	4,354	0	4,354	0.63	0.00	0.63	0.9	0.0	0.9	6,911	0	6,911	0.6	4,566	0	4,566	0.0	212	0	212
Aug 00	7,964	0	7,964	0.5	4,314	0	4,314	0.63	0.00	0.63	0.9	0.0	0.9	6,847	0	6,847	0.5	4,314	0	4,314	0.0	0	0	0
Sep 00	7,964	0	7,964	0.4	2,814	0	2,814	0.63	0.00	0.63	0.6	0.0	0.6	4,466	0	4,466	0.4	2,814	0	2,814	0.0	0	0	0
Total	7,964	0	7,964	2.2	17,734	0	17,734	0.63	0.00	0.63	3.5	0.0	3.5	28,149	0	28,149	2.7	21,583	0	21,583	0.5	3,849	0	3,849

Meadow Pasture-X

	Area (Acres) SW	Area (Acres) GW	Area (Acres) Total	Unit ETAW (ft)	ETAW (Acre-feet) SW	ETAW (Acre-feet) GW	ETAW (Acre-feet) Total	Consumed Fraction SW	Consumed Fraction GW	Consumed Fraction Tot	Unit Applied Water (feet) SW	Unit Applied Water (feet) GW	Unit Applied Water (feet) Tot	Applied Water (Acre-feet) SW	Applied Water (Acre-feet) GW	Applied Water (Acre-feet) Total	Unit ET (ft)	ET (Acre-feet) SW	ET (Acre-feet) GW	ET (Acre-feet) Total	Unit EP (ft)	EP (Acre-feet) SW	EP (Acre-feet) GW	EP (Acre-feet) Total
Oct 99	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Nov 99	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0

Monthly Ag Water Use by DAU County

Crops

	Area (Acres)			Unit ETAW (ft)	ETAW (Acre-feet)			Consumed Fraction			Unit Applied Water (feet)			Applied Water (Acre-feet)			Unit ET (ft)	ET (Acre-feet)			Unit EP (ft)	EP (Acre-feet)		
	SW	GW	Total		SW	GW	Total	SW	GW	Tot	SW	GW	Tot	SW	GW	Total		SW	GW	Total		SW	GW	Total
2000 Water Year																								
003 - Siskiyou																								
Meadow Pasture-X																								
Feb 00	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.2	400	0	400	0.2	400	0	400
May 00	1,651	0	1,651	0.2	406	0	406	0.63	0.00	0.63	0.4	0.0	0.4	644	0	644	0.4	592	0	592	0.1	186	0	186
Jun 00	1,651	0	1,651	0.5	850	0	850	0.63	0.00	0.63	0.8	0.0	0.8	1,350	0	1,350	0.5	883	0	883	0.0	33	0	33
Jul 00	1,651	0	1,651	0.2	384	0	384	0.63	0.00	0.63	0.4	0.0	0.4	609	0	609	0.3	479	0	479	0.1	95	0	95
Aug 00	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Sep 00	1,651	0	1,651	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Total	1,651	0	1,651	1.0	1,640	0	1,640	0.63	0.00	0.63	1.6	0.0	1.6	2,603	0	2,603	1.4	2,354	0	2,354	0.4	714	0	714
Other Field																								
Oct 99	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Nov 99	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	0	46	46	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	2	2	0.0	0	2	2
Jun 00	0	46	46	0.2	0	7	7	0.00	0.78	0.78	0.0	0.2	0.2	0	9	9	0.3	0	13	13	0.1	0	6	6
Jul 00	0	46	46	0.4	0	20	20	0.00	0.71	0.71	0.0	0.6	0.6	0	28	28	0.6	0	26	26	0.1	0	6	6
Aug 00	0	46	46	0.7	0	30	30	0.00	0.73	0.73	0.0	0.9	0.9	0	41	41	0.7	0	30	30	0.0	0	0	0
Sep 00	0	46	46	0.2	0	7	7	0.00	0.70	0.70	0.0	0.2	0.2	0	10	10	0.3	0	16	16	0.2	0	9	9
Total	0	46	46	1.4	0	64	64	0.00	0.73	0.73	0.0	1.9	1.9	0	88	88	1.9	0	87	87	0.5	0	23	23
Other Truck																								
Oct 99	0	19	19	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Nov 99	0	19	19	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	0	19	19	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	0	19	19	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	0	19	19	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	0	19	19	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	0	19	19	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	0	19	19	0.1	0	1	1	0.00	1.00	1.00	0.0	0.1	0.1	0	1	1	0.1	0	1	1	0.0	0	0	0
Jun 00	0	19	19	0.2	0	4	4	0.00	0.67	0.67	0.0	0.3	0.3	0	6	6	0.3	0	6	6	0.1	0	2	2
Jul 00	0	19	19	0.5	0	9	9	0.00	0.69	0.69	0.0	0.7	0.7	0	13	13	0.6	0	11	11	0.1	0	2	2
Aug 00	0	19	19	0.6	0	11	11	0.00	0.73	0.73	0.0	0.8	0.8	0	15	15	0.6	0	11	11	0.0	0	0	0
Sep 00	0	19	19	0.1	0	2	2	0.00	0.67	0.67	0.0	0.2	0.2	0	3	3	0.3	0	6	6	0.2	0	4	4
Total	0	19	19	1.4	0	27	27	0.00	0.71	0.71	0.0	2.0	2.0	0	38	38	1.8	0	35	35	0.4	0	8	8

Monthly Ag Water Use by DAU County

Crops

	Area (Acres)			Unit ETAW (ft)	ETAW (Acre-feet)			Consumed Fraction			Unit Applied Water (feet)			Applied Water (Acre-feet)			Unit ET (ft)	ET (Acre-feet)			Unit EP (ft)	EP (Acre-feet)		
	SW	GW	Total		SW	GW	Total	SW	GW	Tot	SW	GW	Tot	SW	GW	Total		SW	GW	Total		SW	GW	Total
2000 Water Year																								
003 - Siskiyou																								
Pasture																								
Oct 99	4,334	1,668	6,002	0.0	58	22	80	0.69	0.77	0.71	0.0	0.0	0.0	84	29	113	0.1	545	210	755	0.1	487	188	675
Nov 99	4,334	1,668	6,002	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	4,334	1,668	6,002	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	4,334	1,668	6,002	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	4,334	1,668	6,002	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	4,334	1,668	6,002	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	4,334	1,668	6,002	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	4,334	1,668	6,002	0.3	1,141	439	1,580	0.69	0.78	0.71	0.4	0.3	0.4	1,654	563	2,217	0.4	1,943	748	2,691	0.2	802	309	1,111
Jun 00	4,334	1,668	6,002	0.6	2,478	954	3,432	0.69	0.78	0.71	0.8	0.7	0.8	3,591	1,222	4,813	0.6	2,593	998	3,591	0.0	115	44	159
Jul 00	4,334	1,668	6,002	0.6	2,543	979	3,522	0.69	0.78	0.71	0.9	0.8	0.8	3,685	1,255	4,940	0.6	2,691	1,035	3,726	0.0	148	56	204
Aug 00	4,334	1,668	6,002	0.6	2,543	979	3,522	0.69	0.78	0.71	0.9	0.8	0.8	3,685	1,255	4,940	0.6	2,543	979	3,522	0.0	0	0	0
Sep 00	4,334	1,668	6,002	0.4	1,734	667	2,401	0.69	0.78	0.71	0.6	0.5	0.6	2,512	855	3,367	0.4	1,734	667	2,401	0.0	0	0	0
Total	4,334	1,668	6,002	2.4	10,497	4,040	14,537	0.69	0.78	0.71	3.5	3.1	3.4	15,211	5,179	20,390	2.8	12,049	4,637	16,686	0.4	1,552	597	2,149
Pasture-X																								
Oct 99	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Nov 99	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Dec 99	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Jan 00	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Feb 00	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Mar 00	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Apr 00	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
May 00	626	210	836	0.3	165	55	220	0.68	0.78	0.70	0.4	0.3	0.4	242	71	313	0.4	281	94	375	0.2	116	39	155
Jun 00	626	210	836	0.6	358	120	478	0.68	0.78	0.70	0.8	0.7	0.8	526	154	680	0.6	375	126	501	0.0	17	6	23
Jul 00	626	210	836	0.2	151	51	202	0.68	0.78	0.70	0.4	0.3	0.3	222	65	287	0.3	194	65	259	0.1	43	14	57
Aug 00	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Sep 00	626	210	836	0.0	0	0	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0
Total	626	210	836	1.1	674	226	900	0.68	0.78	0.70	1.6	1.4	1.5	990	290	1,280	1.4	850	285	1,135	0.3	176	59	235
003 - Siskiyou Total	16,587	15,248	31,835	2.1	34,417	31,677	66,094	0.66	0.78	0.71	3.2	2.7	2.9	52,269	40,657	92,926	2.5	41,671	39,117	80,788	0.5	7,254	7,440	14,694
	0	0	0	Double Crop Acreage																				
	16,587	15,248	31,835	Irrig. Land Area																				
2000 Total	16,587	15,248	31,835	2.1	34,417	31,677	66,094	0.66	0.78	0.71	3.2	2.7	2.9	52,269	40,657	92,926	2.5	41,671	39,117	80,788	0.5	7,254	7,440	14,694
	0	0	0	Double Crop Acreage																				
	16,587	15,248	31,835	Irrig. Land Area																				

Appendix D

Mountain-Front Recharge

Appendix D
Mountain-Front Recharge

SUMMARY

Mountain-front recharge for the Scott River Valley groundwater model is estimated through examination of available water in the bordering mountains and hills, and surface water runoff to the valley, in a water balance approach. Available water is calculated as the difference between average monthly precipitation and monthly evapotranspiration over the mountainous area adjacent to the valley. The method allows for carryover of a portion of unused available water during spring and early summer months, representing available water storage in snowpack. Available water is allocated between surface water run-off and mountain-front recharge at the valley margin.

The procedure is initiated with the delineation of watersheds contributing to surface and subsurface inflow to the valley (Figure D-1). For each watershed, precipitation and potential evapotranspiration are computed over PRISM grid cells (Prism Climate Group, www.prism.oregonsate.edu), with dimensions of approximately 600 meters on a side (at the latitude of the Scott River Valley). Precipitation and climatologic input are based on monthly averages from the period 1971 to 2000, as computed and distributed by the Prism Climate Group. Available water is computed using climatologic as well as physical data including slope, aspect, elevation for each PRISM grid cell, and solar radiation. Available water is that portion of water not consumed by evaporation or evapotranspiration in the mountainous area and that comprises natural basin inflow, including channel and overland flow, and subsurface mountain-front recharge.

Average annual available water for watersheds bordering the groundwater model boundary is estimated to be 266,291 acre-feet per year, distributed among the component watersheds as shown in Table D-1. Assuming that on average, 85% of this amount comprises run-off, the remainder, approximately 40,000 acre-feet per year, constitutes subsurface or mountain-front recharge. The distribution of available water between run-off and subsurface recharge will vary among watersheds; a range of values is shown on Table D-2 using alternate distributions between run-off and subsurface recharge ranging from 95% / 5% to 75% / 25%. The suitability of values within the range is examined in model calibration.

METHOD DETAIL

Available Water

For each of the watersheds sharing boundaries with the groundwater model, available water is calculated. Additional watersheds contributing surface water flow to the Scott River are also included in the analysis for general reference. The watersheds are shown on Figure D-1. Climatologic inputs for the watersheds are based on PRISM grid cell data.

Average annual available water is calculated using a methodology based on Sankarasubramanian and Vogel (2002), Fernandez et al. (2000), and communication with Dr. Vogel of Tufts

University. These papers developed methods for watershed-scale calibration of a watershed model based on a water-balance calculation. The principal equation solved for is:

$$Q = P - \Delta S - ET$$

Where:

- Q = average annual available water (acre-feet/year)
- P = average annual precipitation (acre-feet/year)
- ΔS = average annual change in storage (acre-feet/year)
- ET = average annual evapotranspiration (acre-feet/year)

Changes in storage are assumed to be negligible, leaving us to solve:

$$Q = P - ET$$

This can be rewritten as:

$$Q = P - P \times \left(\frac{ET}{P}\right)$$

Where ET/P is the Evaporation Ratio, the ratio of evapotranspiration (ET) to precipitation. The advantage of reframing the equation using the Evaporation Ratio is that extensive work has been conducted on empirical relationships between the Evaporation Ratio and the Aridity Index (PET/P), as relationships of this type provide approximations to ET from measurements of rainfall and potential ET (PET). In this work, the Evaporation Ratio is calculated using the following empirical equation from Sankarasubramanian and Vogel (2002), which takes into account soil moisture storage and therefore provides a better fit than earlier empirical relationships:

$$\frac{ET}{P} = \frac{1}{2}\left\{1 + \gamma(1 - R) - \left[1 - 2\gamma(1 - R) + \gamma^2(1 - 2R + R^2)\right]^{1/2}\right\}$$

where:

- $R = e^{(-\Phi/\gamma)}$
- Φ = PET/P, the aridity index; the ratio of potential evapotranspiration to precipitation
- γ = b/P, a soil moisture storage index
- b = model parameter; b= $\max(ET_t + S_t)$
- S_t = soil moisture holding capacity of the basin in units of length, which could be thought of as a depth

The value of b used in the soil moisture storage index is estimated using a physically based approach using the observed precipitation, potential ET, and maximum soil moisture holding capacity of the basin. In their model calibration, Sankarasubramanian and Vogel use the maximum value of b, the sum of the maximum actual ET and the maximum soil moisture holding capacity. The maximum soil moisture holding capacity, $\max(S_t)$, is obtained from

Dunne and Willmott, 1996. The maximum ET, $max(ET_t)$, is precipitation, if precipitation is less than potential ET, or potential ET.

This equation is applied by first calculating potential ET (PET) using gridded maximum and minimum monthly temperature data for the 1971-2000 period obtained from the PRISM Group, Oregon State University (www.prism.oregonstate.edu). These data were used in conjunction with a digital elevation model and monthly average percent possible sunshine data (for Red Bluff, California; obtained from the Western Regional Climate Center, http://www.wrcc.dri.edu/htmlfiles/westcomp.sun.html) to calculate potential ET via the Jensen-Haise method (Jensen, 1973) using code adapted from Deep Percolation Model (Bauer and Vaccaro, 1987).

The Jensen-Haise method is an empirical equation for potential evapotranspiration (PET). The Jensen-Haise method was selected over other methodologies for two reasons: it requires only temperature and incident solar radiation data, both readily available for the region[1], and it is particularly suitable to arid and semi-arid climates. The Jensen-Haise PET is computed as a function of average daily temperature, daily incident solar radiation, and elevation:

$$\text{PET} = \frac{R_I T_x}{C_L + 13 * C_H}$$

where

R_I = incident solar radiation
$T_x = [T = 2.5 + 0.14(E_2 - E_1) + A/550]$
$C_L = (38 - 2A/305)$
$C_H = 50/(E_2 - E_1)$
T = mean air temperature in degrees C
A = land surface altitude in meters
E_1 and E_2 = saturation vapor pressure at the long-term mean minimum and maximum temperatures for the warmest month of the year, in millibars

In application, the monthly reference percent possible sunshine for the area (Red Bluff, California) is varied for slope and aspect to provide R_I for each grid cell. In mountainous areas, this type of adjustment is critical, given that south facing slope are often bare in mid-winter while north-facing slopes are fully snow-burdened.

Potential ET was calculated for the PRISM grid. The mean slope, aspect and elevation values of the cell centroids within the PRISM cells were used to represent the entire cell area. Gridded PRISM monthly precipitation data for the 1971 to 2000 period were then used, in conjunction with the calculated values of potential ET, to calculate available water using the Sankarasubramanian and Vogel (2002) empirical equation given above. This methodology results in available water, Q, remaining after ET is removed, where ET losses are somewhat less than potential ET.

[1] One of the principal strengths of the Jensen-Haise equation is its limited data requirements. The Penman-Monteith approach, a well known and regularly used approach to calculating evapotranspiration, requires specific humidity data. Though this data is readily available in many agricultural settings, it is generally unavailable over diverse topographic areas such as mountainous regions.

Computed monthly available water was adjusted to allow for evapotranspiration of available water stored in the snowpack from previous months, in addition to allowing for evapotranspiration of precipitation that accumulated during a given month. Adjustment factors reflecting monthly carryover storage of available water due to snow accumulation were identified using basin-wide water budget constraints, with annual outflow at the Scott River near Ft. Jones gage, plus upland and valley-wide water depletion, providing a limit on total annual available water. The adjustment factors allowed a percentage of unused available water from winter months to be accumulated and later used to satisfy upland evapotranspiration demand in late spring and early summer months in which precipitation was insufficient to meet demand, while maintaining consistency with the annual basin-wide water budget.

Allocation of Available Water between Run-Off and Mountain-Front Recharge

Available water represents that portion of precipitation remaining after watershed demand is satisfied; or, the sum of run-off and mountain front recharge. The allocation of available water between run-off and mountain front recharge is a function of watershed characteristics, the timing and quantity of precipitation and other factors. Where available, gaged streamflow data can be used in estimating mountain front recharge as the difference between available water and run-off. For the Scott Valley, records of tributary inflow for upland watersheds are typically limited to a period of a few years (Appendix B), and, detailed upstream diversion, water use and return flow records are not readily available; nevertheless, the existing records provide some insight. Records for French Creek and the South Fork of the Scott River, suggest that gaged run-off accounts for approximately 85 to more than 90 percent of available water. The network of diversions and ditches within the French Creek Basin adds complexity to the analysis that goes beyond the scope of this assessment; however, the occurrence of consumptive use within the basin supported by irrigation practices, beyond that accounted for in the PRISM analysis, argues for reducing the estimate of mountain-front recharge obtained using the PRISM-based available water and gaged record. Records for Shackleford Creek suggest that only minimal opportunity for subsurface recharge is present in this watershed. Historic records for Moffett Creek and more recent records for the East Fork of the Scott River were also examined, and it was noted that run-off represents a significantly lower percentage of available water than in the other watersheds examined. This difference might be associated with the size and complexity of these watersheds which may support higher levels of consumptive use.

Many of the sub-watersheds included in the analysis are not drained by perennial streams or are ungaged. In the case of ungaged watersheds with similar characteristics to that of French Creek or the South Fork, one may expect a similar allocation of run-off to subsurface recharge. Watersheds without significant streams may provide greater opportunity for subsurface recharge resulting in a higher percentage of available water being attributable to mountain front recharge. Table D-2 identifies a range of values for mountain-front recharge, assuming this quantity to be 5%, 15% and 25% of calculated available water.

Mountain-Front Recharge Input to the Scott Valley Groundwater Model

Table D-2 provides a starting point for assigning mountain-front recharge to the groundwater model based on the simplified watershed water balance analysis described above. An initial allocation of 15% of available water was taken as mountain-front recharge for each contributing watershed, amounting to total mountain-front recharge of 39,944 acre-feet. The recharge was assigned to the groundwater model for the winter/spring and early summer seasons during which mountain-front recharge is most likely to accrue to the valley margins. The initial values are adjusted in model calibration, considering localized aquifer conditions at and near the mountain-front for each watershed.

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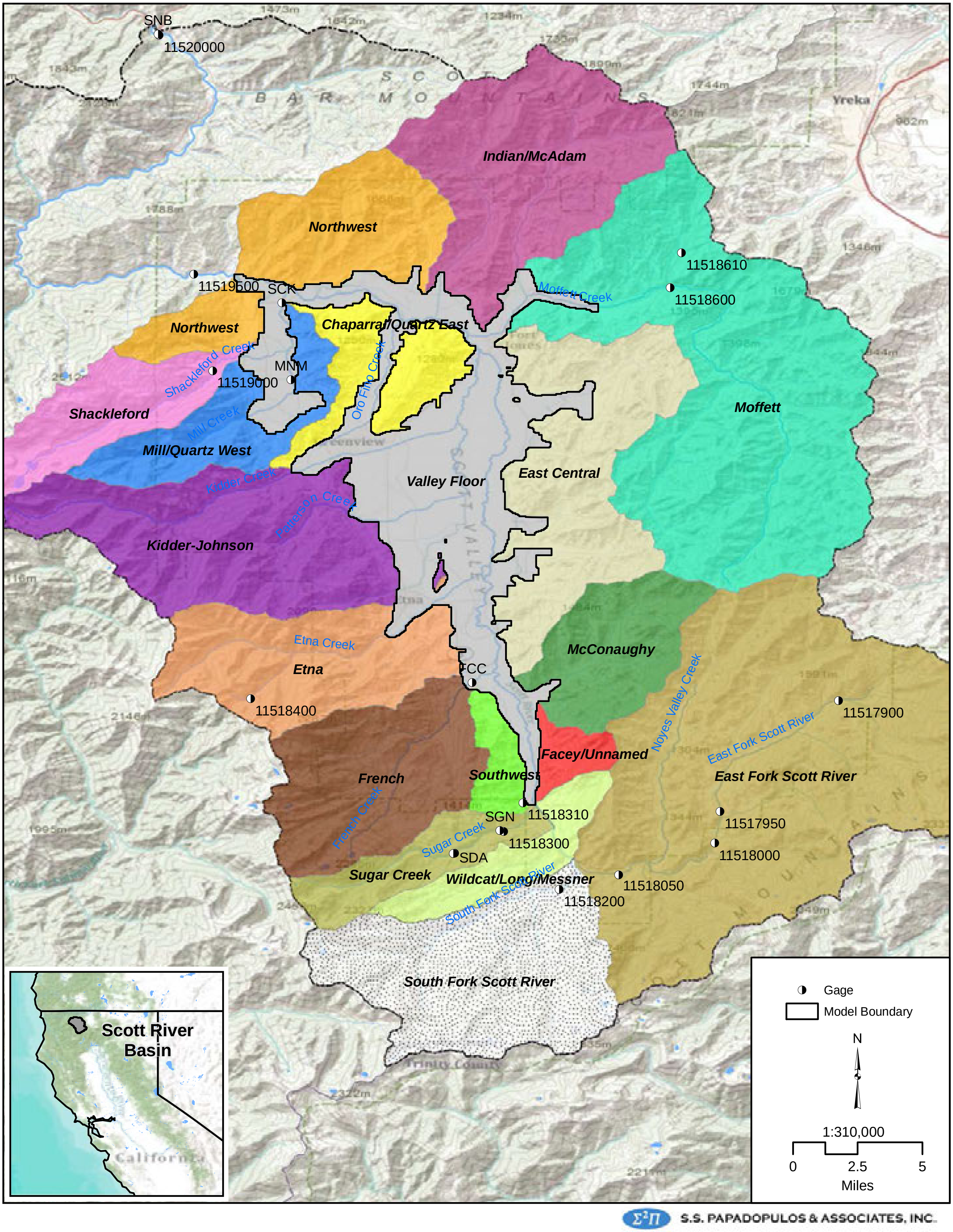


Figure D-1 Sub-basin Designations for Mountain-Front Recharge Estimation

Table D-1
Average Annual Watershed Water Budget, 1971-2000 Period

Watershed	Area of Contributing Watershed, acres	Potential ET, acre-feet	ET, acre-feet	Precipitation, acre-feet	Available Water, acre-feet
Watersheds Bounding Groundwater Model					
Facey/Unnamed	2,960	12,090	4,595	6,275	1,680
McConaughy	13,137	55,638	21,443	29,076	7,632
East Central	26,027	111,771	42,593	52,561	9,967
Moffett	59,675	240,817	94,739	153,139	58,399
Indian/McAdam	29,600	119,588	46,764	69,370	22,607
Northwest	20,172	87,545	33,578	44,102	10,523
Shackleford	12,374	41,779	16,767	42,561	25,794
Mill/Quartz West	11,201	43,509	16,522	27,855	11,333
Chaparral/Quartz East	9,432	41,809	15,731	18,478	2,746
Kidder-Johnson	29,883	111,041	43,659	99,314	55,655
Etna	19,925	74,480	29,392	61,784	32,392
French	21,097	80,035	30,850	57,494	26,644
Southwest	3,594	15,740	5,914	6,831	917
Subtotal	**259,079**	**1,035,841**	**402,548**	**668,838**	**266,291**
Watersheds Upstream of Groundwater Model					
South Fork Scott River	28,139	89,604	35,929	96,776	60,847
Sugar Creek	8,504	30,519	11,919	24,039	12,120
Wildcat/Long/Messner	7,554	30,451	11,586	16,262	4,675
East Fork Scott River	73,844	272,352	109,210	269,396	160,186
Subtotal	**118,042**	**422,926**	**168,644**	**406,472**	**237,829**

Table D-2
Mountain-Front Recharge

Watershed	Available Water, acre-feet	Mountain-Front Recharge as Percent of Available Water, acre-feet		
		5%	15%	25%
Facey/Unnamed	1,680	84	252	420
McConaughy	7,632	382	1,145	1,908
East Central	9,967	498	1,495	2,492
Moffett	58,399	2,920	8,760	14,600
Indian/McAdam	22,607	1,130	3,391	5,652
Northwest	10,523	526	1,579	2,631
Shackleford	25,794	1,290	3,869	6,449
Mill/Quartz West	11,333	567	1,700	2,833
Chaparral/Quartz East	2,746	137	412	687
Kidder-Johnson	55,655	2,783	8,348	13,914
Etna	32,392	1,620	4,859	8,098
French	26,644	1,332	3,997	6,661
Southwest	917	46	138	229
Total	**266,291**	**13,315**	**39,944**	**66,573**

Exhibit H

Klamath River Project Adult Fish Counting Facility In-season Update

January 13, 2023

The California Department of Fish and Wildlife annually operates adult fish counting facilities on the Shasta River, Scott River and Bogus Creek. This in-season update provides preliminary 2022 returns of Fall-run Chinook Salmon and Coho Salmon to each counting facility. Preliminary in-season updates will be provided as data becomes available throughout the season. The Shasta River station was operational on September 2, 2022 and **4,612** adult Chinook Salmon and **48** adult Coho Salmon have been observed through December 30, 2022. The Bogus Creek station was operational on September 15, 2022 and **1,286** adult Chinook Salmon and **192** adult Coho Salmon have been observed through January 1, 2023. The Scott River station was operational on September 29, 2022 and **72** adult Chinook Salmon and **236** Coho Salmon have been observed through December 26, 2022. The Shasta River station is located roughly 600 feet from the confluence with the Klamath River and serves as a census for the entire Shasta River. The Scott River station is 18 miles upstream of the confluence with the Klamath River and the Bogus Creek station is 0.25 miles upstream of the confluence with the Klamath River. Depending on the year significant fractions of the adult salmonid populations in the Scott River and Bogus Creek spawn downstream of the counting stations. This in-season update doesn't report the spawning escapement that is observed downstream of these two stations. Final reports detailing the total escapement to each river will be available after the data is finalized. If you have questions regarding these in-season updates please contact Morgan Knechtle morgan.knechtle@wildlife.ca.gov or Domenic Giudice domenic.giudice@wildlife.ca.gov.

