Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix A

Mad River Environment

Overview of the Mad River

The Mad River is one of the many river systems in the Evolutionary Significant Units (ESU), which have been listed under the ESA. However, its contribution to the overall abundance of listed species is limited by natural constraints.

The Mad River watershed drains an area of approximately 500 square miles; the basin is 100 miles in length, averages six miles wide, and is bounded by parallel ridges of the Coast Range. Ridge elevations are 3,000 feet on the west and 5,000 feet on the east; water flows northwest from the headwaters in Trinity County to the river's mouth northwest of Arcata in Humboldt County.

Geomorphically, and for purposes of anadromous salmonid distribution, the Mad River can be stratified into four distinct zones. (Refer to Figure 1 in the HCP main body). Anadromous salmonids fully occupy the estuary and lower river zone and its tributaries up to River Mile (RM) 34; the middle river zone from RM 34 to 61 can be characterized as a geologically unstable and steep (between Wilson Creek RM 45.5 and Bug Creek RM 49, the river drops 600 feet in elevation). In the middle river zone, depending on local conditions and flow, the boulder canyon contains barriers at RM 45, 49, and 53. These barriers prevent anadromous salmonid migration to the upper river zone, which starts above RM 61. Under natural conditions, this zone often had no flow in August or September.

Six tributaries of the Mad River are fish-producing streams:
(Refer to Figure 1 in main body of HCP)

- RM 10.8 Lindsay Creek, drainage area 17 square miles;
- RM 14.8 North Fork, drainage area 50 square miles;
- RM 20.6 Canon Creek, drainage area 16 square miles;
- RM 32.1 Maple Creek, drainage area 17 square miles;
- RM 33.4 Boulder Creek, drainage area 19 square miles;
- RM 60.7 Pilot Creek, drainage area 40 square miles
  (This creek is accessible to steelhead only if barriers below on the Mad River are passable).

The watershed's precipitation is affected by its proximity to the Pacific Ocean and its altitude, with annual average precipitation of 40 inches in the lower zone, and an average of 80 inches in the middle zone. Snow is common above 4,000 feet on the eastern ridgeline, with average annual snowfall of one to five feet. The Mad River has two distinct seasons (dry and wet), and from June through October, coastal fog moderates ambient air and water temperatures in the lower zone. (See Figure 1, Isothetyal Map)

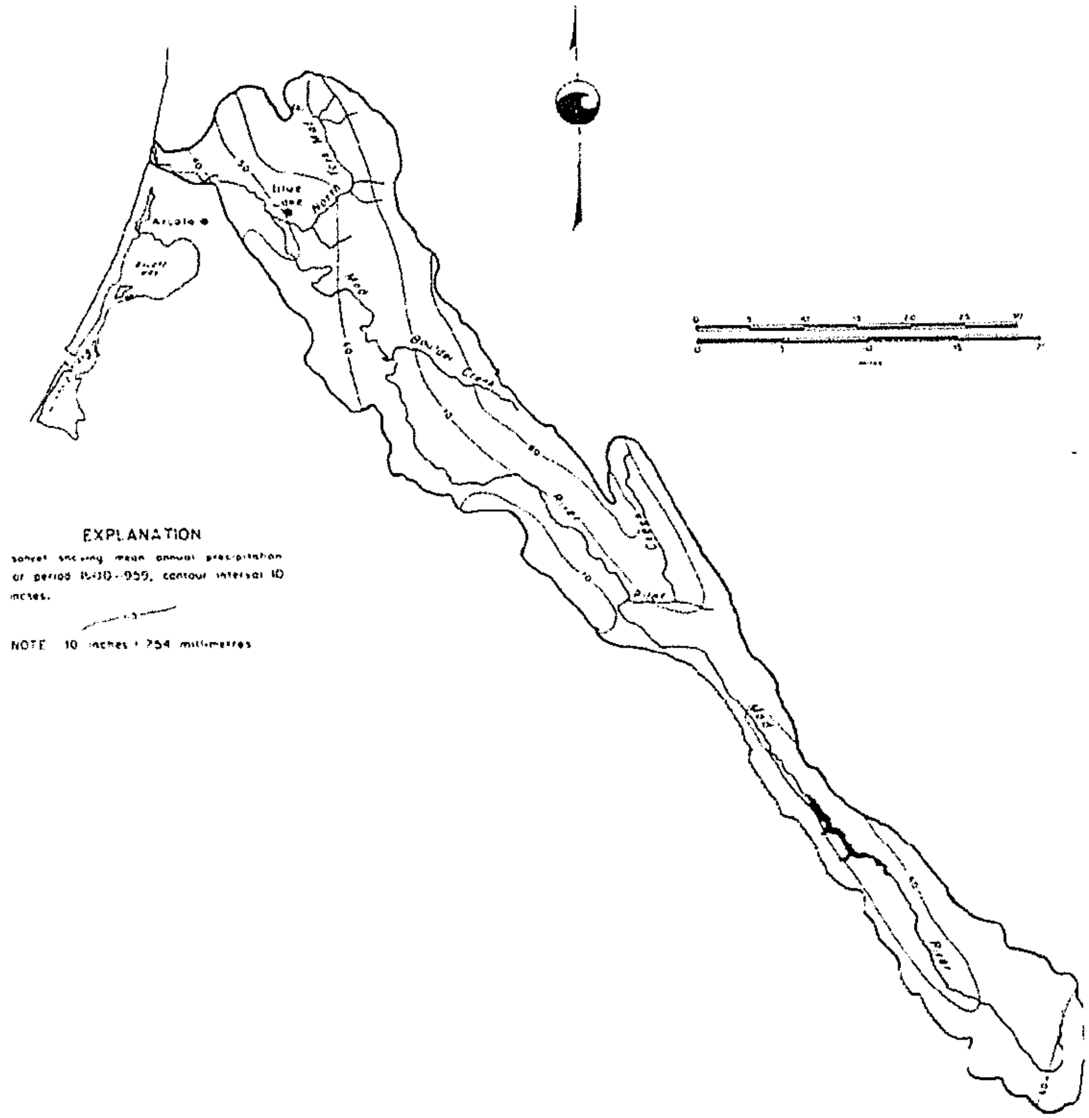

Figure 1 Isothetyal map of the Mad River basin (Department of Water Resources, 1982).

The annual average water yield from the Mad River is approximately 1 million-acre feet. Natural flow in the Mad River varies greatly; eighty-five percent of the water yield or discharge occurs from November through March. Severe storms periodically cause wide spread flooding and channel adjustments.

Historically, the lower Mad River would flood through multiple floodplain/slough channels to Humboldt Bay. As a result, the Mad River infrequently flushed its estuary of accumulated sediments, and according to historical accounts from 1870 to 1915, the mouth of the Mad River was often closed during the low flow period of October, November, December. Local fishermen would artificially breach the sand bar, primarily to allow salmon to migrate into the river. Since the early 1900s, the lower Mad River has been channelized and straightened; its overflow channels have been sealed, its banks armored, and now most moderate floods remain confined in the lower Mad River channel (Scalici 1993). Degradation of the lower Mad River is one consequence of concentrating flood flows in the main channel. Also, its tidal prism and estuary have expanded, and currently the lower 4.4 miles of the Mad River, up to Highway 101, are tidally influenced. From 1975 to 1998, the mouth of the Mad River migrated north along the coastal bluffs, greatly elongating its estuary area, but in 1998, the mouth began to return south, reducing its estuary area. The estuary and the tidal portion of the Mad River lack adjoining tidelands or tidal sloughs, which serve as important rearing habitat for anadromous salmonids, particularly for chinook salmon.

Under natural conditions, the Mad River was perennial up to the confluence with Pilot Creek (RM 61), but above this point, flow was intermittent particularly in August and September. The eastern slope in the middle zone receives the greatest amount of precipitation (annual average of 80 inches) which greatly affects the Mad River's aquatic environment. The middle zone is predominately composed of Francisican Melange, and the combination of high precipitation and very unstable slopes results in the zone contributing high volumes of sediment in the Mad River. Erosion of the riverbed and bank, and the transport of suspended sediment, occurs during bankfull discharges. In the middle zone, high flows erode the toes of slides leading to continual upslope failures, which convey more sediment and boulders to the channel below. These landslides have extended from the river to the ridgeline, encompassing several hundred acres. The boulder reach near Bug Creek is an example of these conditions, which create barriers to salmonid migration.

Figure 2 – Bug Creek Barrier

Suspended sediment is a significant water quality issue in the Mad River, which has been listed by the Environmental Protection Agency as sediment (turbidity) impaired. The Mad River basin is one of several in northern coastal California, where suspended sediment is of 5 to 50 times that of comparably sized streams in the United States.

The quality and availability of coho and chinook rearing habitat in the mainstem or in the estuary is poor or lacking entirely. The boulder-cobble middle zone of the main stem and the tributaries, provide higher quality steelhead rearing habitat. Of the six major tributaries and the main stem, Lindsay Creek is the primary spawning and rearing habitat for coho and coastal cutthroat trout.

In summary, the environmental conditions which have affected the distribution and abundance of Mad River anadromous salmonids are as follows:

- Historically, the mouth closed during low flow conditions. Presently, the mouth remains open, although adults migrating upriver still wait for the first fall freshets to enter the river.
- Historically, the lower 61 miles of the river were naturally perennial; the reaches above RM 61 were naturally intermittent.
- The estuary and tidal reach of the river exhibit limited structural diversity such as adjoining tidelands or tidal sloughs. Valuable rearing habitat is limited, particularly for chinook juveniles.
- The mainstem also exhibits limited structural diversity which is normally provided by large woody debris, and as a result, rearing habitat is limited.
- The middle zone (RM 34-61) is a major source of sediment that affects the quality of aquatic habitat down river.
- Natural barriers exist which prevent anadromous salmonid migration to the upper river zone. Only the lower 45 to 53 miles of the mainstem are accessible to adult coho and chinook salmonids migrating upriver. Steelhead occasionally spawn in the upper zone if flow conditions and the boulder reach configuration are conducive.
- The quality and availability of coho and chinook rearing habitat in the mainstem or in the estuary is poor or lacking entirely. The boulder-cobble middle zone of the main stem and the tributaries provide higher quality steelhead rearing habitat. The primary tributaries are also limited in the amount of habitat they provide. Lindsay Creek is the primary spawning and rearing area for coho salmon and coastal cutthroat trout.

Overview of Essex Reach

The District's diversions, infrastructure, and maintenance activities are concentrated in the Essex reach of the lower Mad River; therefore, this reach is described in greater detail.

The District's diversion facilities are located in the Essex reach of the Mad River. This reach, from RM 8.8 to 10.7, is a low gradient, confined segment of the Mad River. Typical of lower river reaches with low gradients, pools dominate the Essex reach with an abundance of fine sediment and few riffles. The Essex reach area is composed of 64% pools, 11% riffles, 22% runs or glides and 3% backwater pools. (Figure 3).

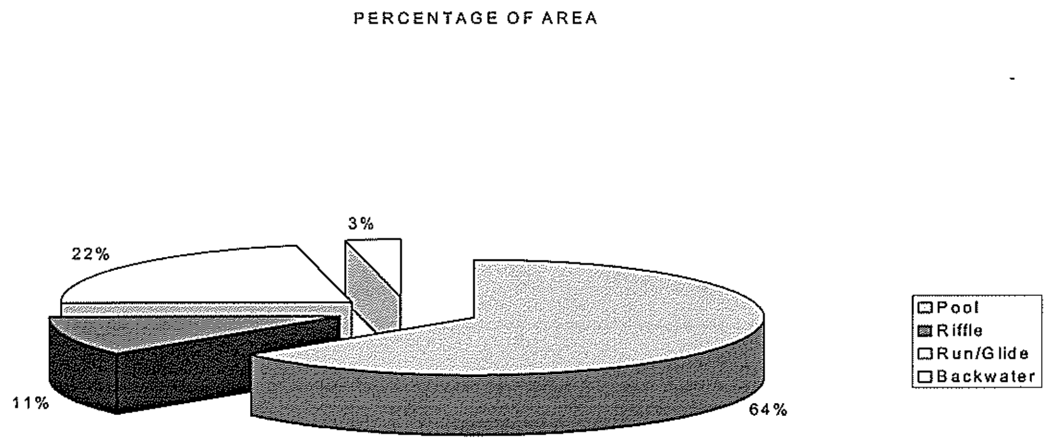

Figure 3 - Percentage of habitat types by area in the Essex Reach (RM 8.8 to 10.7)

Most of the pools are lateral scour pools along bedrock on the outside of meanders, with very little shelter for fish. The substrate throughout this reach is characterized by sand and small gravel, which can cause poor production of food organisms for juvenile salmonids, poor spawning, low egg survival rates, and poor over-wintering cobble habitat for juveniles. Large woody debris is noticeably missing in this section of the Mad River. Large wood is an important shelter element for coho juveniles, and the lack of it reduces the quality of available habitat.

According to the District's Engineer, the bed of the Mad River has degraded significantly in the Essex reach (an estimated 6 to 10 feet) since the District installed its Ranney collectors in 1962. By 1991, bed degradation had reached a critical level and the District had to install a rock grade control structure, in order to maintain the minimum water elevation necessary to operate its surface diversion facility. Since 1992, the District has established and maintained eight cross sections to monitor changes in bed and water surface elevations in the Essex reach. These cross sections document that varying annual degradation of the channel has occurred through 1997 with some slight aggradation thereafter.

Because the District controls access to the area and owns most of the Essex reach, the riparian habitat has been largely protected from disturbances. The riparian habitat in the Essex reach is stratified by successional zones beginning with herbaceous vegetation at the back edge of gravel bars; farther from the water, woody vegetation is composed of mostly Coyote bush and Arroyo willow. The woody vegetation increases in density with distance from the water, progressing into the beginnings of a riparian forest of black cottonwood and red alder. The riparian forest also increases in density farther from the water.

Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix B

Collection of Salmonid Data for the Mad River

Coho, chinook, steelhead, and coastal cutthroat trout do not have access to the entire Mad River basin due to natural barriers. The Mad River mainstem and its tributaries from the mouth to just beyond Blue Slide Creek (River Mile (RM) 35) are the primary regions used by coho and chinook salmon. An unstable, steep, boulder-dominated middle reach, approximately 30 miles in length, separates the lower Mad River from the equally low gradient upper Mad River near the Humboldt-Trinity County line. The upper limit for steelhead migration is between Wilson Creek (RM 45) to near Deer Creek (RM 53). In 1981, CDFG and Six Rivers National Forest personnel attempted to modify the principal barrier on the Mad River below Deer Creek, yet due to the changing configuration of the riverbed in this cascade reach, it remains a barrier to migrating steelhead. The North Fork Mad River also has a natural migration barrier approximately 5 miles from its confluence with the Mad River. (Refer to Figure1, Watershed Map, in main body of HCP).

