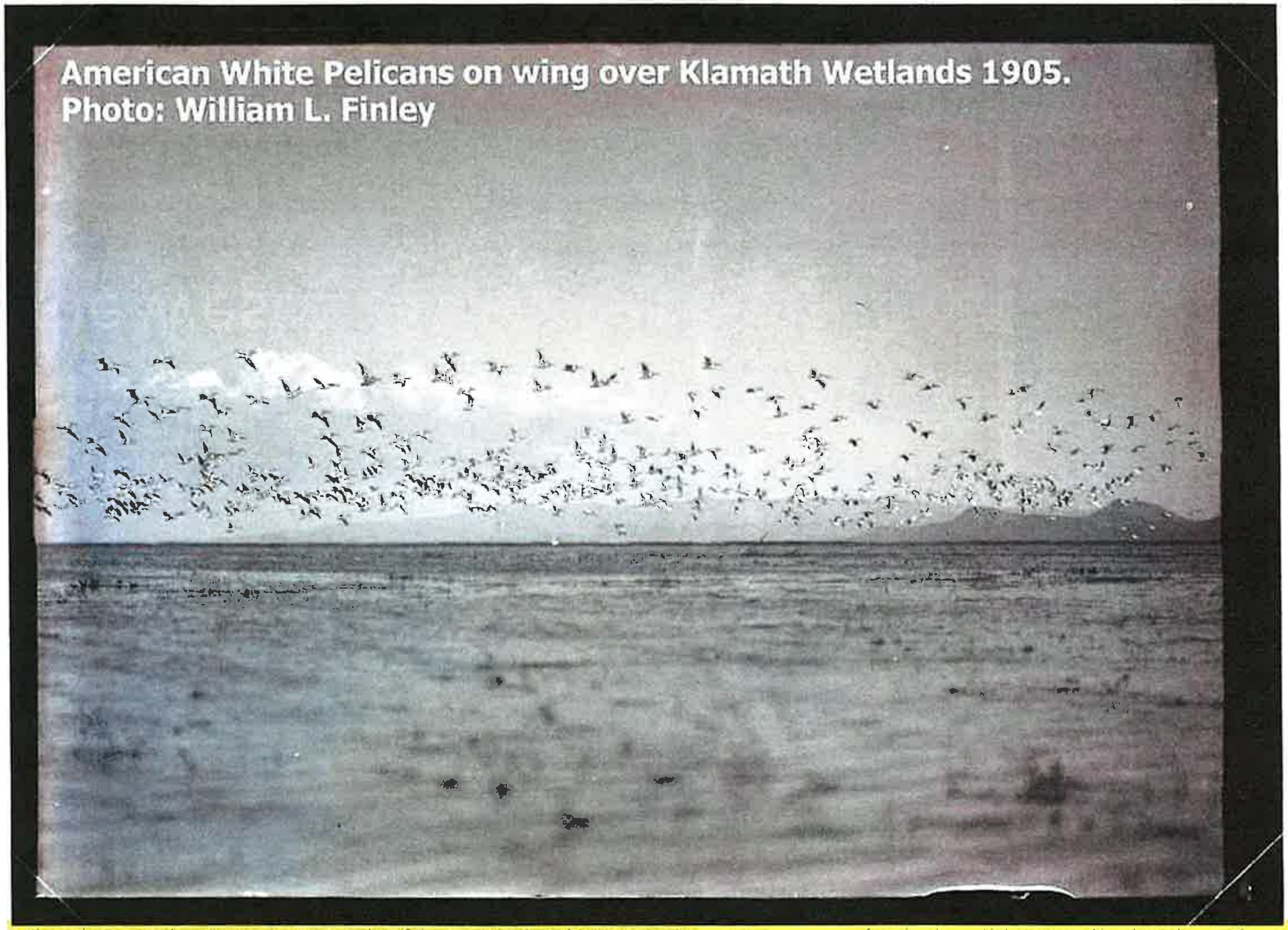
Klamath, Once referred to as "The Everglades of the West"

Presentation created by Gene Souza
Executive Director Klamath Irrigation District

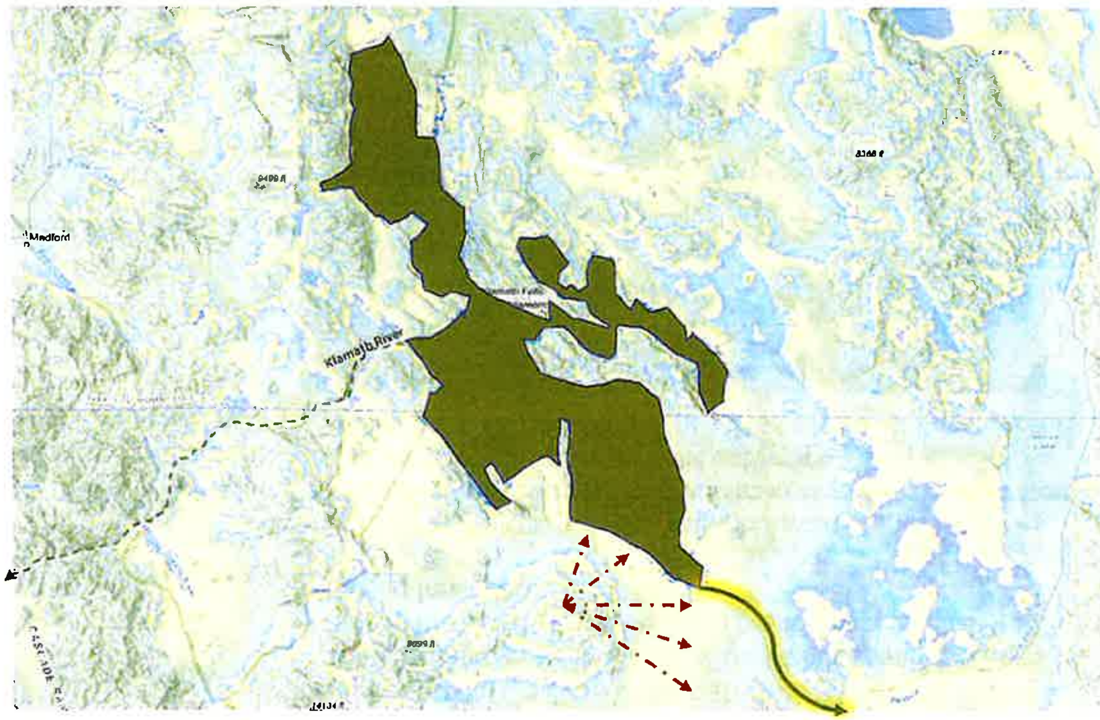


American White Pelicans on wing over Klamath Wetlands 1905.
Photo: William L. Finley

How did Klamath water create some of the Nation’s most fertile soils?

- Ancient Lake Modoc: Geologic Influences on Water

- An ancient pluvial lake…consisted of several connected arms with an overall length of 75 miles… the 400 miles of shoreline was at a uniform elevation of 4,240 feet above sea level (**about 100 feet higher than the elevation of Upper Klamath Lake today** and nearly 200 feet above some of the farmlands in Tule Lake).
- At 110 sq miles, Upper Klamath Lake remains as last large body of water, the largest [continuous surface area] in Oregon.
    - (Samuel Dicken, 1980)
      U of O Geology Professor



Before the Medicine Lake shield volcano blocked its path (~ 10,000 years ago), water would flow south into the Pit River.
Ash from Mt. Mazama and cascades filled the lakebed (note chalkrock)

Geological conditions slowed water flow, creating a giant lake filled with volcanic ash from the cascade volcanos, originally draining south, not west.