Scott River Fish Counting Facility

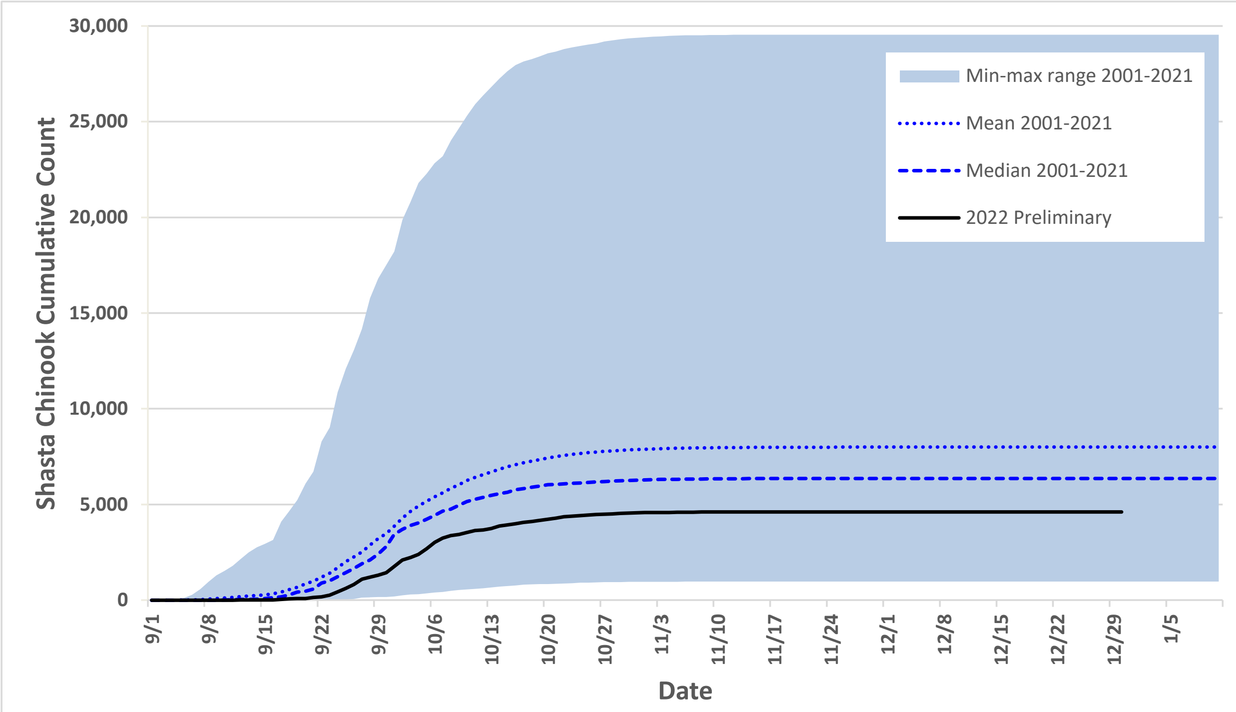


Figure 1. 2022-2023 in-season preliminary Chinook Salmon observations at the Shasta River adult fish counting facility compared with 2001-2021 (**4,612** adult Chinook Salmon have been observed through December 30, 2022).

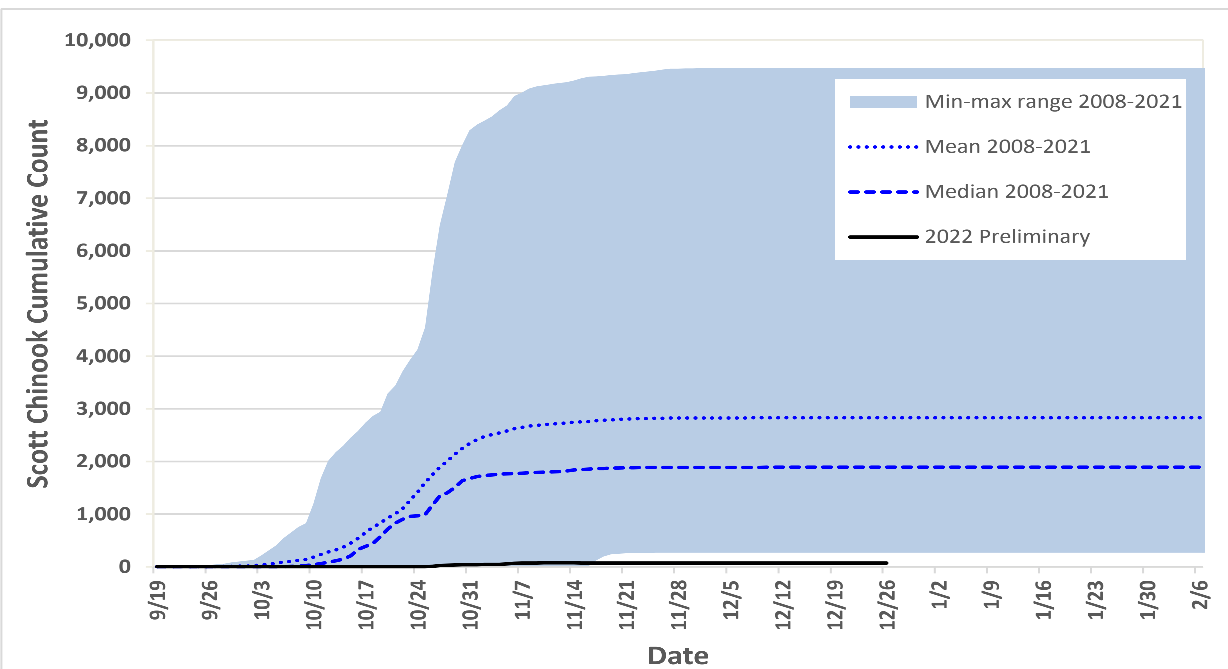


Figure 2. 2022-2023 in-season preliminary Chinook Salmon observations at the Scott River adult fish counting facility compared with 2008-2021 (**72** adult Chinook Salmon have been observed through December 26, 2022).

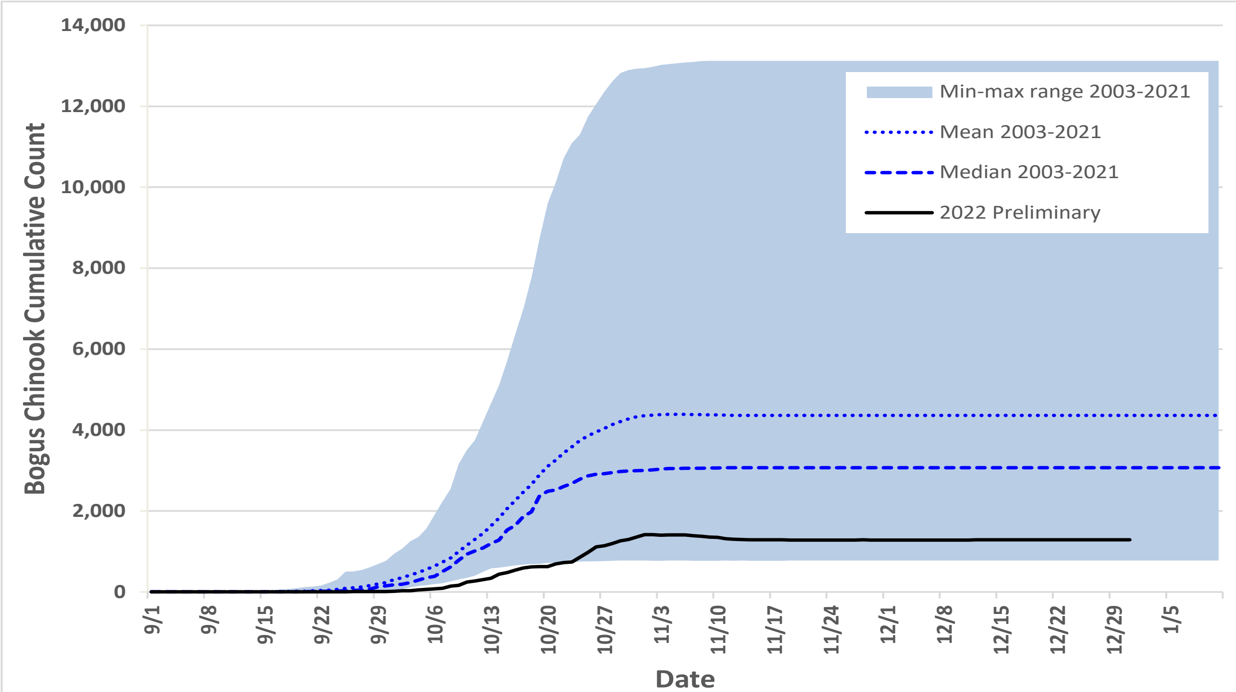


Figure 3. 2022-2023 in-season preliminary Chinook Salmon observations at the Bogus Creek adult fish counting facility compared with 2003-2021 (**1,286** adult Chinook Salmon have been observed through January 1, 2023).

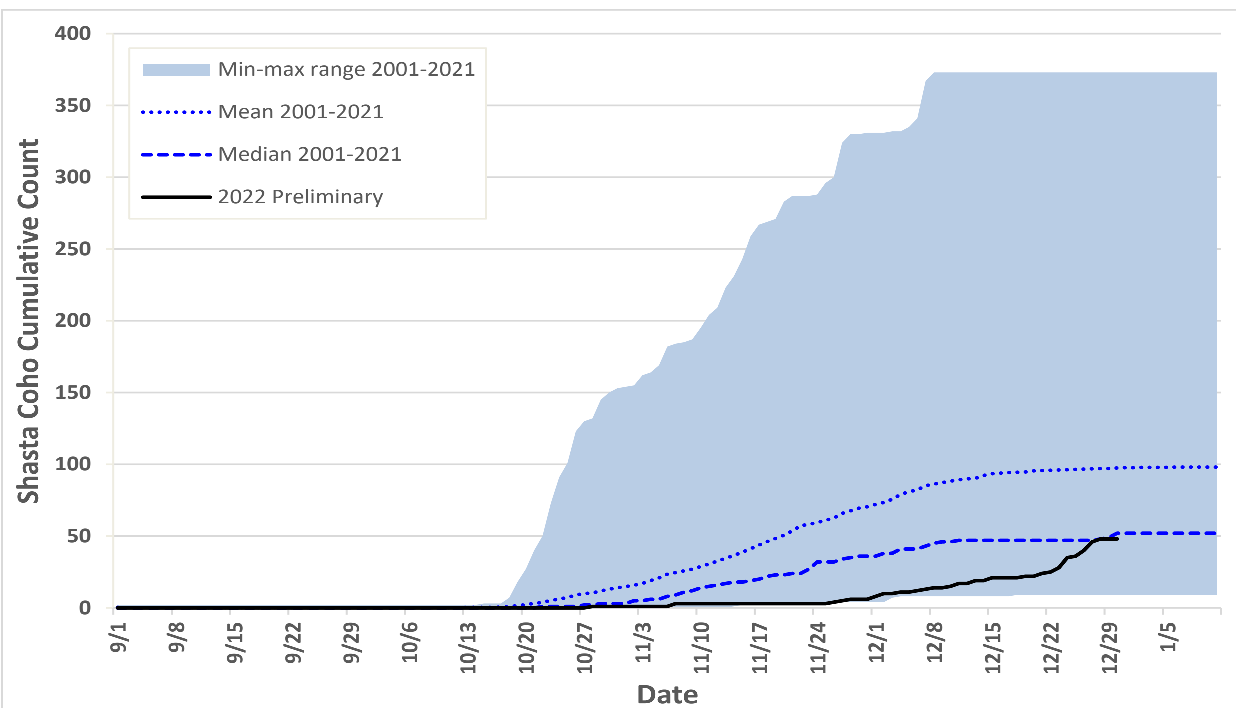


Figure 4. 2022-2023 in-season preliminary Coho Salmon observations at the Shasta River adult fish counting facility compared with 2001-2021 (**48** adult Coho Salmon have been observed through December 30, 2022).

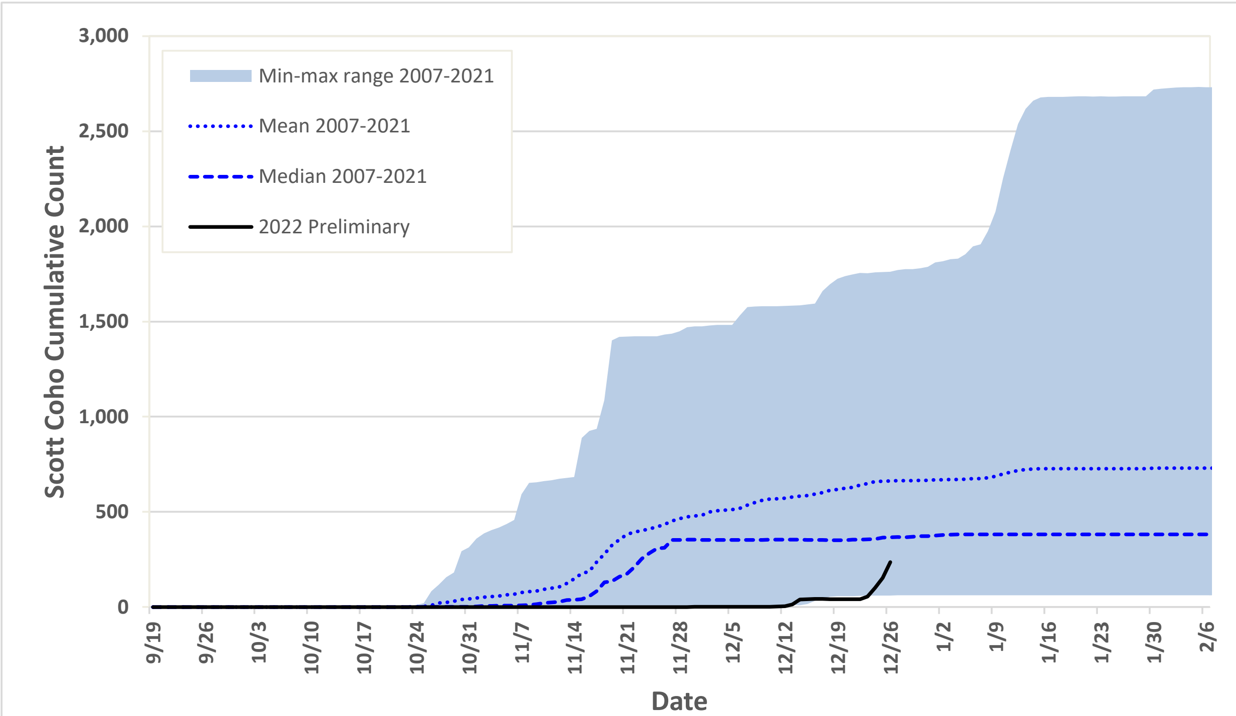


Figure 5. 2022-2023 in-season preliminary Coho Salmon observations at the Scott River adult fish counting facility compared with 2007-2021 (**236** adult Coho Salmon has been observed through December 26, 2022).

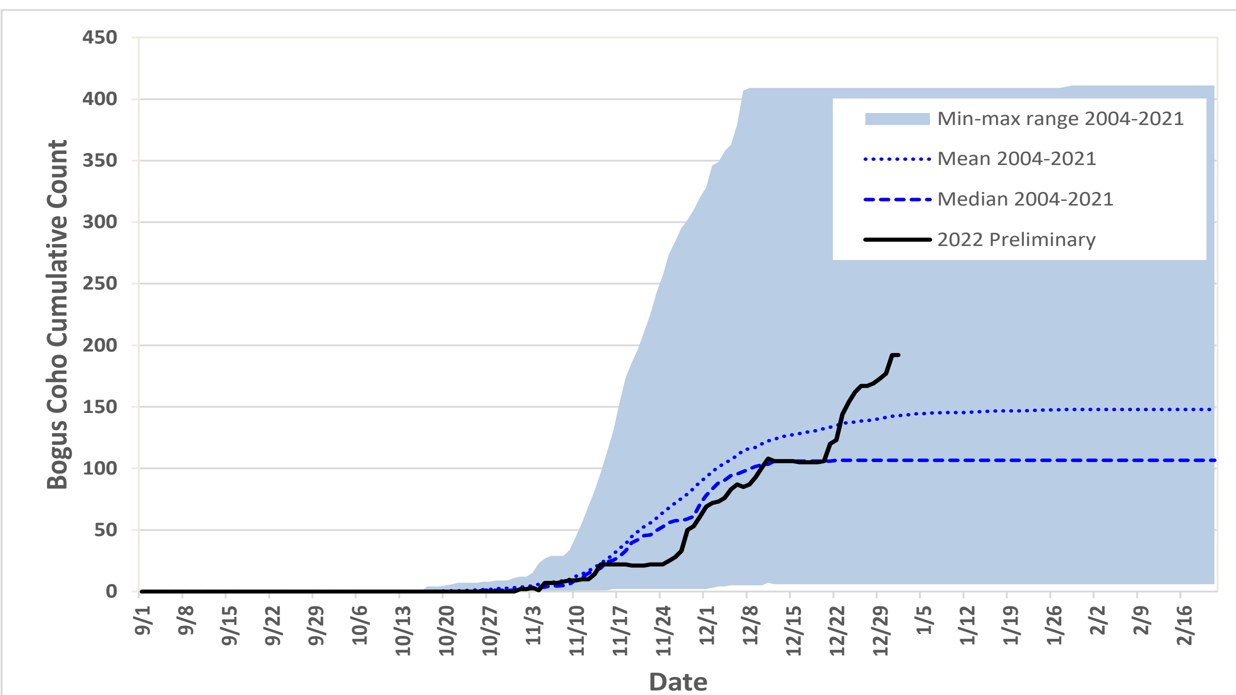


Figure 6. 2022-2023 in-season preliminary Coho Salmon observations at the Bogus Creek adult fish counting facility compared with 2004-2021 (**192** adult Coho Salmon have been observed through January 1, 2023).

Exhibit I

2022 - 2023 – Coho Salmon Spawning Ground Surveys

Scott River Watershed Council

Between January 4 and January 27, 2023, the Scott River Watershed Council conducted spawning ground surveys on French Creek, Miners Creek, Sugar Creek and the mainstem Scott River (Table 1). Each accessible stream reach was surveyed three to four times during this period. The goal of this effort was to observe live salmonids and redds, as well as to collect biological samples from carcasses.

1.4 kilometers (0.9 miles) of French Creek were surveyed three times during the spawning season. On January 12, two redds were observed, one of which had a live Coho Salmon (*Oncorhynchus kisutch*) adult. On January 18, two Coho carcasses were observed. One more redd was observed on January 26. In addition to observations made during formal surveys, two incidental observations of live Coho adults were made: One on January 2 and one on January 13.

0.35 km (0.2 miles) of Miners Creek were surveyed three times during the spawning season. No live fish, redds or carcasses were observed during these efforts.

1.2 km (0.75 miles) of Sugar Creek were surveyed three times during the spawning season. On January 10, one redd was observed. On January 19, one live Coho adult, one redd and one Coho carcass were observed.

0.3 km (0.2 miles) of the mainstem Scott River upstream and downstream of the confluence with Sugar Creek were surveyed four times during the spawning season. On January 4, two live Coho were observed.

Stream	French Creek	Miners Creek	Sugar Creek	Scott River
Distance Covered (km)	1.4	0.35	1.2	0.3
Live Coho Observed	3	0	1	2
Redds Observed	3	0	2	0
Coho Carcasses Observed	2	0	1	0

Table 1. All stream reaches surveyed with distance covered, live fish, redds and carcasses observed.

The California Department of Fish and Wildlife operates a weir and video counting station on the mainstem Scott River at river kilometer (rkm) 29.2. According to CDFW's Klamath River Project In-season Update from January 13, 2023, preliminary observations from this station counted 236 adult Coho Salmon, although the weir was removed on December 26, 2022 due to a sharp increase in flows. At the time of removal, it appeared that the number of Coho coming through the station was on the rise (Figure 1).

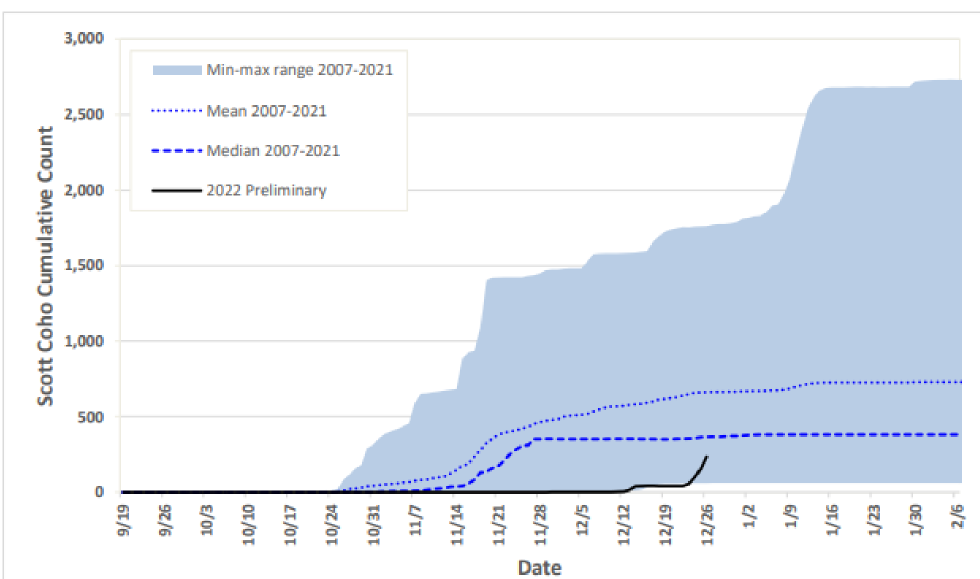


Figure 1. 2022 preliminary Coho Salmon observations from CDFW Scott River counting station, compared to historical mean, median and min-max range.

The number of observations made by SRWC staff were fewer than expected given historical survey data and the number of fish seen at the CDFW counting facility. Precipitation events in late December and mid-January caused large spikes in streamflow that may provide an explanation for this. From December 27 to January 17, flows at the USGS Fort Jones Gage on the mainstem Scott River did not dip below 500 cubic feet per second (cfs) and were greater than 1,000 cfs for much of that time (Figure 2). This period of sustained flows would have allowed Coho spawners to access a wide range of habitat throughout the watershed. This contrasts to recent years in which lower winter flows limited the accessible stream area for returning adults. A wider distribution of spawners throughout the Scott River and its tributaries would explain the perceived lack of density in the reaches that SRWC was able to survey. In addition, these spikes of flow were accompanied by increased turbidity and sediment movement that may have obscured live fish, redds and carcasses.

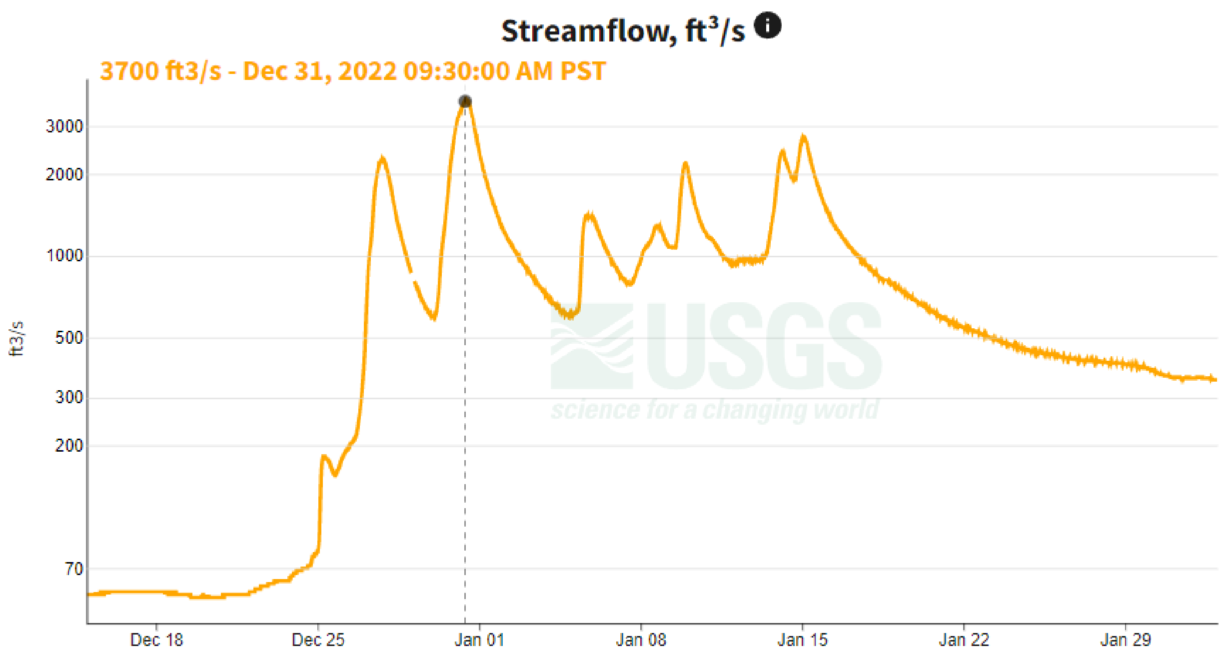
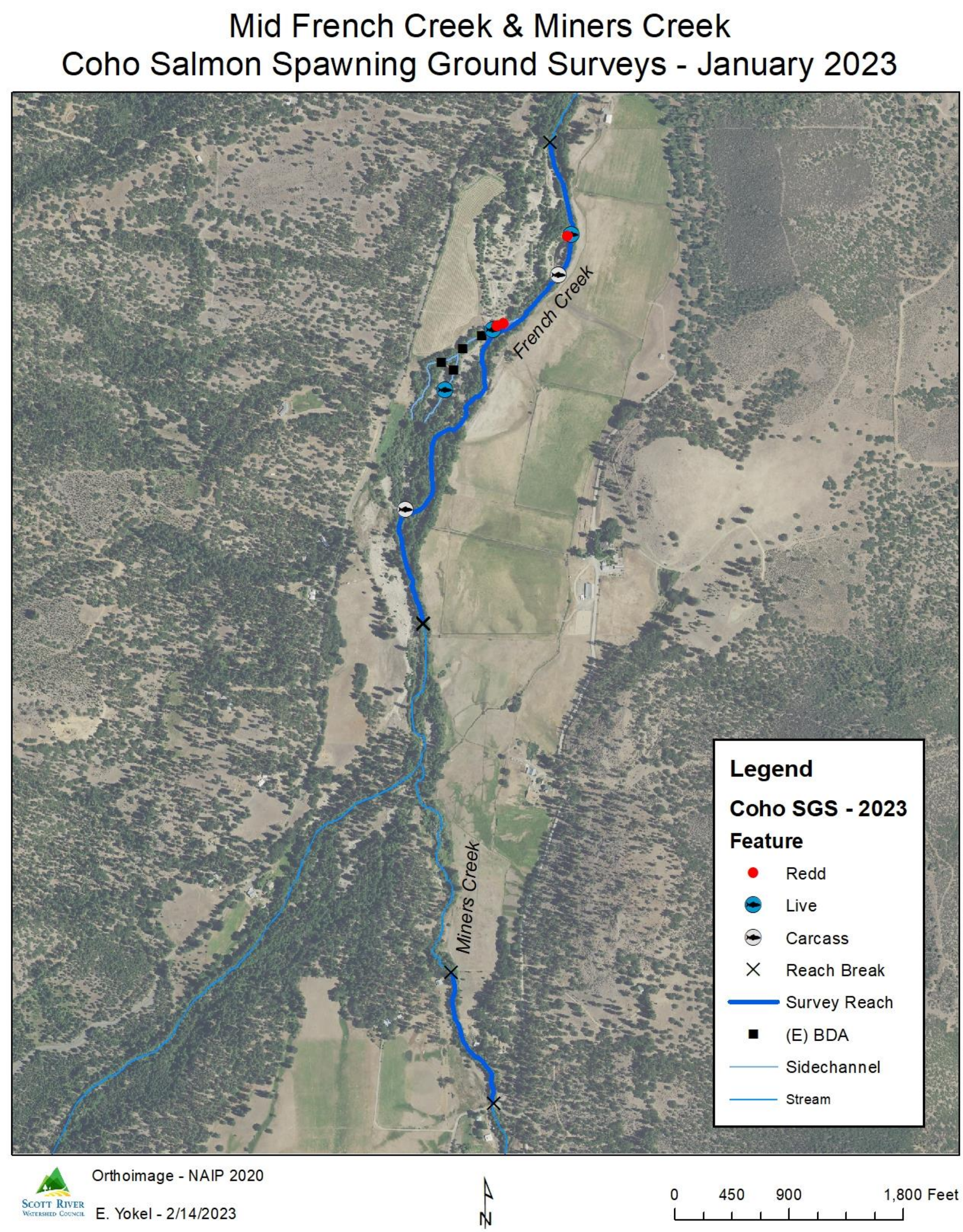
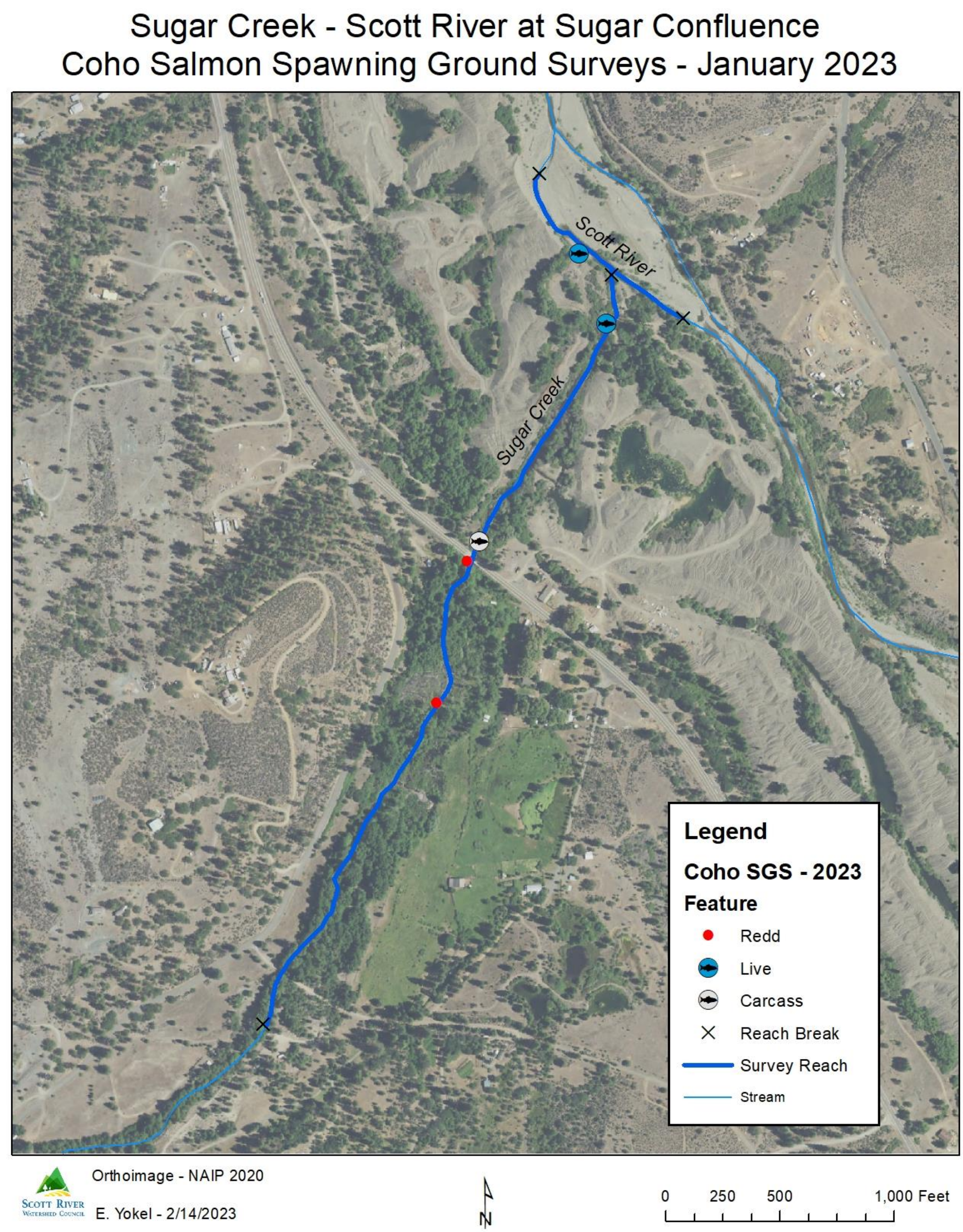


Figure 2. Streamflow (cfs) at the USGS Scott River Station (11519500) - December – January 2023.