Historically, American settlers along the Mad River created the first significant declines in salmon and steelhead. Historic salmon runs in the Mad River included pink or humpback, king, silver and steelhead (Arcata Union Sept. 6, 1928). In years of low flow, large numbers of salmon would be speared at the entrance of the Mad River (Arcata Union 1896). Commercial fishermen used seine nets, gill nets, and later, trolling. Seining was banned on the Mad River in 1913, but gill netting was still legal (in season). The salmon and steelhead on the Mad River have never fully recovered from over harvesting during the last half of the 1800s. The abundance of coho salmon in the first half of the 1900s has been estimated at 2,500; chinook salmon at 10,000, and steelhead at 6,000. Although fish may have begun to recover from the over harvest of the last century, that recovery was slowed significantly by two floods on the Mad River in 1953 and 1955. Fish counts for coho salmon declined 91 percent to an average of 37 fish; chinook salmon declined 76 percent to an average of 325 fish; and steelhead declined 64 percent to an average of 1,556 fish. Compounding the impact of these earlier floods was the impact of the 1964 flood. Since fish counts ceased at Sweasey Dam in 1964, the impacts of the 1964 flood could not be quantified. *(Note – Sweasey Dam was the first water impoundment structure on the Mad River. It had a storage capacity of 2,000 acre-feet, but completely filled with sediment by 1955. It was located 22 miles from the mouth of the Mad River, and was in operation from 1938 to 1962. It was removed in 1970).*

Non-native salmon and steelhead were introduced in the early 1900s. In 1912, approximately 100,000 salmon fry were annually stocked from Price Creek Hatchery on the Eel River, into the Mad River. In 1917, as many as 500,000 Quinnat salmon from the State Hatchery near Fort Seward, and 250,000 steelhead were stocked in the Mad River. This practice of stocking salmon in the Mad River continued at least through 1925 (Arcata Union 1913, 1917, and 1925).

Beginning in 1957, California Department of Fish and Game (CDFG) "enhanced" the salmonid population with non-native salmonids. The Mad River Hatchery is the only one out of nine state hatcheries for which the purpose is "enhancement" rather than mitigation. However, the Mad River Hatchery currently raises only steelhead trout, which are marked for identification, to enhance the local sport fishery.

Since 1990, the return of steelhead to the Mad River Hatchery has <u>increased</u> 165%, while the return of adult coho and chinook salmon has declined significantly. Coho have declined 89% and chinook 91%. Since 1990, based on Brown's (1994) estimate of the ratio of hatchery (44%) to "naturalized" fish (66%), the total run of coho salmon in the Mad River could average as low as 134 adults, of which 59 returned are hatchery and 75 are "naturalized". Information on each of the salmonid species follows.

Coho salmon (Oncorhynchus kisutch)

Evolutionary Significant Unit: Southern Oregon-Northern California Coasts

Regulatory Status: Listed as Threatened in 1997, critical habitat designated in 1999.

Life History Periods:

Egg Incubation/Sac Fry:	October-mid. May
Fry Emergence:	Late February-late June
Juvenile Rearing:	Year-round
Juvenile Outmigration:	May to mid-July (Peak, May)
Adult Migration:	October-February (Peak mid-November to mid-December)
Spawning:	November-February (Peak early December)

Distribution: Coho salmon distribution can be described temporally and spatially. The temporal distribution of coho varies with rainfall and runoff. Coho begin moving upstream to spawn when heavy autumn rains increase the Mad River's flow. Sudden drops in stream flow can check their migration; these drops often occur after a heavy rainstorm has passed. When another storm causes stream stage height to rise again, the coho continue their up migration. Adult coho up migration peaks during mid-November to mid-December.

The "lower" forty five miles of the Mad River, up to Wilson Creek, are accessible to adult coho salmon migrating upriver to spawn. Lindsay Creek and its tributaries are regarded as the most important coho salmon watershed in the Mad River system. Coho have been observed in Mill Creek, Warren Creek, Hall Creek, Leggit Creek, Powers Creek, Quarry Creek, the North Fork Mad River, Maple Creek, and the Mad River main stem.

Artificial Propagation: The abundance of coho salmon following the floods of 1953 and 1955 declined to an average of just 37 fish/year passing Sweasey Dam. In response, in 1957, CDFG began its "enhancement" stocking program for coho salmon using stock from the Quilcene and Klaskanine Rivers in Oregon. Annual plantings of 40,000 to 75,000 since 1957 resulted in higher returns (average of 1,137 fish) for the period from 1959 to 1964 at Sweasey Dam (CDFG 1968). Adult coho salmon returns to CDFG's Mad River Hatchery from 1971 to 1989 averaged 525 fish; but since 1990, coho returns averaged 59 fish, an 89 percent decline. (Refer to Table 2, page 6).

The Mad River Hatchery has stocked the river with non-native fish 18 times since 1970 (CDFG 1994). Coho salmon stocks that have been used by Mad River Hatchery are:

- Central California Coast ESU- Warm Springs, Noyo River
- S. Oregon/N. Calif. Coast ESU- Humboldt State University, Mad River, Prairie Creek, Trinity River, Iron Gate
- Oregon Coast ESU-Alsea/Fall Creek, Trask
- Lower Columbia River. Southwest Coast Washington ESU-Klaskanine, Sandy
- Puget Sound/Strait of Georgia ESU-Skagit, Green River, Minter Creek
- Other- Silverado" (Weitkamp, 1995).

Abundance: By the 1950s, the Mad River's native coho population was estimated to be between 2,500 to 3,000 fish (CDWR 1965). In response to CDFG's enhancement program described above, counts of coho salmon at Sweasey Dam increased a dramatic 3,000 percent, averaging 1,138 fish from 1959 to 1964 (see Table 1). Unfortunately, as a result of CDFG's past stocking and hatchery program, Mad River coho salmon are considered one of the most genetically diverse in the State, dominated by non-native populations (CDFG 1994).

Table 1. Sweasey Dam coho salmon counts (CDFG 1968)

YEAR	NUMBER OF FISH	YEAR	NUMBER OF FISH
1938	498	1952	72
1939	725	1953	91
1940		1954	59
1941	308	1955	2
1942	378	1956	21
1943	259	1957	11
1944	NA	1958	3
1945	NA	1959	541
1946	415	1960	244
1947	NA	1961	710
1948	515	1962	3580
1949	512	1963	1419
1950	147	1964	332
1951	414	AVERAGE	474

In 1958, DWR assumed that the number of fish migrating above Sweasey Dam represented approximately 16% of the total Mad River population. Most coho salmon utilized the lower 22 miles of the Mad River and its tributaries, such as Lindsay Creek. For the pre-flood period of 1938 through 1951, an average of 396 coho salmon migrated past Sweasey Dam. Using DWR's 16% assumption, the average run for the entire Mad River could have been 2,475 fish.

Following the major floods of 1953 and 1955, the naturally reproducing coho salmon passing Sweasey Dam dropped to an average of 37 fish, indicating that the total run for the Mad River could have dropped to 231 fish, a 91 percent decline. The first returns of non-native coho salmon stocks planted in 1957 would have returned in 1959. However, since that time, the proportion of naturally producing coho salmon run is unknown. One estimate is that the Mad River coho salmon run is made up of 56% "naturalized" adults and 44% hatchery adults (Brown 1994). Since 1990, on average 65 coho adults have returned to CDFG's Mad River Hatchery. Using Brown's assumption of the ratio of naturalized to hatchery fish, the naturalized run of coho salmon in the Mad River averages 83 adults.

Fish counts on the mainstem have not been conducted since 1970 when Sweasey dam was removed. Whether salmon are utilizing the mainstem area above the former location of Sweasey Dam is unknown. Since 1964, the only fish counts for coho salmon are: 1) those at Mad River Hatchery (Table 2), and 2) at Canon Creek and the North Fork Mad River (Table 3). Adult coho salmon returns to Mad River Hatchery from 1971 to 1989 averaged 525 fish. Since 1990, hatchery staff counted an average, of 56 fish, an 89 percent decline.

Table 2. Adult coho salmon returns to CDFG's Mad River Hatchery (Barngrover 1994, Heartright 2002)

YEAR	MALES	FEMALES	GRILSE	TOTAL
1971	90	178	69	337
1972	105	130	231	466
1973	105	176	46	327
1974	67	74	19	160
1975	167	339	1597	2103
1976	88	129	976	1193
1977	163	290	195	648
1978	42	31	524	597
1979	39	90	223	352
1980	56	106	341	503
1981	16	62	57	135
1982	73	76	473	622
1983	11	11	65	87
1984	12	8	4	24
1985	24	14	7	45
1986	29	30	265	324
1987	94	126	733	953
1988	93	161	591	845
1989	18	17	221	256
1990	17	27	48	92
1991	6	13	18	37
1992	24	32	11	67
1993	15	18	6	39
1994	46	23	5	74
1995	7	5	0	12
1996	58	47	154	259
1997	9	30	1	40
1998	7	5	1	13
1999	8	7	5	20
2000	12	5	0	17
2001	2	1	0	3
AVERAGE	48	73	222	343

Table 3. Numbers of coho salmon surveyed in index reaches on Canon Creek and North Fork Mad River (CDFG 2000)

YEAR	CANON CREEK	NORTH FORK MAD RIVER
1985-86	14	1
1986-87	3	88
1987-88	19	25
1988-89	7	15
1989-90	9	5
1990-91	4	0
1991-92	--	--
1992-93	1	0
1993-94	0	0
1994-95	2	0
1995-96	4	--
1996-97	5	0
1997-98	0	0
1998-99	0	0
1999-2000	1	0
AVERAGE	5	9

Chinook salmon (Oncorhynchus tshawytscha)
Evolutionary Significant Unit: California Coastal

Regulatory Status: Listed as Threatened in 1999, and critical habitat designated in 2000. The critical habitat designation for chinook was vacated by a descent decree issued by a Federal Court in May 2002.

Life History Periods:

Egg Incubation/Sac Fry:	November-mid. May
Emergence:	late February-early May
Juvenile Outmigration:	April-July (Peak early to mid-June)
Adult Migration:	September-February (Peak November)_
Spawning:	November-February (Peak December- mid January)

In the 1993 "Humboldt County Programmatic Environmental Impact Report On Gravel Removal From The Lower Mad River" chinook life history is described. The chinook salmon of the Mad River exhibit the "ocean-type" behaviors defined by Healey (1991) because these populations migrate to sea during their first year of life, (normally within three months after emergence from the spawning gravel) spend most of their ocean life in coastal waters, and return to their natal river in the fall, a few days or weeks before spawning. Annual peak downstream migration, in the river and entering the estuary, occurs at the same time, indicating Mad River juvenile chinook spend little time rearing in the lower mainstem.

Distribution: Before Sweasey Dam was removed, most chinook and coho salmon spawned below the dam while steelhead spawned above it (CDFG, 1957). Ridenhour (1961) found that the most important spawning area was from Highway 299 to Sweasey Dam, including the North Fork and Canon Creek. Ridenhour also observed three natural barriers to Chinook salmon migration; one was located below Bug Creek (RM 49.6), another was located two miles below Bug Creek, and the third located one half mile above Showers Creek (RM 54.4). The barrier one half mile below Bug Creek terminated in a 25-foot fall. It is the upper limit of anadromous fish migration on the Mad River, and is the reason no fish access facilities were required at Matthews Dam (CDWR 1965, and ACOE 1968).

Artificial Propagation: The CDFG has operated a hatchery on the Mad River for the enhancement of chinook salmon since 1970 (see Table 4). Since 1995, the Mad River Hatchery no longer collects chinook salmon. The number of returning fish tallied after this date are volunteers.

Table 4. Numbers of chinook salmon returning to CDFG Mad River Hatchery (Barngrover 1994, Heartright 1999)

YEAR	MALES	FEMALES	GRILSE	TOTAL
1971	60	178	85	323
1972	241	415	380	1036
1973	337	53	105	495
1974	110	71	50	231
1975	53	41	184	278
1976	323	155	183	661
1977	95	68	87	250
1978	37	19	190	246
1979	51	77	17	145
1980	26	40	20	86
1981	32	6	213	251
1982	257	391	252	900
1983	119	194	124	437
1984	21	13	48	82
1985	149	28	98	275
1986	106	121	72	299
1987	253	315	278	846
1988	49	110	83	242
1989	10	19	17	46
1990	0	0	1	1
1991	2	4	4	10
1992	13	12	2	27
1993	2	5	4	11
1994	27	35	5	67
1995	16	6	34	56
1996	24	18	22	64
1997	3	1	3	7
1998	17	12	11	40
1999	20	5	25	50
2000	9	2	0	11
2001	26	26	0	52
AVERAGE	80	79	84	243

Abundance:

In 1958, the California Department of Water Resources (DWR) and the CDFG reported,

> *"During two recent years, 1952 and 1954, the Department of Fish and Game conducted tagging and recovery programs to estimate the size of the king salmon runs. In 1952, when 401 king salmon passed over Sweasey Dam, it was estimated that 5,120 spawned downstream from the dam, and that anglers in the river below the dam took 800. In 1954, when 403 king salmon passed Sweasey Dam, an estimated 3,266 fish spawned downstream from the dam, and the angler catch was estimated to be 238 fish. Using an average of 4,000 fish spawning below Sweasey Dam, and 1,174 fish spawning above the dam, it is estimated that on the average, about 5,175 king salmon spawn in the Mad River" (CDWR-CDFG 1958).*

The mainstem of the Mad River has been considered to be the primary area of importance for the propagation of chinook salmon (Ridenhour (1961). The historic estimates of chinook salmon abundance in the Mad River can be based on commercial salmon shipping reports in the Arcata Union. Ridenhour (1961) estimated that the total run was 10,000 plus the sport catch and spawning escapement. In 1958, CDFG ran tagging and recovery programs and estimated the total chinook salmon run at 5,175.

Of the 5,175 total, CDFG in 1958 estimated that 23 percent of the chinook spawned above Sweasey Dam and the remaining 4,000 spawned below. During the pre-flood period of 1938 through 1952, an average of 1,329 chinook salmon migrated past Sweasey Dam (see Table 5). Based on DWR's distribution estimate, the average run for the Mad River during this period would have been approximately 5,778 adults. Following a flood in 1953, an average of 325 naturally reproducing chinook salmon passed Sweasey Dam. The total run, based on DWR's distribution estimate, would have declined to 1,413 fish, a 76 percent reduction. Similar to chinook and coho estimates, the impact of the 1964 flood on the abundance chinook salmon cannot be assessed, because Sweasey Dam fish counts ceased in 1964.