Ancient Lake Modoc – Pit River Connection vs Klamath River: Genetics of Klamath Redband Trout vs Klamath Steelhead

- In June 1894, Gilbert sampled rainbow trout from Klamath River and Upper Klamath Lake. He was unable to distinguish them from typical Salmo pairdneri, stating that the larger specimens had the characteristics of sea-run or land locked fish with a few spots and a truncate tail.

- **Oregon State University Study on RedBand Trout – Podcast 55**
- https://myodfw.com/beaver-state-podcast/klamath-lake-redband-trout?fbclid=IwAR07dSiW3Y3IKnsVBDTg8MT3pqRYn83R20I2_32dRK466dLCSeKQVQQANrc

- OSU Study Klamath Redband genetics came from the east…
  - 05:15 – 6:30 minute mark

- **Klamath Redband is genetically different from Klamath River steelhead. Klamath Redband Salmon / Trout are genetically more identical to Great Basin species than Klamath River species of Steelhead.**
  - **7-minute mark**

Question to Ponder: Why have Klamath River Steelhead not bred with Klamath Redband Salmon/Trout for over 10,000 years?

- **Rainbow Trout** are a type of ocean-going **trout**.
  - The steelhead branch of the rainbow trout spends most of its time in the ocean, while the main branch spends all of its time in freshwater.

  - Outside of Alaska, **redband salmon / trout in the Upper Klamath are the largest-bodied strain of native rainbow trout that remain in freshwater their entire lives**. Fish over 24 inches are common and 30-inch trout are caught each year.

 Geological conditions connected water to the fish now found In The Great Basin areas (closed to the ocean)

Klamath Climate Changes and Cycles

- Perhaps 10,000 years ago the climate gradually settled into its present semi-arid, fluctuating, and unpredictable state, and Lake Modoc began to shrink." (Samuel Dicken, 1980)
- This change, coupled with ***the erosion of the natural basalt reef near Keno, Oregon, lowered the elevation of Lake Modoc,*** thereby creating a series of isolated lakes which initially earned the area the title of "Lake County" by early settlers (read more in Klamath Echoes Volume 1) . **In the 1870s, much of the lands currently irrigated were covered in water for 10 months or more every year.**
- David M. Meko, Connie A. Woodhouse, and Ramzi Touchan revisited a 1937 study by F.P Keen on historical precipitation in the Klamath. These 1000-year studies clearly show routine dry periods in the Klamath precipitation cycle. **Each yellow and pink bar on the graph shows a recurring dry period that occurred in the Klamath Basin,** and at times, interacting with the weather patterns of the Sacramento and San Joaquin watersheds.
- Both Klamath Falls and **Klamath Keno reconstruction shows a dry-run of 21-years below the median in the mid-1600s;** routine extended dry periods exceeding 5 years every 87-96 years with notable dry conditions in 1840s and 1930s which can be matched with written records. (Meko, Woodhouse, Ramzi, 2014)

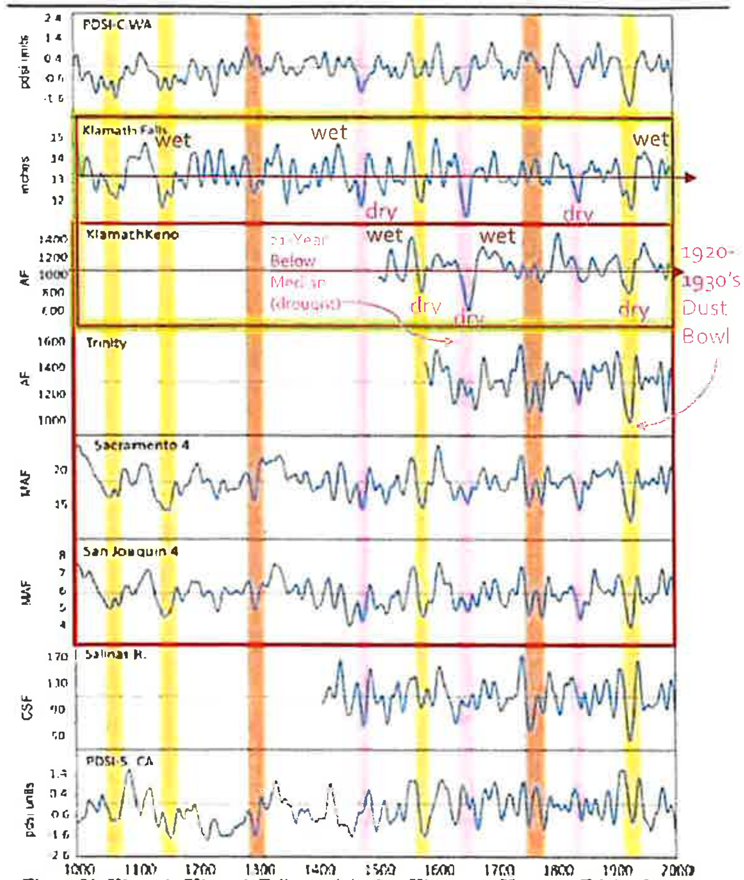
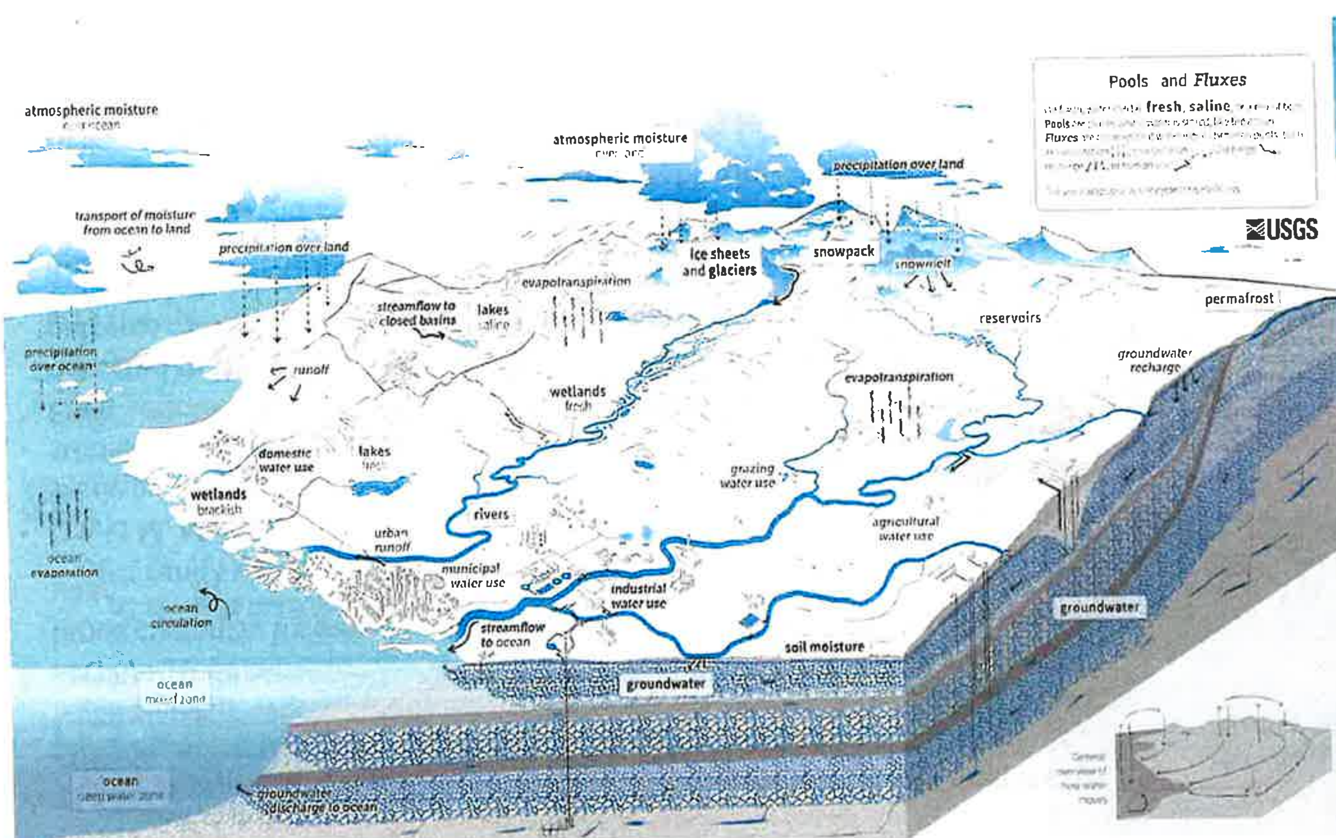