Map 1 – Survey reaches and observations – Mid French Creek and Miners Creek



Map 2 – Survey reaches and observations – Sugar Creek and Scott River at Sugar Creek Confluence

Exhibit J

Scott and Shasta River Juvenile Salmonid Outmigration Monitoring

In-Season Update

June 24, 2022

Since 2001, the California Department of Fish and Wildlife has operated rotary screw traps on the Scott and Shasta Rivers to estimate abundances of outmigrating Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*Oncorhynchus kisutch*) and rainbow trout/steelhead (*Oncorhynchus mykiss*). The Scott River rotary screw traps (RST) are located approximately 7 river kilometers (RK) upstream from the confluence with the Klamath River, while the Shasta River RST is located approximately 0.2 RK from the confluence with the Klamath River. The data presented below is preliminary and subject to revision.

The Shasta River RST operated from January 13 to June 10. Mark-recapture trials were conducted on age 0+ Chinook Salmon and age 1+ Coho Salmon, allowing for a preliminary population estimate. An estimated **1,497,650 age 0+ Chinook Salmon** outmigrated from the Shasta River (Figure 1). An estimated **2,378 age 1+ Coho Salmon** outmigrated from the Shasta River (Figure 2).

The raw catch at the Shasta RST was as follows:

Chinook Salmon		**Coho Salmon**		***Oncorhynchus mykiss***			
Age 0+	Age 1+	Age 0+	Age 1+	Age 0+	Age 1+	Age 2+	Age 3+
380,365	31	245	549	7,697	152	3,769	282

Raw catch numbers are not population estimates.

The Scott River 8-foot RST operated from January 26 to June 23. The 5-foot RST operated from February 7 to June 23. Mark-recapture trials were conducted on age 0+ Chinook Salmon and age 1+ Coho Salmon, allowing for a preliminary population estimate. An estimated **509,485 age 0+ Chinook Salmon** outmigrated from the Scott River (Figure 3). An estimated **82,014 age 1+ Coho** outmigrated from the Scott River (Figure 4).

The raw catch from **both** Scott RST's is as follows:

Chinook Salmon		**Coho Salmon**		***Oncorhynchus mykiss***			
Age 0+	Age 1+	Age 0+	Age 1+	Age 0+	Age 1+	Age 2+	Age 3+
30,611	67	588	1,750	11,458	1,507	298	15

Raw catch numbers are not population estimates.

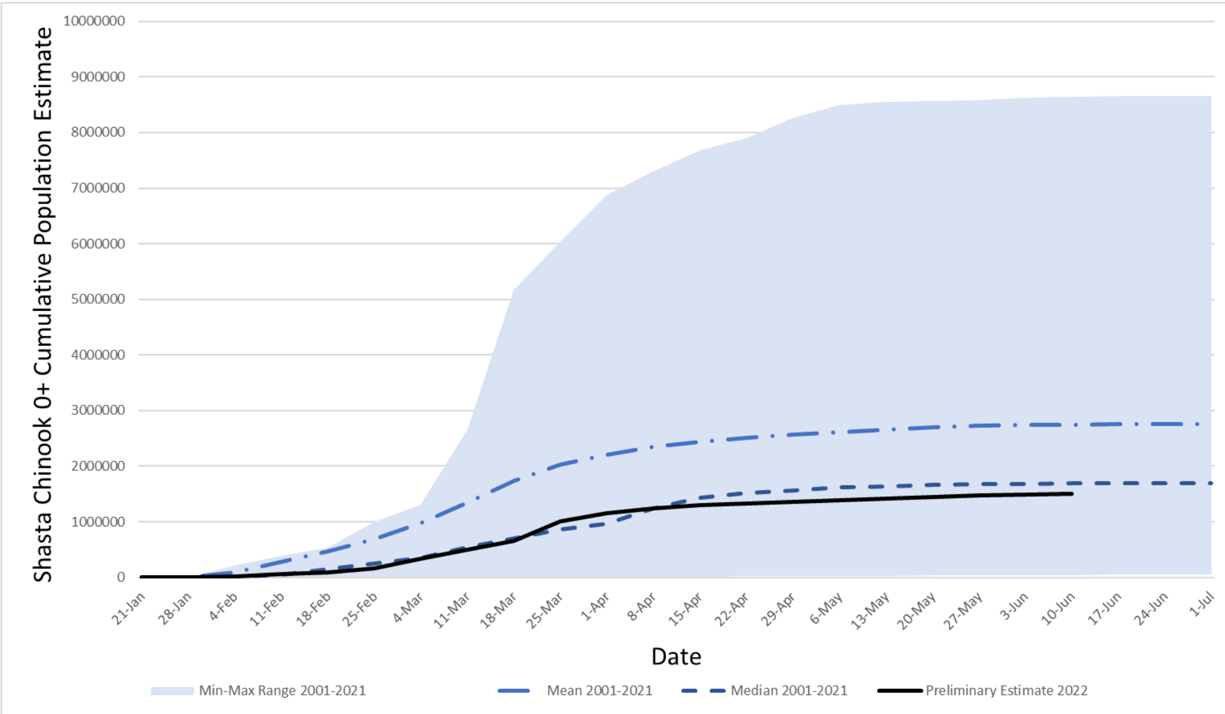


Figure 1. 2022 preliminary population estimates for Chinook Salmon age 0+ at the Shasta RST compared to historical mean, median, and min-max range.

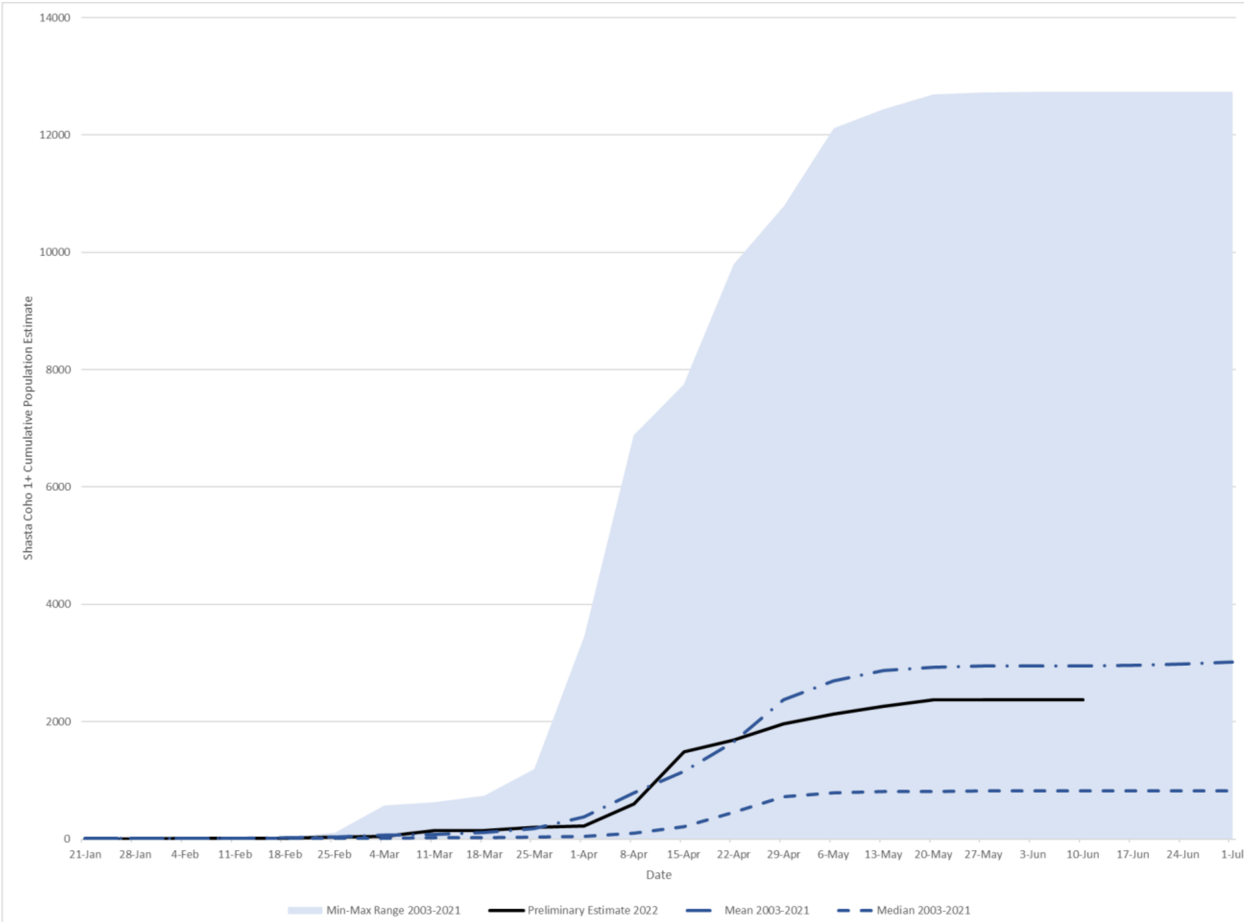


Figure 2. 2022 preliminary population estimates for Coho Salmon age 1+ at the Shasta RST compared to historical mean, median, and min-max range.

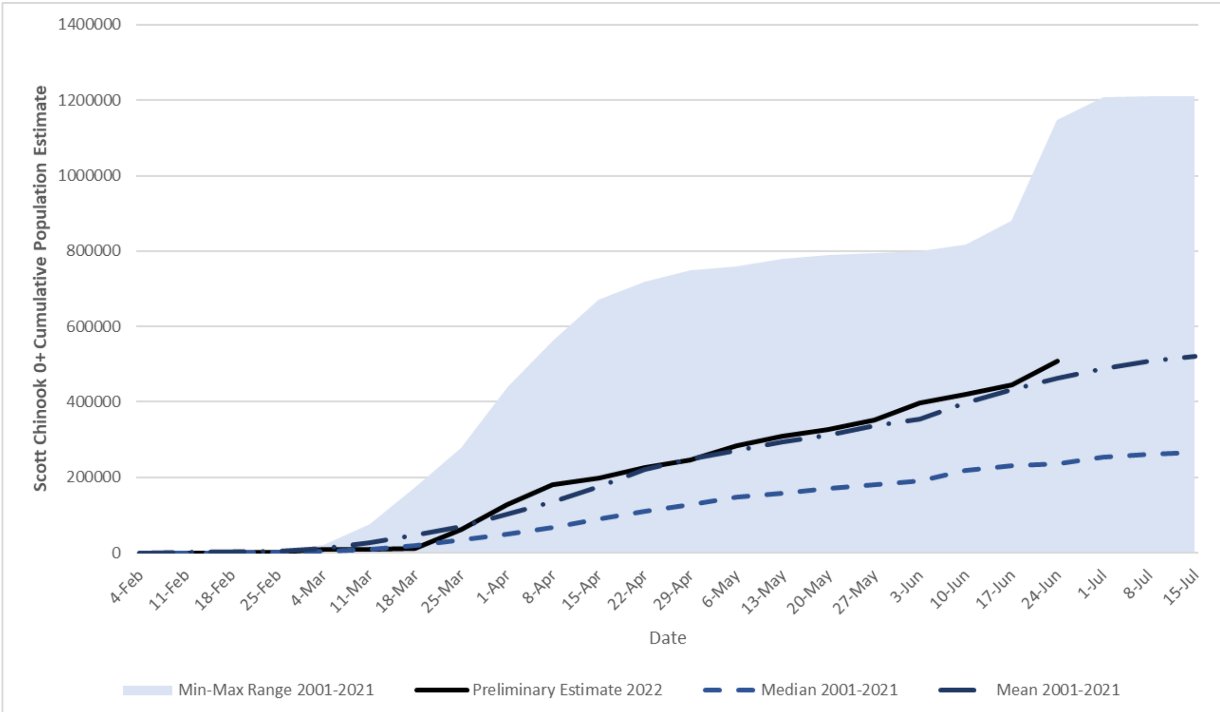


Figure 3. 2022 preliminary population estimates for Chinook Salmon age 0+ at the Scott RST compared to historical mean, median, and min-max range.

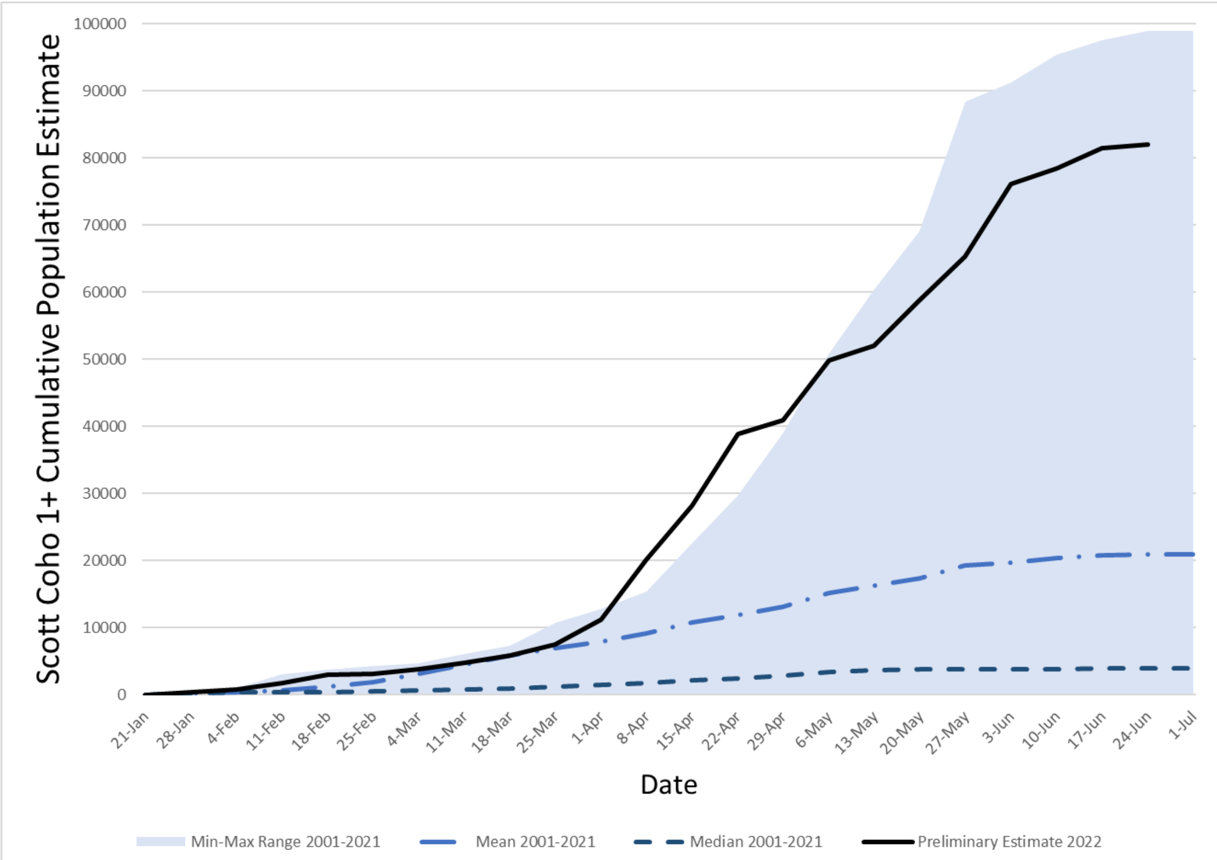


Figure 4. 2022 preliminary population estimates for Coho Salmon age 1+ at the Scott RST compared to historical mean, median, and min-max range.

Exhibit K

Klamath River Project Adult Fish Counting Facility In-season Update

January 7, 2022

The California Department of Fish and Wildlife annually operates adult fish counting facilities on the Shasta River, Scott River and Bogus Creek. This in-season update provides preliminary 2021 returns of Fall-run Chinook Salmon and Coho Salmon to each counting facility. Preliminary in-season updates will be provided as data becomes available throughout the season. The Shasta River station was operational on September 1, 2021 and **6,908** adult Chinook Salmon and **50** adult Coho Salmon have been observed through January 5th, 2022 @ 11:21 when the weir was removed. The Scott River station was operational on September 17, 2021 and **1,324** adult Chinook Salmon and **829** adult Coho Salmon have been observed through January 3, 2022 @ 9:24 when the weir was removed. The Bogus Creek station was operational on September 8, 2021 and **2,072** adult Chinook Salmon and **309** Coho Salmon have been observed through January 6, 2022. The Shasta River station is located roughly 600 feet from the confluence with the Klamath River and serves as a census for the entire Shasta River. The Scott River station is 18 miles upstream of the confluence with the Klamath River and the Bogus Creek station is 0.25 miles upstream of the confluence with the Klamath River. Depending on the year significant fractions of the adult salmonid populations in the Scott River and Bogus Creek spawn downstream of the counting stations. This in-season update doesn't report the spawning escapement that is observed downstream of these two stations. Final reports detailing the total escapement to each river will be available after the data is finalized. If you have questions regarding these in-season updates please contact Morgan Knechtle morgan.knechtle@wildlife.ca.gov or Domenic Giudice domenic.giudice@wildlife.ca.gov.

Scott River Fish Counting Facility

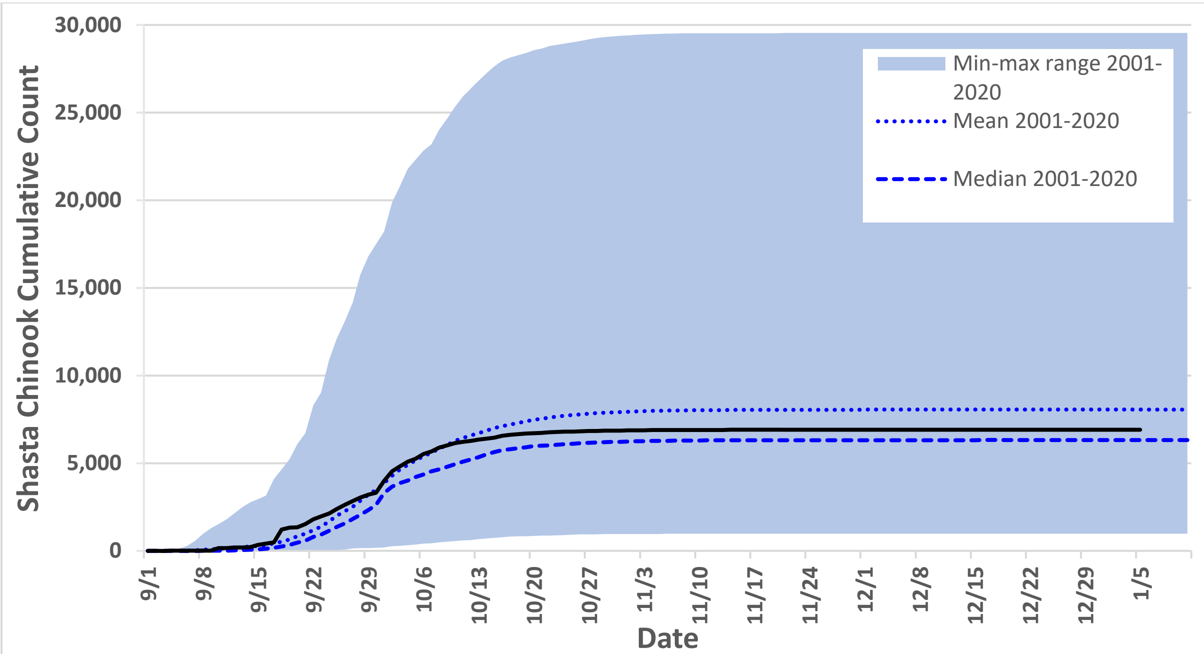


Figure 1. 2021-2022 in-season preliminary Chinook Salmon observations at the Shasta River adult fish counting facility compared with 2001-2020 (**6,908** adult Chinook Salmon have been observed through January 5, 2022).

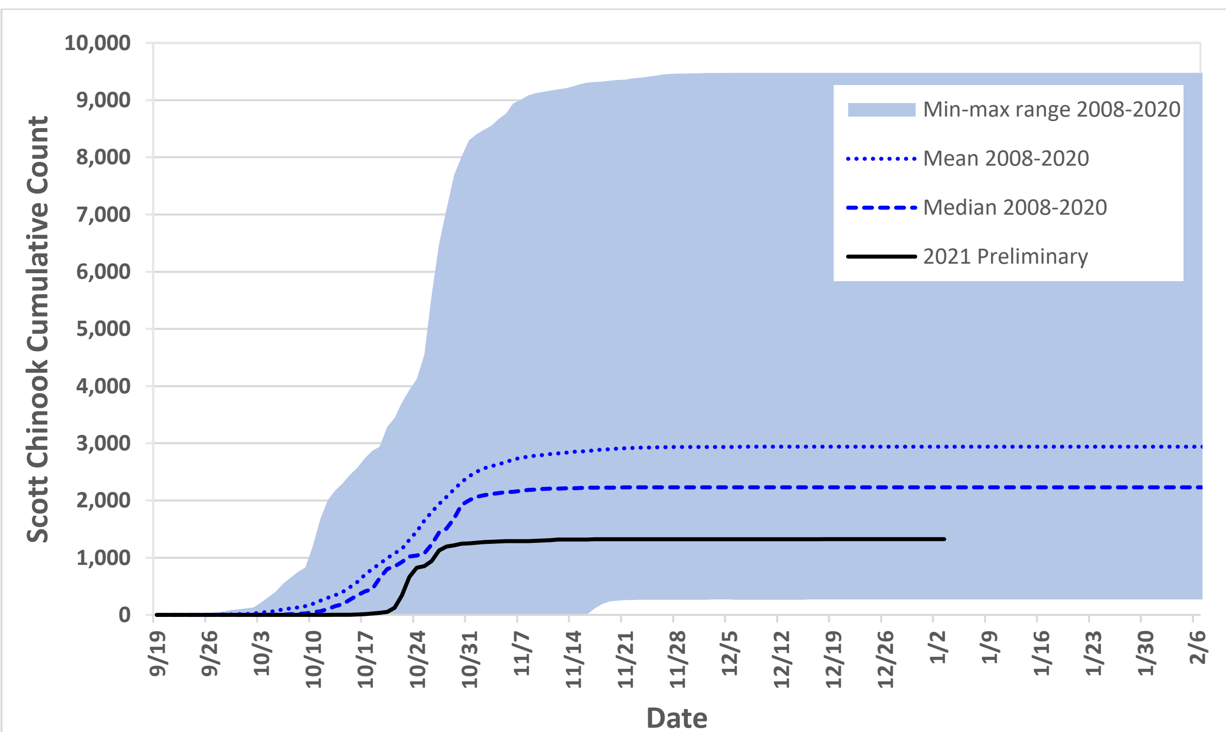


Figure 2. 2021-2022 in-season preliminary Chinook Salmon observations at the Scott River adult fish counting facility compared with 2008-2020 (**1,324** adult Chinook Salmon have been observed through January 3, 2022).

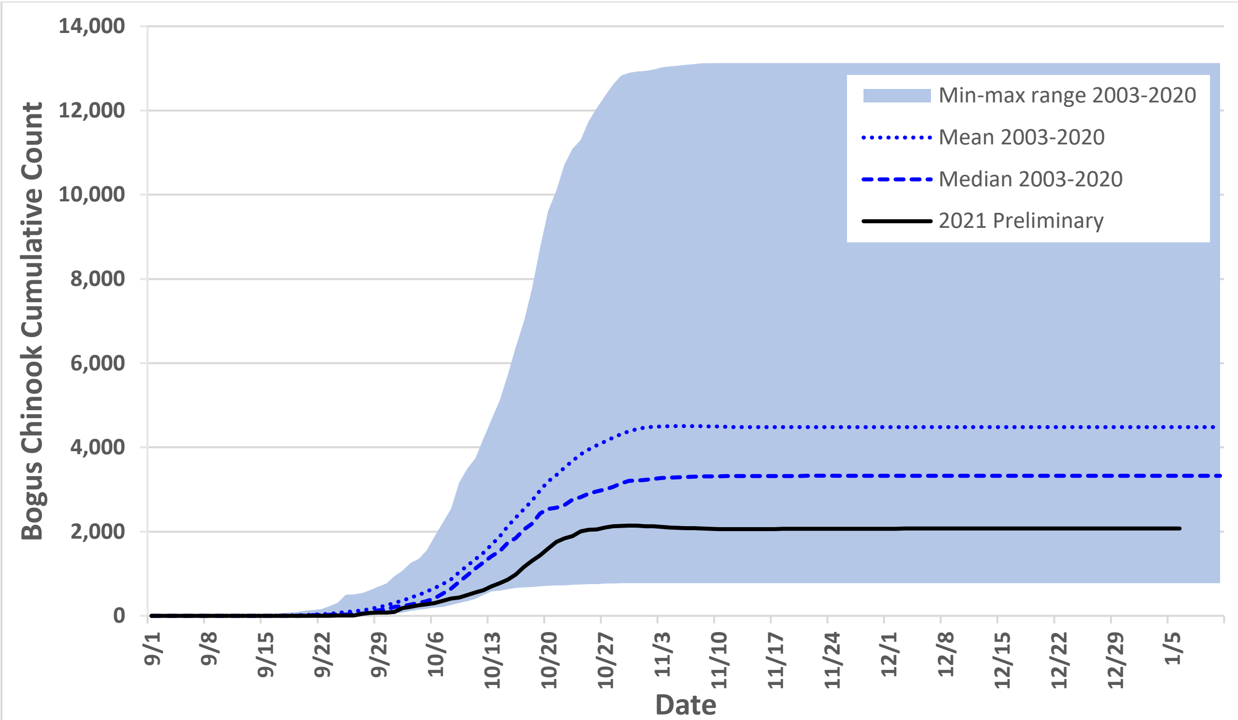


Figure 3. 2021-2022 in-season preliminary Chinook Salmon observations at the Bogus Creek adult fish counting facility compared with 2003-2020 (**2,072** adult Chinook Salmon have been observed through January 6, 2022).