Table 5 Number of chinook salmon counted at Sweasey Dam from 1938 to 1964 (CDFG 1968)

YEAR	NUMBER OF FISH	YEAR	NUMBER OF FISH
1938	1273	1952	401
1939	1257	1953	853
1940	1293	1954	403
1941	3139	1955	390
1942	1676	1956	129
1943	1236	1957	494
1944	-	1958	478
1945	-	1959	19
1946	1181	1960	55
1947	717	1961	40
1948	672	1962	238
1949	484	1963	232
1950	1505	1964	492
1951	1519	AVERAGE	807

When Sweasey Dam was removed in 1970, the impacts on chinook were similar to that of coho. Fish counts on the mainstem have not been conducted since, so once again, it is unknown whether chinook are utilizing the mainstem area above the former location of Sweasey Dam. Since 1964, the only fish counts for chinook salmon are: 1) those at Mad River Hatchery, which began in 1971 (Table 4), and 2) those in index reaches of Canon Creek and the North Fork Mad River (Table 6). Adult chinook salmon returns to Mad River Hatchery from 1971 to 1989 averaged 375 fish. Since 1990, hatchery staff counted an average of 33 fish, a 91 percent decline.

Table 6. Numbers of chinook counted in index reaches of Canon Creek and North Fork Mad River (CDFG 2000)

YEAR	CANON CREEK	NORTH FORK MAD RIVER
1985-86	514	364
1986-87	90	212
1987-88	117	200
1988-89	69	238
1989-90	9	33
1990-91	0	2
1991-92	2	--
1992-93	57	153
1993-94	20	22
1994-95	32	6
1995-96	93	--
1996-97	129	553
1997-98	53	84
1998-99	66	52
1999-2000	162	64
2000-2001	79	192
AVERAGE	**93**	**155**

Steelhead trout (Oncorhynchus mykiss)

Evolutionary Significant Unit: Northern California

Regulatory Status: Listed as Threatened in 2000. The critical habitat designation for steelhead is still under consideration.

Life History Periods:

Egg Incubation/Sac Fry:	January-June
Emergence:	May-June
Juvenile Outmigration:	May-August (Peak, July)
Winter Run Migration:	mid-August to mid-April (Peak, December-February)
Summer Run Migration:	mid-March to mid-July
Spawning:	late-December-mid. April (Peak, mid-January to mid-March)

In the 1993 "Humboldt County Programmatic Environmental Impact Report On Gravel Removal From The Lower Mad River" steelhead life history is described.

> *"Boydstun (1974) reported earlier downstream trapping at Sweasey Dam by CDFG documented most age classes were migrating from May 1 through August, peaking in July. Adult winter Steelhead can enter the Mad River at the same time as Chinook salmon (late August), though most of the run enters later in the winter. For example, Bailey (1953) seined 252 Chinook salmon and four Steelhead in the Bugenig and Carson holes from October 10 to November 1952. Peak migration usually occurs from December to late February, overlapping the Coho runs more than Chinook runs. Spawning can occur from late-December to mid-April, depending on annual flows".*

Life History: An overview of steelhead life history was provided by Busby in 1996, during NMFS's status review of steelhead.

> *"Unlike the coastal/inland groups, summer and winter Steelhead co-occur in several river basins, primarily within the range of the coastal Steelhead group. The few genetic analyses that have considered this issue indicate that summer and winter Steelhead from the same river basin are more genetically similar to each other than to the same run type in another river basin. This indicates that all summer Steelhead, for example, are not descended and distributed from one ancestral source and, therefore, are not a monophyletic unit" (Busby 1996).*
>
> *"Half-pounders are only reported in the literature from a small geographic region in southern Oregon and northern California. However, genetic data do not show a particularly strong affinity among rivers having half-pounders; rather, the affinities are geographic, including streams both with and without half-pounders" (Busby 1996).*

Steelhead of the northern Coastal California ESU exhibit more flexible life history strategies than steelhead of other Pacific Coast ESU's, and than chinook and coho salmon (Trush 1993). Steelhead half-pounders have been reported in the Mad River (Snyder 1925, Kesner and Barnhart 1972, Everest 1973, Barnhart 1986 in Trush 1993). In 1974, Boydstun reported that an early winter stock was also present in the Mad River, but in low numbers. A significant run of summer steelhead, averaging 374 fish, has been inventoried since 1994 (CDFG-Preston 1999).

Distribution: A natural barrier about one-half mile below Bug Creek has a 25-foot fall at its head, and has been the historic upper limit for anadromous salmonids. A second natural barrier is found five miles up the North Fork Mad River (CDWR-CDFG 1958). The bulk of the steelhead run in the Mad River is believed to have spawned above Sweasey Dam (CDWR-CDFG 1958, DWR 1965). In 1981, Six Rivers National Forest and CDFG modified the barrier just below Bug Creek. Since 1982, some summer steelhead negotiated the barrier below Deer Creek, but only during sufficient physical conditions in this cascade region of the Mad River inner gorge.

A boulder falls below Deer Creek also appears to be a selective barrier (CDFG-L.Preston 1999, 2002). While large numbers of summer steelhead have been counted below Deer Creek, over the last three years, a declining number of steelhead have been able to negotiate this barrier. In 1998, only four fish were observed in the upper Mad River, where Six Rivers National Forest maintains its index reach. The unstable geology from Wilson Creek through to Showers Creek makes fish passage uncertain, in any given year, depending on channel and flow conditions.

Artificial Propagation: The Mad River has a long history of receiving non-native steelhead stocks. As early as 1917, 250,000 steelhead from Price Creek Hatchery on the Eel River were planted on a regular basis (Arcata Union 1917). Winter steelhead were established at the Mad River Hatchery with eggs from Van Arsdale Fisheries Station on the Eel River and San Lorenzo River (Cramer et al. 1995). Since 1971, the Mad River Hatchery has been the primary steelhead hatchery in this ESU, which CDFG operates to "enhance" steelhead stocks (CDFG, McEwan and Jackson 1996). From 1971 to 1989, adult steelhead returns to Mad River Hatchery have averaged 1970 fish; since 1990 hatchery staff counted an average of 5,213 fish, a 165% increase.

Table 7. Steelhead stocks released into the Mad River by the Hatchery (CDFG 1994)

RUN	RELEASED STOCK	PERIOD OF RECORD	TOTAL STEELHEAD RELEASED
Summer	Skamania	1972-81	349,880
Summer	Mad River	1968-91	909,311
Winter	Eel River	1972-74	292,210
Winter	Mad River	1968-91	3,986,235
Winter	Mad River (fry)	1982-85	720,330
Winter	Russian River	1989-90	22,320
Winter	Russian River (fry)	1989	64,180
Winter	San Lorenzo River	1973	100,800

Summer steelhead were established at the Mad River Hatchery from Skamania stock, but CDFG terminated its summer steelhead program in 1995. Approximately 233,000 juvenile steelhead of various stock origins are released annually into Mad River (CDFG 1994).

Table 8. Numbers of steelhead counted at the Mad River Hatchery (Barngrover 1990, Heartright 2002)

YEAR	ADULTS	YEAR	ADULTS
1971	42	1987	4303
1972	52	1988	2529
1973	2872	1989	1027
1974	2138	1990	915
1975	190	1991	3463
1976	658	1992	7497
1977	1317	1993	5591
1978	2190	1994	11118
1979	1411	1995	11520
1980	730	1996	8713
1981	442	1997	1807
1982	1087	1998	2371
1983	838	1999	3085
1984		2000	1399
1985	753	2001	5075
1986	13833	AVERAGE	3225

Significant predation of hatchery steelhead trout yearlings occurs when the CDFG Mad River Hatchery releases its stock. Flocks of cormorants have been observed below the hatchery, following and preying on the newly released fish in the spring.

Abundance:

According to NMFS's Biological Review Team, steelhead abundance estimates are uncertain. First, steelhead run sizes throughout the ESU are unknown, and estimates were based largely on evidence of habitat degradation and the few dam counts and survey index estimates of stock trends in the region. Second, the genetic heritage of the natural winter steelhead population in the Mad River is uncertain.

In the 1940s, historical abundance of steelhead was estimated at 3,800 (Murphy and Shapovalov 1951). In the 1960s, steelhead counts ranged from as low as 2,000 to 6,000 (CDWR 1965, CDFG 1966, and McEwan 1996). From 1938 to 1954, Sweasey dam steelhead counts averaged 4,230 fish; following the 1953 flood, the average count declined 59 percent to 1,741 fish (see Table 9).

Table 9. Sweasey Dam steelhead Counts (*no counts taken in 1944, and 1945, CDFG 1968)

YEAR	NUMBER OF FISH	YEAR	NUMBER OF FISH
1938	3110	1952	5613
1939	3118	1953	2943
1940	5706	1954	2390
1941	4583	1955	148
1942	6650	1956	2717
1943	4921	1957	1957
1944	-	1958	1780
1945	-	1959	1376
1946	5106	1960	1343
1947	3582	1961	1985
1948	3139	1962	1708
1949	4074	1963	2178
1950	4430	1964	373
1951	5543	AVERAGE	3218

From 1994 to 1998, annual summer steelhead have been surveyed from Matthews Dam to Highway 101 by a cooperative multi-party review team (California Trout, CDFG, USFS, Simpson Timber Co., Gravel Operator's consultant NRM Inc.), (and HBMWD in 1995) (see Table 10). Surveyors make direct observation population estimates of all adults greater than 16 inches, and "half-pounder" adults less than 16 inches. In 1999, surveyors counted the fewest summer steelhead (82) since complete river counts began in 1994. The 1999 count was 119 adult fish lower than the 1998 count, or less than one quarter of the population for the years 1994 to 1998 (L.Preston 2002*)*.

Table 10. Number of Mad River summer steelhead and "half-pounders" 1994 to 2001 (CDFG-L.Preston 2002)

YEAR	ADULTS	½ POUNDERS
1994	287	172
1995	569	21
1996	515	26
1997	284	12
1998	201	20
1999	82	19
2000	N/A	N/A
2001	N/A	N/A
AVERAGE	323	45

Coastal cutthroat trout (Oncorhynchus clarki clarki)

Evolutionary Significant Unit: Southern Oregon and California Coasts

Regulatory Status: In 1999, NMFS determined that listing was not warranted in the Southern Oregon and California Coasts ESU (Johnson 1999). During the same year, the USFWS assumed jurisdiction for coastal cutthroat trout, and they are presently conducting a status review. Unlike NMFS, USF&WS does not utilize ESUs in the definition of a species under the ESA.

Life History Periods:

Emergence:	March-June
Juvenile Outmigration:	March-June (Peak April)
Adult Spawning Migration:	August-November (Peak September)
Spawning:	November-June (Peak January)

Distribution:
Coastal cutthroat trout require small, low gradient streams and estuarine habitats, such as Lindsay Creek on the lower Mad River and the North Fork of the Mad River (Moyle 1989, ACOE 1973).

Artificial Propagation:
No information specific to the Mad River was presented in the Status Review Report (Johnson 1999).

Abundance:
No information specific to the Mad River was presented in the NMFS Status Review Report (Johnson 1999).

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Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix C

District's Mad River Operations

Introduction

The District provides water on a wholesale basis to municipal and industrial customers in the Humboldt Bay area, and also to a number of retail customers. The District's wholesale municipal customers include the Cities of Arcata, Blue Lake and Eureka, and the Humboldt, McKinleyville, Manila and Fieldbrook Community Services District. Via the wholesale relationship, the District serves a population of approximately 80,000 in the greater Humboldt Bay area.

Two separate and distinct delivery systems convey water from the District's diversion facilities on the Mad River to the wholesale customers - one for domestic use and one for industrial use.

The District's operations and maintenance activities that are within the HCP planning area were introduced in the main body of the HCP in Section 5. These activities, which are discussed in greater detail in this appendix, are as follows:

Current Activities Which Occur on an Ongoing Basis: These activities include: releasing flow at Matthews Dam; diverting flow in the Essex Reach (subsurface via Ranney collectors and surface via direct diversion facility); bypassing flow below Essex; operating the direct diversion facility (Station 6) including the fish screens; dredging the forebay in front of Station 6; and maintaining adequate water surface elevation to Station 6 during the low-flow months.

Current Activities Which Occur Only As-needed: These activities include: maintaining adequate capacity in tailrace and spillway pools below Matthews Dam (by excavation if sediment, gravel or debris accumulates); gaining access to and maintaining Ranney collectors; maintaining adequate flow to Station 6 (by dredging/excavation of the low-flow channel in front of Station 6 if gravel or debris accumulates); and protecting banks and structures (by repairing/installing rock structures or revetment).

Possible Future Activities: The District will likely need to pursue a number of new projects or activities over the course of the HCP planning horizon (50 years). Possible future activities include: restoring channel capacity below Matthews Dam (if impeded by material resulting from landslide, or other significant deposition); repairing, rehabilitating, or replacing laterals or water lines in the riverbed in the Essex reach; and constructing additional grade control structures in the Essex Reach.

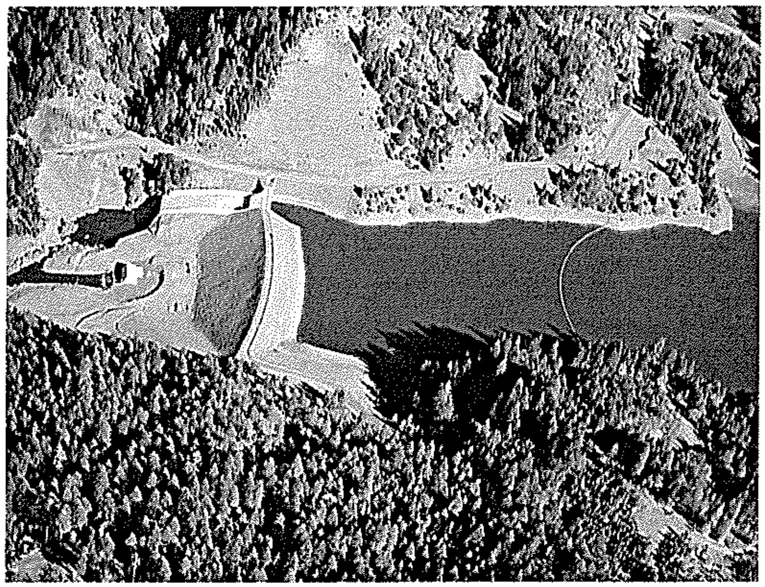
Current Activities, Which Occur on an Ongoing Basis

1. Releasing flow at Matthews Dam, and 2. Diverting Water in the Essex Reach

These activities are discussed together since they represent the District's flow-related activities on the Mad River. First, a brief introduction is provided. This is followed by a discussion of Mad River flows to illustrate how the District's operation fits in the broader context of the Mad River watershed. Finally, several specific questions related to diversions are addressed.

Activities 1 and 2: Introduction

Completed in 1961, R.W. Matthews Dam is a 172-foot earth-filled dam located at River Mile 84 on the Mad River. The dam impounds runoff from approximately 121 square miles (25% of the Mad River basin), and thereby forms Ruth Lake. The capacity of Ruth Lake is approximately 48,000 acre-feet. A portion of the water stored in Ruth Lake is released each summer and fall to satisfy both the District's downstream diversion requirements and minimum bypass flow requirements below the diversion.