Figure 31. Klamath (Klamath Falls precipitation, Klamath at Keno and Trinity flow), Sacramento (4 rivers average), and San Joaquin (4 rivers average) with other western hydroclimate reconstructions, smoothed with a 20 year spline. Series are arranged from north to south. Major region-wide droughts are indicated with yellow bars, dry south-wet north are orange, and dry north-wet south are pink. Start dates are variable, all end in 2005.

Klamath is no stranger to change. Climate cycles can have large swings on precipitation and effect the availability of water at Keno.



The Water Cycle

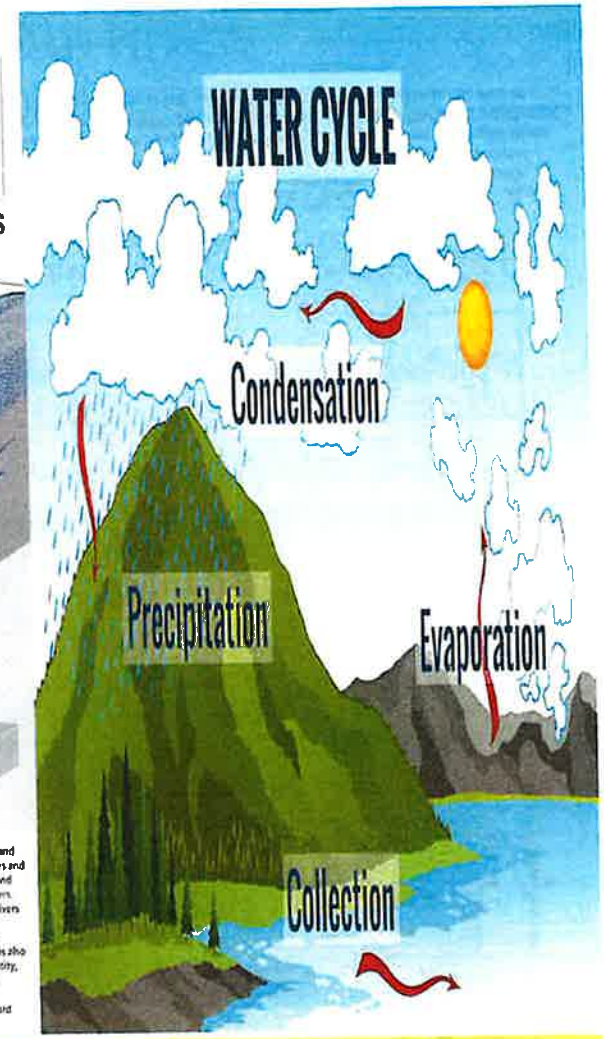
The water cycle describes where water is found on Earth and how it moves. Water can be stored in the atmosphere, on Earth's surface, or below the ground. It can be in a liquid, solid, or gaseous state. Water moves between the places it is stored at large scales and at very small scales. Water moves naturally and because of human interaction, both of which affect where water is stored, how it moves, and how clean it is.

Liquid water can be fresh, saline (salty), or a mix (brackish). Ninety-six percent of all water is saline and stored in **oceans**. Places like the ocean, where water is stored, are called **pools**. On land, saline water is stored in **saline lakes**, whereas fresh water is stored in liquid form in **freshwater lakes**, artificial **reservoirs**, **rivers**, **wetlands**, and in soil as **soil moisture**. Deeper underground, liquid water is stored as **groundwater** in aquifers, within the cracks and pores of rock. The solid, frozen form of water is stored in **ice sheets**, **glaciers**, and **snowpack** at high elevations or near the Earth's poles. Frozen water is also found in the soil as **permafrost**. Water vapor, the gaseous form of water, is stored as **atmospheric moisture** over the ocean and land.

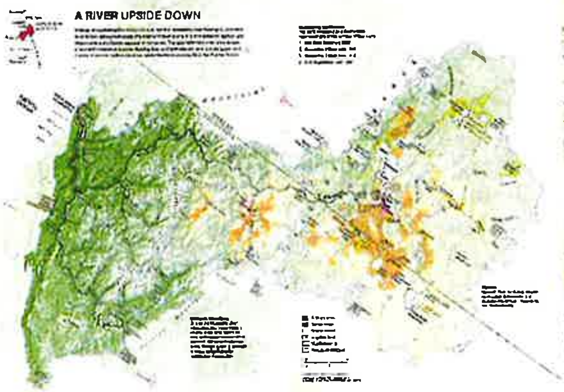
As it moves, water can transform into a liquid, a solid, or a gas. The different ways in which water moves between pools are known as fluxes. Circulation mixes water in the oceans and transports water vapor in the atmosphere. Water moves between the atmosphere and the Earth's surface through **evaporation**, **evapotranspiration**, and **precipitation**. Water moves across the land surface through **snowmelt**, **runoff**, and **streamflow**. Through infiltration and **groundwater recharge**, water moves into the ground. When underground, groundwater flows within aquifers and can return to the surface through **springs** or from natural **groundwater discharge** into rivers and oceans.

Humans alter the water cycle. We redirect rivers, build dams to store water, and drain water from wetlands for development. We use water from rivers, lakes, reservoirs, and groundwater aquifers. We use that water (1) to supply our **homes and communities**; (2) for **agricultural** irrigation and **grazing** livestock; and (3) in **industrial** activities like thermoelectric power generation, mining, and aquaculture. The amount of available water depends on how much water is in each pool (water quantity). Water availability also depends on when and how fast water moves (water timing), how much water is used (water use), and how clean the water is (water quality).

Human activities affect water quality. In agricultural and urban areas, irrigation and precipitation wash fertilizers and pesticides into rivers and groundwater. Power plants and factories return heated and contaminated water to rivers. Runoff carries chemicals, sediment, and sewage into rivers and lakes. Downstream from these types of sources, contaminated water can cause harmful algal blooms, spread diseases, and harm habitats. **Climate change** is also affecting the water cycle. It affects water quality, quantity, timing, and use. Climate change is also causing ocean acidification, sea level rise, and extreme weather. Understanding these impacts can allow progress toward sustainable water use.