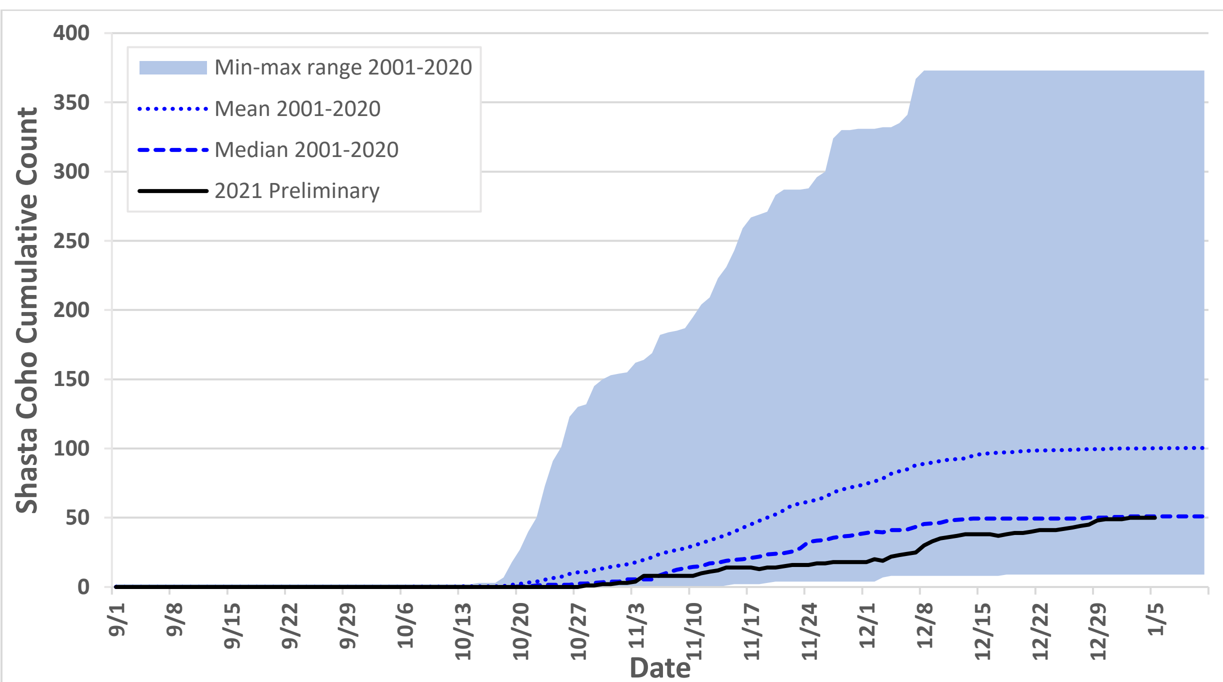


Figure 4. 2021-2022 in-season preliminary Coho Salmon observations at the Shasta River adult fish counting facility compared with 2001-2020. (**50** adult Coho Salmon have been observed through January 5, 2022).

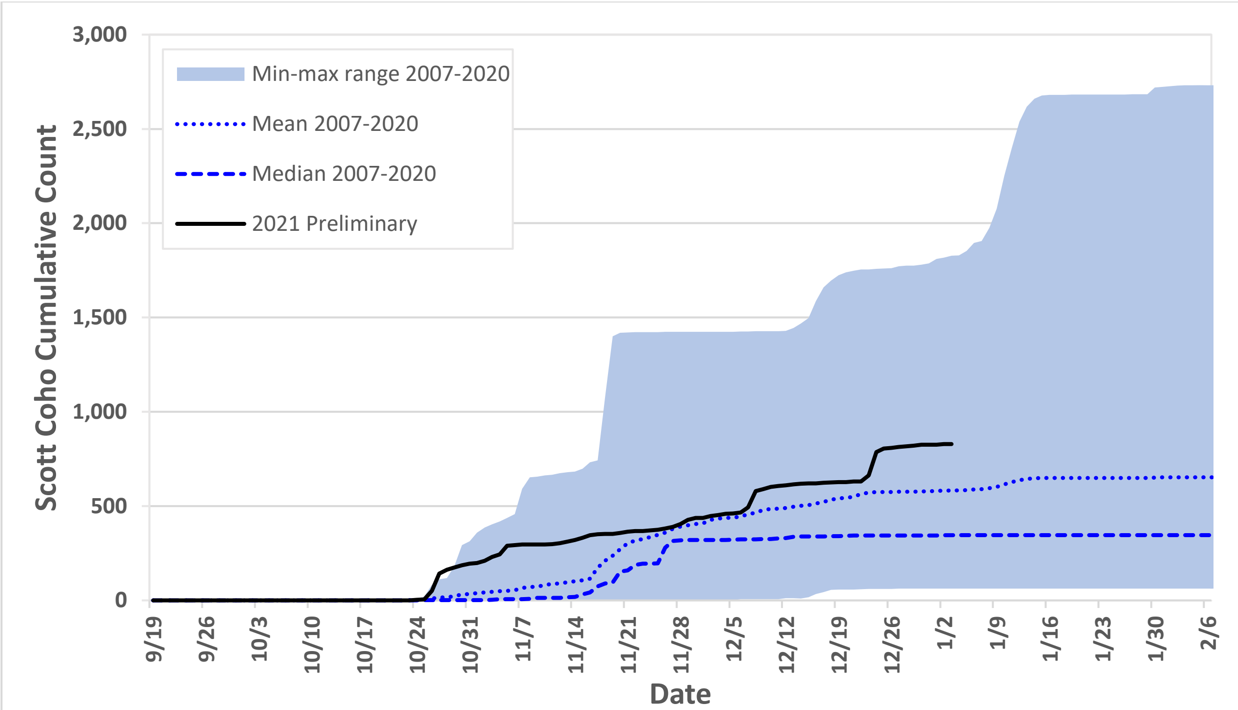


Figure 5. 2021-2022 in-season preliminary Coho Salmon observations at the Scott River adult fish counting facility compared with 2007-2020 (**829** adult Coho Salmon have been observed through January 3, 2022).

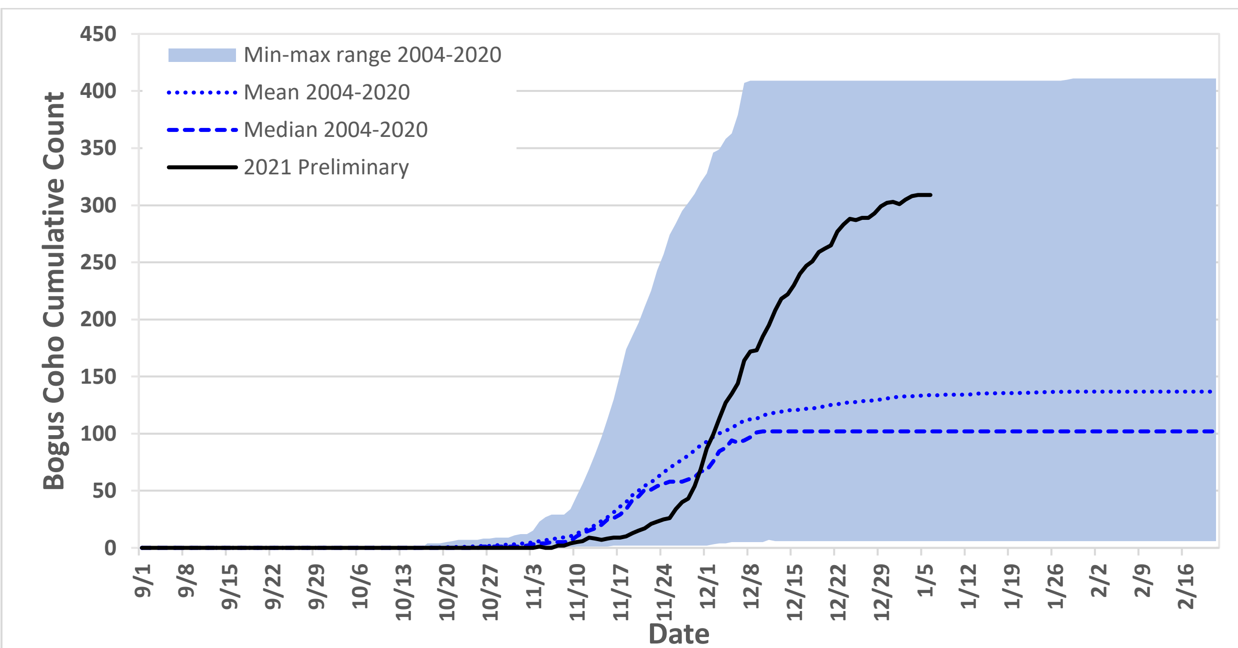


Figure 6. 2021-2022 in-season preliminary Coho Salmon observations at the Bogus Creek adult fish counting facility compared with 2004-2020 (**309** adult Coho Salmon has been observed through January 6, 2022).

Exhibit L

California Water Boards

Edmund G. Brown Jr.
Governor

Matthew Rodriquez
Secretary for
Environmental Protection

State Water Resources Control Board

DEC 3 2013

Ms. Patricia A. Grantham
Forest Supervisor
U. S. Department of Agriculture
Klamath National Forest
1711 S. Main Street
Yreka, CA 96097-9518

Dear Ms. Grantham:

FOREST SERVICE SCOTT RIVER DECREE RIGHT FOR INSTREAM FLOWS

As you indicate in your letter of September 10, 2013, the Adjudication Decree in the Scott River Adjudication recognizes United States Forest Service (Forest Service) rights for instream flow. Your letter also concludes, however, that because most of the other rights in the Scott River are not limited by the Forest Service's instream flow rights, only a relatively small amount of water is being diverted in a manner inconsistent with the Forest Service's rights. I am responding to your request that the State Water Resources Control Board (State Water Board) confirm or correct that assessment.

Your assessment is basically correct, in that the vast majority of the water rights recognized in the Adjudication Decree are not subject to curtailment during periods when flows are insufficient to satisfy the Forest Service instream flow rights. But the categories of water rights subject to the Forest Service instream flow right are broader than recognized in your letter, and the amount diverted in a manner inconsistent with the Forest Service instream flow right therefore may be somewhat greater than you indicate.

Paragraph 45 of the Adjudication Decree recognizes Forest Service rights to stream flow in the Scott River measured at the USGS Gage below Fort Jones. These include a first priority right, equal and correlative with first priority rights in Schedule D4, to specified flows that are set forth by month of the year, or in some cases half-month, and the minimum flow during that month or half-month. These minimum flows apply in all years, including critically dry years. Paragraph 45 includes an additional allotment to the Forest Service for instream flow, with a priority inferior to first priority rights but superior to all other rights in Schedule D4.

Like other rights in Schedule D4, however, the United States Forest Service rights generally do not provide a basis for curtailment of rights in other schedules.[1] There are two significant exceptions to this general treatment of rights in different schedules. First, rights set forth in the surplus priority class in Schedules B and D are subject to curtailment to protect senior rights, including the Forest Service's rights under Paragraph 45. (See Paragraphs 19, 21 & 25) Second, post-1914 appropriative rights in Schedule E are junior to all other rights (in all classes), including the Forest Service's rights, except that Schedule E rights are senior to surplus class rights.

Your letter indicates that only a small amount of water is diverted by those who hold rights in Schedule D4 that have a lower priority than the Forest Service's rights. To determine whether significant quantities are being diverted that should be curtailed to avoid infringement of the Forest Service's rights it would also be necessary to look at diversions of surplus water in Schedule B and in Schedules D1 through D3, and diversions under Schedule E.

State Water Board staff reviewed reports of permittees and licensees for 2012. The reports indicate that water right holders in Schedule E reported diversions totaling over 35 cfs in July, and over 3 cfs in August and September. Many permit and license holders in the Scott River watershed failed to file reports, so the actual amount diverted may be higher.

There is no watermaster for the Scott River Adjudication. Those holding surplus class right or permits or licenses for diversions upstream of the USGS Gage below Fort Jones may not be aware of the need to curtail their diversions when the Forest Service right is not being met. The State Water Resources Control Board (State Water Board) will inform them of this requirement before the 2014 irrigation season, so they can plan accordingly.

It should be noted that the Scott River Adjudication was completed before the California Supreme Court issued its landmark public trust opinion in *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419 (*Audubon*) The State Water Board could consider whether the Adjudication Decree should be updated to take into account any new information available concerning the effect of diversions and groundwater extractions on instream flows and to apply the public trust doctrine if a petition is filed by a claimant or claimants to water in the Scott River stream system. *Audubon* makes clear that a party with standing to raise public trust issues may be a claimant.

I appreciate your concern about this matter, and for your support of local efforts to provide adequate instream flows.

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[1] For example, paragraph 19 provides that: "Exercise of rights in Schedule B will not have an effect on rights in Schedules C and D great enough to warrant reduction of diversions when rights in Schedules C and D are not being fully fulfilled." Further, paragraph 21 states that: "Exercise of rights in each D Schedule will not have an effect on rights in the higher numbered D Schedules great enough to warrant reduction of diversions when rights in the higher numbered D Schedules are not being fulfilled."

If you have any questions, feel free to contact me at (916) 341-5615 or by e-mail at Tom.Howard@waterboards.ca.gov.

Sincerely,

Thomas Howard

Thomas Howard
Executive Director

cc: The Hononable Jared Huffman
U.S. House of Representatives
1630 Longworth House Office Building
Washington, D.C. 20515

Mr. Buster Attebery
Council Chairman
Karuk Tribe
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Happy Camp, CA 96039

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Tribal Chairperson
Quartz Valley Indian Reservation
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Fort Jones, CA 96032

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District 5 Supervisor
Siskiyou County Board of Supervisors
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Scott Valley Groundwater Advisory Committee
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Executive Director
Scott River Water Trust
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Scott River Watershed Council
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District Manager
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Assistant Regional Administrator
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NOAA Fisheries West Coast Region
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Yreka, CA 96097

Mr. Chuck Bonham, Director
California Department of Fish and Wildlife Service
1416 9th Street, Room 1205
Sacramento, CA 95814

Mr. Jim Patterson
District Conservationist
USDA Natural Resources Conservation Service
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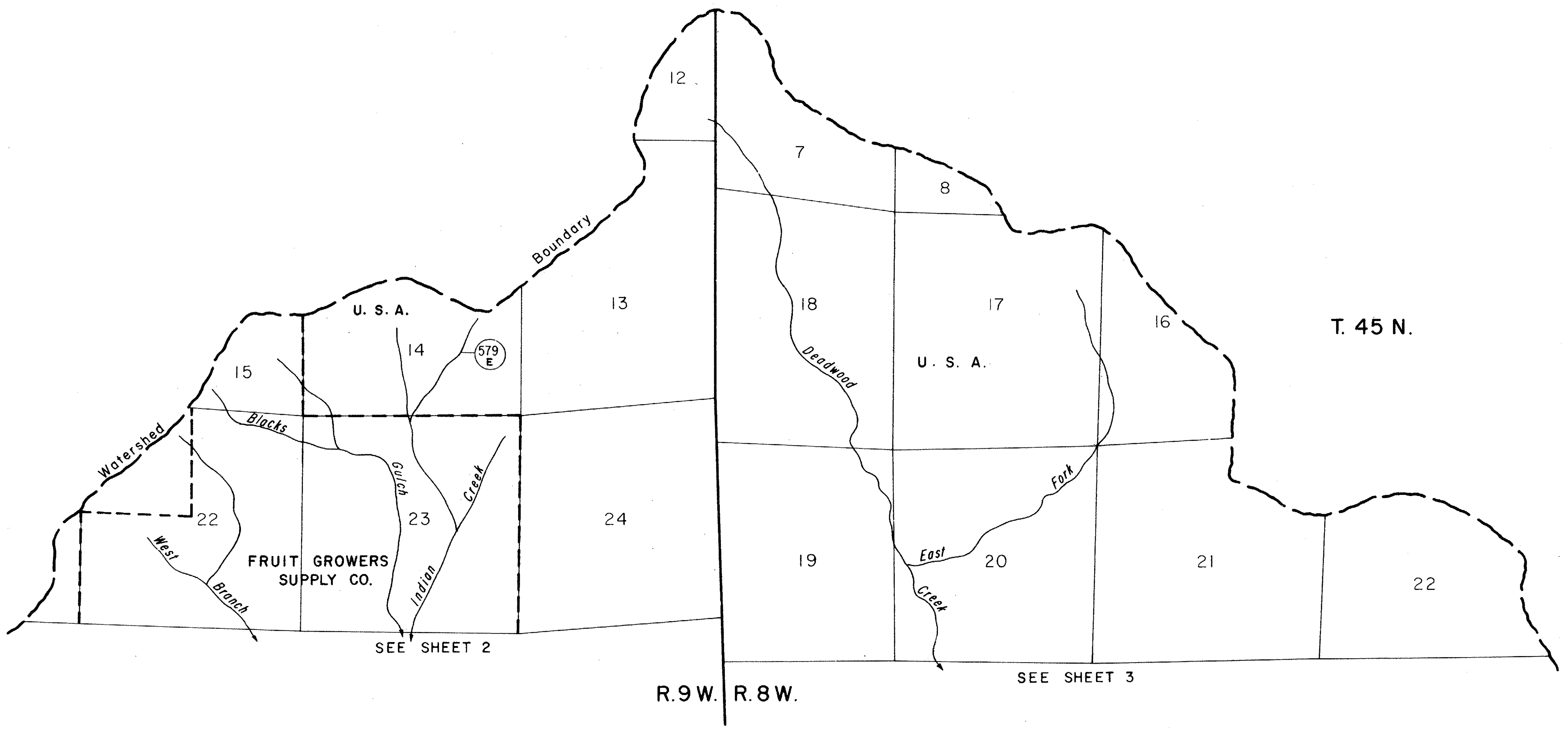
Yreka, CA 96097-2629

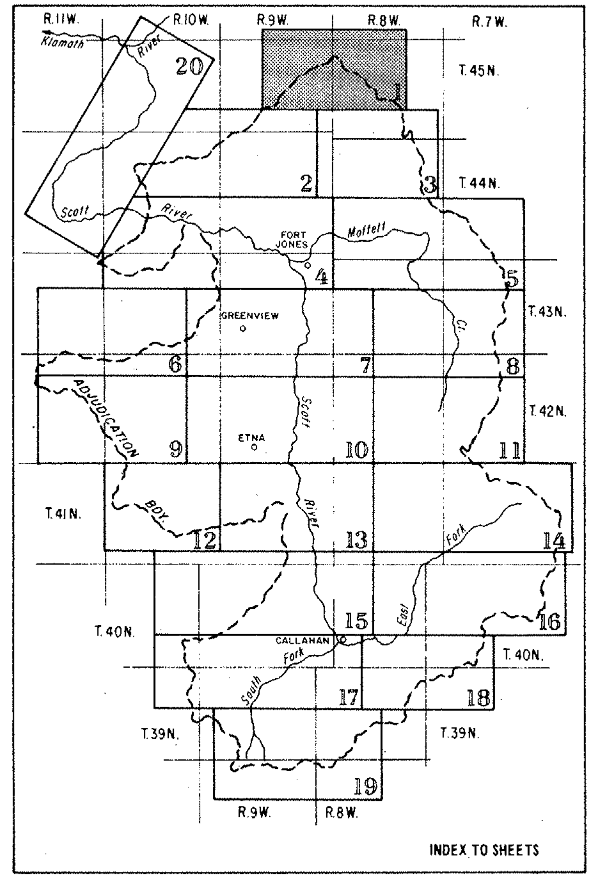
ec: Michael Lauffer
Michael.Lauffer@waterboards.ca.gov

Bryan McFadin
Bryan.Mcfadin@waterboards.ca.gov

Exhibit M

MT. DIABLO
BASE and MERIDIAN





LEGEND

c	CORN
f	ORCHARD
g	GRAIN
p	PASTURE
a	ALFALFA
h	HAY
si	SUBIRRIGATED
•	PUMP
o	WELL
	SPRING
	CREEK
	DITCH
	PIPELINE OR FLUME
	ROAD
	TOWNSHIP LINE
	SECTION LINE
	PROPERTY LINE
	U.S.G.S. GAGING STATION
19	LOCATION OF INSTREAM FLOW ALLOTMENT
57 / 82	POINT OF DIVERSION AND SCHEDULE NUMBER
58 / B3	PROPOSED POINT OF DIVERSION

State of California
THE RESOURCES AGENCY
STATE WATER RESOURCES CONTROL BOARD

SCOTT RIVER STREAM SYSTEM

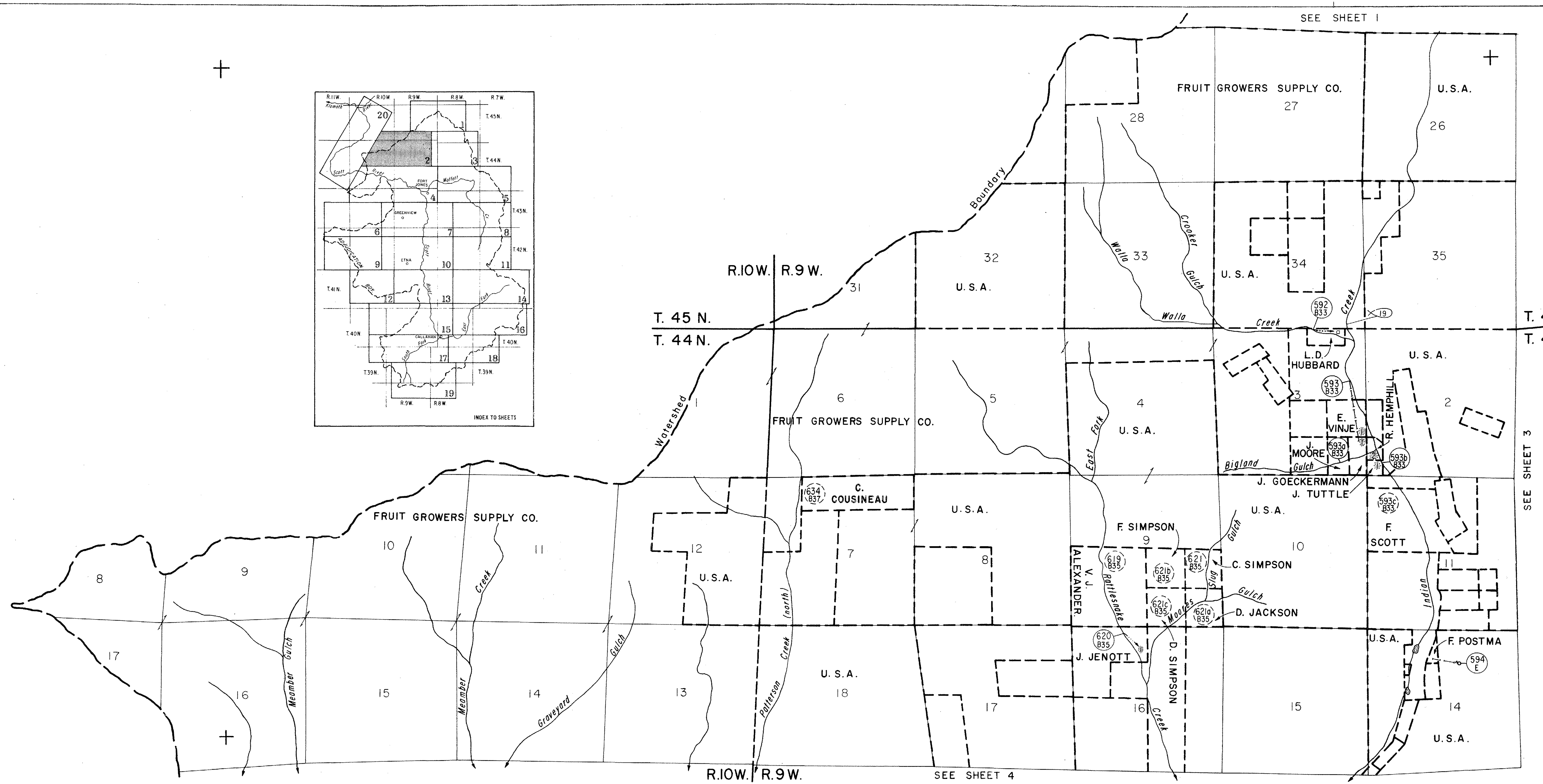
SHOWING

DIVERSIONS and IRRIGATED LANDS

SISKIYOU COUNTY

1979

0 1320 2640 5280 FEET
0 1 MILE



MT. DIABLO
BASE and MERIDIAN

LEGEND

c	CORN
t	ORCHARD
g	GRAIN
p	PASTURE
a	ALFALFA
h	HAY
si	SUBIRRIGATED
●	PUMP
○	WELL
	SPRING
	CREEK
	DITCH
	PIPELINE OR FLUME
	ROAD
	TOWNSHIP LINE
	SECTION LINE
	PROPERTY LINE
	U.S.G.S. GAGING STATION
19	LOCATION OF INSTREAM FLOW ALLOTMENT
57 B2	POINT OF DIVERSION AND SCHEDULE NUMBER
58 B3	PROPOSED POINT OF DIVERSION
	IRRIGATED LAND
	PRESENTLY NOT IRRIGATED