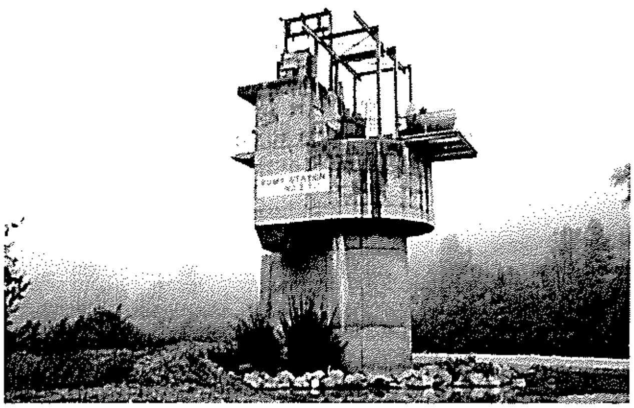
Matthews Dam and Ruth Lake

The District's place of diversion is located in the Essex Reach (RM 9.1 to 10.8), about 75 miles downstream of Matthews Dam. Ruth Lake was designed to supply a "safe yield" of 75 million gallons per day (MGD) average annual diversion at Essex, and to maintain bypass flows in the Mad River below Essex in accordance with requirements in the District's water rights permit. The State Water Rights Board and California Department of Fish and Game stipulated minimum flow requirements below Matthews Dam and below the Essex diversions for the protection and preservation of fish. The stipulated minimum flows are as follows:

a) The District shall release a minimum flow of five cubic feet per second into the natural streambed of Mad River immediately below Ruth Dam (now known as Matthews Dam).

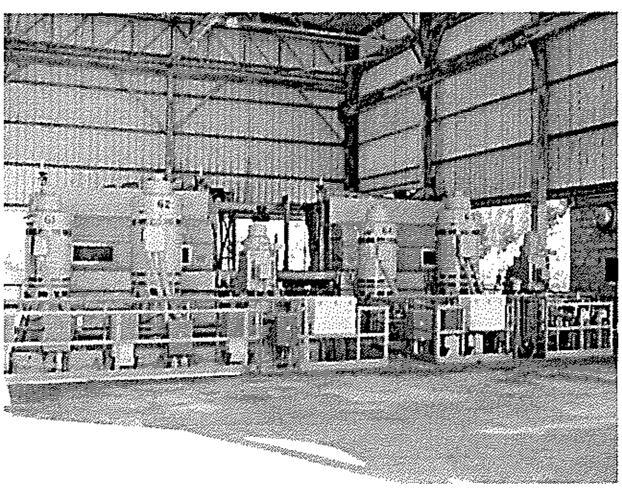
b) The District shall bypass or release into the natural streambed of the Mad River immediately below the Essex diversion the following minimum flows or the natural flow of the Mad River as regulated by diversions now in existence, whichever is less:
   - October 1 through October 15 — 30 cfs
   - October 16 through October 31 — 50 cfs
   - November 1 through June 30 — 75 cfs
   - July 1 through July 31 — 50 cfs
   - August 1 through August 31 — 40 cfs
   - September 1 through September 30 — 30 cfs

The District initially constructed four Ranney collectors (numbers 1 & 1A, 2, 3, and 4) in the Essex Reach to deliver water to its domestic and industrial customers. Upon completion, the District was unable to meet the water demands of both its municipal customers and industrial customers, the latter of which had contracted for 60 MGD. In the mid 1960's the District constructed Collector #5 and converted Collectors #3, #4 and #5 for industrial water delivery, with the addition of upper laterals. Collector #3 was converted to a direct diversion facility, with a pre-settling pond, trash rack, traveling water fish-debris screen, and low-flow weir. However, Collector #3 did not meet the design criteria, and was inadequate as a permanent direct diversion facility. The District later determined that a new direct river diversion facility was required if it was to reliably meet the industrial water needs of 60 MGD.



Ranney Collector

The Ranney collectors house two or three large electric-driven pumps and associated equipment. The collectors draw water from the aquifer via lateral pipes located 60 to 90 feet beneath the bed of the river. This water is then treated in accordance with standards set by the California Department of Health Services, and delivered to the District's municipal customers. Currently, collectors 1, 1A, 2, 3 and 4 are in operation and provide domestic water for municipal purposes. Station 5 is currently not in service.



Station 6

In 1976, a new direct diversion facility was constructed (Station 6) to deliver 60 MGD to the District's industrial customers. Station 6 is comprised of a forebay, which is directly adjacent to the Mad River and extends transverse to the direction of flow, and a concrete pumping structure. This facility and its operation are described in greater detail under Activity 4 later in this appendix.

In 1981, the Federal Energy Regulatory Commission (FERC) granted Exemption No. 3430 for a 2 MW hydroelectric plant at Matthews Dam. The District has a contract to sell "as available" energy and capacity to PG&E. The District does not operate the plant as an electric "peaking" facility, nor does the District "ramp" its flow releases (e.g. change dramatically in a short period of time in response to power needs). Power production is incidental to water released for the District's water supply function.

Activities 1 and 2: Overview of District Operation in Context of Mad River Watershed

The District's operations do not significantly affect the natural flow regime in the Mad River. The reasons for this are several: 1) the total volume of water impounded and diverted represents a small fraction of the natural yield of the Mad River watershed, 2) tributaries downstream of Matthews Dam contribute significantly to the Mad River discharge, and 3) there is no out-of-basin transfer in the upper watershed such as occurs on some other river systems.

Matthews Dam impounds a small fraction of the winter-season runoff from approximately 121 square miles (the upper 25 percent) of the Mad River basin. This impoundment forms Ruth Lake. The total capacity of Ruth Lake is approximately 48,000 acre-feet. The Mad River's average annual discharge into the Pacific Ocean is just over 1,000,000 acre-feet, so Ruth Lake, in its entirety, represents less than 5% of the total average annual runoff from the Mad River basin. The entire 48,000 acre-feet are not drawn down each year, so the amount of winter-season runoff captured in the reservoir the subsequent season is yet a smaller percentage of the total runoff in the watershed.

Tributaries are a major influence on flow rates in the Mad River below Matthews Dam. A former USGS gage station at Forest Glen was located nine miles below the dam prior to the confluence of any major tributaries. The annual mean flows at Forest Glen increased by an average of 22 percent compared to the mean flows from Ruth Lake. The major tributaries to the Mad River are downstream of this former gage station at Forest Glen. These tributaries contribute significantly to Mad River discharge and also provide a buffering effect on the river at times when the District is releasing less than the natural flow from Ruth Lake.

The current withdrawal rate at the District's Essex diversion is approximately 25 to 30 MGD (28,000 to 34,000 acre-feet per year), which is only 3% of the total average runoff of the Mad River watershed. In prior years, the entire 75-MGD safe yield has been under contract, and up to 67 MGD has been withdrawn. A withdrawal rate of 75 MGD, (84,000 acre-feet per year) equates to approximately 8 percent of the total annual runoff of the Mad River watershed.

During much of the winter and spring high-discharge period, the District does not control the amount of water released from Ruth Lake in that once elevation 2654 feet is achieved, water flows freely over the spillway structure. During higher-flow periods, the District may utilize natural flow from the river to satisfy some of its diversion requirement, although any amount so used represents but a fraction of the total discharge in the river.

Conversely, during the summer and fall low-flow periods, the District releases a sufficient amount of water from storage to meet its downstream diversion requirement and its bypass flow requirement below Essex. If and when the District's diversion requirement increases (due to municipal growth or a new industrial customer), then the amount of water released from storage each day would be increased accordingly to meet the new diversion requirement. Therefore, during the low-flow summer and fall months, the bypass flows below Essex would not be reduced when the District's diversion increases (up to the full safe yield of 75 MGD). This point is portrayed in Figure 1.

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The following subsections discuss Mad River flows at various locations on the river (Matthews Dam, Forest Glen, and downstream Essex reach).

The District's flow releases have augmented flows compared to what otherwise occurred naturally. The District analyzed average monthly flow releases from Matthews Dam between 1989 and 2001. The average monthly flow release from Matthews Dam has augmented natural "pre-District" flows by at least one order of magnitude during the low-flow months. Table 1 presents this monthly flow data. Flow augmentation has many beneficial effects, including expanding river habitat for the benefit of aquatic species.

Table 1. District's flow releases from Matthews compared to natural flow (in cfs) (Monthly average, 1989- 2001)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
"Natural" flow above Ruth Reservoir, prior to District operations	772	622	500	250	123	59	9	1	0	5	55	320
District's releases from Matthews Dam	941	812	691	342	177	111	58	70	77	77	70	281
Net increase in flows resulting from flow releases	169	190	191	92	54	52	49	69	77	72	15	-39

The District also analyzed daily flow data from the USGS gage station near Forest Glen (No. 11480500), which was located approximately nine miles downstream of Matthews Dam. This station operated between 1953 and 1994, and thus recorded flows prior to, and following, construction of Matthews Dam.

The daily mean flows recorded at this station significantly increased during the low-flow months after the District's operation commenced in 1961. Table 2 presents the minimum, maximum and average daily stream flows during the low-flow months of the year at the USGS gage station near Forest Glen for 1953 through 1994.

Table 2. Daily Mean Stream Flows (cfs) during Low-flow Months (1953 to 1994)
At USGS Gage Station Near Forest Glen (located approximately 9 miles downstream of Matthews Dam)

Period 1 - Prior to Operation of Matthews Dam												
	August			September			October			November		
Year	Min	Max	Avg	Min	Max	Avg.	Min	Max	Avg.	Min	Max	Avg.
1953							3	16	5	4	2330	279
1954	2	7	3	2	4	3	2	11	5	5	987	120
1955	2	5	3	1	3	2	2	5	2	3	1890	176
1956	2	5	4	2	2	2	2	1050	52	10	214	42
1957	3	7	5	2	23	4	7	1400	168	32	3350	455
1958	2	18	8	6	19	14	1	5	2	2	72	13
1959	2	2	2	2	20	7	2	9	6	2	3	2
1960	2	7	5	1	3	2	2	5	3	2	1250	117
1961	1	10	5	1	8	4	2	8	3	2	380	51
AVG	2	8	4	2	10	5	2	279	27	7	1164	139
Period 2 - After Matthews Dam in Operation												
1962	12	20	14	13	21	17	16	3840	620	217	1150	379
1963	48	135	92	118	271	220	9	213	65	29	807	362
1964	94	98	96	92	98	94	91	100	95	53	420	114
1965	45	73	53	65	73	70	69	79	76	73	425	213
1966	80	111	88	76	158	91	56	75	72	52	369	128
1967	81	121	101	99	119	111	123	269	171	70	178	122
1968	72	103	90	70	108	82	63	109	82	81	367	225
1969	73	105	95	73	119	97	95	113	109	95	206	134
1970	90	104	101	98	119	105	107	127	114	107	722	235
1971	83	100	94	95	111	100	92	141	107	102	228	122
1972	79	100	93	91	128	102	80	117	107	101	198	128
1973	83	123	95	95	118	104	102	199	111	105	3060	1262
1974	97	123	114	117	124	119	111	134	117	65	169	104
1975	70	108	88	87	108	91	87	330	117	123	620	316
1976	45	71	56	54	86	62	77	102	92	37	98	78
1977	57	81	68	14	69	56	10	51	37	9	238	44
1978	69	100	89	93	114	96	91	94	93	72	95	87
1979	93	104	98	100	102	101	45	361	94	46	1500	302
1980	88	106	96	99	106	101	96	104	99	38	100	78
1981	81	93	84	81	91	85	34	139	70	27	3000	814
1982	43	76	62	70	114	91	44	182	139	111	584	181
1983	41	137	63	70	116	87	98	143	124	147	2600	584
1984	77	93	80	83	88	86	83	94	88	94	3320	867
1985	85	96	91	90	98	95	51	121	92	40	84	63
1986	99	108	104	104	129	109	100	149	112	15	115	83
1987	90	95	93	89	97	92	87	93	90	29	87	57
1988	86	98	93	92	107	98	92	109	96	24	861	201
1989	94	104	99	83	103	98	55	231	98	55	115	90
1990	80	118	107	96	103	101	96	118	105	50	99	88
1991	94	105	99	94	102	97	34	103	88	13	86	48
1992	93	97	95	88	96	92	53	88	76	11	61	33
1993	41	43	42	42	58	52	57	64	60	59	64	61
1994	51	64	56	56	67	62	65	68	67			
AVG	73	97	85	81	107	93	72	250	112	67	688	238

Additionally, the District analyzed daily flow data from the USGS Forest Glen gage station for the winter period to determine if the District's operation at Matthews Dam diminished the *peak* discharge in the Mad River. Figures 2.1 and 2.2 present the maximum daily mean stream flow for December and January, respectively, at the Forest Glen gage station between 1953 and 1994. As shown, the maximum daily stream flow for a given month is highly variable (which is to be expected), however, the maximum daily flow did not diminish after the District's operation commenced in 1961.

Figure 2.1
Maximum Daily Mean Stream Flow each December, 1954-1994 (cfs)
(at USGS Gage Station at Forest Glen)

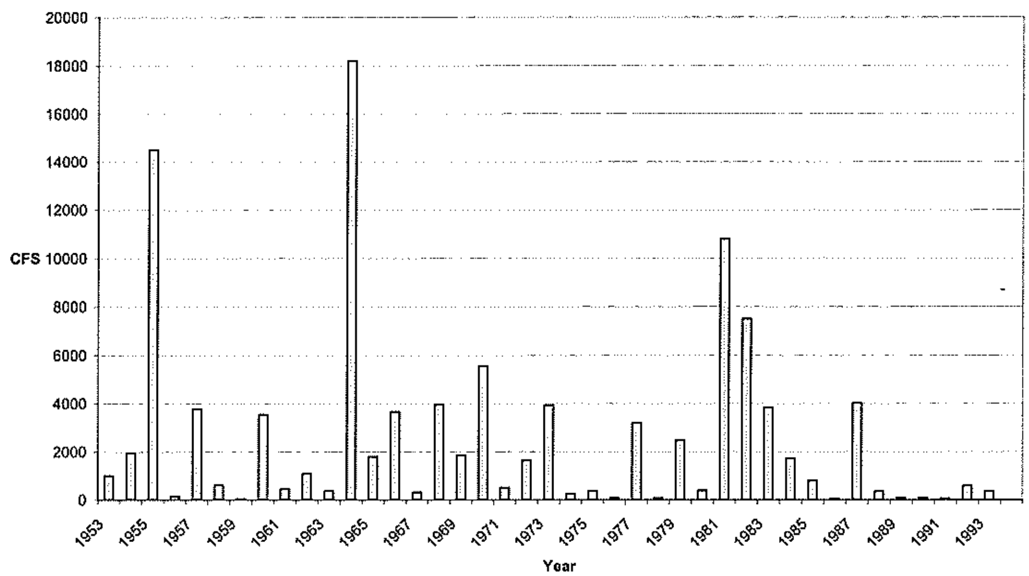


Figure 2.2
Maximum Daily Mean Stream Flow each January, 1954-1994 (cfs)
(at USGS Gage Station at Forest Glen)