Evapotranspiration (ET) creates humidity and results in moderated temperatures. ET is not a "loss of water", but rather a relocation of water to precipitation over land

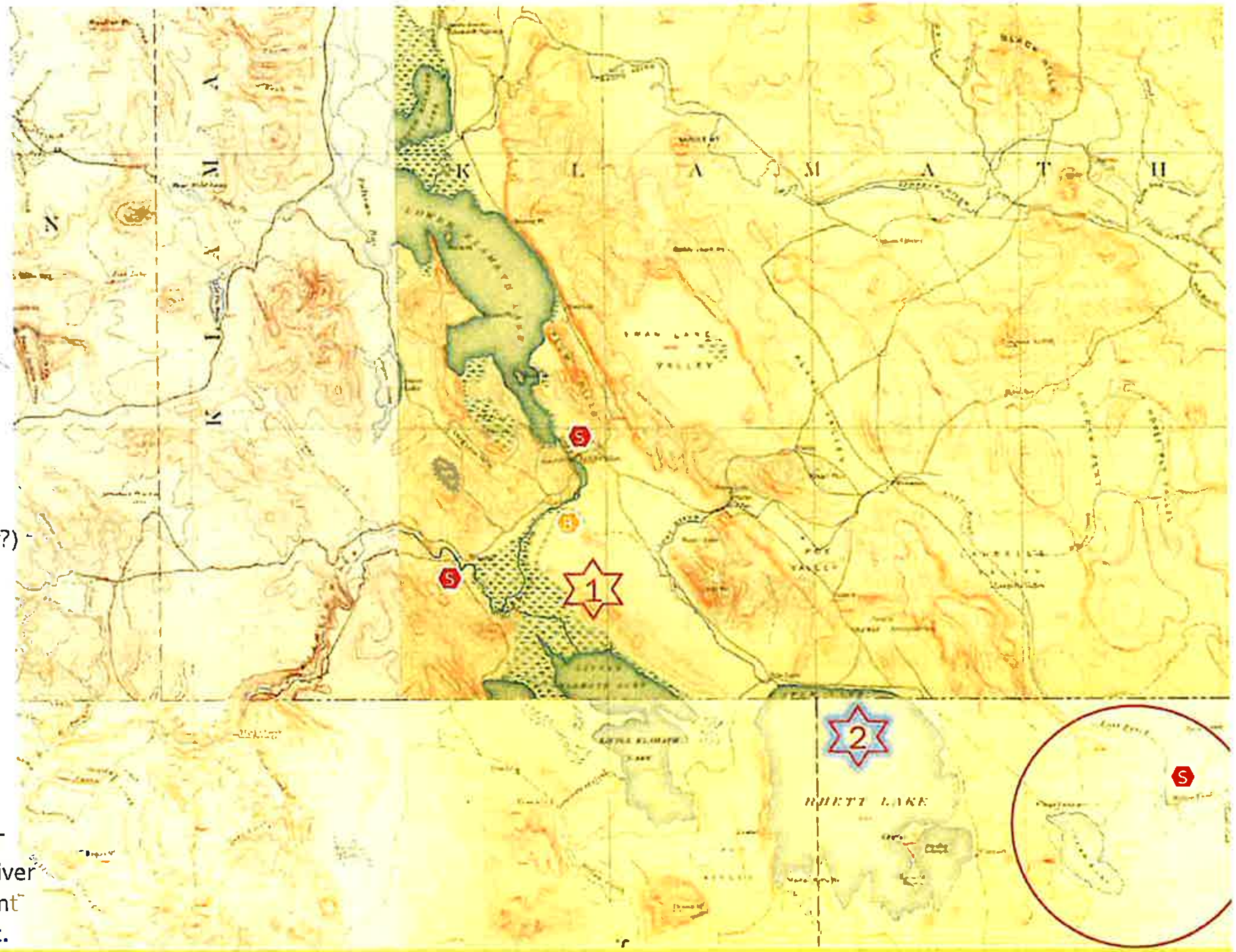


Klamath – A River Upside-Down

2x Natural Reefs at head of Link River
Natural Reef at Lake Ewahna
Natural Reef at Snow Goose
Natural Reef at Keno (porous, underground flow?)
Natural Reef at Clear Lake
Natural Reef to Klamath Marsh (Rootbeer Falls)
Underground flows in Sprague and Lost Rivers

ET and flood losses to Klamath River
Between Link River and Keno:
1. Lower (Little) Klamath Lake" ~267,000 AF ET
2. Lost River Slough Loss = 1,200 cfs
in spring /wet conditions
to Tule (Rhett) Lake: ~267,000AF ET
Lost River was closed to Klamath River
Clear Lake not connected to Lost River in drought

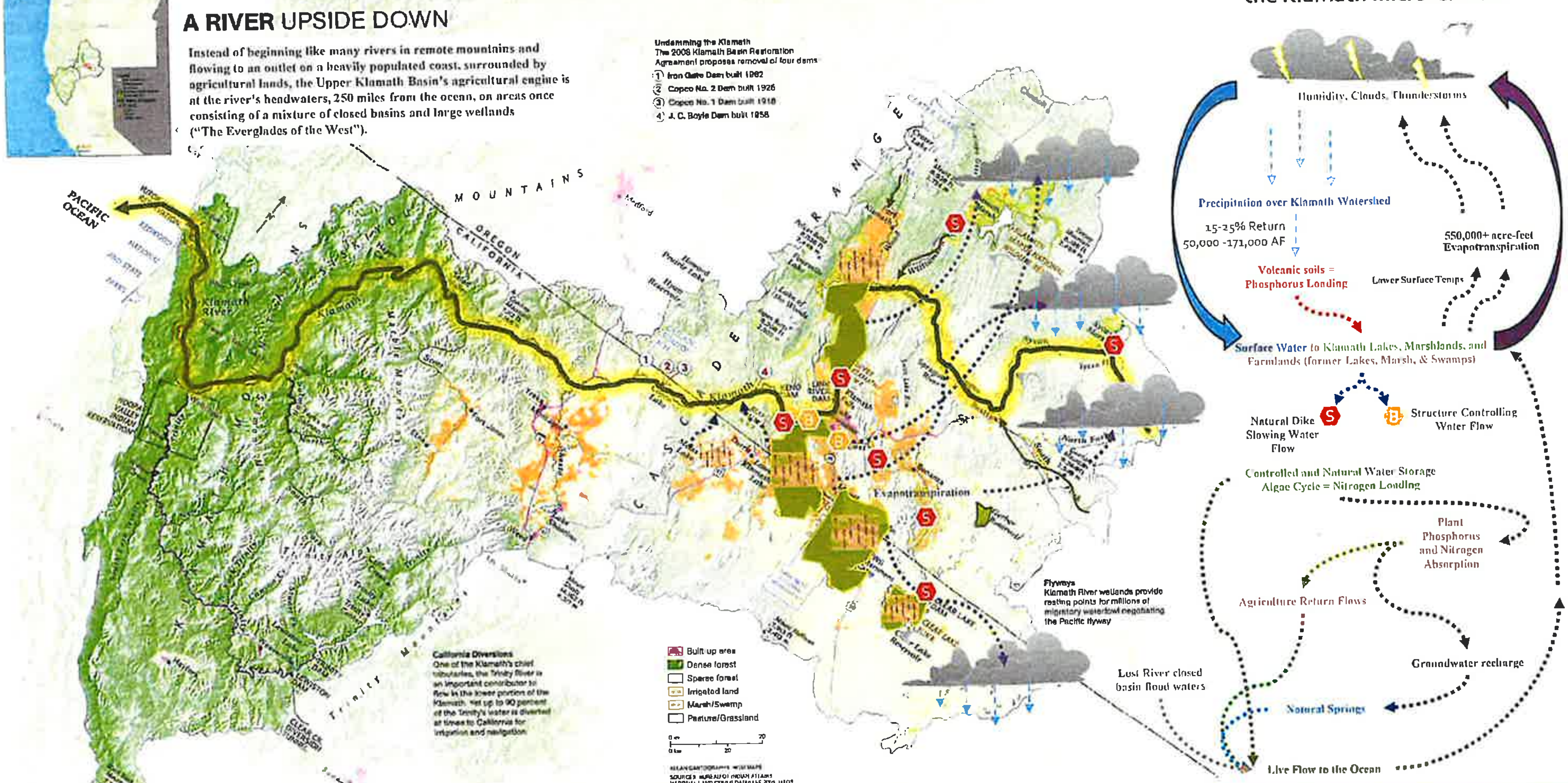
Water flows towards the temperate rainforest.