State of California
THE RESOURCES AGENCY
STATE WATER RESOURCES CONTROL BOARD

SCOTT RIVER STREAM SYSTEM

SHOWING

DIVERSIONS and IRRIGATED LANDS

SISKIYOU COUNTY
1979

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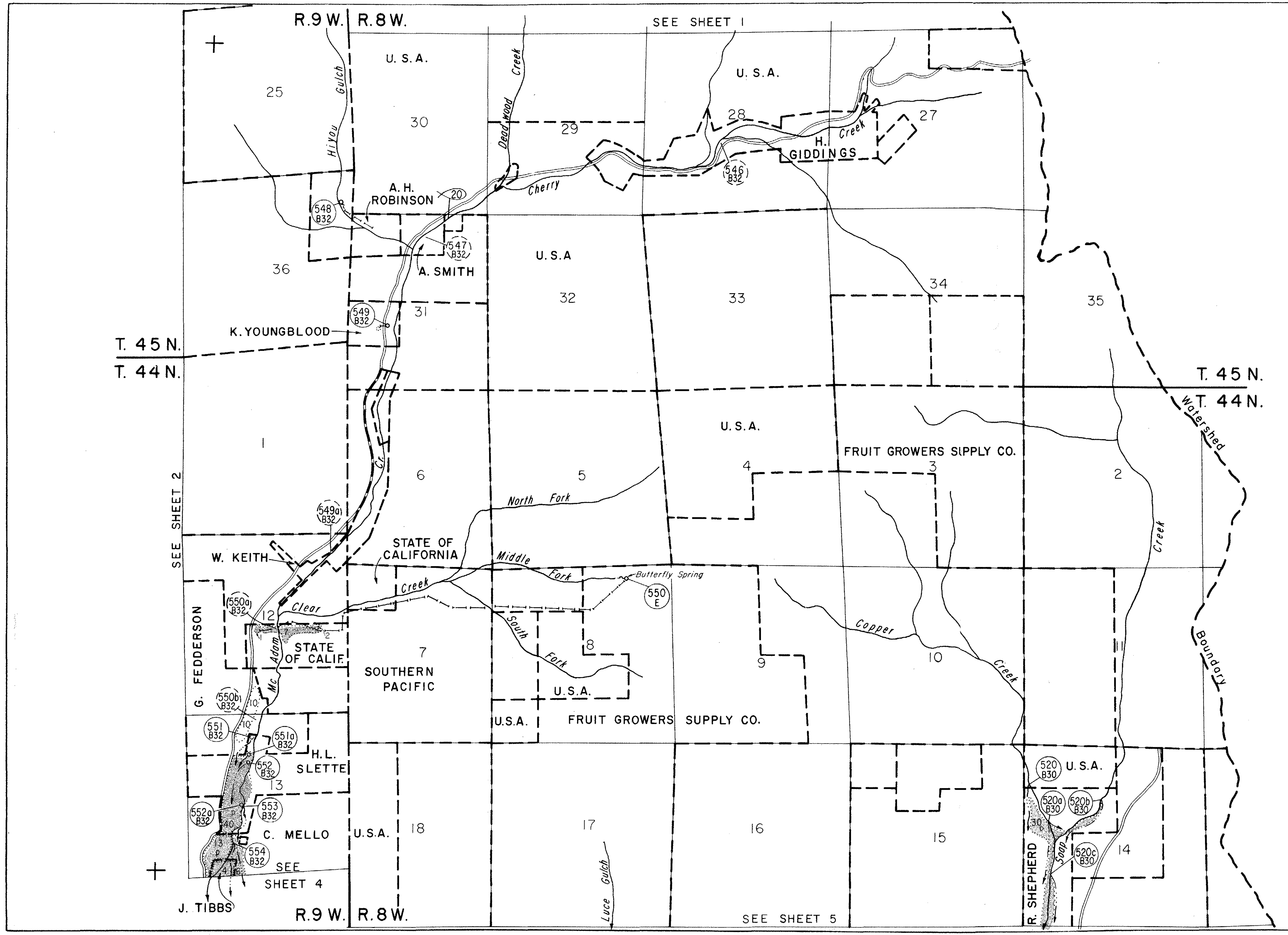
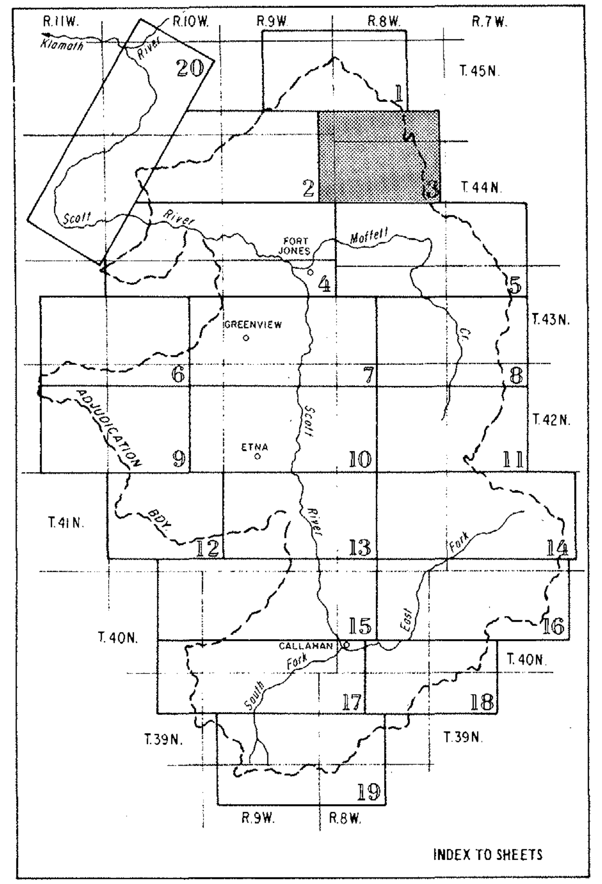
0 1 MILE





LEGEND

- c CORN
- f ORCHARD
- g GRAIN
- p PASTURE
- a ALFALFA
- h HAY
- si SUBIRRIGATED
- PUMP
- WELL
- SPRING
- CREEK
- DITCH
- PIPELINE OR FLUME
- ROAD
- TOWNSHIP LINE
- SECTION LINE
- PROPERTY LINE
- U.S.G.S. GAGING STATION
- (19) LOCATION OF INSTREAM FLOW ALLOTMENT
- (57/B2) POINT OF DIVERSION AND SCHEDULE NUMBER
- (58/B3) PROPOSED POINT OF DIVERSION
- IRRIGATED LAND
- PRESENTLY NOT IRRIGATED

MT. DIABLO BASE and MERIDIAN

State of California
THE RESOURCES AGENCY
STATE WATER RESOURCES CONTROL BOARD

SCOTT RIVER STREAM SYSTEM

SHOWING

DIVERSIONS and IRRIGATED LANDS

SISKIYOU COUNTY
1979

0 1320 2640 5280 FEET
0 1 MILE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LEGEND
c CORN
f ORCHARD
g GRAIN
p PASTURE
a ALFALFA
h HAY
si SUBIRRIGATED
PUMP
WELL
SPRING
CREEK
DITCH
PIPELINE OR FLUME
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R.11 W. R.10 W.
R.10 W. R.9 W.
R.9 W. R.8 W.
T. 44 N.
T. 43 N.
FRUIT GROWERS SUPPLY CO.
INTERNATIONAL PAPER CO.
U.S.A.
J. KENNEDY
HOWARD TERMINAL CORP.
7 D RANCH CO.
SCOTT VALLEY PELLET MILL
DUNSMUIR WATER CORP. FORT JONES WATER SUPPLY
FORT JONES
H. TOZIER
R. SMITH
D. BRAZIL
EVANS
D. MENNE
E. DUERR
R. KINSEY
R. MASON
C. McCONNELL
W. HULLQUIST
V. ALEXANDER
P. LOOGMAN
K. A. JOHNSON
H. B. MONTREUIL
J. FOWLER
A. ANDERSEN
T. LARKOWSKI
F. M. LEARY
J. C. RICHARD
F. GREINER
C. B. SARTWELL
V. E. THICKENS
R. E. HOUSTON
J. R. TOLLE
M. COLLINS
S. STOWELL
J. TIBBS
C. MELLO
R. H. BROWN
R. HOUSE
C. MYERS
D. CONWAY
T. SMITH
G. LIMPERT
J. DIEMER
L. McGEE
P. ROLLEI
J. LIEBLIG
C. SHERMAN
B. OASTER
M. WELLS
M. JOHNSON
R. ROWE
G. STAFFORD
R. ASH
C. HARRINGTON
C. ALDRICH
O. BABCOCK
C. RILEY
B. BURTON
J. MOKRES
H. JONES
JAMES & GAGLIARDI
D. GAGLIARDI
T. BROCE
C. DODSON
N. HOLT
E. BURTON
C. PEARSON
R. McCLELLAN
T. BLACK
F. BLUE
HEIDE
T. WEATHERS
T. BALL
D. FOSTER
G. STRUCKMAN
H. SYLVIA
D. BLACKMORE
R. NULL
E. SMITH
J. LANGFORD
J. WALKER
C. C. CARTER
SHUCK
PLUMER
G. EVANS
B. BURTON
W. McMILLAN
A. R. ANDERSEN
SPOTTS
R. SAGE
J. J. LUCKENSMEYER
GANSBURG
SCOTT RIVER
U.S.G.S. GAGING STATION near Fort Jones
Meamber Bridge
Shackleford Creek
Mill Creek
Moffett Creek
Watershed Boundary


R.9 W. R.8 W.
SEE SHEET 3
TO YREKA
R.8 W. R.7 W.
Watershed
SEE SHEET 4
TO FT JONES
T.44 N.
T.43 N.
Boundary
R.9 W. R.8 W.
SEE SHEET 7
SEE SHEET 8
R.8 W. R.7 W.
KLAMATH NATIONAL FOREST
SOUTHERN PACIFIC LAND CO.
A. COSTA
R.E. SHEPHERD
D. SHEPHERD
K.N.F.
J.R. DEAS
L.D. TANKERSLEY
A.E. DWYER
W. GADSBY
D. DEPPAN
I.J. EGLAND
M.J. VARDANEGA
U. BRANDON
J. ALLEN
C. CRAMER
A. COSTA
R.D. BRYAN & H.G. TUEY
B. AUSTIN
A.G. CRAMER
F.W. BURTON
A.E. DWYER
J.D. KELLY
H. HOHBERG
R. MYER
J. OSTER
BUREAU OF LAND MANAGEMENT
U.S.A.
F.G. CRAMER
G. CRAMER
C. CHAMBERS
B. CARNES
E. BIEHN
SIMONSON LUMBER CO.
H. KUES
W.L. ROWE
U.S.A.
Schoolhouse Gulch
Costa Gulch
Soap Cr.
Moffett Cr.
Trail Gulch
Unnamed Stream
Cottonwood Creek
Hamlin Gulch
WATER TROUGH
LEGEND
c CORN
f ORCHARD
g GRAIN
p PASTURE
a ALFALFA
h HAY
si SUBIRRIGATED
PUMP
WELL
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DITCH
PIPELINE OR FLUME
ROAD
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SISKIYOU COUNTY
1979
5280 FEET
1 MILE


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BASE and MERIDIAN
Shackleford Creek Adjudication
SEE SHEET 4
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R.11 W.
R.10W.
T. 43 N.
T. 42 N.
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U. S. A.
U. S. A.
Buzzard Lake
Kidder Lake
Kidder
Creek
Watershed
Boundary
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SHACKLEFORD CREEK ADJUDICATION
SEE SHEET 4
SEE SHEET 6
SEE SHEET 8
SEE SHEET 10
R.10W. R.9W.
R.9W. R.8W.
T. 43 N.
T. 42 N.
LEGEND
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Scott Valley Irrigation District Ditch
Wright & Fletcher Ditch
Barker Ditch
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DIVERSIONS and IRRIGATED LANDS

SISKIYOU COUNTY

1979


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U. S. A.
U. S. A.
U.S.A.
INTERNATIONAL PAPER CO.
INTERNATIONAL PAPER CO.
T. 42 N.
R.11 W.
R.10 W.
Kidder
18
Hayes Cr.
Creek
Shelly Fork
Glendenning Fork
Babs Fork
Unnamed Stream
Unnamed Stream
Patterson Creek
(West)
Watershed
Boundary
MT. DIABLO
BASE and MERIDIAN
LEGEND
c CORN
f ORCHARD
g GRAIN
p PASTURE
a ALFALFA
h HAY
si SUBIRRIGATED
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SISKIYOU COUNTY
1979
0 1320 2640 5280 FEET
0 1 MILE


SHEET 10 of PLATE I
MT. DIABLO BASE and MERIDIAN
PROPERTY OWNERS SEC. 28, T. 42 N. R. 9 W.
a G. SIMAS
b H. DENURE
c C. SNAPP Sr.
d C. SNAPP Jr.
e A. HICKS
f L. COATNEY
g R. DICKINSON
LEGEND
c CORN
f ORCHARD
g GRAIN
p PASTURE
a ALFALFA
h HAY
si SUBIRRIGATED
PUMP
WELL
SPRING
CREEK
DITCH
PIPELINE OR FLUME
ROAD
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INTERNATIONAL PAPER CO.
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E. L. BIGHAM
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R.S. YOUNG
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N. HAYDEN
C. CASSADY
G. JENNER
M. A. BRYAN
D. DOWLING et al
M. BRYAN
F. HAYDEN
J.W. SHELEY
J. SWEEZEY
SMITH BROS.
J. PIMENTEL
W. D. MATHEWS
SCOTT VALLEY ANGUS RANCH
J. JENNER
RANCHO DEL SOL
K. WHIPPLE
G. FRANKLIN
F. MEEK
R. SMITH
ETNA
R. OLSON
J. STACHER
R. KRAMER
J. McCANN
F. HORN
V. BASHAM
S. M. FRIDEN
N. HELM
T. AXTON
A. SNAPP
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R. HART
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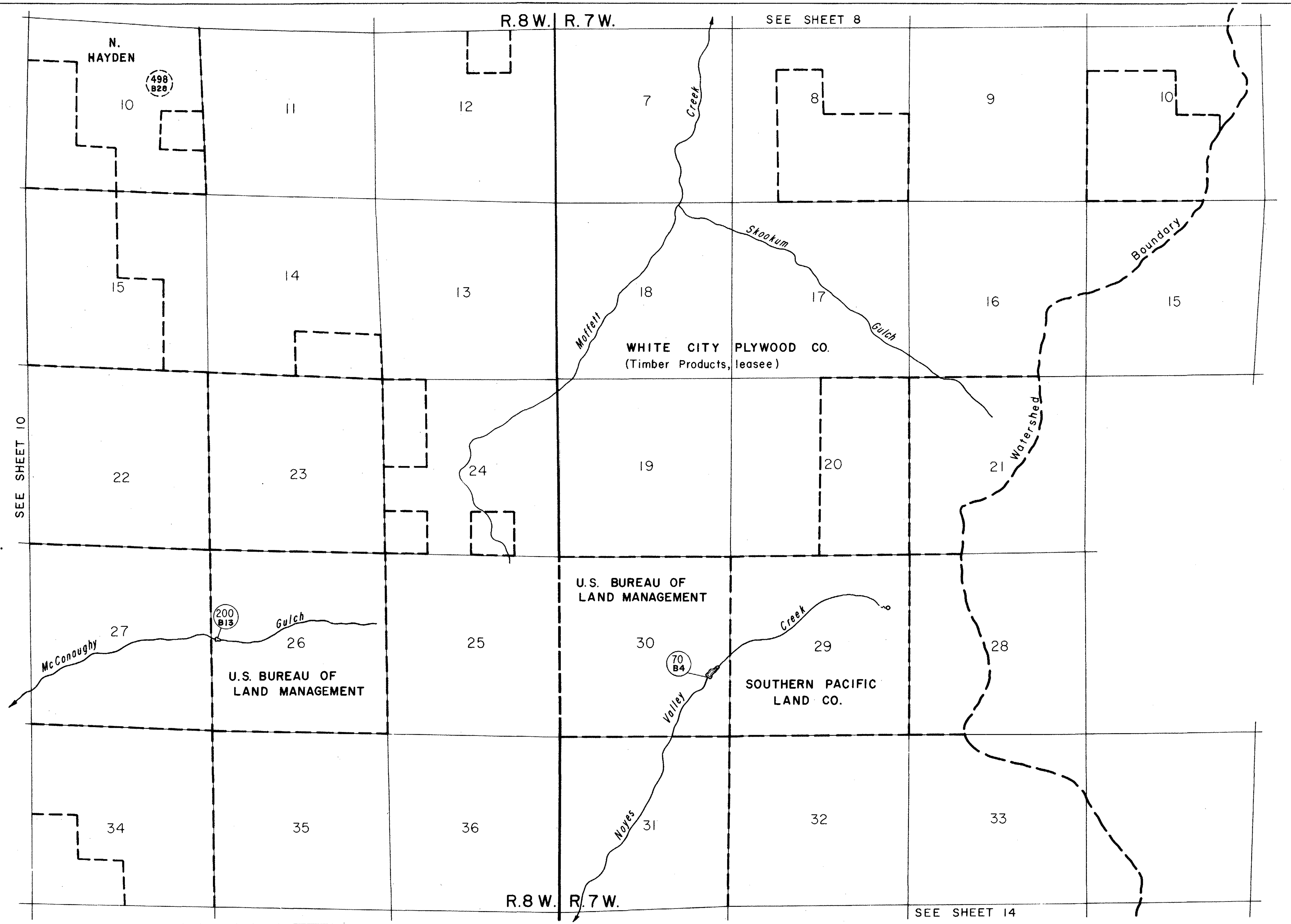

MT. DIABLO
BASE and MERIDIAN

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	U.S.G.S. GAGING STATION
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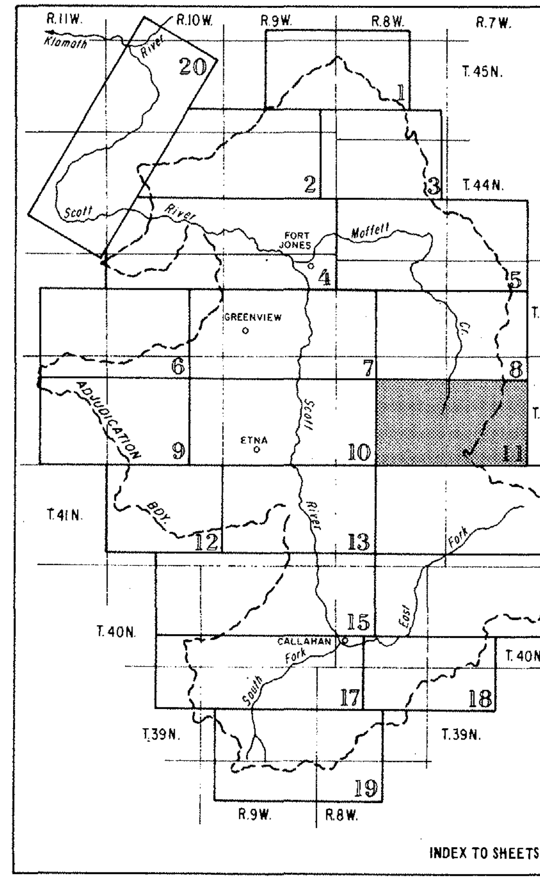
57 B2	POINT OF DIVERSION AND SCHEDULE NUMBER
58 B3	PROPOSED POINT OF DIVERSION



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STATE WATER RESOURCES CONTROL BOARD

SCOTT RIVER STREAM SYSTEM

SHOWING

DIVERSIONS and IRRIGATED LANDS

SISKIYOU COUNTY
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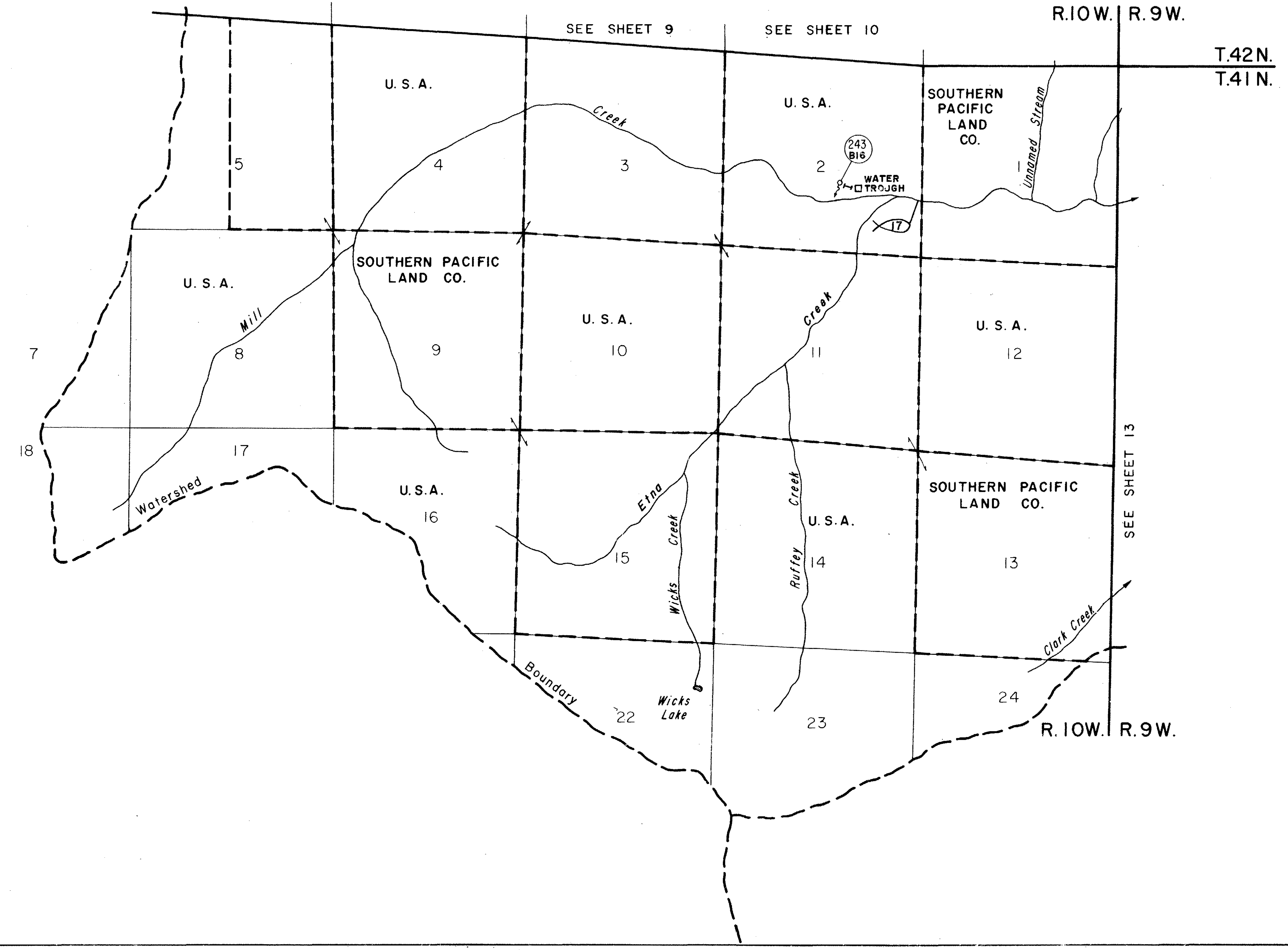

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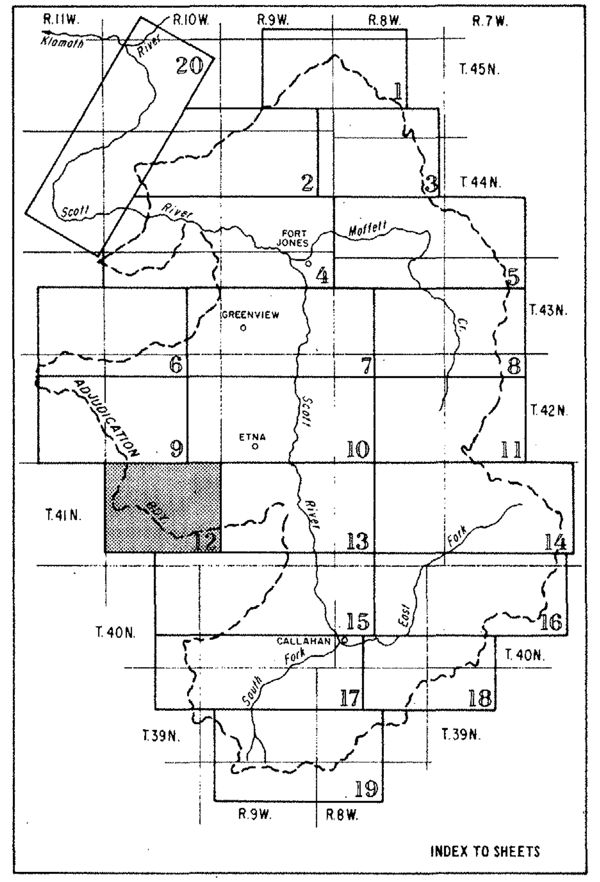

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H.O. & E.J. WALKER
C. FOWLER
M. & B. RAIS
N.C. MARVIN
E. CROWLEY
JAFAM CORP.
K.E. FOWLE
H.F. & P.T. SPENCER
Q. TOBIAS
J.T. & M.F. TIMMONS
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SOUTHERN PACIFIC LAND CO.
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BARNES et al
G. TOLBERT
G.C. & B. BARNES
L.L. & N. WOLFORD
E. MERLO
R. BROCK
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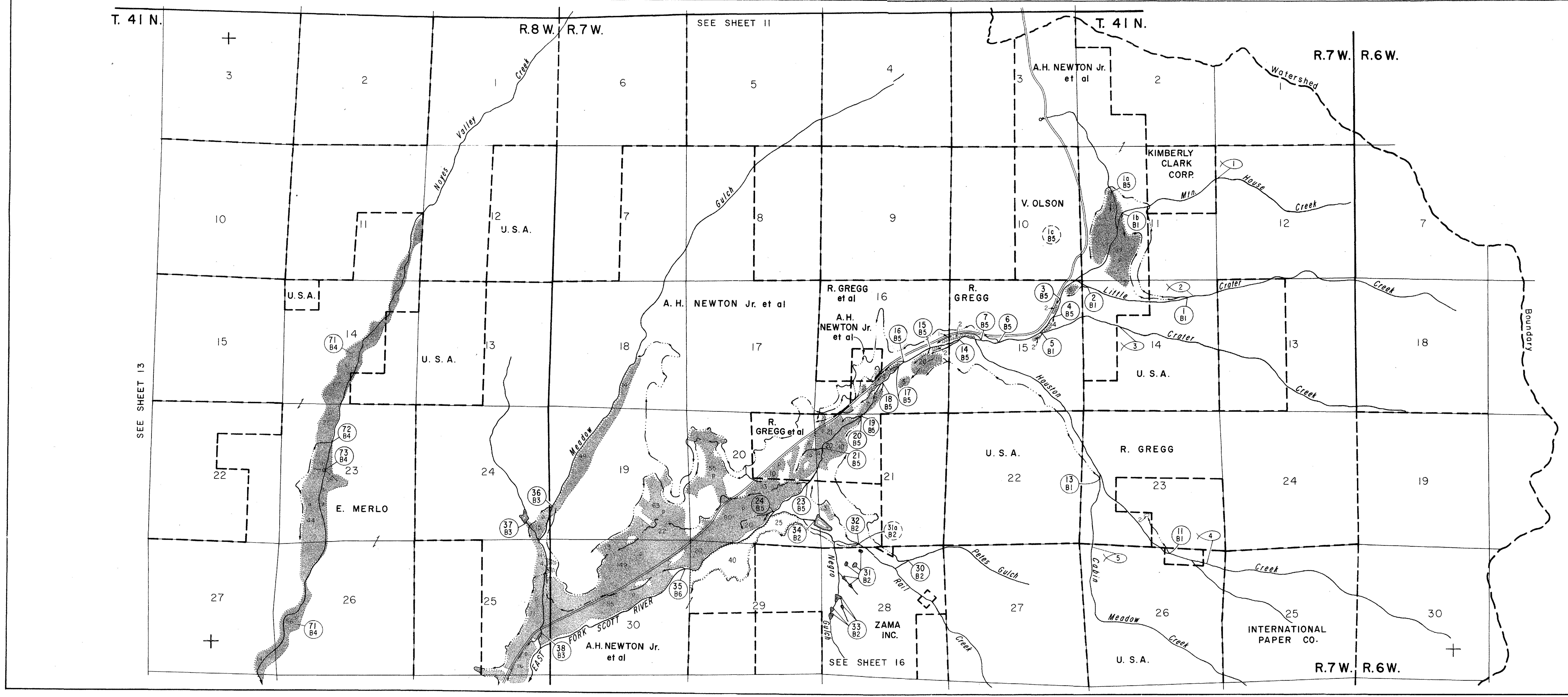