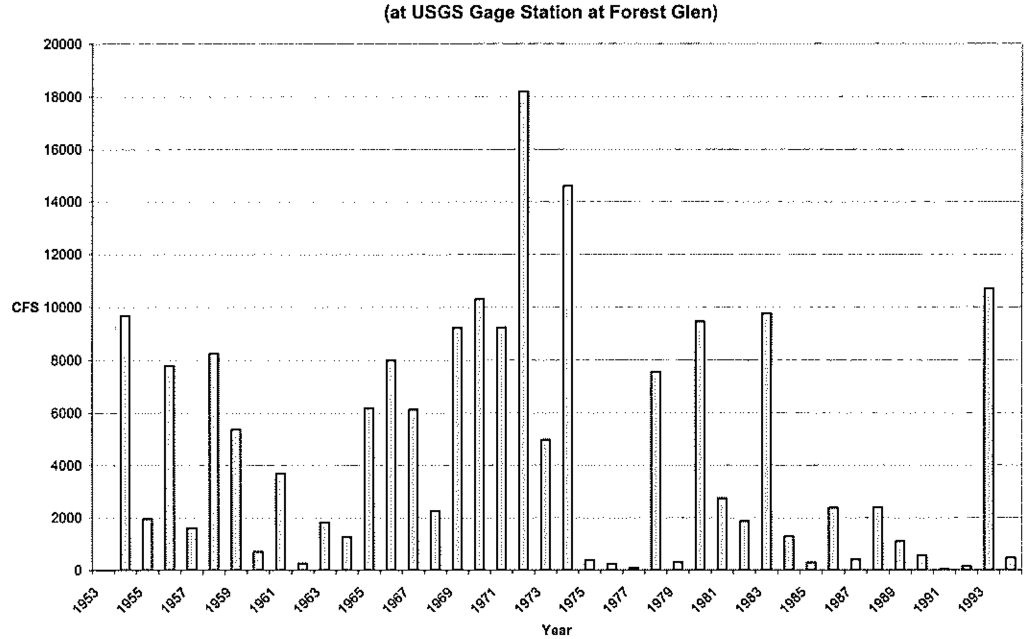


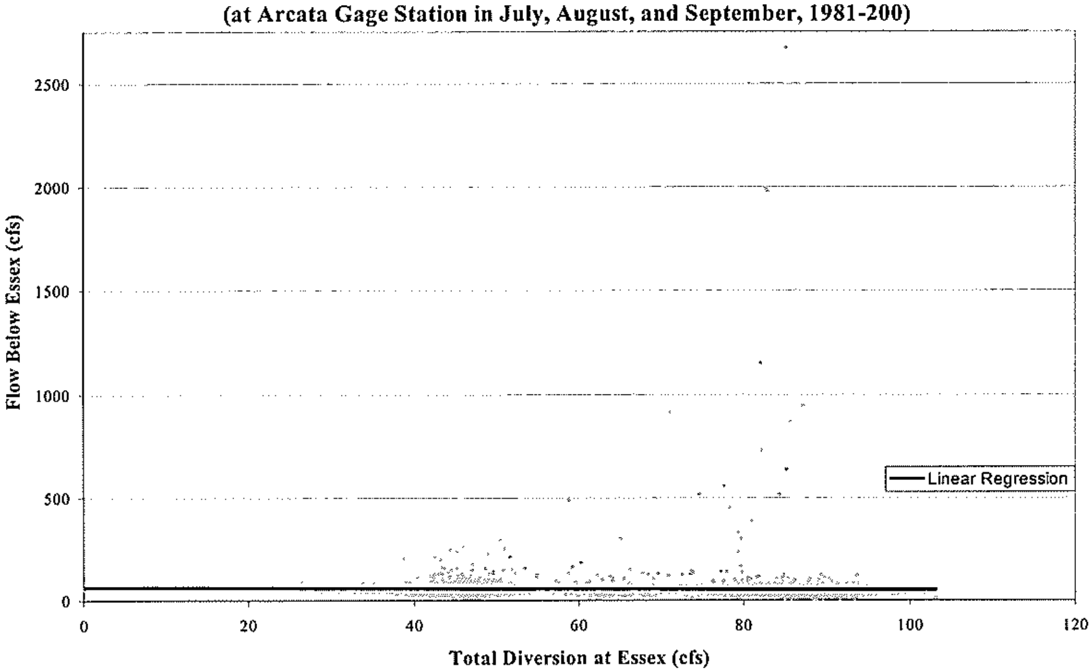
Table 3 presents the monthly mean flow of the Mad River below Essex. July, August, and September are clearly the months having the lowest flows in the Mad River. For those months combined, daily flows below Essex are plotted against the total withdrawal at Essex in Figure 3. Figure 3 illustrates that there is essentially no correlation between diversion rate at Essex and flow below Essex. In other words, a higher diversion rate at Essex does not mean lower flow below Essex because the District releases from storage sufficient water to meet its downstream diversion requirements.

Table 3. Monthly Mean Flow of the Mad River Below Essex (Arcata Gage Station, 1981 – 2001)

YEAR	Monthly Mean Flow at the Arcata Gaging Station (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1,612	2,505	2,388	883	370	112	29.4	14.4	30.5	251	3,484	6,723
1982	3,101	4,519	2,844	5,610	686	103	42.8	20.8	27	234	1,313	5,809
1983	3,963	6,818	6,336	3,410	1,407	260	115	123	126	91.8	3,906	7,694
1984	1,511	3,185	2,509	1,953	1,293	395	97.4	53.8	35.8	139	4,607	2,010
1985	505	1,870	1,124	1,060	181	89.1	33.5	40.3	62.5	244	397	1,295
1986	2,335	9,796	3,744	509	711	97.1	39.9	40.3	392	208	644	694
1987	1,887	2,306	3,174	427	141	38.7	32.1	24.2	24	29.7	60.1	2,651
1988	2,973	671	194	165	373	758	46.4	33.7	29.2	34	2,212	1,447
1989	3,216	1,559	5,411	1,820	365	131	45.9	38.6	35.8	137	136	101
1990	1,738	2,483	2,207	341	1,267	1,025	63.3	52.2	39.5	55.4	72.9	181
1991	481	552	2,383	1,396	740	131	60.3	53.8	39.7	54.5	88.3	229
1992	361	1,526	1,046	1,137	170	69.6	37.9	16.7	15	21.3	206	2,005
1993	4,458	2,934	3,600	2,988	1,408	1,721	126	44.2	41	48.6	52.6	868
1994	1,252	2,478	1,119	689	575	125	48.4	43.3	43.5	42.6	805	1,903
1995	8,811	2,413	6,000	3,681	1,654	391	110	46.9	44.2	55.4	72.2	3,850
1996	5,998	4,414	3,436	2,196	1,048	245	74.3	42.2	59.2	144	784	7,596
1997	7,109	1,886	1,278	1,155	529	168	73	57.3	64	195	1,044	1,749
1998	7,707	7,369	4,089	1,904	1,002	499	90.3	43.7	38.5	55.7	2,448	2,814
1999	2,519	5,899	3,698	1,998	752	175	68.2	50.3	50.4	58.1	310	1,083
2000	3,649	4,547	2,299	824	744	209	64.3	44.1	50.5	83.2	185	469
2001	502	1,135	1,083	552	219	79.6	38.8	18.1	21.1			
Mean of Monthly Flows	3,128	3,375	2,855	1,652	745	325	64	43	60	109	1,141	2,559

Figure 3

Total Water Diversion at Essex vs. Flow Below Essex, Based on Daily Flows (at Arcata Gage Station in July, August, and September, 1981-200)



As previously mentioned, total runoff (or discharge) from the Mad River basin averages just over one million acre-feet per year. However, the total annual runoff varies due to significant variations in the total precipitation in the watershed each season. Figure 4 presents total runoff from the Mad River watershed from the early 1980's to 2000, and Table 4 organizes the total runoff into three relative categories – drier, "normal" and wetter years.

Figure 4
Total Annual Runoff (AF) from Mad River Basin for Water Years 1982/83 to 1990/00
(Source: USGS Mad River Gage Station #11481000, near Arcata)

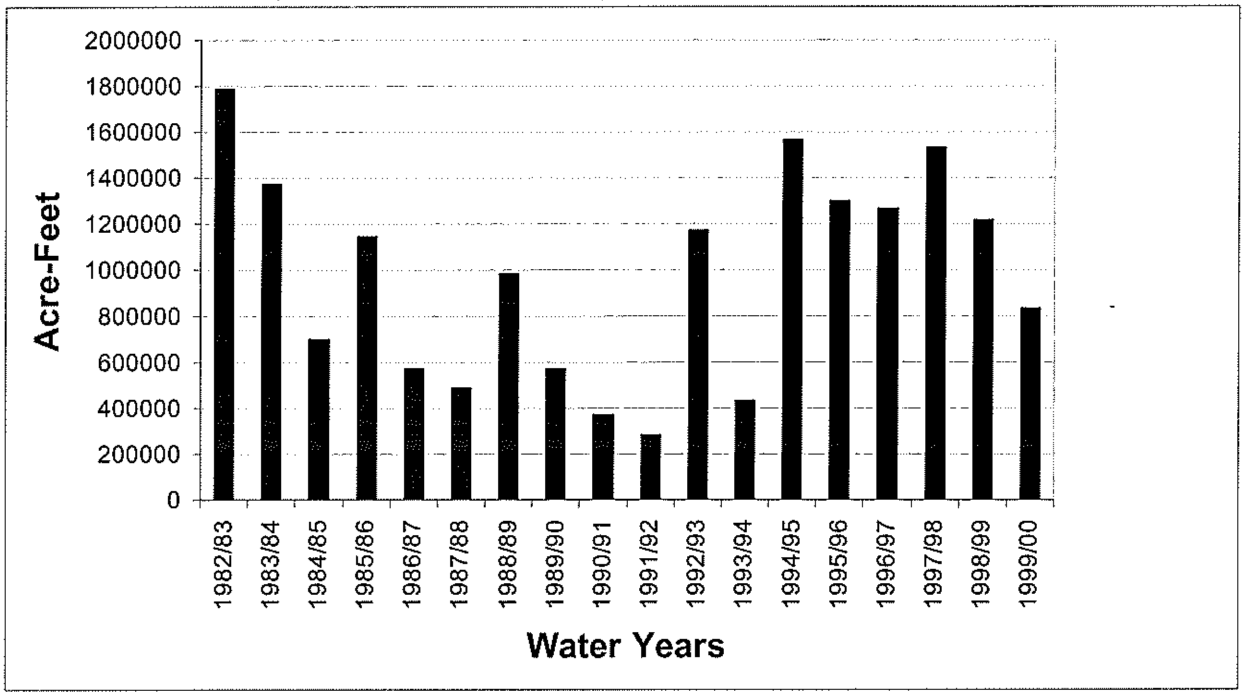


Table 4
Total Annual Runoff (AF) from Mad River Basin by Type of Water Year

Drier-than-Normal Years		"Normal" Years		Wetter-than-Normal Years	
Water Year	Acre-Feet	Water Year	Acre-Feet	Water Year	Acre-Feet
1991/92	283,500	1999/00	832,700	1998/99	1,218,000
1990/91	371,300	1988/89	985,700	1996/97	1,266,000
1993/94	435,000	1985/86	1,144,000	1995/96	1,299,000
1987/88	486,400	1992/93	1,175,000	1983/84	1,372,000
1989/90	571,800			1997/98	1,531,000
1986/87	574,300			1994/95	1,569,000
1984/85	698,100			1982/83	1,789,000
Averages:	**488,629**		**1,034,350**		**1,434,857**

The District examined the historical data to find a scenario which should be of interest – a year in which the diversion rate is much higher than what exists today, under extremely "dry" conditions in the Mad River watershed. Water years 1990/91 and 1993/94 were selected. As noted in Table 4 they were very dry years, with total discharge representing approximately 37% and 43%, respectively, of the average annual runoff from the basin.

Figure 5 presents the District's total daily diversion during water year 1990/91 versus water year 1993/94. As illustrated, the total diversion in 1990/91 is significantly higher (at times more than double) the total diversion for water year 1993/94 due to the fact that the District was serving a second Pulp Mill (Simpson) at that time.

Figure 5
Comparison of Total Diversion (cfs) at Essex for Water Years 1990/91 and 1993/94