Pre 1890 conditions = wetlands, moderate temps, humidity, massive evaporation losses…and marshland plants that absorbed the natural phosphorus – increasing nitrogen loading

Klamath – A River Upside-Down

Evapotranspiration is critical to the Klamath Micro-Climate



The upper basin micro-climate is self-serving

AI Analysis of recycled ET in the Klamath Watershed above Keno

Scenario	Summer ET (Jun–Sep)	ET Rainfall Recycled Above Keno (15–25%)	Basin-avg ET Rain (inches)
Natural (pre-1905)	~340–570 TAF	~51–143 TAF	~0.25–0.70 in
Developed (1964- 2000)	~155–179 TAF	~23–45 TAF	~0.12–0.22 in
Dewatered (2001, 2020–2023)	~10–20 TAF	~1.5–5 TAF	~0.01–0.03 in **+WILDFIRES**

- The natural marsh/lake system returned 2–5× more recycled rain above Keno than the irrigated landscape.
- The irrigated landscape still contributed a **meaningful recycled rainfall pulse (~25–50 TAF)**.
- **Under dewatering, recycled rainfall disappeared, with only trace inputs**.

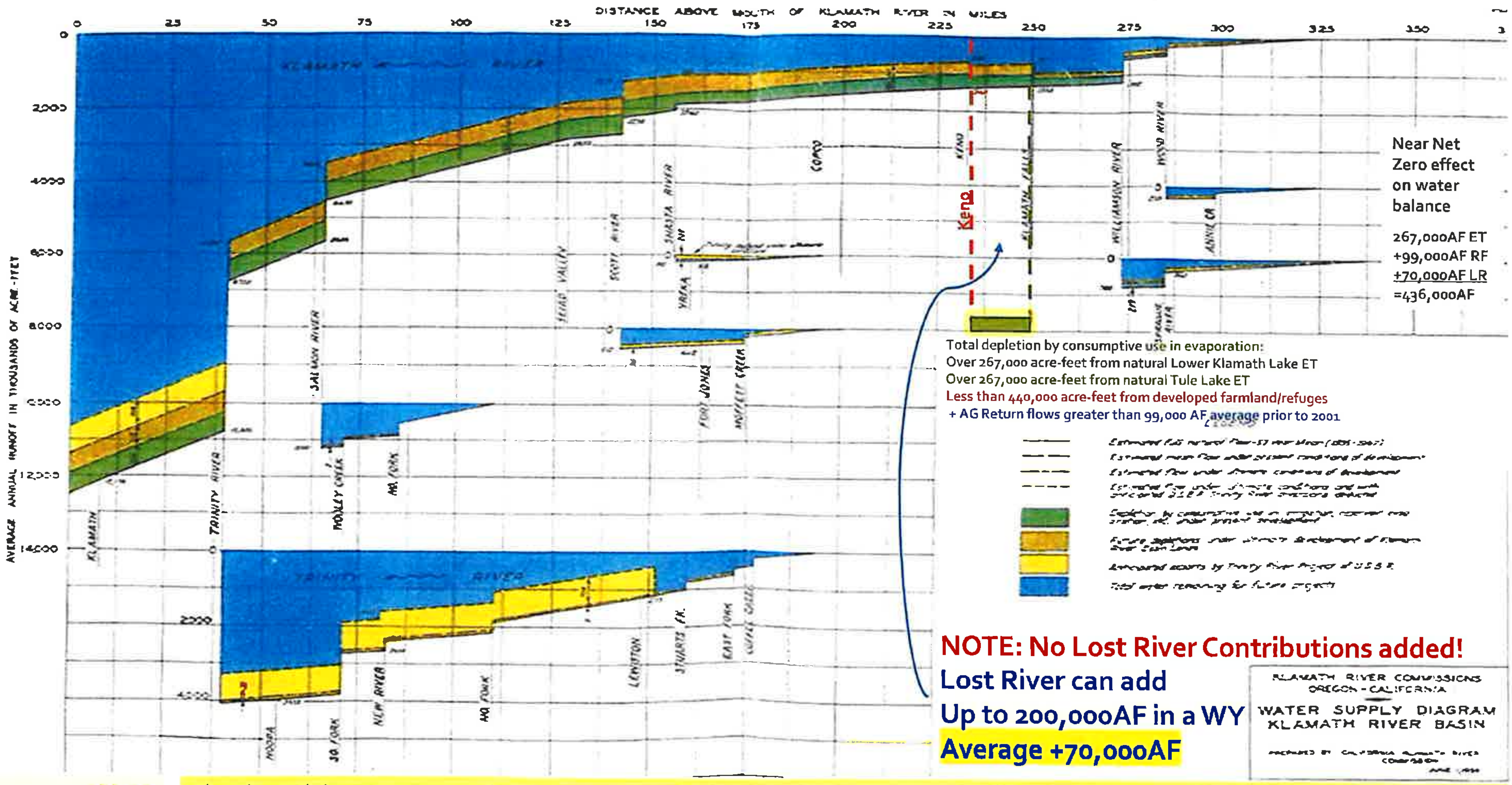
Where does this return of ET rain occur?

Summer winds & lake/valley breezes favor **east–northeast transport and orographic triggering** on the **eastern Cascades & Fremont–Winema highlands,** so the recycled share that does fall **above Keno** is most likely to show up **east/northeast of Upper Klamath Lake (Williamson/Sprague headwaters & adjacent uplands)** and along **terrain-favored ridges** rather than the basin floor—consistent with PRISM-style summer patterns and observed wind roses.