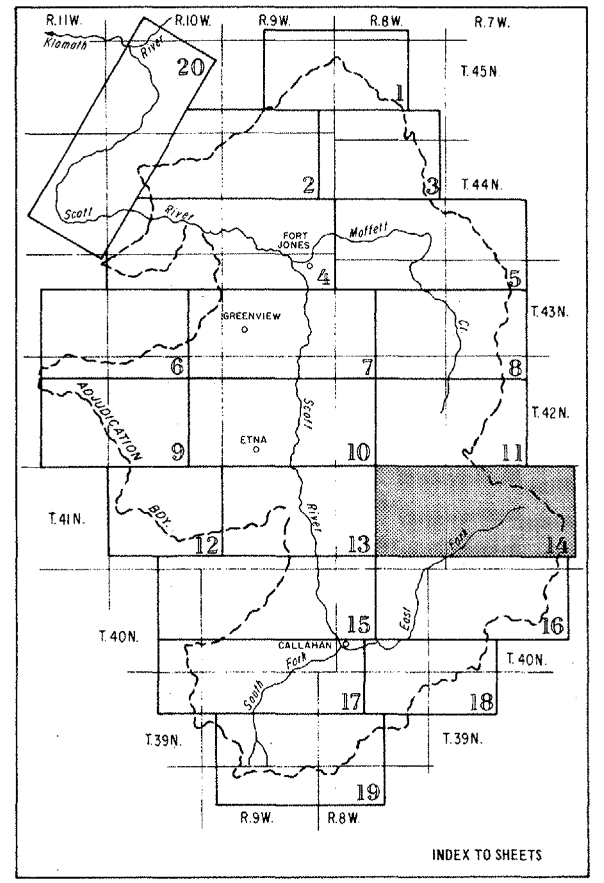

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T. 41 N.
T. 40 N.
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R. 7 W.
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N. HAYDEN
A. H. NEWTON Jr. et al
R. GREGG
EAGLES REST RANCH
C. FOWLER
A. H. NEWTON Jr. et al
THE LAND OFFICE
E. MARTIN
A. H. NEWTON Sr.
INT'L PAPER CO.
SOUTHERN PACIFIC LAND CO.
Lily Pad Lake
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L. BRAUN
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A. BOEHM
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Rock Fence Creek
Meadow Creek
Kangaroo Creek
Valley Creek
Noyes
Grouse Creek
Little Carmen Cr.
Big Carmen Creek
Big Carmen Lake
Hayes Gulch
EAST FORK SCOTT RIVER
Big Mill Cr.
Mile Creek
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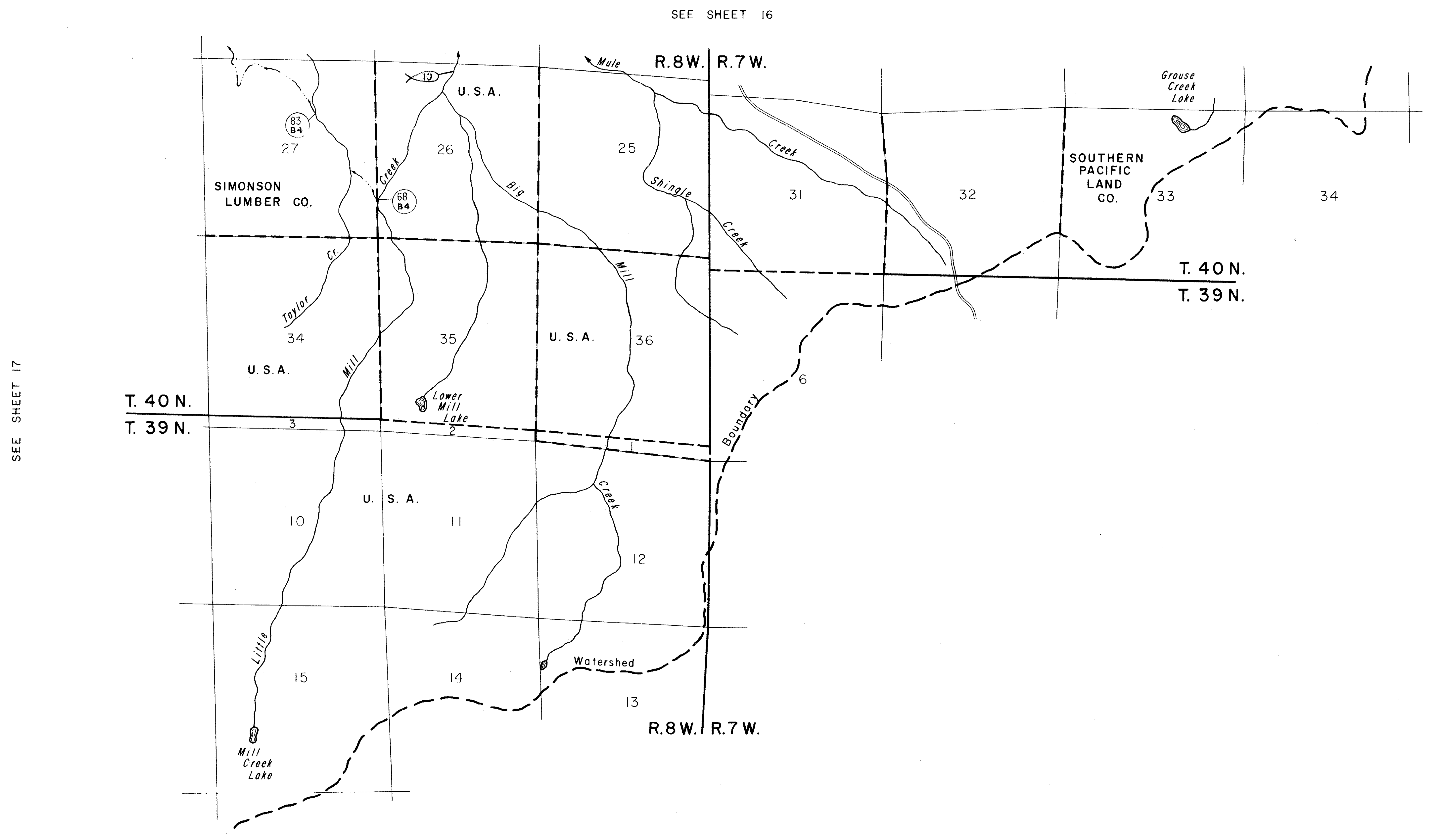

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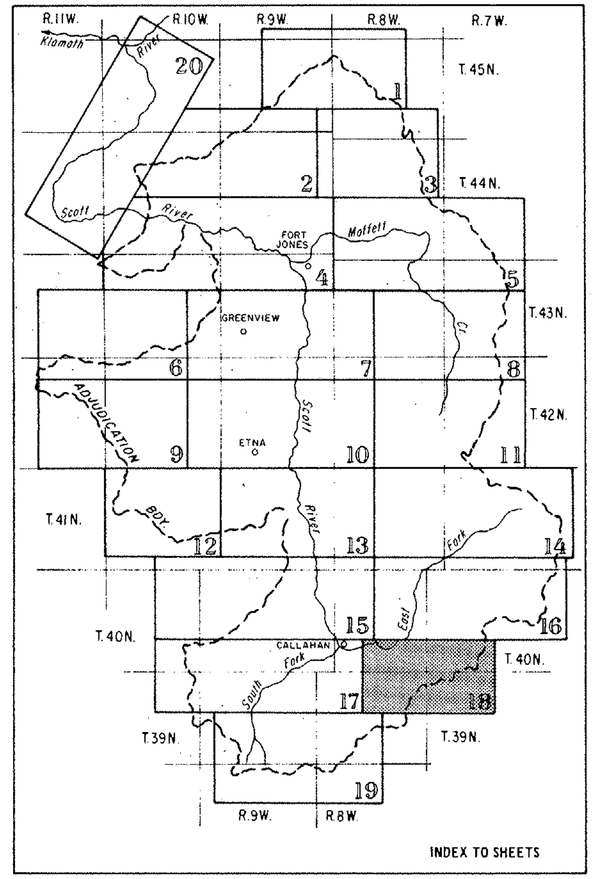

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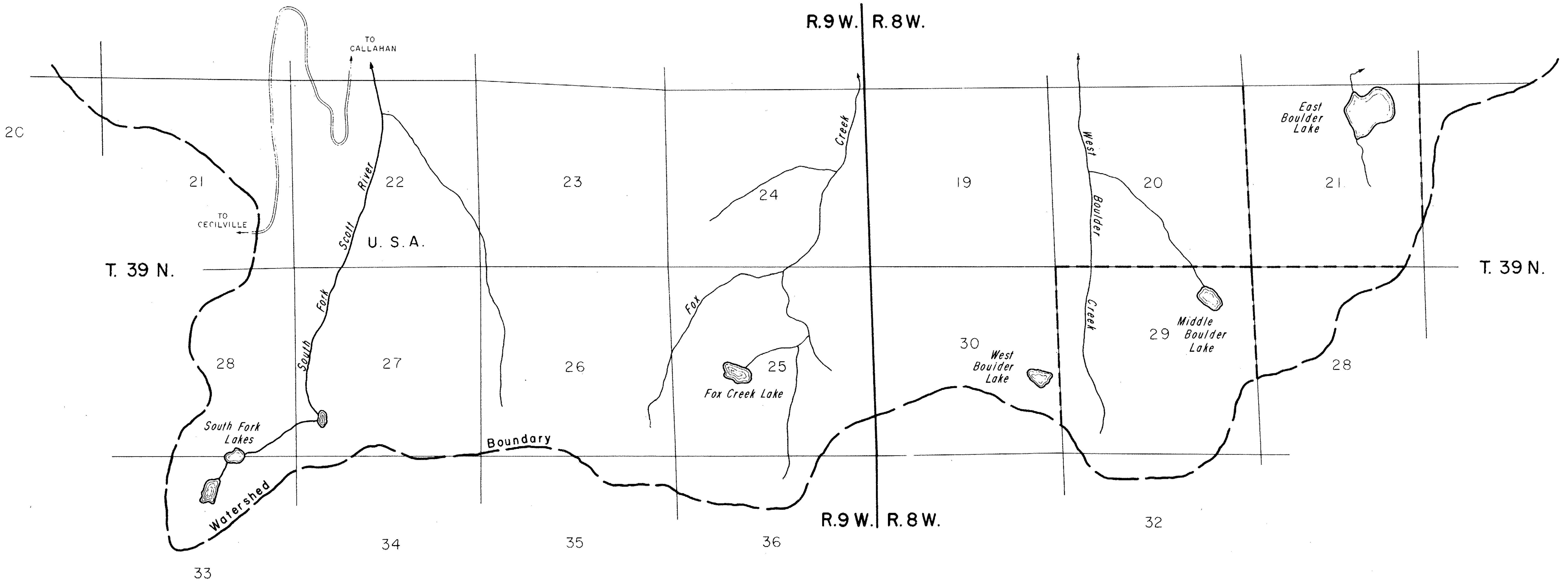

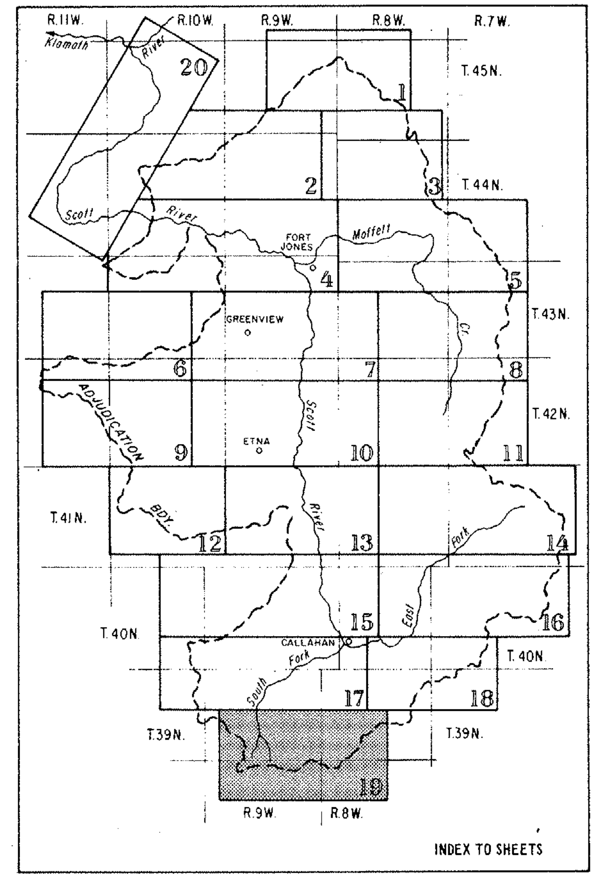

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1979

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Exhibit N

REPORT ON THE HYDROGEOLOGIC CONDITIONS

OF SCOTT VALLEY

SISKIYOU COUNTY, CALIFORNIA

NOVEMBER 1975

This report prepared under the direction of

Alvin L. Franks .... Supervising Engineering Geologist

By

Gilbert Torres, Jr. .... Associate Engineering Geologist

For the Division of Water Rights

Plates By

Adan Garcia .... Senior Delineator

PREFACE

The Scott River water rights adjudication was initiated in 1970 by petition to the State Water Resources Control Board from the Scott Valley Irrigation District. Preliminary investigation determined that the flow of the Scott River was so closely connected to the underlying ground water that any effective adjudication of water rights would have to include both rights to divert surface flow and to pump interconnected ground water. Since the adjudication statutes in effect at the time were limited to determining surface rights only, special legislation was required if the Scott River water rights were to be properly determined. Such legislation was adopted in 1971 and are now set forth as Water Code Section 2500.5 which reads as follows:

> 2500.5 "(a) As used in this chapter with respect to the Scott River in Siskiyou County, 'stream system' includes ground water supplies which are interconnected with the Scott River, but does not include any other underground water supply. (b) The Legislature finds and declares that by reason of the geology and hydrology of the Scott River, it is necessary to include interconnected ground waters in any determination of the rights to the water of the Scott River as a foundation for a fair and effective judgment of such rights, and that it is necessary that the provisions of this section apply to the Scott River only. (c) If this section is for any reason held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this chapter, or of any proceedings thereunder, but shall affect only the validity of the proceedings with respect to such interconnected ground water supplies."

The Board is required by Section 2500.5 to determine which ground waters are interconnected with the Scott River and as a corollary must also determine which ground waters are not interconnected with the Scott River.

This report and the accompanying plates present the Board's staff determination of interconnected ground water and delineates the surface area overlying such ground water. The area of interconnected ground water represents the surface projection overlying the ground water reservoir from which pumping could tend to cause a reduction in Scott River flow before the end of the current irrigation season. This area corresponds with the highly permeable floodplain deposits beneath and adjacent to the river. Excluded are all other valley alluvial material of significantly lower permeability.

The report also discusses relationships between surface flow of Scott River and ground water pumping and recharge characteristics of importance in reaching an equitable determination of interrelated ground water and surface water rights.

It should be stressed that the lack of available data preclude precise delineation between interconnected ground water and other ground water. In fact, a precise demarcation could really never be drawn because of the broad transition zones between ground water obviously not interconnected and ground water freely and completely interconnected. The demarcation lines drawn in this report should be viewed in this light and accepted as the most probable location of such a line.

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INTRODUCTION

The groundwater* supply of Scott Valley complements surface water flows that are or can be diverted for agricultural, municipal or domestic purposes. In general, waterbearing strata of the Scott Valley Groundwater Basin are in hydraulic continuity with the local perennial, intermittent and ephemeral stream systems.

Seasonally, when groundwater extraction may exceed replenishment (by direct infiltration of precipitation and/or surface runoff) along local stream reaches, reversal of groundwater gradients may affect surface runoff and may possibly adversely affect prior rights to the surface waters. Excessive groundwater pumpage can lead to a surface water supply loss to downstream water users.

In recognition of the interrelationship between surface and groundwater in Scott Valley, the State Water Resources Control Board has evaluated readily available data concerning the geologic framework of the basin within which subsurface water is recharged, stored, and transmitted. An evaluation of groundwater occurrence is necessary to better understand the over-all hydrologic factors related to the water rights adjudication in the Scott River Valley.

Based principally on these data, it is estimated that there is a plentiful amount of groundwater in storage along the Scott River upstream from Fort Jones. As part of a basin management plan, this groundwater could be used for irrigation of all usable land and to sustain desired downstream river flows during the dry seasons.

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*Technical terms used in this report are defined in the "Glossary of Geology" which was published by the American Geological Institute in 1972.

SCOPE OF STUDY

This study has entailed the collection and review of existing or published geologic, hydrologic, and water quality data. A minimal amount of field work involved a reconnaissance-level survey of the aereal geology and location of groundwater wells for which drillers' logs (lithologs) were available. In the hydrogeologic assessment of this watershed, of special value has been the United State Geological Survey (USGS) Water Supply Paper (WSP) 1462 which was published in 1958 and is entitled, "Geology and Groundwater Features of Scott Valley, Siskiyou County, California". That report appropriately depicts and describes the geology of the area. Except for minor modifications, that information has been used in this statutory adjudication. The hydrogeologic data presented in the USGS report have been updated by the use of lithologs and hydrologic information obtained by various data-collection agencies since about 1958.

During the evaluation and interpretation of the basic (geologic and hydrologic) technical data preliminary geologic cross-sections were drawn. Concurrently, the hydrologic data collected (during the Spring 1972 thru Spring 1974 period) by the Divison of Water Rights was used to better understand the hydrogeologic regimen of the valley.

AREA OF STUDY

Scott Valley consists primarily of a relatively narrow alluvial floodplain that is about 28 miles long and varies from about one-half to four miles wide. It is in west central Siskiyou County approximately 30 miles south of the Oregon state line and 15 miles southwest of the City of Yreka. The valley is bordered by the Scott Bar Mountains on the north and northwest, by the Salmon Mountains on the west and southwest, by the Scott Mountains on the south and southeast, and by a northerly extension of the Scott Mountains-Trinity Mountains trend on the east.

The elevation of this intermountain valley floor varies from about 3,100 feet (above mean sea level) in the upstream area near the community of Callahan to about 2,700 feet near the downstream extremity. The valley floor extends over a gross area of approximately 100 square miles. In 1958*, the land irrigated by surface diversions was less than 32,000 acres.

Identification of Water Wells

For convenience in establishing an identification system for pertinent data gathered from water wells, numbers have been assigned according to their

* Department of Water Resources Bulletin No. 94-5, "Land and Water Use in Shasta-Scott Valleys Hydrographic Unit, Volume 1: Text, July 1965".

location in the rectangular system for the subdivision of public land. For example, in the State well number 43N/9W-24F1, that portion of the number preceding the slash indicates the Township (43N), that portion of the number between the slash and the hyphen is the Range (9W), the number between the hyphen and the letter indicates the Section (24), and the letter indicates the 40-acre tract within the section as shown below.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

24

Within each 40-acre tract, some wells have been numbered serially (by the Department of Water Resources) as indicated by the final digit. Thus, well number 43N/9W-24F1 is the first well to be listed in tract "F" of Section 24, Range 9 West, Township 43 North.

In this report, all wells are referenced to the Mount Diablo Base and Meridian.

GEOLOGY

A thorough understanding of the subsurface geology must be established to ascertain the relationship between streamflow and underflow.

Scott River surface and subsurface flows are the principal water supply within the watershed. For this reason, the waterbearing materials underlying the Scott River floodplain were most intensely studied. Generally, other portions of the watershed have minimal subsurface data available.

DRAINAGE FEATURES

The watershed tributary to the adjudicated area drains approximately 650 square miles*. Headwaters of the Scott River form in the Scott Mountains to the southeast (East Fork Scott River) and to the south (South Fork Scott River) where mean annual precipitation is in the range of 40 to 50 inches. These forks merge at Callahan to form the main stem of the river which flows northerly for about 20 miles to the community of Fort Jones. Downstream from Fort Jones, the river flows west-northwesterly and skirts the northern

*Soil Conservation Service, U. S. Department of Agriculture, "Inventory and Evaluation of the Natural Resources, Scott River Watershed, Siskiyou County, California, May 1972".

portions of Chaparral and Quartz Hills before exiting the valley near Meamber Gulch. The Scott River flows into the Klamath River about 20 miles further downstream.

Mean annual precipitation ranging from 40 to 70 inches within the Salmon Mountains is reflected by numerous perennial streamflows that exist along the western slopes of the watershed. In terms of this water rights adjudication, the most significant inflows to the valley develop within the Kidder, Patterson (west), Etna and French Creek tributaries. Except for streams in the vicinity of the French and Etna Creek drainages, the others provide intermittent runoff to Kidder Creek within the valley floor. These flows combine along the northeastern portion of Chaparral Hill and discharge into the river near Fort Jones. Oro Fino Creek flow supplied by diversion from Kidder Creek is similarily intermittent between Chaparral and Quartz Hills before merging with the Scott River.

Moffett Creek is a major intermittent tributary to the Scott River that drains the eastern portion of the watershed where mean annual precipitation approximates 30 inches. This streamflow merges with the seasonal runoff from the McAdam Creek drainage where mean annual precipitation is in excess of 30 inches. The merged Moffett-McAdam Creek waters flow southwesterly for about two miles before discharging to the Scott River near Fort Jones.

Where mean annual precipitation is less than 30 inches, ephemeral flows develop within the gulches that drain the eastern foothills bordering the floodplain. These include streamflow within McConaughy and Hamlin Gulches which are the most areally extensive.

West of McAdam Creek, mean annual precipitation is more than 40 inches within Indian, Rattlesnake, Patterson (north), and Meamber Creek drainages where perennial streamflows prevail at the higher mountain elevations. However, those flows are insufficient to sustain continuous surface runoff into the alluvial valley of the Scott River.

Perennial inflow from Quartz Valley to the Scott River by the Shackleford Creek drainage system has been previously adjudicated. Therefore, the downstream terminus for the study has been arbitrarily selected to be in the vicinity of Meamber Bridge which is about one-third mile upstream from the confluence of Shackleford Creek and the Scott River.

GEOLOGIC SETTING

Data suggest that the present elongated shape of Scott Valley was controlled primarily by folding, faulting, and uplifting related to mountain building. The northwest-southeast trending fault along the western margin of the valley (see Plate 1) indicates that displacement may have continued through Cretaceous time. Additionally, the surficial geology and limited litholog information indicate possible downwarping and significant downcutting of bedrock occurred prior to accumulation of the Quaternary deposits that constitute the Scott Valley Groundwater Basin.

It is generally known that during early Pleistocene time, base levels probably were a few hundred feet higher than at present. Thereafter, conditions became such that Pleistocene older alluvium was deposited throughout the valley. Concurrent with this sediment accumulation, it can be reasoned that bedrock movement related to faulting continued in Scott Valley.

Possibly during middle and late Pleistocene time, a recurrence of significant uplift and deformation changed base levels which caused extensive denudation of the older alluvium. Available lithologs suggest that stream entrenchment removed these Pleistocene materials along the main course of the Scott River. Remnants of the older alluvium can be observed along the margins of the valley as shown on Plate 1.

Accumulation of recent alluvial fan deposits and stream channel and floodplain deposits marks another change in base levels. However, incision of the Scott River into the floodplain deposits suggests that uplift since Pleistocene time continues.

GEOLOGIC UNITS

As shown on Plate 1, there are several rock and sediment types within the watershed. In addition to the groundwater-bearing deposits, only the most prominent nonwaterbearing bedrock units will be discussed. Based on a relative oldest to youngest age sequence, and in accordance with USGS WSP 1462, these are the: (1) pre-Silurian Chanchellula (Sc), (3) Devonian undifferentiated greenstone (Dg), (4) Jurassic serpentine (Js), (5) Jurassic or Cretaceous granodiorite (KJg), and (6) Quaternary older (Qoal) and younger (Qf and Qsp) alluvium.

The Quaternary alluvium, which ranges from Pleistocene to Recent in age, is the major source of groundwater in the valley. Furthermore, data indicate that the stream channel deposits are in direct hydraulic continuity with Scott River flows. If groundwater extractions at wells solely penetrating these channel deposits were to be maintained for prolonged periods in excess of subsurface recharge conditions, then it is conceivable that streamflow could be adversely diminished seasonally.

Even though there is a considerable amount of available data such as lithologs, over-all geologic control is inadequate to appropriately differentiate or delineate the physical and hydraulic characteristics of all the various groundwater-bearing materials. However, the following includes a description of those Quaternary materials such as as old alluvial fan and terrace deposits, young alluvial fan deposits, and stream channel and floodplain deposits using available data.

Abrams and Salmon Schists (Stuart Fork Formation)

The oldest rock unit within the study area consists of the eastward dipping Abrams Mica Schist and the Salmon Hornblende Schist. These schists are also deemed to be representative in more recent work by the USGS* of the blue-schist facies metamorphic rocks of the Stuart Fork Formation. WSP 1462 describes the Abrams as a thick series of metasedimentary rocks that is dominantly a quartz-mica schist and unconformably overlain by the metavolcanic Salmon hornblende schist. In contrast, the Stuart Fork formation is noted to be composed predominantly of phyllitic quartzite in the Fort Jones area. This formation comprises a portion of the mountain area from northeast of the Moffett-McAdam Creek confluence southwesterly through the Fort Jones area, forms Chaparral Hill, and several knolls or hillocks along the western margin of the valley. Furthermore, it extends further south through the foothill vicinity of the community of Etna to about the French Creek watershed.

Although the Abrams-Salmon Schists are shown in WSP 1462 to occur along the east side of valley from the area of Hamlin Gulch to Shell Gulch, the USGS Journal of Research paper shows that area to be Paleozoic micaceous marble and amphibolite. Nevertheless, the Abrams-Salmon Schists constitute bedrock that underlies the alluvial valley area along that southwesterly trend from the McAdam-Moffett Creeks mergence area to the vicinity of Etna. This rock unit is estimated to be several thousand feet thick within Scott Valley.

Although infiltration and percolation of precipitation may occur through joints, fractures, and weathered portions of this formation, the amounts of water that can be stored and transmitted are too limited to supply wells. For this reason, these schists are considered to be nonwater bearing.

Chanchellula Formation (Gazelle and Duzel Formations)

The Chanchellula formation unconformably overlies the Abrams-Salmon Schists to the east of Scott Valley. This formation, which is known as the Ordovician and Silurian Gazelle and Duzel formations further to the east, is described to be in excess of 5,000 feet and to consist of chert, quartzite, sandstone, slate, shale, chlorite-sericite schist, and limestone beds that dip eastward. These sedimentary and metamorphic rocks extend from within the Moffett Creek headwaters area south-southwesterly along the eastern watershed slopes of Scott Valley to the vicinity of Callahan. Beneath the valley alluvium, this formation extends from McConaughy Gulch to Callahan.

Chanchellula materials are nonwater bearing because they are generally of very low permeability or too impervious to provide adequate amounts of water to wells. However, it is probable that precipitation and runoff that

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*United States Geological Survey. "Blueschist Metamorphism in the Yreka-Fort Jones Area, Klamath Mountains, California". Journal of Research, Volume 1, No. 1, pp. 53-61, January-February 1973.

infiltrates into the subsurface can be transmitted through joint and fracture systems to supply springs and/or emanate to partially supply surface flow or underflow of intermittent or perennial streams.

Greenstone (Greenstone-Chert Assemblage)

Greenstone, also known as the Paleozoic and Triassic (?) Greenstone-Chert Assemblage, is metamorphosed rock of volcanic origin that is known to contain sedimentary interbeds of chert, argillite, and limestone. The pale grayish green to dark green greenstone is several thousand feet thick and the sedimentary beds vary in thickness from a few to several hundred feet.

Generally, this rock unit forms part of the mountain and foothill area north of the Scott River from the McAdam Creek drainage westerly to Meamber Gulch. Extending to the south, the greenstone forms Quartz Hill and the toe area of the Salmon Mountains from about Kidder Creek southeasterly for approximately four miles to Patterson (west) Creek. This is the probable bedrock unit underlying most of valley alluvium northwest of Chaparral Hill.

The greenstone is considered to be nonwater-bearing although it probably transmits water through fractures and other openings to supply springs and/or local streamflows.

Serpentine

Dark greenish-gray to light gray serpentine is an intrusive rock that solidified from a magma within the host Abrams-Salmon Schists. It is exposed along a two to three mile band from northeast of Moffett Creek southwesterly to Hamlin Gulch. From there, it continues along the eastern margin of the valley to the vicinity of McConaughy Gulch where it underlies the Scott River. The serpentine is known to be exposed west of the river to as far south as Callahan.

Although the serpentine is strongly jointed and fractured, this nonwater-bearing unit weathers easily to fill rock openings with a fine-grained low permeability materials. These materials preclude significant infiltration and/or percolation of precipitation.

Granodiorite

Granodiorite, another rock that solidified from a magma, is light gray and medium- to coarse-grained. It intruded the Abrams-Salmon Schists and, possibly, the greenstone in the vicinity of Etna from about Crystal Creek south to the French Creek drainage. Granodiorite rocks are known to be exposed further to the south within this mountain portion of the Scott River watershed.

This rock unit probably transmits minimal amounts of water to springs and/or streams through fracture openings. However, this material is essentially impervious and nonwaterbearing.

Older Alluvium

The oldest sediments that comprise part of the Scott Valley alluvial fill may have been deposited during early Pleistocene time. WSP 1462 designates these as the older alluvium that is found along the valley margins. These are alluvial fan and terrace deposit remnants that consist primarily of sand and silty clay with boulders. However, older alluvium is not considered to be an important groundwater source or aquifer due to their limited areal extent and topographic position above prevailing water table elevations.

There are no known wells that have been drilled and constructed within areas where older alluvium is exposed on the surface. For this reason, knowledge concerning the hydraulic characteristics of these materials is nonexistent.

WSP 1462 shows older alluvium occurrence at several relatively small isolated patches. These are: (1) a terrace remnant in Oro Fino Valley (SE¼ of Section 18); (2) an alluvial fan near Etna (SE¼ of Section 29 and NE¼ of Section 32) that is considered to attain a maximum thickness in excess of 100 feet; (3) two terrace remnants west of the river in the SE¼ of Section 1 near Sugar Creek and the other which extends from Sugar Creek southeasterly to Wildcat Creek (NW¼ of Section 17) and; (4) four elongated terrace remnants (east of the river) that extend from about Messner Gulch (NW¼ of Section 6) southeasterly to the NE¼ of Section 17 near Callahan.

Younger Alluvium

The younger alluvium, deposited in Recent geologic time, is also discussed herein as described in WSP 1462. Except for the older alluvium remnants, the younger alluvium constitutes the sediment fill of Scott Valley.