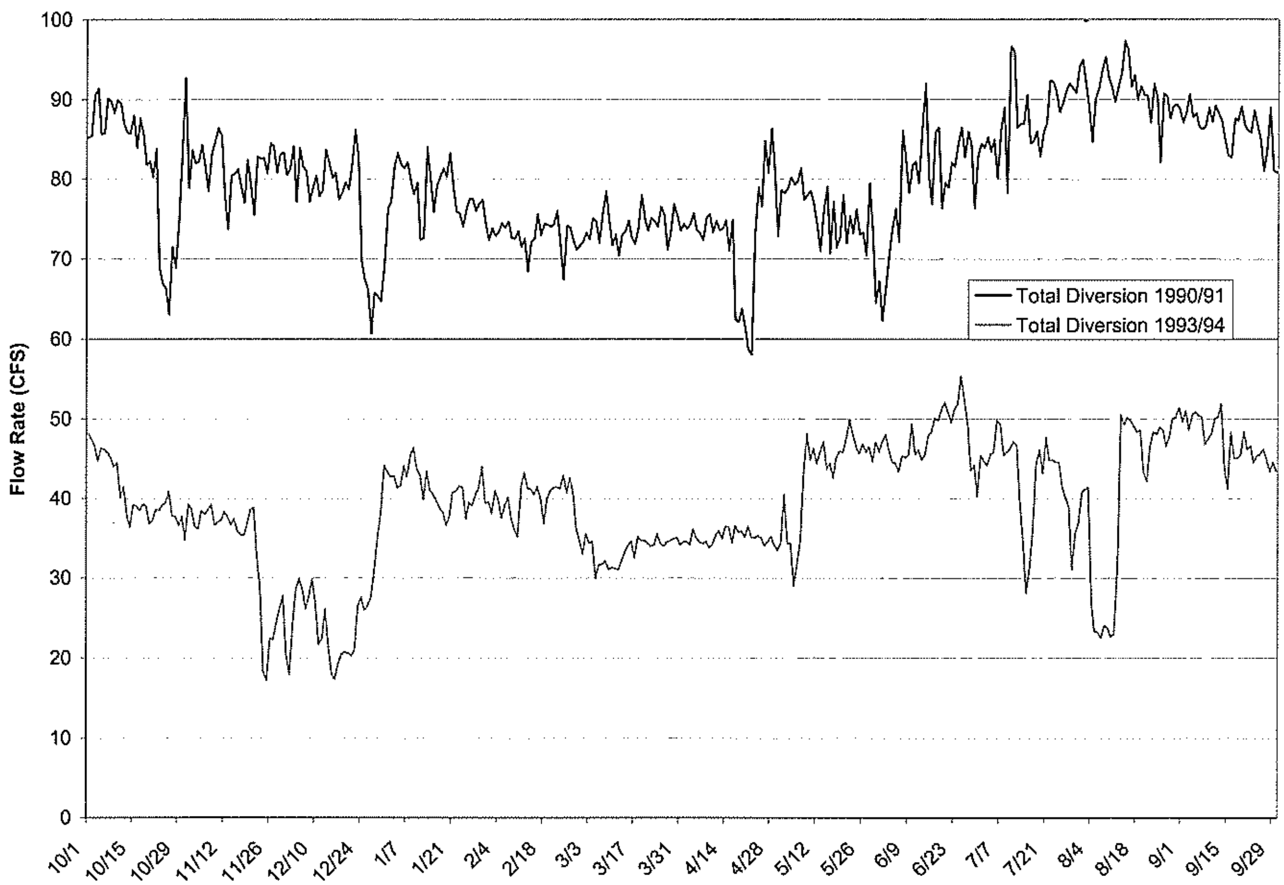
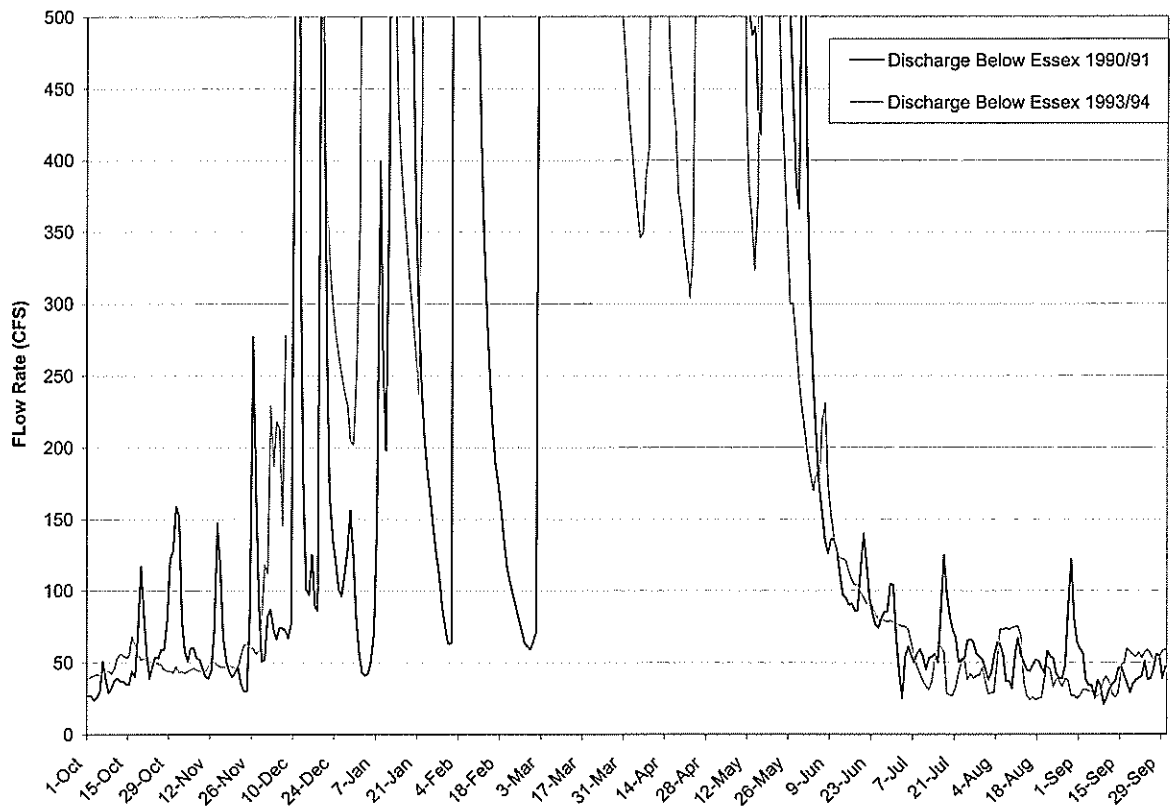


Figure 6 shows the comparative flows below Essex for these two water years (1990/91 and 1993/94). As shown, the flows below Essex are not less in water year 1990/91 despite the total diversion being significantly greater that year. This is due to the key point made several times above - that during the low-flow periods, the District releases water from Ruth Lake to meet its diversion requirements and the bypass flows below Essex. Therefore, more water was released from storage in 1990/91 to meet the higher diversion rate.

Figure 6
Comparison of Total Discharge below Essex (cfs) for Water Years 1990/91 and 1993/94
(Source: USGS Mad River Gage Station #11481000 near Arcata)



Activities 1and 2: District Management of Flow Releases
The District carefully plans and manages its water releases from Matthews Dam on a daily basis to ensure sufficient water is available year round for the District's downstream diversion requirements and minimum bypass flow requirements below Essex. Additionally, the District accounts for other factors, such as evaporative losses, in determining the amount of water it must release.

The District has the ability to accurately plan its diversion requirements based on known customer demands. The District is able to monitor wholesale customer usage on a real-time basis given the District's SCADA system (Supervisory Control and Data Acquisition). The District also has the ability to calculate natural flow in the Mad River below Essex on a daily basis. Natural flow is defined as follows:

Essex Diversion + Flow Below Essex + Inflow into Ruth at Zenia – Flow Release at Matthews Dam

Natural flow is calculated on a daily basis using daily flow data from the U.S. Geological Survey (USGS) gage stations. USGS gage stations currently exist at three locations on the Mad River – near Zenia which measures the inflow into Ruth Lake, immediately downstream of Matthews Dam which measures the flow release from Matthews Dam, and just downstream of the Essex diversion near the Highway 299 bridge over-crossing. The District has just completed a project with the USGS to improve the accuracy of flow measurement on the Mad River just below Matthews Dam. The District has installed a USGS-approved flow meter, which will measure water flowing through the penstock. The District has also developed rating tables, which will be used to calculate the volume of water that flows over the ungated spillway during the winter season, and the volume of water that may occasionally flow through the 10-inch "bypass" pipe (which is used to provide discharge to the river if the penstock is temporarily out of service). The sum of the flow through the penstock, over the spillway, and through the bypass pipe is the total flow released into the Mad River below Matthews Dam. The District will continue its cooperative relationship with the USGS, who will periodically validate the flow measurement techniques and results, and will continue to make the resulting flow data available to the public.

As noted above, the District uses USGS flow data during its daily planning process. It is important to note that the USGS data used by the District in its daily planning process will invariably differ from that which USGS later publishes for two reasons. First, the USGS published data represent daily mean discharge, yet the District uses USGS flow data for a particular time of the day (generally seven or eight in the morning). Furthermore, the USGS published data may incorporate after-the-fact adjustments based on "corrections" they believe should have been applied for a certain period of time. These adjustments are incorporated into their final daily mean flow records as published in their annual Water Resources reports.

USGS staff visits the gage stations on the Mad River on a regular basis to assess whether an adjustment to the staff gage height (e.g. "correction factor") is warranted to provide more accurate flow measurement. If USGS establishes a "correction factor" for a station on the Mad River, they provide it to the District in a timely manner. If the District receives a correction factor from USGS and determines that the flow downstream of Essex no longer meets the minimum bypass requirements, the District will increase its release from Matthews Dam. It is important to note that it takes approximately 72 hours for the increased flows to reach Essex. Therefore, the District could be out of compliance with respect to the minimum bypass flows below Essex for a period of up to three days following receipt of a new USGS correction factor.

During technical consultation with NMFS on this HCP, NMFS staff inquired how this process works and how many correction factors had been received from USGS in the recent past. Table 5 presents daily flow data downstream of Essex associated with the most recent USGS correction factors at their gage station near the Highway 299 crossing. The new correction factors are highlighted. The table presents flow for the day preceding, the day of, and the day following receipt of a new USGS correction factor, as well as the resulting natural flow.

Table 5 – USGS "Correction Factors" at Highway 299 Gage Station (May 2001 – Oct. 2002)

	Staff Gage Height (Feet)	Corresponding Flow on USGS Rating Table (cfs)	Correction Factor (Feet)	Adjusted Staff Gage Height (Feet)	Adjusted Flow from USGS Rating Table (cfs)	Natural Flow (cfs)	Compliance with Bypass Flow Requirements? (yes/no)
5/14/01	4.74	127.7	0.15	4.89	159.5	174.9	yes
5/15/01	4.93	165.8	0.27	5.20	232.5	250.0	yes
5/16/01	5.57	354.2	0.27	5.84	459.9	482.4	yes
6/13/01	4.22	42.9	0.27	4.49	82.5	86.8	yes
6/14/01	4.21	41.7	0.20	4.41	69.4	72.5	no - 3.1 cfs short
6/15/01	4.19	39.3	0.20	4.39	66.4	55.4	yes
6/16/01	4.13	32.9	0.20	4.33	57.6	47.4	yes
7/8/01	4.10	30.0	0.20	4.30	53.5	40.3	yes
7/9/01	4.05	25.2	0.15	4.20	40.9	26.3	yes
7/10/01	4.07	27.0	0.15	4.22	43.2	27.1	yes
7/26/01	3.86	10.0	0.15	4.01	21.5	26.8	no - 5.3 cfs short
7/27/01	3.87	10.5	0.09	3.96	17.4	18.4	no - 1.0 cfs short
7/28/01	3.90	12.5	0.09	3.99	19.9	20.5	no - 0.6 cfs short
7/29/01	3.90	12.5	0.09	3.99	19.9	20.9	no - 1.0 cfs short
7/30/01	3.91	13.1	0.09	4.00	20.7	17.7	yes
8/30/01	3.98	18.9	0.09	4.07	27.0	13.0	yes
8/31/02	3.94	15.2	0.08	4.02	22.4	7.9	yes
9/1/01	3.97	17.9	0.08	4.05	25.1	13.6	yes
				0.00			
11/7/01	4.10	30.0	0.08	4.18	38.5	19.7	yes
11/8/01	4.10	30.0	0.11	4.21	42.0	7.9	yes
11/9/01	4.10	30.0	0.11	4.21	42.0	6.8	yes
2/5/02	7.11	1258.0	0.11	7.22	1344.9	1257.5	yes
2/6/02	7.06	1216.0	-0.17	6.89	1081.6	985.9	yes
2/7/02	7.08	1216.0	-0.17	6.91	1095.6	1091.4	yes
2/8/02	10.01	5017.0	-0.17	9.84	4734.2	4811.3	yes
2/9/02	9.60	4317.0	0.22	9.82	4699.3	4521.3	yes
2/21/02	11.22	7439.0	0.22	11.44	7885.3	7413.0	yes
2/22/02	9.67	4432.0	0.34	10.01	5035.2	4674.2	yes
2/23/02	9.23	3723.0	0.34	9.57	4273.2	5123.7	yes
3/6/02	7.12	1266.0	0.34	7.46	1557.2	1509.2	yes
3/7/02	7.69	1777.0	-0.13	7.56	1650.8	1731.5	yes
3/8/02	7.72	1806.0	-0.13	7.59	1679.4	1622.3	yes

Table 5 (Continued)

	Staff Gage Height (feet)	Corresponding Flow on USGS Rating Table (cfs)	Correction Factor (feet)	Adjusted Staff Gage Height (feet)	Adjusted Flow from USGS Rating Table (cfs)	Natural Flow (cfs)	Compliance with Bypass Flow Requirements? (yes/no)
4/1/02	6.84	1043.0	-0.13	6.71	951.9	852.7	yes
4/2/02	6.75	977.4	-0.24	6.51	819.2	866.7	yes
4/3/02	6.46	786.0	-0.24	6.22	647.8	689.7	yes
5/1/02	6.26	667.3	-0.24	6.02	543.8	579.1	yes
5/2/02	6.17	617.7	-0.16	6.01	538.9	550.3	yes
5/3/02	6.06	560.8	-0.16	5.90	486.8	498.6	yes
5/8/02	5.76	423.7	-0.16	5.60	361.9	376.5	yes
5/9/02	5.73	411.7	-0.14	5.59	358.2	374.2	yes
5/10/02	5.68	392.8	-0.14	5.54	339.9	154.7	yes
5/28/02	5.33	273.8	-0.14	5.19	229.8	252.3	yes
5/29/02	5.36	282.7	-0.47	4.89	159.5	179.8	yes
5/30/02	5.31	267.9	-0.47	4.84	149.9	198.6	yes
7/14/02	4.81	141.9	-0.47	4.34	59.0	57.4	yes
7/15/02	4.76	131.7	-0.70	4.06	26.1	16.0	yes
7/16/02	4.79	137.9	-0.70	4.09	29.0	-4.6	yes
7/19/02	4.88	155.8	-0.70	4.18	38.5	21.4	yes
7/20/02	4.87	153.8	-0.65	4.22	43.2	32.0	yes
7/21/02	4.87	153.8	-0.65	4.22	43.2	31.5	yes
8/7/02	4.82	143.8	-0.65	4.17	37.4	10.4	yes
8/8/02	4.80	140.0	-0.66	4.14	34.1	8.9	yes
8/9/02	4.82	143.8	-0.66	4.16	36.3	9.0	yes
9/5/02	4.72	123.8	-0.66	4.06	26.1	8.2	yes
9/6/02	4.70	120.0	-0.70	4.00	20.7	6.2	yes
9/7/02	4.80	140.0	-0.70	4.10	30.0	16.6	yes
9/25/02	4.82	143.8	-0.70	4.12	32.0	14.8	yes
9/26/02	4.78	135.8	-0.74	4.04	24.2	7.5	yes
9/27/02	4.80	140.0	-0.74	4.06	26.1	8.3	yes
10/24/02	4.87	153.8	-0.74	4.13	33.1	9.9	yes
10/25/02	4.85	149.8	-0.71	4.14	34.1	16.5	yes
10/26/02	4.86	151.8	-0.71	4.15	35.2	20.0	yes

Activities 1 and 2: Impacts of Diversion on River Stage Elevation

During technical consultation with NMFS on this HCP, NMFS staff questioned to what extent the District's diversion operations (and in particular, the direct diversion facility) has on river stage height. The District does not adversely affect downstream habitat or cause stranding due to changes in river stage height resulting from its diversions.

It is important to understand the channel configuration in the vicinity of the direct diversion facility. During low-flow conditions, the existing permanent rock weir, temporary gravel berm and rock jetty (which together control the water surface elevation to the diversion facility) also create a reservoir of water above the rock weir amounting to 20-25 acre feet of storage and extending 800 to 1000 feet upstream of the weir. This impounded water volume has a tremendous modulating effect upon flow changes below the rock weir in response to changes in diversion rates. As a result, changes in water depth and surface width resulting from changes in the District's diversion rate occur gradually over many hours.

To help demonstrate this, the District analyzed actual diversion and river stage elevation data based on recent diversion rates. Additionally, the District performed a hydraulic analysis to estimate changes in water depth and surface width based on the maximum change possible in the diversion rate at the direct diversion facility (e.g. 0 to 60 MGD). The results of these analyses are discussed separately below.