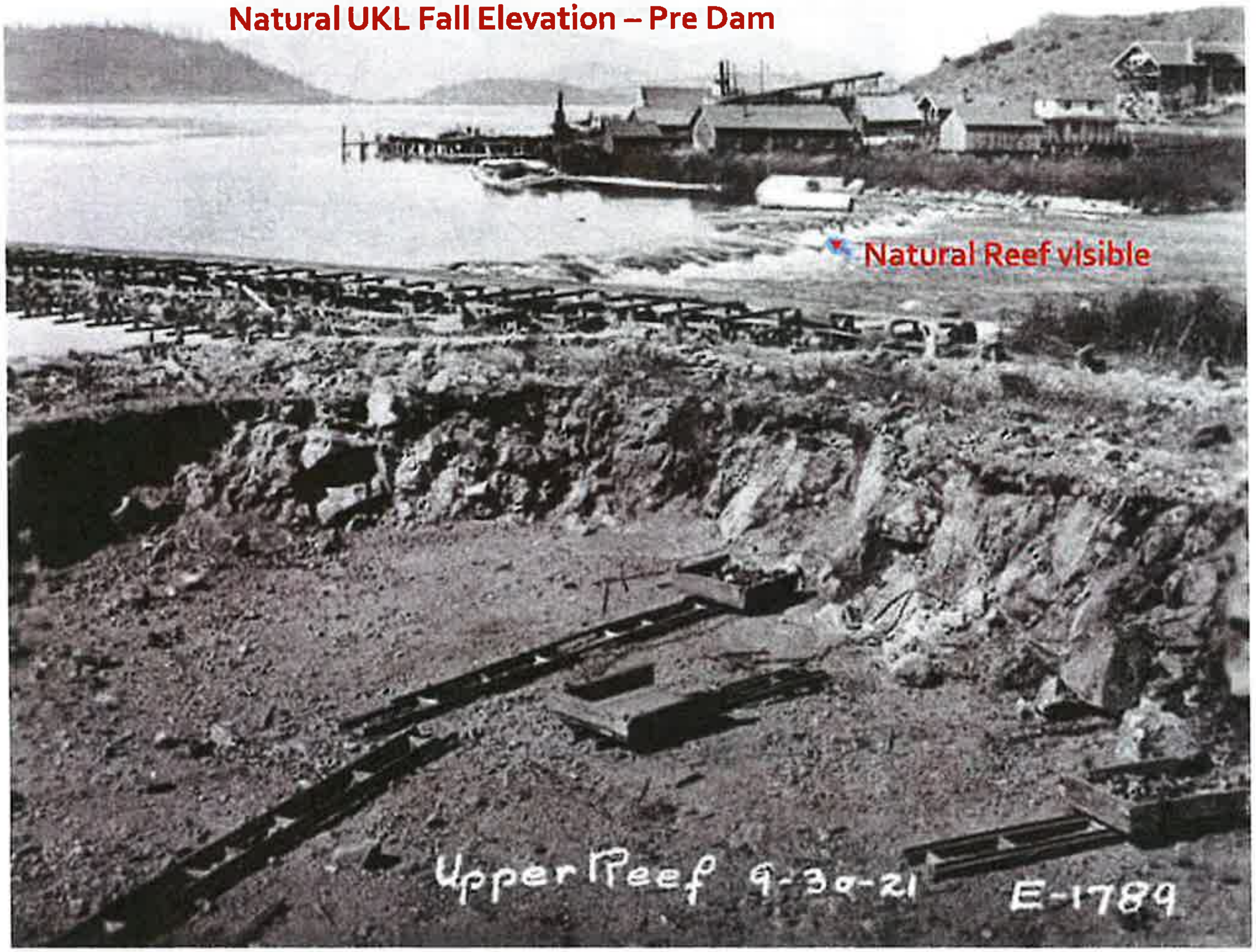
Where have the dangerous / large wildfires occurred during farm & refuge dewatered conditions?

- **Bootleg Fire** — *Beatty / northeast of Sprague River (Fremont-Winema NF)* — **2021**
- **Jack Creek / Jack Fire** and related 2021 Klamath County fires
- Van Meter Fire – Poe Valley 2022
- **Moccasin Hill Fire (near Sprague River)** — *Sprague River community / Sprague watershed* — **2014**

Klamath Watershed Water Supply Diagram – Averages 1958



 9/3/2025 Klamath water balance – average water flows in thousands of acre-feet per year as of 1958. Average at Klamath Falls about 1,000,000 acre-feet. At Keno about 750,000 acre-feet.



Natural Rock Reef at Outlet of Upper Klamath Lake

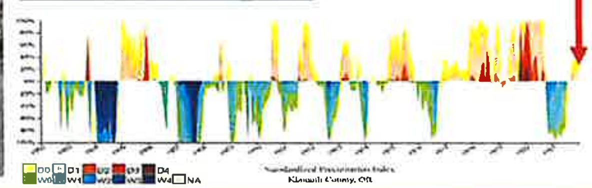
– 30 September 1921

*Developing D1 conditions in Klamath County

Reef elevation 4,137.8′ as recorded by JC Boyle

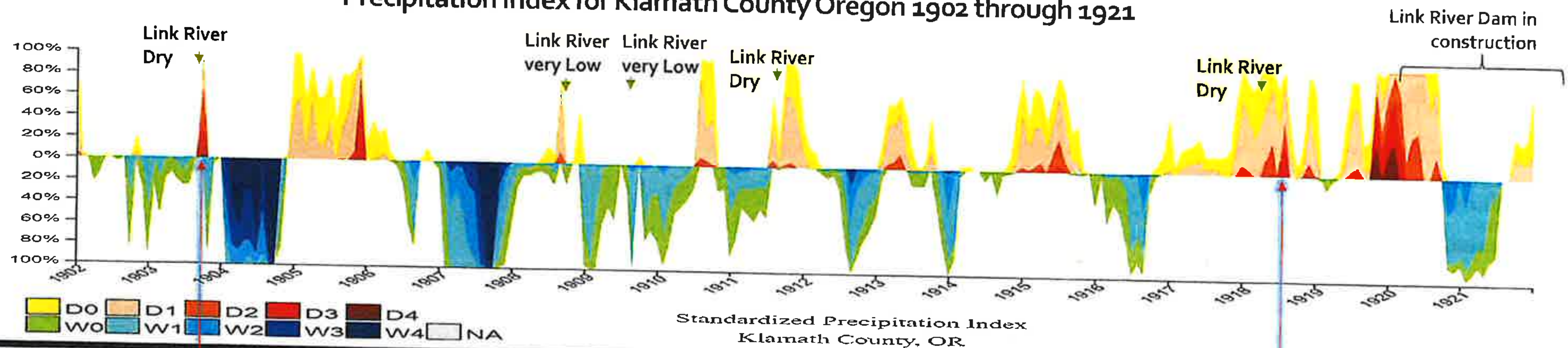
"**University of Oregon Emeritus Professor of Geography Samuel Dickens** says…the river began where the waters of Upper Klamath Lake flowed over a basalt reef (ridge); **this reef was nearly the same elevation as the surface of the lake**, so the water was not very deep where it ran over the reef…**the discharge of the river was low enough to have left it dry for a time.**"