Surficially and/or topographically, these younger sediments have been categorized (by the USGS) as alluvial fan and stream channel-floodplain deposits. The alluvial fan sediments are chiefly sandy clay with boulders that were deposited by lateral tributaries along certain valley margins and that are able to supply groundwater to wells in amounts suitable only for domestic and stock purposes. Stream channel-floodplain sediments are primarily sand and gravel with clay deposited by the Scott River and the major tributaries. These deposits are known to yield the largest amounts of groundwater to wells.

Although there is a significant number of well lithologs, the available subsurface geologic control is insufficient to accurately distinguish at depth between the two types of younger alluvium on the attached geologic cross-sections (Plates 2A-E).

In accordance with the physiography of Scott Valley, it would be reasonable to assume that the maximum younger alluvium thicknesses exist approximately beneath the present course of the river. However, WSP 1462 indicates that the deepest known well was drilled to a depth of more than 400 feet at the site of a destroyed well in the vicinity of 42N/9W-9G*. At that site "nonwaterbearing" (as noted in the litholog) Quatuary sediments were not fully penetrated through to underlying bedrock. Since 1958 when WSP 1462 was published, available lithologs indicate that no other drilled wells had approached that depth within Scott Valley. However, in August 1973, well 43N/9W-10M was drilled to a depth of about 220 feet approximately one-half mile east-southeast of the well -9G site. The younger alluvium was not fully penetrated at that site, but the litholog suggests that the local subsurface sediments are predominantly alluvial fan deposits that may be interbedded with floodplain deposits.

Well 43N/9W-24L, located near the mouth of Hamlin Gulch, was deepened from 119 to 250 feet in October 1974. The sediment sequence penetrated varied from brown sand to brown cemented gravel (lower Pleistocene?) before entering bedrock (broken serpentine) at a depth of 210 feet. Nearby well 43N/9W-24F1, completed in March 1953 at approximately the same ground surface elevation, was similarly drilled through about a 201-foot alluvial thickness before penetrating bedrock.

The only other area that is known to be underlain by sediments that are more than 200 feet thick is near the mouth of Rattlesnake Creek in the vicinity of well 44N/9W-28N. This well, which was completed in July 1955, encountered bedrock at depth of approximately 218 feet after penetrating a sediment interval consisting of gravel and clay.

Geologic sections were drawn where litholog information was available. These sections also show the relative thickness of the younger alluvial sediments at various parts of the valley. In the absence of strategically located lithologs, it is readily apparent that the complex discontinuity of clays, sands and gravels does not allow for accurate lateral correlation between wells. However, where log control is available, the stream channel sands and gravels appear to be virtually devoid of interlayered low permeability fine-grained clays. In those areas, these coarse-grained deposits are in direct hydraulic continuity with river flows. These sands and gravels are the principal groundwater supply source for irrigation, domestic and livestock uses.

Based on limited specific capacity data, it is estimated that permeability values of the river channel deposits is in the range of 1,000 gallons per day per square foot (gpd/ft^2).

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*See pages 2-3 for well location description and well designation.

Sediments along the western margin of the valley is primarily alluvial fan material deposited by the series of streams that discharge from the foothills of the Salmon Mountains. This alluvial fan deposit area is continous from the Kidder and Oro Fino Creeks drainage on the north to Etna Creek on the south. Generally, this deposition has been in the form boulder and cobble accumulations near the fanheads that gradually diminish and grade to fine-grained sand, silt and clay along the valleyward fan extremities. There, the fan deposits are interfingered with the westernmost floodplain deposits of the Scott River. In the vicinity of Patterson Creek (west), the lithologs (see Plate 2A) suggest that the fan-floodplain transition zone is east of well 42N/9W-10M and west of wells -10K1 and -10Q1. Clay is the predominant sediment within the upper 120 feet at well -10M, while the corresponding interval at the latter two wells consists primarily of sand and gravel. Furthermore, the 16-foot thick gravel below the 126-foot depth at well -10M appears to contain groundwater that is confined or artesian. Under artesian conditions, long-term groundwater extractions at this well would not adversly diminish the flows in the river.

To the south from Section 42N/9W-10, the alluvial fan-floodplain deposits transition zone probably approximates the alignment of the Abrams-Salmon Schist hillocks northeast of Etna as shown on Plate 1. The predominant sands and gravels at wells 43N/9W-23F1, -26C2, -26L1, and -35D, indicate that the eastern edge of the fine-grained alluvial fan deposits is west of Island Road in the middle of Scott Valley. Also, near-surface groundwater within fine-grained sediments that extend from west of the north-south alignment of Patterson (west) and Kidder Creeks indicate that the western margin of the floodplain deposits in hydraulic continuity with the river is as shown on the Plate 1. Lithologs for wells 43N/9W-11N and -14N north of Serpa Lane show that the stream channel floodplain deposits of the Scott River coincide with the northeastern edge of Chaparral Hill.

Sediments penetrated at two exploratory holes along Oro Fino Creek at 43N/9W-4D and -5G (see Plate 2D) indicate that subsurface materials between Chaparral and Quartz Hills are comprised chiefly of low permeability clay with relatively lesser quantities of gravel and sand. The near-surface groundwater saturated conditions are similar to those that occur in the fan extremities of Patterson (west) and Kidder Creeks. Therefore, in this report, the surficial alluvium in the Oro Fino Creek area is considered to be fan deposits to as far north as the present course of the Scott River where it is 138 feet thick.

Subsurface data concerning the alluvial fill along the eastern margin of the valley is scarce. Hamlin Gulch, which is the largest tributary, has a 92-foot thick interval of sediment overlying bedrock in the vicinity of well 43N/8W-17G (see Plate 2E). This well is about four miles from the Scott River. The penetrated materials were logged as sand and gravel with clay interlayers primarily within the 60- to 88-foot depth interval. Downslope from well -17G and near the mouth of Hamlin Gulch, the litholog for well

43N/9W-24F1 shows a significant clay layer increase that is essentially uniformly interspersed with the sand and gravel to the bedrock depth of 205 feet. The lateral clay content increase in the sediments between the two wells suggests that the Hamlin Gulch alluvium is a subdued fan deposit type to as far west as the schist bedrock knoll along East Side Road. Furthermore, at well -24F1, the gravel layers below the uppermost 40-foot thick clay interval suggests that artesian conditions exist locally that are governed by recharge from the upslope area of Hamlin Gulch. Therefore, because of the surficial clay occurrence and the existing artesian conditions, pumpage at well -24F1 would not induce percolation of surface flow from the river into the stream channel deposits.

The litholog for nearby well 43N/9W-24F2 shows interlayered clays and gravels through the entire sediment interval. This suggests that the transition to floodplain alluvium is immediately to the west of well -24F1. North of well -24F1, the easternmost extent of the stream channel-floodplain deposits would appear to be along an alignment between the aforementioned bedrock knoll and another adjacent to the river in the vicinity 43N/9W-14B. South of well -24F1, the litholog data for wells 43N/9W-24L and -25C (see Plate 2A) indicate that the penetrated alluvial materials are not the highly permeable stream channel-floodplain deposits.

In the Hurds Gulch area, the lack of producing wells suggests that the eastern extent of the stream channel-floodplain deposits would be west of East Side Road. At well 43N/8W-30K, 107 feet of sediments were penetrated before reaching bedrock. The description of the interlayered clays and gravels indicates that there are cemented sediments (Qoal?) below a depth of about 35 feet. Data also indicate that these cemented sediments are of low permeability and could be correlative with those encountered at previously mentioned well 43N/9W-25C.

In the vicinity of the 34-foot deep irrigation (manifold) well 43N/9W-35Q and 79-foot deep irrigation well 42N/9W-2G1 (see Plate 2A), gravels, sands, and clays were encountered. These suggest that the stream channel floodplain deposits to be between these wells at the bedrock outcrop skirted by East Side Road.

No lithologs are available for the Shell Gulch area. The lack of wells suggests that subsurface sediment conditions probably approximate those in the vicinity of Hurds Gulch.

In the Heartstrand Gulch area stream channel-floodplain deposits extend to in excess of one-half mile east of the present course of the Scott River in accordance with the litholog for irrigation well 42N/9W-23J (see Plate 2A). At this well, there is a surficial 6-foot clay layer that is underlain by a sequence of sand and gravel to a depth about 76 feet. Below that 76-foot depth, there is an interval of interlayered sand and gravel to a total depth of 110 feet. Perforated casing data and groundwater production at this well suggest that the sands and gravels are highly permeable. Therefore, these could be attributable to stream channel and/or floodplain deposition.

Upstream from Horne Lane to McConaughy Gulch, the eastern extent of the stream channel deposits would appear to be approximately midway between the present course of the river and the exposed bedrock. The lack of irrigation wells in McConaughy Gulch suggests that the permeability of those sediments is too low to produce appreciable amounts of groundwater.

West of the river and upstream from Horne Lane, available litholog data similarly indicate that the occurrence of waterbearing deposits approximates the halfway distance to the exposed bedrock. At irrigation well 41N/9W-2E (see Plate 2A), the sediments consist primarily of sand and gravel with relatively thin clay interlayers to a depth of 94 feet. However, at irrigation well 41N/9W-11F (see Plate 2A) which is within 1,000 feet west of the present river channel, cemented gravel (Qoal?) was encountered at a 12-foot depth below a surficial layer of boulders. The cemented gravel was found to be interbedded principally with clays to bedrock at a depth of 127 feet. Based on specific capacity data, the permeability of these materials are estimated to be less than 300 gpd/ft^2 which is not representative of the more permeable stream channel deposits. Therefore, it would not be expected that long-term pumpage at this well would induce detectable streamflow losses or adversely influence underflow in this area.

The 12-foot boulder depth penetrated at well 4N/9W-11F is significant because it has been reported in WSP 1462 that river gravels within Section 1, T40N, R9W were found to be only 12 feet thick.

Lithologs for three unlocated wells drilled within Section 24, T41N, R9W, show that as much as 65 feet of sediments, consisting principally of sand, silt and cobbles, were penetrated before encountering bedrock. However, estimates based on specific capacity data obtained at those wells indicate that the permeability values for sediments ranges between 100 and 300 gpd/ft^2. It is then evident that the hydraulic characteristics of the local alluvium would not allow the extraction of large volumes of groundwater to significantly affect underflow of the river in the immediate area.

In view of the foregoing, it can be reasoned that groundwater pumpage cannot detectably reduce river flows upstream from Section 11, T41N, R9W, and possibly along the remainder of the river canyon to as far north as the vicinity of Horne Lane.

Well tests results obtained by drillers suggest that groundwater withdrawals from the floodplain-stream channel deposits, in the vicinity of Fort Jones, induce Moffett Creek streamflow infiltration. These sediments are unconfined and are at least 75 feet thick at community well 43N/9W-2B. Long-term intense pumpage at this well probably could diminish the duration of the seasonal flows within the nearby reach of Moffett Creek.

Upstream from well -2B, the litholog for well 44N/9W-36G shows that gravel is 20 to 32 feet thick. Although this gravel is overlain by a 20-foot thick sequence of clay and gravel, the driller's tests suggest that groundwater extractions at this well could conceivably affect the seasonal intermittent flows of the local stream system.

East of the confluence with McAdam Creek, groundwater extractions from the stream channel deposits would similarly affect the seasonal Moffett Creek flows. At irrigation wells 44N/8W-30P, -30R, and -33B (see Plate 2C), groundwater in the sands and gravels would be in hydraulic continuity with local streamflow despite the local occurrence of interlayered clays. However, the restricted physical extent of these deposits does not allow for the storage or transmission of large quantities of groundwater. Also, there is an apparent decrease in the permeability of the alluvial deposits eastward of McAdam Creek. Specific capacity data obtained at well 44N/8W-33B suggest that the permeability of the locally 55-foot thick stream channel deposit to be in the range of 250 gpd/ft^2.

Domestic well 44N/8W-29M and irrigation well 44N/8W-33M have lithologs that indicate the thickness of alluvial fan deposits along Moffett Creek to be as much as 85 feet thick. These sediments evidently contain a greater percentage of fine-grained materials than the stream channel deposits. Consequently, it is reasonable to assume that these fan deposits are less permeable than the Moffett Creek channel deposits upgradient from the confluence with McAdam Creek.

Litholog information within the McAdam Creek drainage is very limited and no specific capacity tests have been conducted to estimate the hydraulic characteristics of the alluvial deposits. Depth to bedrock is 65 feet at domestic well 44N/9W-24P which is adjacent to the creek. At this well, the sediments are predominantly clay and gravel. Similar clay and gravel or sand and clay to a depth of 68 feet was penetrated at domestic well 44N/9W-25G. Domestic well 44N/9W-12 (unlocated) also was drilled through brown clay and rock to a depth of about 35 feet where bedrock was encountered.

In view of the foregoing lithologic information and permeability estimates, there is no evidence which suggest that groundwater extractions upstream from the confluence of Moffett and McAdam Creeks could adversely affect seasonal surface runoff. However, downstream from this confluence, it is evident that intense pumpage could probably cause a more frequent diminution of Moffett Creek stream runoff and/or underflow to the Scott River.

Downstream from Fort Jones the subsurface configuration of the stream channel-floodplain deposits is not fully known. Irrigation well 43N/9W-2M evidently produces from the gravel encountered from 12 to 57 feet in depth. The estimated permeability value of about 500 gpd/ft^2, which is considerably lower than those for the stream channel-floodplain deposits in upstream areas suggests an increase in fine-grained material content within the gravel shown on the litholog. However, despite the surficial and potentially confining 12-foot thick clay, the gravel would be in hydraulic continuity with stream channel-floodplain deposits that transmit river underflow. Also, even though drilling at this well was terminated within clay and gravel at a 60-foot depth, it appears that the maximum sediment thickness would be approximately 150 feet in the immediate vicinity. Except for domestic wells 44N/10W-35B and irrigation well -27G near the downstream extremity of the valley, there are no other wells west of Fort Jones that have lithologs showing the character and thickness of the stream channel and floodplain

deposits. Approximately 52 feet of sediments, consisting primarily of fine gravel and sand, were penetrated at well -35B. The bedrock depth at well -27G is 34 feet and the overlying sediments that were penetrated consist predominantly of gravel with relatively thin clay interlayers.

The remaining wells with lithologs in this northwestern portion of the valley are those located along Scott River Road. From east to west, noteworthy are wells 44/9W-28R, -28N, -29E, and -30J. One hundred feet of alluvium at Indian Creek was penetrated at irrigation well -28R without encountering bedrock. Extracted groundwater is from sand and gravel that has an estimated permeability of about 800 gpd/ft^2. Even though these sediments probably extend downslope toward the more permeable stream channel deposits, the relative topographic location and depth of this well suggests that local pumpage would be primarily intercepting Indian Creek underflow and would not directly affect Scott River flow.

Well -28N, located at the mouth of Rattlesnake Creek is the deepest known well in the valley that has a litholog. Its total drilled depth into bedrock is 243 feet of which the upper 218 feet are alluvial materials. The sediments are comprised mainly of gravel with some sand and clay interlayers. Two cemented gravel (Qoal?) layers (35 feet and 40 feet thick, respectively) indicate that the estimated permeability 175 gpd/ft^2 is representative primarily of those materials below the 30-foot depth. Although this "test" well had not been in use through late 1974, anticipated long-term extractions in this area would be supplied principally from water that develops within Rattlesnake Creek watershed. Pumpage at this well cannot directly cause inducement of river flow infiltration.

During the drilling of irrigation wells -29E and -30J, the materials penetrated were similar to those at well -28N. The respective drilled depths were 112 and 147 feet. At well -30J, bedrock was reached at a 141-foot depth. The estimated permeability values for the sediments at both wells is about 135 gpd/ft^2. This approximate permeability indicates that pumpage at this well cannot directly affect Scott River flows. Recharge to these wells is primarily from Tyler Gulch underflow.

By projecting the protruding hill in the NE corner of Section 30 to that on the south in the NE corner of Section 31, the bedrock depth a well -30J suggests that there is a buried bedrock (greenstone) ridge. In view of ground surface elevations adjacent to the river along this buried ridge, the approximate alluvial depth beneath the present course of the river should be less than 40 feet. Assuming that the groundwater hydraulic gradient is essentially constant at about 15 feet per mile in this area (see Plate 1 of WSP 1462), based on Darcy's equation where the underflow $Q = PIA$, then maximum underflow would be about 50 cfs.

HYDROLOGY

Where subsurface waterbearing sediments are in hydraulic connection with significantly permeable deposits underlying or adjacent to surface streams, infiltration of runoff can be induced by pumpage at wells when groundwater levels are lowered to below those of stream levels. To evaluate streamflow infiltration or runoff dimunution due to groundwater extractions, it is necessary to obtain detailed geologic and hydrologic data. These would include specific information such as the: (1) thickness, lateral extent, and horizontal permeability of the waterbearing materials (aquifer), (2) vertical permeability of the streambed materials which may be part of the aquifer, (3) distance between groundwater extraction well(s) and area of streambed infiltration, (4) impediment(s) to flow within or adjacent to the aquifer, (5) available groundwater in storage within the aquifer (6) groundwater level(s) in the aquifer (7) saturated thickness reduction in the aquifer due to groundwater withdrawals, (8) range of stream stages and heads, and (9) local subsurface hydraulic gradients.

Based on the readily available information, the following is an assessment of the groundwater hydrology in Scott Valley as it relates to streamflow of the Scott River.

Groundwater Occurrence

In Scott Valley, the main source of groundwater is the stream channel and floodplain deposits that are beneath and contiguous to the course of the Scott River where groundwater is normally found within ten feet below ground surface. Generally, the most permeable and productive deposits underlie the area between Horne Lane, which is east of Etna to approximately the north-eastern periphery of Chaparral Hill. It is evident that the Moffett Creek stream channel deposits in the vicinity of Fort Jones are hydraulically continuous with those of the Scott River. Beneath the boulder layer sequence upstream from Horne Lane, the alluvium predominantly consists of "cemented gravels" and clay (well 41N/9W-11F) which generally have estimated permeabilities of 300 gpd/ft^2 or less. These permeabilities and local aquifer boundary conditions caused by the valley bedrock walls are apparently unsuitable for long-term sustained yields at wells for irrigation purposes.

Downstream from the Scott River-Moffett Creek confluence, the physical and hydraulic characteristics of the stream channel-floodplain deposits remain virtually unknown. However, the surficial alluvial fan remnant in the vicinity of Meamber Bridge indicates that the lateral extent of the more permeable river-deposited sediments would be essentially restricted to near the present stream course.

The most permeable sediments along the western margin of the valley are those deposited in the fanhead areas by Etna, Patterson (west), and Kidder Creeks. Surficial evidence and sparse well data indicate that groundwater can readily

infiltrate and percolate through the coarse-grained sediments in the upper reaches of the streambeds. Consequent water table underflow from the fanhead-streambed area migrates in a fan-like manner to the areas where fine-grained materials predominate. In the fine-grained extremities of the alluvial fans, subsurface fluid transmission capacity is more restricted than in the fanhead areas. There, groundwater discharges to the surface to form a marsh-like area. Furthermore, interfingering of coarse and fine layers cause seasonal artesian flows in portions of the alluvial fan as demonstrated by wells 42N/9W-4P1, -4Q1, and -21A1, and 43N/9W-33G1. The eastern extent of the artesian areas is transitional with the water table conditions within the western margin of the area underlain by the Scott River stream channel and floodplain deposits.

Oro Fino Creek area alluvium consists primarily of clays that contain laterally discontinuous coarse materials possibly derived from nearby Chaparral and Quartz Hills as slope wash. These materials, which also appear to be related to Kidder Creek alluvial fan deposition, are insufficient to supply irrigation wells. However, these materials are seasonally fully saturated to allow for collection of subsurface water at excavated sumps that is used for irrigation purposes.

Alluvium within the lateral tributaries east of the Scott River transmit groundwater that infiltrates principally along the intermittent streambeds. However, the permeability of this alluvium is low and generally provides only sufficient quantities of groundwater for domestic purposes. Limited litholog data indicate that groundwater conditions within Hamlin Gulch vary from unconfined in the upslope vicinity of well 43N/8W-17G to semiconfined and/or confined in the downslope area that approximates the eastern margin of the Scott River floodplain in the vicinity of wells 43N/9W-24F1 and -24F2.

In the Moffett Creek and McAdam Creek drainage system, unconfined groundwater occurs within moderately permeable stream channel deposits. Alluvial fan materials in the minor lateral tributaries to these creeks have permeabilities too low for production of significant amounts of groundwater at wells.

West of Fort Jones, alluvium within the lateral tributaries such as Indian, Rattlesnake, and Patterson (north) Creeks are incapable of storing sufficient groundwater to supply irrigation wells. Limited data indicate that sediments below the water table along Scott River Road have moderate permeabilities. Upslope from the valley margin, these materials are probably more permeable, but subsurface bedrock conditions restrict the storage capacity and negate sustained groundwater extractions at wells for irrigation purposes.

Groundwater Recharge, Movement, and Discharge

Groundwater recharge to the alluvium is due to direct infiltration of precipitation and percolation of surface runoff into the valley alluvium. There is probable subsurface recharge of the alluvium by water transmitted through bedrock openings primarily in the lateral tributary areas. Also, significant recharge results from infiltration losses from conveyance ditches

and deep percolation of irrigation waters. It is evident that the major source of continous recharge into stream channel and floodplain deposits between Etna and Fort Jones is due underflow and surface runoff that originates upstream from Horne Lane. This northward groundwater movement is supplemented mainly by underflow associated with runoff from the western tributaries. Subsurface recharge from the west is sustained groundwater released from storage by the fan sediments of lesser permeability during periods of low flow within the Scott River.

The general physical characteristics of the alluvium within the eastern lateral tributaries suggests that underflow contribution is relatively minor from that portion of the valley to the stream channel-floodplain deposits of the river. The only other significant source of underflow to these deposits during low river stages could be that from Moffett Creek. From Fort Jones downgradient to Meamber Bridge, subsurface inflow from the lateral tributaries to westerly river underflow seems to be minor in comparison to that which is more readily provided from upstream sources.

Groundwater hydraulic gradients reflect the premeability of the underlying materials and generally conform with the local ground surface slopes in some areas. Prevailing hydraulic gradients between the given locations are estimated to be as follows (in the direction of flow): (1) McConaughy Gulch to Horne Lane, 10 feet per mile; (2) Horne Lane to Ellen Lane, 7 feet per mile; (3) Ellen Lane to Fort Jones, 4 feet per mile; and (4) Fort Jones to Meamber Bridge, 10 feet per mile.

Based on available data, estimates of subsurface inflow and outflow through the stream channel deposits could be made at Horne Lane and Meamber Bridge. By applying Darcy's equation which can be expressed as $Q = PIA$, where Q is the underflow, P is the coefficient of permeability of the waterbearing sediments, I is the local hydraulic gradient, and A is the vertical cross-sectional area through which there is underflow. The maximum saturated sediment thickness that can be reasonably expected at both locations is about 100 feet and the sediment width approximately 3,000 feet at Horne Lane and 2,000 feet at Meamber Bridge. An applicable permeability value at Horne Lane would be about 300 gpd/ft^2 and the stream channel deposits would have permeabilities in the range of 600 gpd/ft^2 in the vicinity of Meamber Bridge. Based on the above assumptions, maximum underflow into Scott Valley at Horne Lane can be about 10 cubic feet per second (cfs) and subsurface outflow approximates 20 cfs at Meamber Bridge.

Groundwater Level Fluctuations

There are several wells at which groundwater level measurements have been obtained since the early 1950's. Two of these, wells 43N/9W-23F1 and -24F1 are known to withdraw subsurface water from stream channel-floodplain deposits and, therefore, are in hydraulic continuity with river flows. At both wells, water level fluctuations have been a maximum of about 10 feet between early spring and late summer. The sediments that are dewatered at

each well during the pumping season, is fully recharged during the ensuant wet season.

Because the relative elevation of the lowest groundwater levels have remained above that of the local reach of the low stage streamflow or streambed, it appears that river flow infiltration has not been induced by pumpage at these wells. As long as the hydraulic gradients remain downward toward the river, this stream will continue to be gaining during the summer months prior to the seasonally wet period. The reason for the prevailing stream gains is that there is sufficient hydraulic head and groundwater in storage to provide lateral inflows to the river during the low stream stage periods.

Similar hydraulic gradient conditions occur at wells 42N/9W-2A2 and 42N/9W-23J where the local sediments are hydraulically connected with these in the vicinity of the river. Measurements at well -2A2, obtained since 1965, indicate that recharge is sufficient to maintain underflow in the direction of the river. Also, measurements obtained at well -23J since mid-1973 show that pumping water levels generally appear to have remained above the seasonally low stream stage (and streambed) along the nearby river reach. It would appear that groundwater released from storage during pumping is supplemented by percolating irrigation return waters and infiltration losses from the Scott Valley Irrigation District Ditch which is upslope from both wells.

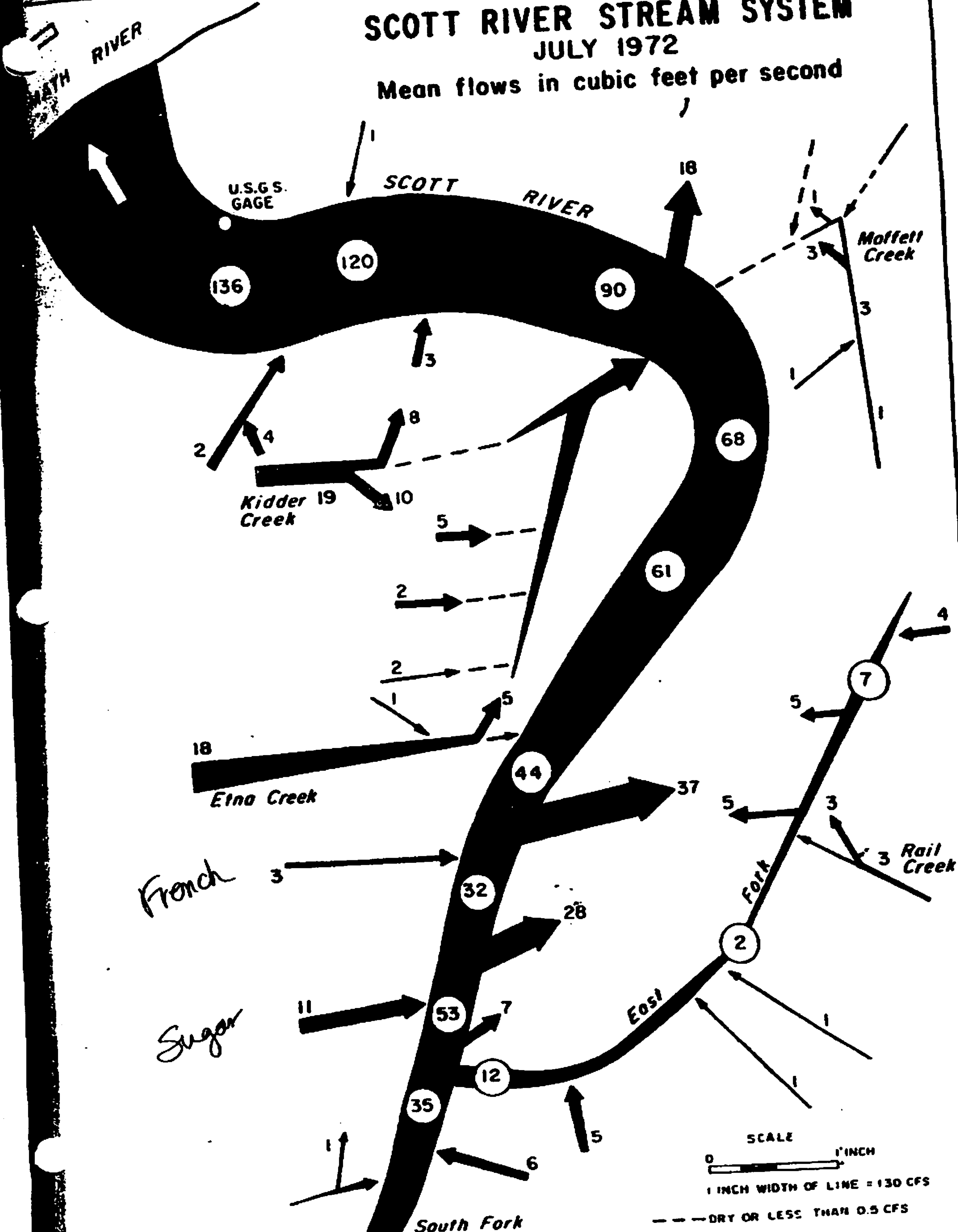
Although there is no definitive groundwater level fluctuation information along other reaches of the river, it is likely that the river continually remains a gaining stream throughout its course within Scott Valley. Thus, it sustains or supplements base flow during low surface inflows to the Etna-Fort Jones reach of the river. There is no other area, underlain by the stream channel floodplain deposits, from which groundwater is as intensely extracted as that between Etna and Fort Jones.