With respect to current operations, it is helpful to understand how the direct diversion facility (Station 6) operates. The direct diversion facility pumps water into a 1 million gallon (MG) reservoir located on the Samoa Peninsula near the industrial customer(s). This reservoir, in turn, supplies water to the industrial customer(s) as needed. The Station 6 pumps operate when the water in the 1 MG tank reaches an established set point, thereby refilling the reservoir. Figure 7 depicts a typical elevation profile in the industrial water reservoir over a 24-hour period. The Station 6 pumps are operating at times when the elevation in the industrial water reservoir is increasing.

Figure 7

Ilustrative Elevaton Changes in 1 MG Industrial Water Reservoir over 24-hours

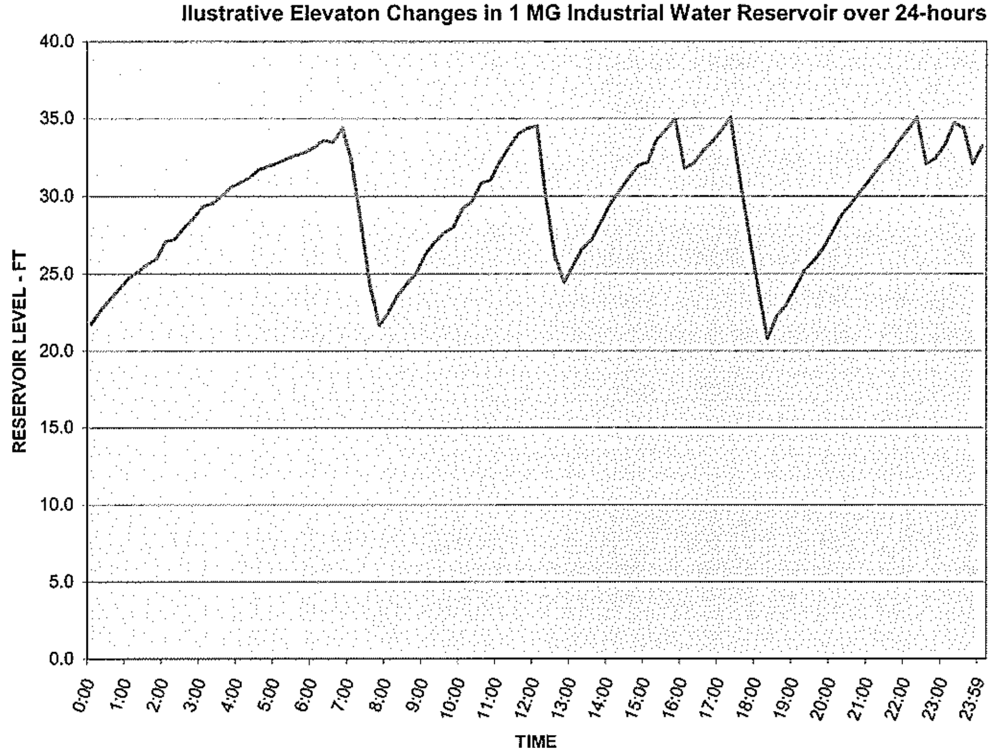


Table 6 presents diversion rates, and corresponding river elevations at Station 6 and downstream at the USGS Highway 299 gage, over a 24-hour period for a representative summer-time day and winter-time day (which were selected at random from 2002). For the summer day, the minimum and maximum diversion rates at the direct diversion facility ranged from 6.2 MGD to 21.1 MGD, as noted by the shaded cells. Despite a wide variation in the diversion rates, the resulting change in river stage at Station 6 and also at the USGS Highway 299 gage is less than one-tenth of one foot over the 24-hour period.

Table 6. Hourly Diversion Rates and River Stage for Illustrative Summer and Winter Day

	Winter-time Day (1/16/02)					Summer-time Day (6/13/02)				
TIME	Domestic System Diversion (MGD)	Industrial System Diversion (MGD)	Total Essex Diversion (CFS)	River Stage at Station 6 (FT)	USGS Gage (at Hwy 299) (FT)	Domestic System Diversion (MGD)	Industrial System Diversion (MGD)	Total Essex Diversion (CFS)	River Stage at Station 6 (FT)	USGS Gage (at Hwy 299) (FT)
0:00	5.9	15.5	33.3	22.3	7.48	12.0	15.4	42.4	21.1	5.08
1:00	6.2	14.9	32.7	22.3	7.45	12.0	15.4	42.4	21.1	5.10
2:00	6.2	15.3	33.3	22.2	7.48	12.0	15.5	42.6	21.1	5.10
3:00	6.2	14.6	32.2	22.2	7.48	12.0	15.2	42.2	21.1	5.11
4:00	6.2	14.6	32.3	22.2	7.48	12.0	15.2	42.1	21.1	5.11
5:00	6.2	14.9	32.7	22.2	7.47	12.0	15.2	42.2	21.1	5.11
6:00	6.3	14.1	31.5	22.2	7.49	12.0	19.8	49.3	21.1	5.09
7:00	6.3	0.0	9.7	22.3	7.49	17.0	6.2	36.0	21.1	5.09
8:00	11.1	15.3	41.0	22.2	7.40	16.9	16.8	52.4	21.1	5.09
9:00	16.0	15.7	49.1	22.2	7.44	16.9	14.0	47.8	21.1	5.10
10:00	15.9	15.1	48.1	22.2	7.43	16.9	17.1	52.7	21.1	5.08
11:00	6.9	13.6	31.8	22.2	7.40	11.8	16.3	43.6	21.1	5.07
12:00	6.2	0.0	9.7	22.3	7.40	0.0	6.7	10.4	21.2	5.10
13:00	6.2	18.7	38.6	22.2	7.38	0.0	15.1	23.4	21.1	5.15
14:00	12.3	18.3	47.4	22.2	7.41	0.0	20.1	31.1	21.1	5.12
15:00	0.0	17.7	27.4	22.2	7.38	0.0	20.1	31.1	21.1	5.12
16:00	6.3	0.0	9.7	22.2	7.38	3.8	19.8	36.6	21.1	5.13
17:00	12.4	8.7	32.6	22.2	7.33	12.1	20.0	49.9	21.1	5.12
18:00	12.3	0.0	19.1	22.2	7.40	11.8	19.7	48.9	21.1	5.11
19:00	12.3	21.1	51.8	22.1	7.39	17.4	19.8	57.6	21.1	5.11
20:00	12.3	20.3	50.5	22.1	7.35	17.0	19.5	56.5	21.1	5.09
21:00	12.4	19.4	49.2	22.1	7.39	17.0	19.2	56.2	21.1	5.09
22:00	6.2	19.0	39.0	22.1	7.33	16.9	19.0	55.7	21.1	5.09
23:00	6.2	8.9	23.3	22.1	7.34	17.0	20.1	57.6	21.1	5.08
23:59	6.2	14.3	31.8	22.1	7.37	16.9	20.1	57.4	21.1	5.08

Additionally, the District reviewed its recent operational data to determine the maximum change in pumping rate at the direct diversion facility over a short period of time. On July 31, 2002, the District's industrial customer experienced problems. Between noon and two-thirty p.m., the diversion rates at the direct diversion facility changed four discrete times as follows: 1) from approximately 16 MGD down to zero, 2) from zero to 15 MGD, 3) from 15 MGD back to zero, and 4) from zero up to 20 MGD. These changes in diversion rates were in essence instantaneous. During this event, the corresponding change in river stage elevation at Station 6 was 20.99 feet to 20.82 feet, which is less than two-tenths of one foot.

As introduced above, the District also performed a hydraulic analysis to estimate the impacts below the diversion facility, which would result from modifying diversion rates using three current operational scenarios and two hypothetical operational scenarios (up to an including the maximum possible diversion rate). The current scenarios utilize actual flow and diversion conditions from September 13, 2000 since the actual channel conditions at two cross sections below the Essex diversion facilities were known that day (based on the cross sectional survey completed by Winzler & Kelly Consulting Engineers for the District). The current scenarios and two hypothetical scenarios are summarized as follows:

Current Operations:

> Scenario 1: Normal summer/fall diversion conditions, i.e. – 41.1 cfs diversion to municipal and industrial customers.
>
> Scenario 2: Immediate cessation of industrial water diversion, i.e. – 13.3 cfs diversion to municipal customers only, thereby adding 27.8 cfs to downstream flows.
>
> Scenario 3: Assumed power outage with immediate cessation of all deliveries i.e. – 41.1 cfs added to downstream flows.

Hypothetical Operations:

> Scenario 4: Maximum industrial and domestic capacity of 116 cfs is in use (93 cfs industrial and 23 cfs domestic), and then industrial demand immediately terminates – i.e., 93 cfs is added to downstream flow.
>
> Scenario 5: Maximum industrial and domestic capacity is in use (116 cfs) and loss of power causes immediate termination of all delivery - i.e., 116 cfs is added to downstream flow.

The five scenarios are applied to known diversions and river hydraulic conditions existing at two river channel cross sections (called Sections 1 and 2) which are located downstream of the Essex diversion facilities. Section 1 is approximately 400 feet wide with bank elevations of 27.8 feet and 41.3 feet. The channel floor has a low-flow channel against the north bank that is approximately 4 feet deep and 50 feet wide with a thalwag elevation of 13.2 feet, and a secondary low-flow channel near the south bank with a thalwag elevation of 15.3 feet. On the survey date (9/13/2000), the water surface elevation at Section 1 was observed in the low-flow channel at elevation 14.8 feet, and in the secondary channel at elevation 16.4 Section 2 is approximately 250 feet wide with bank elevations of 34.2 feet and 27.0 feet. The channel floor has a low-flow channel against the south bank that is approximately 12 feet deep and 210 feet wide with a thalwag elevation of 14.8 feet, and a secondary low-flow channel near the north bank with a thalwag elevation of 19.0 feet. On the survey date, the water surface elevation at Section 2 was observed in the low-flow channel at elevation 18.2 feet, and there was no flow in the secondary channel.

A hydraulic analysis of the various flow characteristics was performed of each cross section. The computer software program used was Flowmaster, Version 6.1, as developed by Haested. Flowmaster computes water surface profiles for regular and irregular shaped channel cross sections using Manning's equation. The water surface profile can be translated into water depths and change in top width of the water surface at the known river cross sections. Table 7 presents the results from this hydraulic analysis for each scenario at the two cross sections.

Table 7. Channel Changes Below Essex based on Results of Hydraulic Analysis

River Cross-Section Number	Changing Conditions Scenario	Increase in Flow rate (cfs)	Change in Water Depth (feet)	Change in Water Surface Width (feet)*
1	2	27.8	0.2	1.7
1	3	41.1	0.4	2.8
1	4	93.0	0.9	14.4
1	5	116.0	1.0	19.4
2	2	27.8	0.1	2.7
2	3	41.1	0.2	4.0
2	4	93.0	0.4	8.1
2	5	116.0	0.5	9.6

* Because of the flat slopes of the gravel bars in the areas of the cross-sections, change in top width of the actual river surface width is equivalent to change in wetted perimeter.

As illustrated in Table 7, the maximum change in water depth for Sections 1 and 2 was 1.0 feet and 0.5 feet, respectively, resulting from Scenario 5, the worst case flow rate change. Similarly, Scenario 5 resulted in the maximum change in top water surface width for Sections 1 and 2 of 19.4 feet and 9.6 feet, respectively.

As discussed previously, the existing rock dike, gravel berm and rock weir (which together control the water surface elevation for Station 6) create a reservoir (i.e. water impoundment) above the rock weir amounting to 20-25 acre feet of storage and extending 800 to 1000 feet upstream of the weir. This impounded water volume has a modulating effect upon flow changes below the rock weir. Therefore, any change in water depth or surface width resulting from changes in diversion rates will occur gradually over many hours. This situation has consistently been observed by District personnel, and confirmed by measured water surface elevations.

3. Bypassing Flows Below Essex

The District maintains bypass flows below Essex in accordance with conditions in its State Water Rights Permits. Management of flow releases, including the minimum bypass requirements, was discussed above under Activities 1 and 2. During technical consultation with NMFS on this HCP, NMFS staff requested that the District provide a summary of its bypass flows below Essex for the recent past. Figures 9.1 through 9.12 (at the end of this appendix) present daily flow records for each water year between 1989 and 2001. These figures present natural discharge, discharge above Essex, and discharge below Essex (e.g. the bypass flow) over a range of water year conditions (wet, normal, dry). As can be seen, but for a very few instances, the bypass flows below Essex are greater than the natural flows which would otherwise exist in the Mad River during the critical low-flow months in the late summer and fall.

4. Operating the direct diversion facility, including the fish screens

In 1976, a new direct diversion facility was constructed (Station 6) to deliver 60 MGD to the District's industrial customers. Station 6 is comprised of a forebay, which is directly adjacent to the Mad River and extends transverse to the direction of flow, and a concrete pumping structure. A shear wall of removable concrete panels across the entrance of the forebay reduces the amount of debris entering during high flows. Cellular steel sheet pile structures make up the forebay sidewalls. The forebay shape is trapezoidal, 90 feet wide at the riverbank, and tapering to 36 feet wide, in front of the trash racks at the back of the forebay. The forebay is approximately 90 feet long, from the shear wall in front at the river to the trash racks in the back. Within the forebay and approach chambers to the fish screens, no undesirable hydraulic effects (i.e., eddies or stagnant flow zones) exist, which would delay, confine, or injure fish.

The concrete intake structure is divided into two equivalent "pumping cells," each one housing three-large electric-driven motors. A composite inclined trash rack at the entrance to the structure protects each cell. The trash racks remove woody debris that ends up in the forebay. The trash racks are made of vertical steel bars spaced two inches apart; their function is to catch floating debris and prevent fish larger than two inches in body width from entering. A mechanical, motor driven trash rake cleans the racks, which is activated manually. The trash rake brings all trash and debris to the pump deck surface for disposal.

Each cell also has a mechanically operated fish screen located approximately 12 feet in front of the pumps. The fish screens are vertical traveling Rex "four post type" screens. The screen, including the structural framing system, completely fills the opening between the concrete sidewalls and is further "guarded" along both sides by redwood 2" x 4" sealing strips, connected directly to the concrete sidewalls. At the bottom of the screen, a steel boot plate reduces any opening at the screen bottom to less than 3/8". The rotation direction of the screen and fish buckets is toward the face of the screen, creating a water movement away from the screen at this point. Each of the two fish screens is 13 feet-2 inches wide (frame to frame) and articulated at 2-foot vertical intervals. The screen material is Type 304 stainless steel wire cloth with 3/16" square opening.

The debris present in the water determines the frequency of screen runs. Normally the screens are set to run for 20 minutes every 96 hours; however, the frequency may increase when the river is over 23.0 feet, or the turbidity is over 30 NTU. The screens also activate automatically if head loss is too high.