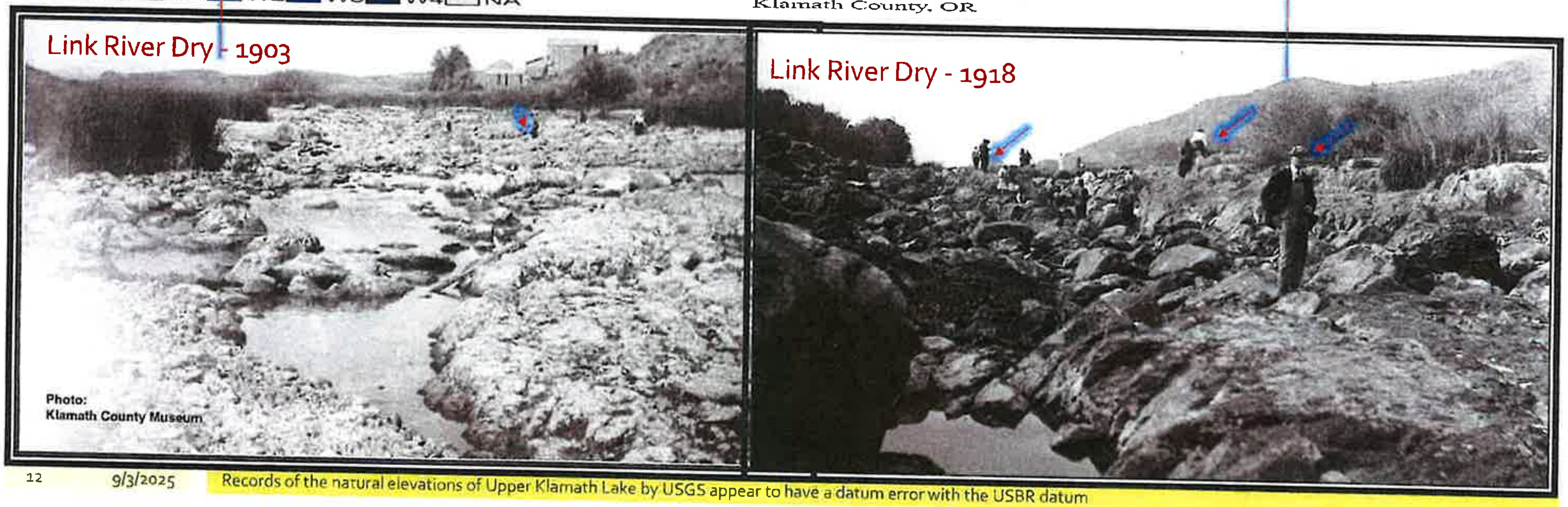
Spindor, Jim. 1996. Yulalona. The Klamath Basin Historical Society. Trumpeter. Accessed at https://klamathcountyhistoricalsociety.org/images/Trumpeters/1996JuneTrumpeter_44.pdf



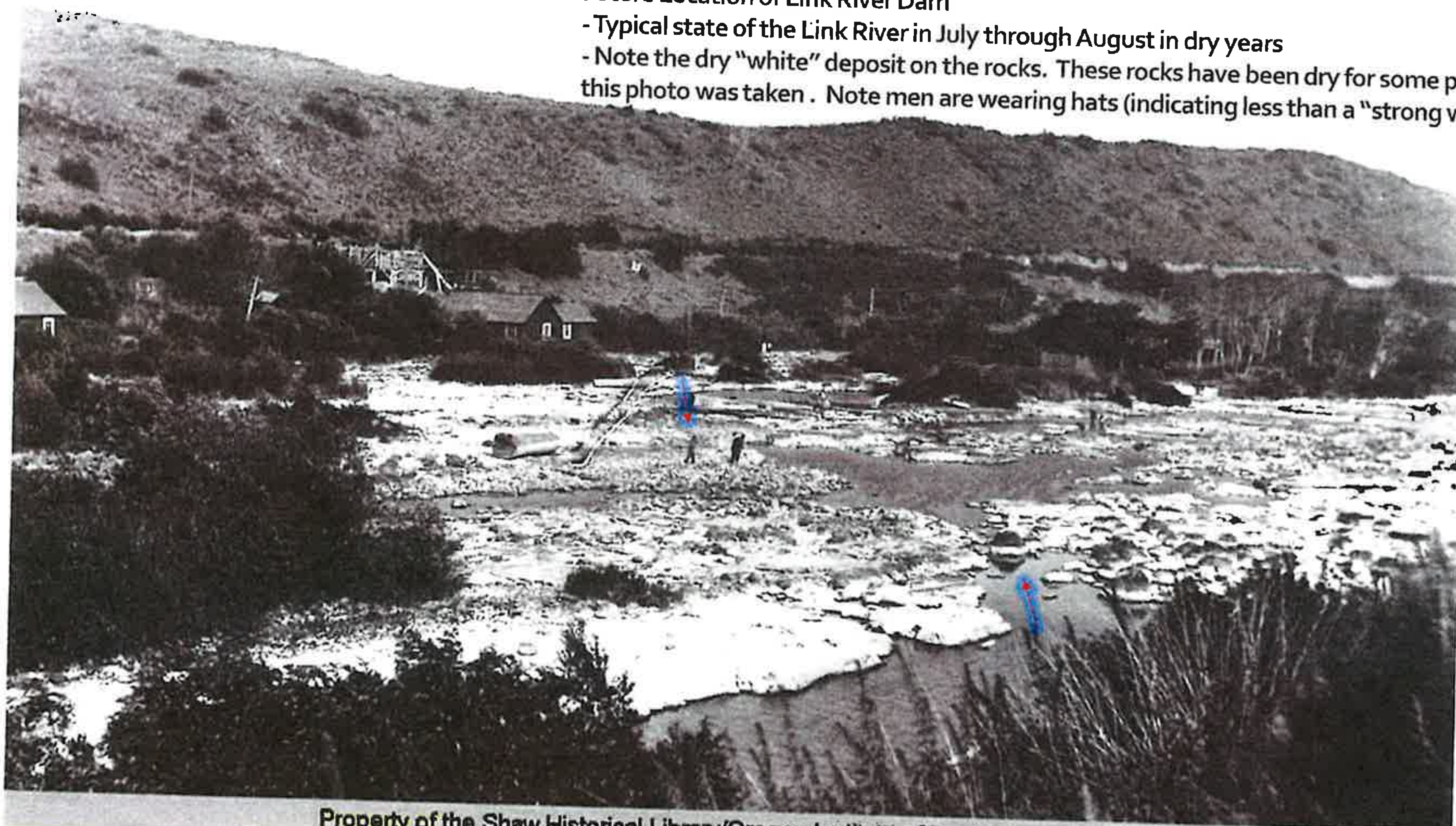
Natural elevations of Upper Klamath Lake were near the natural lava barrier at the head of the Link River. Since 1992, elevations have been maintained above 4,138 in most years.