Groundwater Storage Capacity

Pumpage at wells along the axis of the valley, between Etna and Fort Jones, and resultant water levels show that groundwater in storage has not been significantly diminished during the intense pumpage periods. Based on the available data and on technically reasonable assumptions, the storage capacity of the channel and floodplain deposits along the Scott River is about 300,000 acre-feet. This would be from about two miles north McConaughy Gulch to the vicinity of Fort Jones. If it were to become necessary, local pumpage in this area possibly could be used in conjunction with a groundwater management plan to irrigate all usable land and to maintain or supplement desired river runoff during the seasonal low flow periods.

SWRCB (1975)

SCOTT RIVER STREAM SYSTEM
JULY 1972
Mean flows in cubic feet per second



accretion (cfs)	Mean	Max	Min
44-68	66.0	74.3	57
44-44	70.9	79.9	62
44-34	71.0	81	61.1

Exhibit O

S. S. PAPADOPULOS & ASSOCIATES, INC.
Environmental & Water-Resource Consultants

Memorandum

Date: August 27, 2012

From: Deborah L. Hathaway

To: Craig Tucker, Klamath Coordinator, Karuk Tribe

Subject: Stream Depletion Impacts Associated with Pumping from within or beyond the "Interconnected Groundwater" Area as Defined in the 1980 Scott Valley Adjudication

Introduction

This memorandum describes an analysis of stream depletion impacts associated with pumping from two areas within the Scott Valley. One area is that within the zone of "Interconnected Groundwater" as delineated in the 1980 Scott Valley Adjudication. The second area is the area of alluvial fill within the Scott Valley that falls outside of the boundaries of the above-referenced zone. The analysis uses the Scott Valley Groundwater Model prepared by S.S. Papadopulos & Associates, Inc. (July 2012).

Background

The 1980 Scott Valley Adjudication (Decree 30662, Superior Court for Siskiyou County, 1980) provided limits on the development of new groundwater uses within a zone of "Interconnected Groundwater", defined as (Paragraph 4):

> "all ground water so closely and freely connected with the surface flow of the Scott River that any extraction of such ground water causes a reduction in the surface flow in the Scott River prior to the end of a current irrigation season. The surface projection of such interconnected ground water as defined herein is that area adjacent to the Scott River as delineated on the SWRCB map in the reach from the confluence of Clarks Creek and Scott River to Meamber Bridge."

The SWRCB map is later referenced (Paragraph 12) as the map entitled "Scott River Stream System showing Diversions and Irrigated Lands, Siskiyou County, 1979", comprised of 20 sheets.

The "Zone of Interconnected Groundwater" shown on the the 1979 map was initially published by the California State Water Resources Control Board, 1975, in a report entitled "Report on Hydrogeologic Conditions, Scott River Valley". The 1975 report discusses characteristics of valley alluvial materials referencing information on driller's logs, including the driller's description of lithology and specific capacity derived from initial pumping. From this information, the author makes inferences as to where pumping from groundwater might be expected to impact the river within the same season. The author did not make stream depletion calculations or otherwise quantify impacts to support delineation of the "Zone of Interconnected Groundwater". Nor did the author consider the cumulative depletion impact that would result from lagged stream impacts following the cessation of pumping in the non-irrigation season that subsequently accrue in the following irrigation season. While the delineation reflects a qualitative mapping of coarser versus finer alluvial sediments, the process does not support a conclusion that pumping from beyond the zone would not result in a stream depletion impact within the same irrigation season or in future years.

Stream Depletion Analysis of Pumping within and beyond the Adjudication Zone of Interconnected Groundwater

In order to provide a quantitative assessment of stream depletion impacts from pumping within the Scott Valley, both within and beyond the zone of Interconnected Groundwater (Adjudication Zone), two scenarios were evaluated using the Scott Valley Groundwater Model (S.S. Papadopulos & Associates, 2012):

- Stream Depletion Impacts of Irrigation Wells beyond Adjudication Zone
- Stream Depletion Impacts of Irrigation Wells within Adjudication Zone

The runs are based on distribution of irrigation wells to correspond with the location and amount of irrigated acreage as mapped for the year 2000. In structuring a stream depletion simulation, ratios of stream depletion can be derived from any change in pumping quantity. In this case, the amounts selected correspond to the difference between the amount pumped under the Partial Build-Out and the Recent Pumping Level cases described in the Scott Valley Groundwater Model report (S.S. Papadopulos & Associates, Inc., 2012). The stream depletion impact is calculated as the difference in net stream losses/gains between the two simulations, which differ only in the amount of irrigation pumping within the zone of interest. Figures 1 through 4 illustrate the results of this stream depletion analysis.

Figure 1 shows the annual average stream depletion in acre-feet associated with pumping outside of the Adjudication Zone. The simulated, incremental, amount of irrigation pumping between the Partial Build-Out and the Recent Pumping Level case is 8,177 acre-feet per year. Figure 1 shows the depletion to the Scott River and the total depletion to the Scott River and tributaries. In the first season of pumping, the total stream depletion is greater than 25% of the pumped volume; in the second season, the total stream depletion exceeds 75% of the pumped volume. Approximately 60 to 65% of the impact accrues to the Scott River mainstem with the remainder accruing to the tributaries. By the seventh year of pumping, stream depletion impacts are nearly equal to the amount of pumping. Figure 2 shows results of the same simulation expressed in terms of cubic feet per second in the late summer/early fall period. This amount is associated with the incremental simulated pumping of 8,177 acre-feet per year as noted above, averaging about 11.3 cubic feet per second. The impact in the late summer/early fall period approaches 12 cubic feet per second, reflecting the fact that impacts are greater during this season due to the timing of pumping.

These results can be used to characterize the stream depletion as a proportion of pumping for a set of wells that are distributed outside of the Adjudication Zone throughout the existing irrigated areas. The stream depletion from any specific well will vary, some being higher and some being lower than the composite, or average, effect shown on Figure 1 and 2 for all wells beyond the Adjudication Zone. Generally speaking, these results can be extended to other pumping amounts by scaling the impact according to the change in pumping, assuming that the spatial and temporal distribution of pumping remains the same. For example, if pumping were to increase or decrease by 20% from the quantity simulated here, the impacts would correspondingly increase or decrease by 20%.

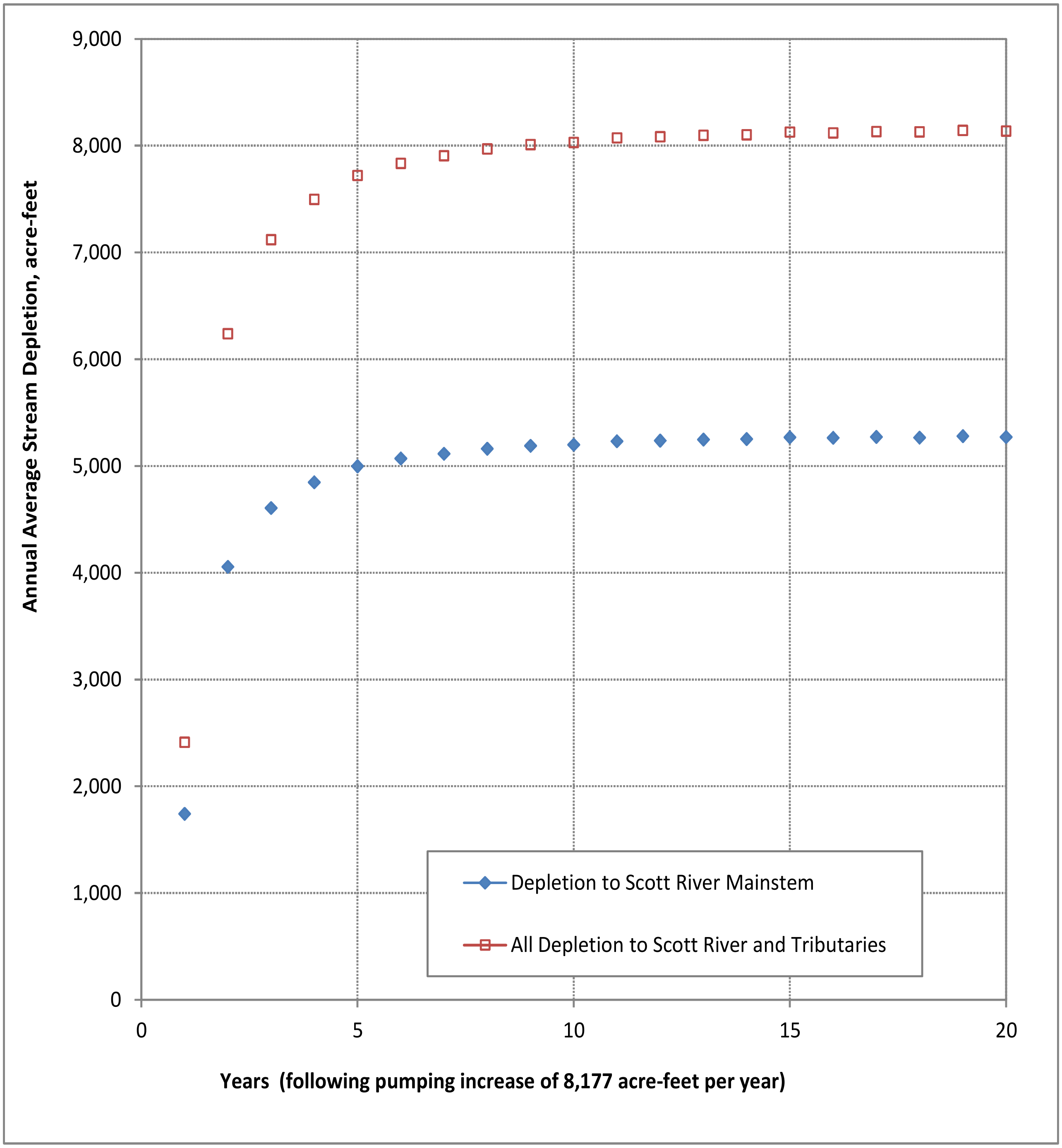
Figures 3 and 4 show stream depletion impacts for pumping within the Adjudication Zone. In these cases, the change in pumping (corresponding to the difference between the Partial Buildout and Recent Condition cases) is simulated as 4,348 acre-feet per year. As would be expected, pumping from within the Adjudication Zone has a more rapid impact on the Scott River and tributaries due to the coarser sediments and the closer proximity to the streams. The stream depletion impact is about 45% of pumping within the first year and rapidly increases, being nearly equal to the pumping amount within a period of 3 to 4 years. Approximately 80% of the depletion impact accrues to the Scott River mainstem with the remainder accruing to the tributaries.

<u>Summary</u>

This quantitative analysis of stream depletion impacts from pumping groundwater within and beyond the Adjudication Zone using the Scott Valley Groundwater Model illustrates the proportion of pumping that can be expected to impact the streams over a multi-year period under average seasonal conditions. The seasonal conditions include winter and spring recharge, mountain-front recharge, recharge from irrigation percolation and groundwater pumping to supplement surface water in meeting crop demand.

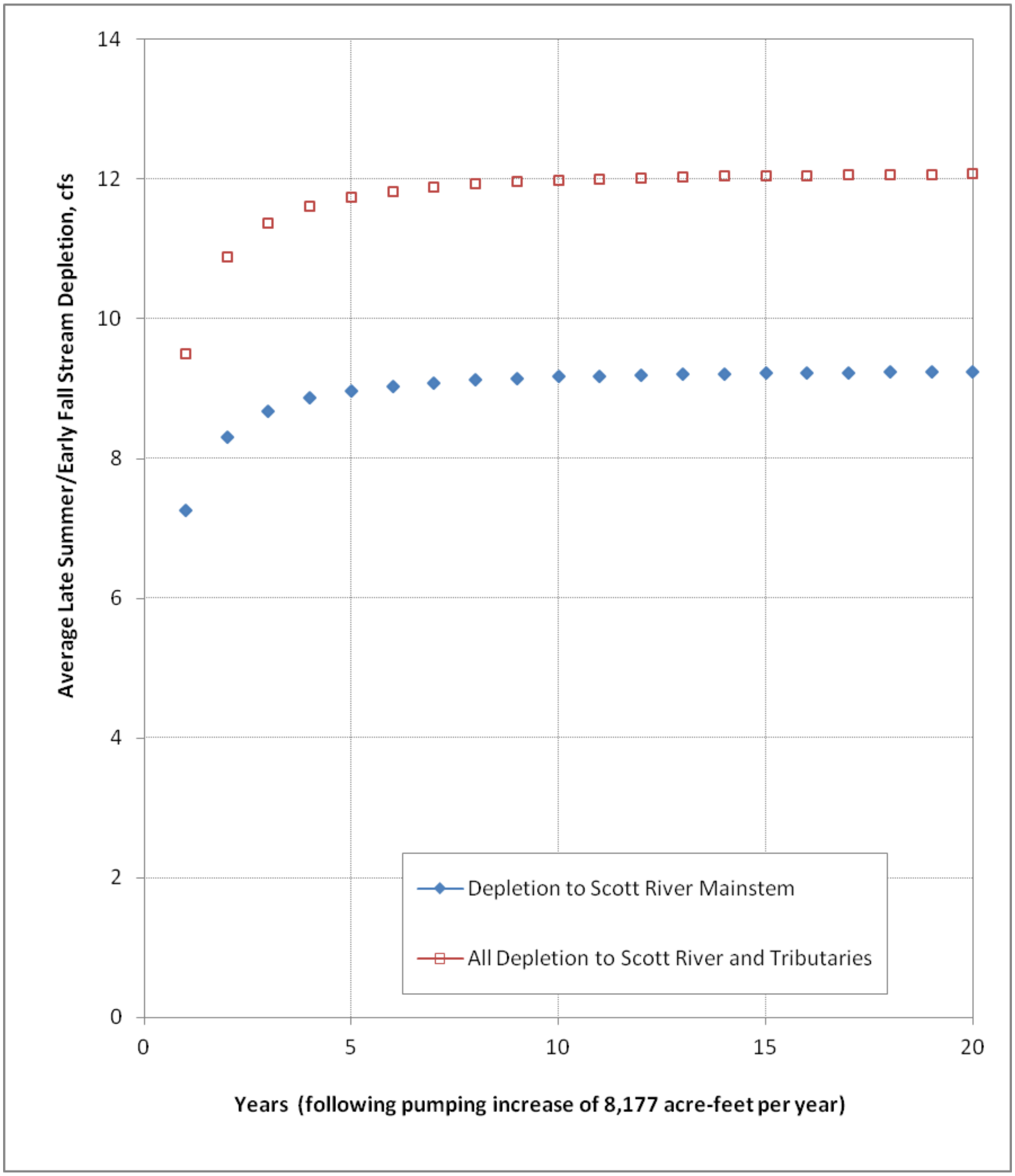
Figures 1 through 4 illustrate the stream depletion impacts from distributed pumping from within and beyond the Adjudication Zone. In both cases, stream depletion impacts are evident within the first season of pumping and increase thereafter. Pumping from within the Adjudication Zone rapidly reaches a steady-state condition with nearly all pumping offset by impacts to the flow in streams within a matter of 3 to 4 years. Approximately 80% of the depletion impact accrues to the Scott River mainstem with the remainder accruing to the tributaries. Pumping from beyond the Adjudication Zone also impacts the Scott River and tributaries, with a higher proportion of impacts accruing to tributaries than as seen for pumping from within the Adjudication Zone. Approximately 60-65% of the impact accrues to the Scott River mainstem with the remainder accruing to the tributaries.

The results indicate that the Adjudication Zone as defined in 1975 is too narrowly drawn to meet the objective of identifying areas wherein pumping would have the effect of reducing surface water flows within the same irrigation season. Furthermore, the results indicate that despite the cessation of pumping during the non-irrigation season and the occurrence of recharge, that stream depletion impacts continue to accumulate over time and have the potential for significantly higher impacts than are seen within the first or same season of pumping.



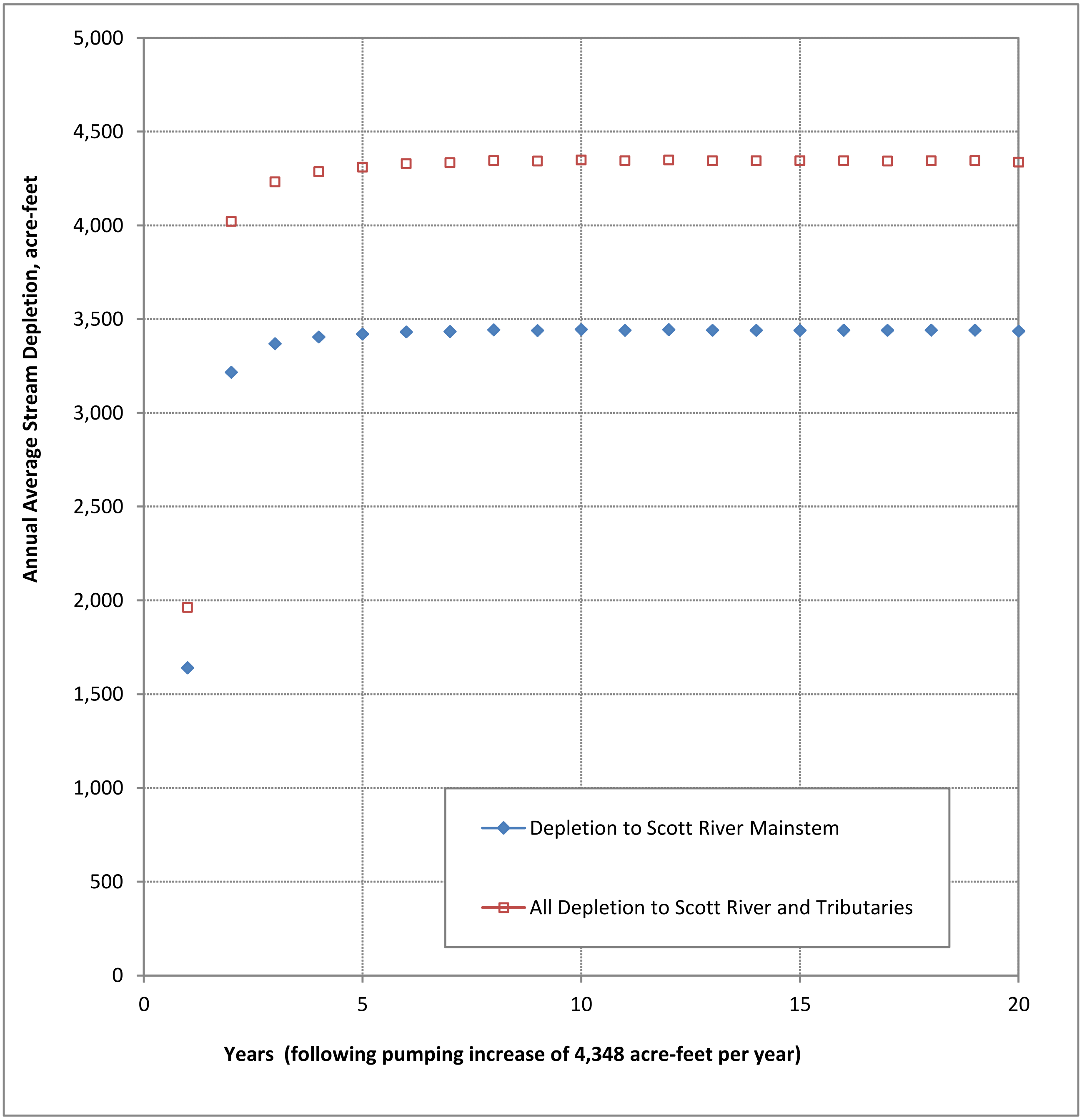
Note: The net increase in pumping is simulated as occurring as a single step; the resulting depletion curve can be used to identify lagged depletion impacts from a gradual change in pumping.

Figure 1. Stream Depletion Impact to Scott River and Tributaries from Increased Groundwater Use, Outside of Adjudication (1980) Interconnected Groundwater Zone



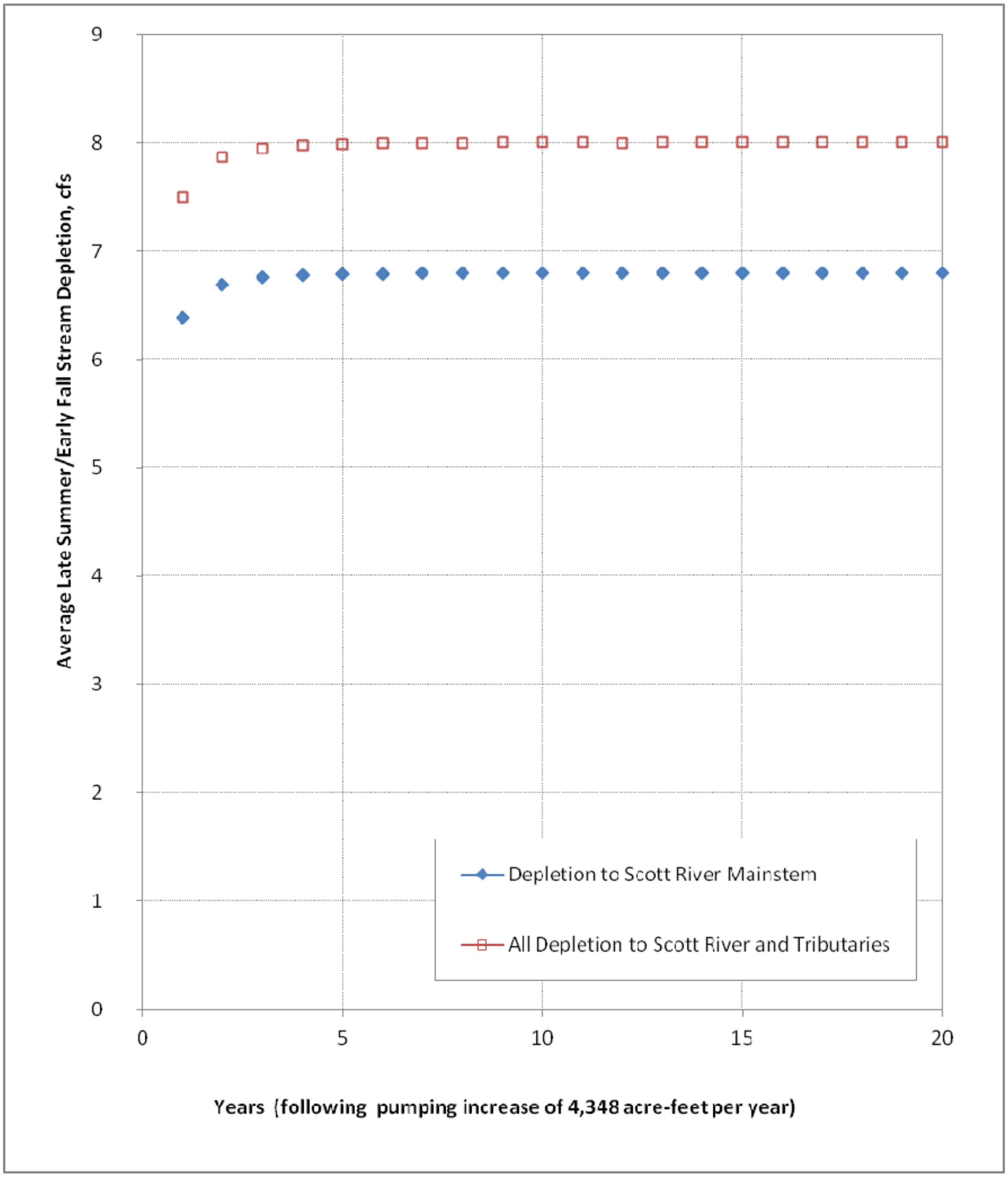
Note: The net increase in pumping is simulated as occurring as a single step; the resulting depletion curve can be used to identify lagged depletion impacts from a gradual change in pumping

Figure 2. Late Summer/Early Fall Stream Depletion Impact to Scott River and Tributaries from Increased Groundwater Use, Outside of Adjudication (1980) Interconnected Groundwater Zone



Note: The net increase in pumping is simulated as occurring as a single step; the resulting depletion curve can be used to identify lagged depletion impacts from a gradual change in pumping.

Figure 3. Stream Depletion Impact to Scott River and Tributaries from Increased Groundwater Use, Inside of Adjudication (1980) Interconnected Groundwater Zone



Note: The net increase in pumping is simulated as occurring as a single step; the resulting depletion curve can be used to identify lagged depletion impacts from a gradual change in pumping

Figure 4. Late Summer/Early Fall Stream Depletion Impact to Scott River and Tributaries from Increased Groundwater Use, Inside of Adjudication (1980) Interconnected Groundwater Zone

Exhibit P

State Water Resources Control Board

June 19, 2020

«Property_Owner»
«Address_Line_2»
«Address_Line_3»

IN REGARDS TO JUNIOR WATER RIGHT(S)(DIVERSION NUMBER- -MAP NUMBER-SCHEDULE); «Water_Right_ID» AS SPECIFIED IN THE SCOTT RIVER ADJUDICATION IN THE SCOTT RIVER WATERSHED

NOTICE OF UNAVAILABILITY OF WATER

FOR DIVERTERS WITH A JUNIOR PRIORITY CLASS RIGHT IN THE SCOTT RIVER WATERSHED SUBJECT TO DECREE NO. 30662

Unavailability of Water for Junior Class Water Rights:
Due to limited precipitation and snowpack, current Scott River flows are insufficient to satisfy demands under senior rights. State Water Resources Control Board (State Water Board) records show you hold a junior priority class right identified in the Scott River Adjudication Decree No. 30662 (Decree) as either: (1) a Priority 2 Class Right in Schedule D-4 of the Decree, (2) a Post-1914 Appropriative Right in Schedule E of the Decree, or (3) a Surplus Class right[1].

This notice is being issued to ensure that diverters with a junior priority class right: (a) are aware of the declining flow conditions of the river; (b) have reliable information regarding the amount of water available for their priority of right; and (c) understand that even though water may be physically available at their location, that water should only be diverted and used under a senior priority class rights. During or following significant rainfall events, State Water Board staff will use an email notification system to notify you if water becomes available for junior priority class rights. You can subscribe to receive email updates about these notices by subscribing to the Water Rights "Scott River Notices" at:
http://www.waterboards.ca.gov/resources/email_subscriptions/swrcb_subscribe.shtml.

Water Unavailability Information Form Request:
We request that you complete a Water Unavailability Certification Form (Form) to advise State Water Board staff of the adjudicated water rights you divert under, whether you are diverting water under other priority class rights, and if/when you stopped diverting under junior rights. Your timely response helps us better manage limited water supplies and staff resources.

[1] You may also have interest in a senior priority class right of the Decree. If so, this notice applies only to the junior portion of your rights, and not to the senior priority class rights.

To submit the form to the State Water Board either:

1. Fill out and mail or email the enclosed form to the State Water Board (further instructions are on the enclosed form)
2. Or, if you would rather fill out an online form and you report your water usage to the State Water Board
    a. Visit: https://public.waterboards.ca.gov/infoorder
    b. Login using the Water Right ID and Password you use to submit your annual water diversion and use reports
    c. Complete the Scott River Water Unavailability Certification Form

Potential Enforcement Upon Finding of Unauthorized Diversion:
Diversion of water beyond what is authorized by the Decree may subject you to administrative fines, cease and desist orders, or prosecution in court. The State Water Board may levy fines of $500 per day of violation. (See Water Code, §§ 1052, 1055.)

If you have any questions, please call Alex Sweat at (916) 319-0724, or contact him by email at:alexander.sweat@waterboards.ca.gov.

Sincerely,

Erik Ekdahl
Deputy Director, Division of Water Rights
State Water Resource Control Board

cc:

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Klamath National Forest
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Yreka, CA 96097-9518

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ec:

Michael Lauffer
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