The fish bypass system begins with the fish baskets/troughs attached to the vertical traveling screens. When the screens are in operation, small organic debris or juvenile fish within 4.5 inches of the screen face will be lifted out of the water column, by one of the 58 troughs, which are attached to the screens at two-foot intervals. The troughs are made of carbon steel (12' l x 2.5" d x 2.5" to 4.5" wide), and are capable of holding water to support fish. As the troughs pass over the head sprockets, fish slide onto a wire screen where a low-pressure spray directs them to a fiberglass trough. Debris generally remains matted on the basket panels and is removed by a high-pressure spray, which blasts debris into a debris trough located immediately below the fish trough. A low pressure flushing flow runs twenty minutes after the screen has stopped operating, to guide the fish back to the river. The fish bypass system is approximately 390 feet long, and descends approximately 40 feet. Fish are returned to the Mad River below a boulder grade control structure, into a flatwater habitat reach.

<u>Compliance with NMFS Fish Screen Criteria</u>

Station 6 was designed in accordance with CDFG's fish screen criteria in 1975. Station 6 was a "state of the art" diversion and screening facility for its time. More recently, NMFS (1997) and CDFG (1999) have adopted updated fish screen criteria applicable for new facilities. Station 6 is able to meet the primary goal established for new facilities – that is to not separate anadromous salmonids from their main migratory route. The forebay basin at Station 6 functions like a backwater pool or off-channel slough. Anadromous salmonids of all age classes that enter the forebay basin are never segregated from their migratory route in the main channel, nor are they prevented from freely swimming out of the facility. The forebay basin provides a slack water environment that allows suspended sediment to settle, and provides low velocity, deep-water habitat for migrating salmonids. Furthermore, Station 6 currently meets all but two of NMFS screen criteria for new facilities, including arguably the most important criterion – that is approach velocity. Refer to Appendix D for a comprehensive evaluation of how the District's fish screens meet NMFS' 1997 Fish Screening Criteria for Anadramous Salmonids.

During the technical consultation with NMFS in 2000, the District agreed to make Station 6 "fish tight" by complying with NMFS' 3/32-inch screen size opening criterion. The District also agreed to remove the existing buckets on the fish screens and replace them with rakes, thereby eliminating the possibility of lifting fish out of the water. This in turn eliminates the need for the fish return system, which does not meet current standards. Additionally, the District will be conducting a comprehensive monitoring program after the Station 6 retrofit project is complete. The Station 6 retrofit project, plus the monitoring program, are outlined in greater detail in the main body of the District's HCP.

5. Dredging the forebay at Station 6

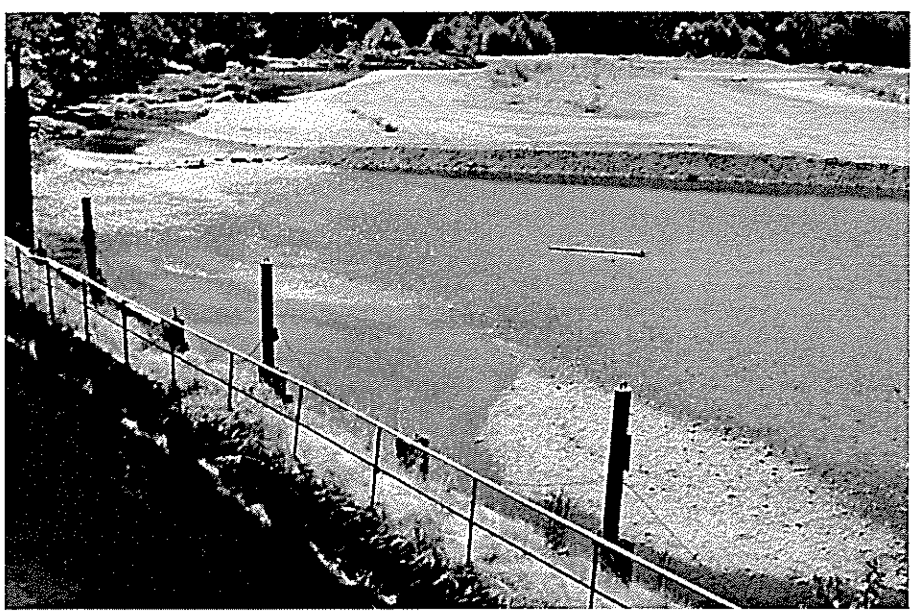
The District performs dredging/excavation each winter to remove accumulated sediment. The Mad River experiences highly varying water surface elevations; stage height can vary by over 20 feet. The Mad River also experiences high sediment and debris load in the winter. Therefore, a principal design criterion of Station 6 was mechanical removal of accumulated silt and gravel in the forebay to protect the pumps. The District must dredge the forebay after high flow events deposit large amounts of silt and gravel. The frequency of dredging depends on the severity of winter storms but generally varies between 2 and 5 times per month. Either a crane with a clamshell bucket, or an excavator, is used to dredge the forebay to a depth of 10 to 12 feet msl. The crane or excavator is also used, as needed, to clear the channel in front of the forebay, maintaining a continuous water flow in the forebay and the low flow channel of the river.

6. Maintaining adequate water surface elevation to Station 6 during low-flow

From 1976 to 1991, channel conditions in the Mad River allowed the District to operate Station 6 (the direct diversion facility) without any grade or water stage control. However, the bed of the Mad River has degraded over time. In the late 1980's the riverbed near Station 6 was approaching an elevation at which the pumps would vortex and no longer operate. Therefore, in 1991, the District installed two rock structures as a means of controlling water surface elevation – a jetty and a weir. The rock jetty, which projects from the north bank of the river, directs the flow toward Station 6. The weir, located 190 feet downriver of Station 6, controls the water surface elevation at Station 6 at approximately 21.5 feet mean sea level (msl). This grade control system ensures sufficient water surface elevation at Station 6 during the low flow months.

When runoff declines in late spring and water stage is close to 21 feet msl, the District constructs a berm connecting the rock jetty to the grade control weir downstream. The berm does not divert water into Station 6, rather it ensures water passes over the weir during the low flow months (as opposed to going around it), thereby ensuring adequate water surface elevation at Station 6. The District constructs the berm from river-run gravel, derived either from a point bar downstream near the north bank or from excavation of the low-flow channel in front of Station 6. The exact location and length of the berm may vary based on channel conditions, but fill is limited to that necessary to connect the rock jetty with the weir. The berm is approximately 350 feet in length, by 20 feet wide, by 3-4 feet high. Therefore, the footprint covers approximately 0.15 acres.

Berm During Construction
(with federally-licensed biologist in the river protecting fish)



Completed Berm
(connecting to the downstream grade-control weir, pictured)

The District has evaluated the use of bladders as an alternative to construction of the gravel berm. Bladders were determined to not be a feasible alternative for a variety of reasons. First, there is no way to install and secure bladders given the existing channel configuration and rock structures at each end (the jetty and weir) absent installation of some permanent concrete structure to which the bladders could be attached. More importantly, there is no way to safely remove the bladders each season. The Mad River water surface elevation changes very rapidly and dramatically in response to storm events. To ensure worker safety, the District would require the bladder to be removed prior to the first significant storms, but then the necessary water surface elevation to Station 6 would not be maintained. If the District waited until after the first storm events (such that the necessary water surface elevation is maintained), the District could not safely remove the bladders, and they would likely be washed away down stream potentially causing third-party injury or damage.

As discussed in the main body of the HCP, the District will initiate a study to determine if a more permanent solution is available to provide the necessary water-surface elevation.

Current Activities Which Occur Only As-needed

7. Maintaining adequate capacity in tailrace and spillway pools below Matthews

Erosion, resulting from high water events passing over the spillway, periodically results in deposition of material in the plunge pool or tailrace channel outlet (the confluence with the Mad River).

In the tailrace channel, aggraded material collects which, in turn, may increase water surface elevation in the tailrace pool. This elevated water surface could result in accelerated bank erosion that threatens the dam face, the hydroelectric facility, or the County road located on the right bank. Aggradations in the past have partially or completely closed off the tailrace channel.

At the spillway plunge pool, riprap encased in concrete has been applied on the left bank. This riprap should stabilize the bank and minimize erosion. However, erosion during high discharge events may still occur. Additionally, course sediment derived from the steep talus slope on the right (east) bank of the spillway may be deposited in the spillway plunge pool.

On an as-needed basis, the District must remove this aggraded material and sediment from the tailrace channel and spillway plunge pool. The tailrace channel, subject to siltation and gravel deposits, covers an area approximately 30 feet by 80 feet (0.05 acres). The spillway plunge pool, subject to siltation and gravel deposits, covers an area approximately 40 feet by 100 feet (0.09 acres).

8. Gaining access to and maintaining Ranney Collectors

District personnel routinely visit the collectors to perform inspections and ongoing maintenance. To gain access to the collectors located in the riverbed, District personnel are transported in an aboveground cable car. The District must occasionally perform major maintenance at the collectors, including repair or installation of new pumps, motors, or other heavy equipment. A crane will usually be required for the major maintenance, and if so, temporary access structures must be constructed to allow the crane to access equipment on the collector decks.

The temporary access structures to Collectors 1, 2 or 4 are constructed by pushing native river run materials with a backhoe, front end-loader, or tractor. The structures will normally be constructed on the exposed riverbed outside of the wetted channel, during the low-flow period. Under emergency conditions, the District may need to gain access during the higher flow months, and thereby work in the wetted channel. The riverbed will be returned to its pre-construction condition upon completion. Two types of temporary access structures exist - roads and ramps - as follows:

- The temporary roads utilize a maximum of 2,000 to 3,000 cubic yards of material. The temporary road entrances, from the top of bank to the exposed bed of the river, have been previously established at each of Station.
- The ramps are 3 to 4 feet above the exposed riverbed elevation, covering an area approximately 40' by 40' adjacent to the Ranney collector. The ramps range in length from 75' to 200' and height from 10' to 20', depending on the channel topography. The ramp also includes a flattened 25' by 25' area on the top for the crane to set.

Currently, the District does not need to cross the wetted channel to access any of the collectors to perform its maintenance. However, should the river channel change in relation to the collector structures, channel crossings may become necessary in the future.

Occasionally, the District must flush its collectors of accumulated sediment or conduct performance tests. Construction of a temporary berm would be necessary to control the run-off generated from these activities. The berm would be constructed by pushing riverbed material 3' to 4' high around a portion of the collector. The length and exact configuration depend on the edge of the low-flow water in relation to the collector and the area of discharge. The berm would be constructed away from the low-flow channel, and would not create any pits or pools. Water discharged from the collector would be contained to allow any sedimentation or turbidity to settle out. The water would then percolate into the riverbed, or be allowed to flow back into the river channel through some form of turbidity control (e.g. silt curtains or screens). The berm area would be regraded to the original channel bed topography when the activity is complete.

9. Maintaining adequate flow to direct diversion facility (Station 6)

Each year, the District must assess changes to channel morphology in front of Station 6. Depending on the magnitude and duration of winter floods, coarse sediment can accumulate behind the rock weir downriver of Station 6. If aggradation threatens to block the forebay and limit exchange of water with the low-flow channel, excavation of aggraded material, or creation of a channel along the south bank, may be necessary. The aggraded gravel must be removed before it causes a bar to form, which blocks the entrance to the forebay, and causes the thalweg to shift to the center of the channel.

When the District excavates to relocate the thalwag in closer proximity to the forebay entrance, the overall bed elevation and slope of the channel are not altered. There is no headwall created, as would occur from in-channel pit mining. The up and down-river riffles are still the hydraulic controls that maintain the overall slope through this reach.

The configuration and extent of the excavation required varies depending on the amount of material that has aggraded in front of Station 6, and the location of the aggraded material in relation to the low- flow channel of the river. Excavations have typically been approximately 250 – 500 feet by 20 feet (0.11 – 0.23 acres). The sediment removed during dredging is removed or utilized in the construction of the low flow berm to minimize excavation of the adjoining gravel bar.

10. Repair of Rock Structures and Revetment

The District has little control over factors that cause degradation or that damage its infrastructure. Existing rock structures and revetments need to be maintained, and rehabilitated or repaired if damaged. Stationary rock structures that are part of the District's facilities include: a grade control weir below Station 6; a rock jetty which projects from the north bank just upstream of Station 6, three wing jetties on the north bank near Station 1; and rock structures protecting the in-river collectors or domestic lines. Existing rock revetments are located in the plunge pool and tailrace outlet below Matthews Dam, and at various locations in the Essex Reach on both banks of the river from Collector 3 to above the Highway 299 bridge. The revetments vary in length from 100 to 800 feet and consist of ¼ ton to 4 ton rocks. The toe trenches or keys into gravel substrate for these revetments encumber a footprint of approximately 0.75 acres in total. Figure 8 shows the approximate location of rip rap and rock structures in the Essex reach.

Possible Future Activities

The District may need to pursue a number of new projects or activities over the course of the HCP planning horizon, which is 50 years. Potential future activities contemplated at this time are as follows:

11. Restoring channel capacity below Matthews Dam

The river channel below Matthews Dam could become partially or totally blocked if a landslide occurred downstream of the dam. Such an event could seriously threaten the safety and integrity of the dam and powerhouse. Excavation of material in the channel below Matthews Dam would be necessary if the channel was impeded by material from a landslide or other significant deposition.

12. Repairing, rehabilitating or replacing water lines or laterals in the riverbed in Essex Reach

The District's domestic system at Essex is comprised of 24" pipelines from the five Ranney collectors, which lie beneath the riverbed. They connect each collector to a main transmission line that is parallel to the south bank of the Mad River. The mainline increases in diameter as it travels downriver from 24" to 51". The District's industrial water line crosses the Mad River to the north bank just downstream of Station 6 (about 10 feet below the channel bed) and then proceeds downriver. Just above the Highway 299 bridge, the line crosses beneath the Mad River again back to the south bank. The industrial line then proceeds through Arcata and down the Samoa Peninsula. Over the term of this HCP, these pipelines may need to be repaired, rehabilitated or replaced. Such work would likely involve excavation (to a depth of approximately 14 to 19 feet) below the gravel surface, installing steel piling under the pipeline (if deemed necessary), encasing the pipe with reinforced concrete, and replacing the excavated material back to original elevation. Where construction could not be performed in an above-ground gravel environment, the river would have to be diverted into a temporary adjacent channel. Additionally, the Ranney collectors have a series of laterals that extend out horizontally from the central caisson below the riverbed. Over the term of this HCP, these laterals may need to be repaired, rehabilitated or replaced.

13. Constructing additional grade control structures in the Essex Reach

From 1976 to 1991, channel conditions in the Mad River allowed the District to operate the direct diversion facility without any grade or water stage control. However, the bed of the Mad River has degraded over time. In the late 1980's the riverbed near Station 6 was approaching an elevation at which the pumps would vortex and no longer operate. Therefore, in 1991, the District installed two rock structures as a means of controlling water surface elevation – a jetty and a weir. The rock jetty, which projects from the north bank of the river, directs the flow toward Station 6. The weir, located 190 feet downriver of Station 6, controls the water surface elevation at Station 6 at approximately 21.5 feet mean sea level (msl), which ensures sufficient water during the low flow months. If the riverbed continues to degrade, additional grade-control structure(s) may be required in the Essex reach to maintain adequate water surface elevation to Station 6 or the collectors.