Precipitation Index for Klamath County Oregon 1902 through 1921

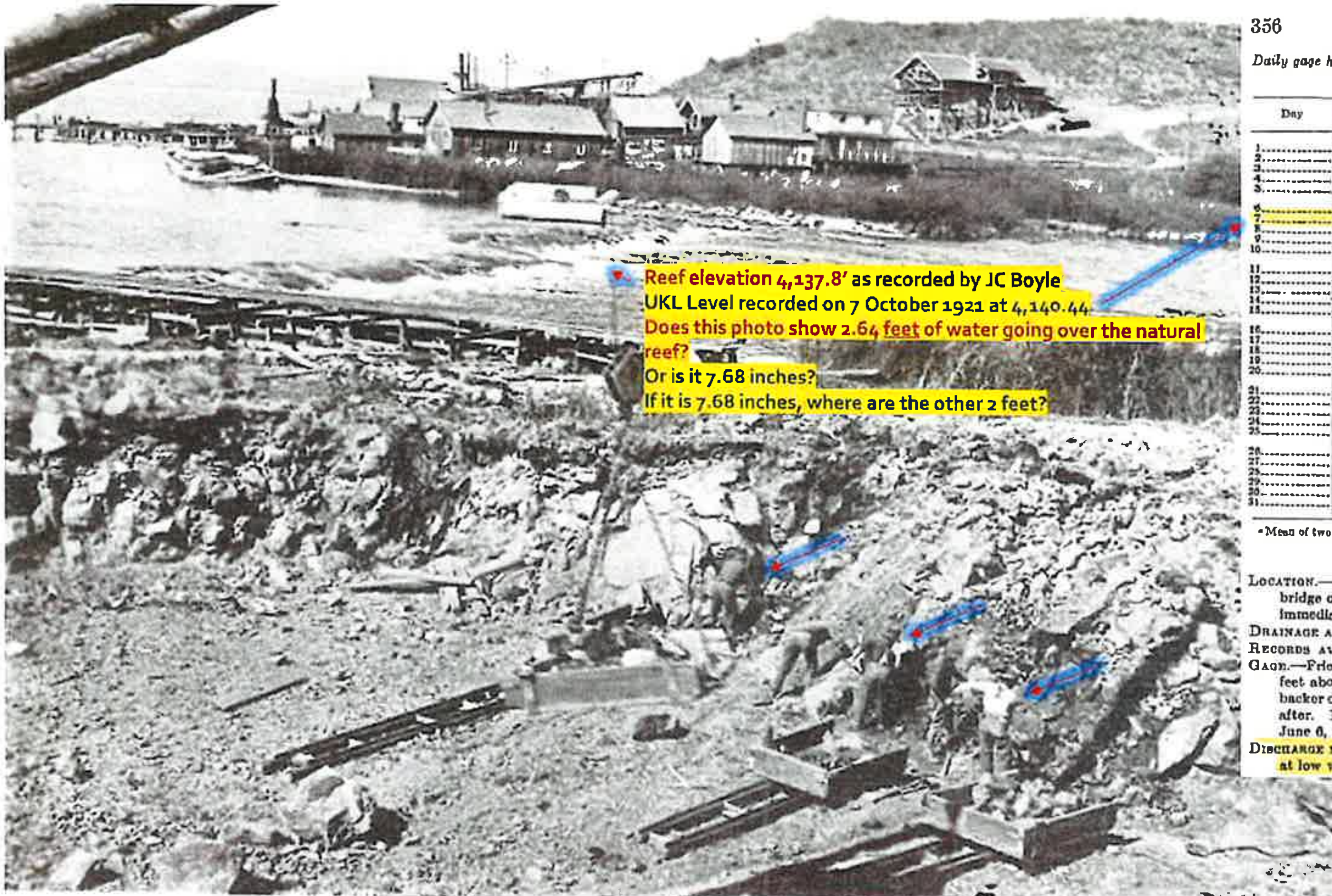




Future Location of Link River Dam
- Typical state of the Link River in July through August in dry years
- Note the dry "white" deposit on the rocks. These rocks have been dry for some period before this photo was taken . Note men are wearing hats (indicating less than a "strong wind").



Natural elevations of Upper Klamath Lake, regulated by the natural reefs, limited flow out of Upper Klamath Lake in the summer.



Excavation through the upper reef at outlet of Upper Klamath Lake. Cut 100 feet wide and 8 feet deep. Shippington in the background. October 7, 1921.

356 SURFACE WATER SUPPLY, 1922, PART XI

Daily gage height, in feet, of Upper Klamath Lake near Klamath Falls, Oreg., for the year ending September 30, 1922

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	40.57	40.63	40.65	41.10	41.06	*41.04	41.13	41.95	41.92	*41.30	40.62	40.02
2	40.27	40.55	41.28	41.10	41.05	41.03	41.13	42.00	41.93	41.34	40.57	40.11
3	40.31	40.54	41.05	41.10	41.05	41.03	41.14	41.91	41.83	41.34	40.47	40.01
4	40.32	40.45	41.03	41.10	41.05	41.01	41.10	41.95	41.81	41.15	40.44	40.02
5	40.31	40.53	40.96	41.09	41.05	41.03	41.32	*42.06	41.73	41.15	40.46	40.05
6	40.31	40.81	41.09	41.09	41.06	41.03	41.23	42.08	41.81	41.13	40.48	39.95
7	*40.44	*40.48	41.10	41.08	41.05	41.03	41.29	42.03	41.70	41.13	40.43	*40.09
8	40.34	40.62	41.06	41.09	41.02	41.04	*41.38	42.03	41.81	*41.17	40.40	40.10
9	40.34	40.64	41.08	41.09	41.03	41.03	41.38	42.58	41.00	41.13	40.26	40.09
10	40.34	40.61	*40.14	41.08	41.03	41.01	41.35	42.12	*41.84	41.05	40.23	40.08
11	40.33	40.60	41.05	41.08	41.03	41.05	41.41	42.00	41.90	41.03	40.15	40.02
12	40.30	40.61	40.95	41.09	41.03	41.03	41.44	42.13	41.98	40.96	40.43	39.99
13	40.24	40.61	41.11	41.08	41.03	41.00	41.60	42.13	42.10	40.98	40.38	39.99
14	39.93	40.76	41.04	41.09	41.03	40.99	*41.70	42.13	41.83	41.00	40.26	40.01
15	40.13	40.59	41.13	41.09	41.03	41.01	41.63	42.19	41.78	40.94	40.06	39.98
16	40.23	40.61	41.13	41.09	41.01	41.00	41.65	42.03	41.80	40.97	40.22	40.01
17	40.13	40.65	40.99	*41.00	41.01	41.02	41.64	42.05	41.73	....	40.16	40.03
18	40.52	40.60	41.03	41.08	....	40.95	41.54	42.00	41.73	....	*39.93	40.05
19	*40.43	40.52	41.05	41.08	41.09	40.97	41.63	42.00	41.70	....	40.08	40.05
20	40.35	40.52	41.13	41.09	41.05	40.98	41.64	*42.16	41.65	40.86	40.10	39.98
21	40.60	40.52	41.18	....	41.05	40.94	41.67	42.13	41.81	40.90	40.17	40.02
22	40.50	40.69	41.14	41.03	41.07	40.97	41.76	42.03	41.03	40.75	40.28	40.09
23	40.33	*40.66	*41.16	41.08	41.05	40.99	41.77	41.93	41.70	40.78	40.38	40.03
24	40.24	40.62	41.13	41.05	41.06	41.03	41.80	41.95	*41.50	40.78	40.07	39.98
25	40.22	40.42	41.15	41.05	41.05	41.03	41.87	42.00	41.53	40.70	40.19	39.94
26	40.29	40.71	41.12	41.05	41.07	41.08	41.73	41.93	41.48	40.72	*39.93	39.81
27	*40.36	40.73	41.13	41.05	41.07	41.03	41.80	*41.92	41.48	40.70	40.09	40.07
28	40.41	40.83	41.13	41.05	*41.04	41.07	41.85	41.93	41.43	40.63	40.07	39.98
29	40.45	40.77	41.13	41.05	....	41.13	*42.15	41.96	41.28	40.08	40.15	40.00
30	40.51	*40.79	41.13	41.05	....	41.15	*42.10	41.93	*41.29	40.57	40.11	*39.90
31	40.53	....	*41.12	*41.06	....	*41.12	....	*41.90	....	*40.52	*39.08	....

* Mean of two readings a day.

LINK RIVER AT KLAMATH FALLS, OREG.

LOCATION.—In NW. ¼ sec. 32, T. 38 S., R. 9 E. one-fourth mile above county bridge over Link River, 1 mile below outlet of Upper Klamath Lake, and immediately above head of Lake Ewauna at Klamath Falls, Klamath County.

DRAINAGE AREA.—3,110 square miles.

RECORDS AVAILABLE.—May 15, 1904, to September 30, 1922.

GAGE.—Friez water-stage recorder on left bank; elevation of zero is 4,080.35 feet above sea level (revised determination); inspected by Blanche Motschenbacker daily to January 17 and by engineers of Bureau of Reclamation thereafter. Friez recorder on opposite bank and a little farther upstream was used June 6, 1908, to August 30, 1912. Chain gage on bridge used 1904 to 1908.

DISCHARGE MEASUREMENTS.—Made from bridge; section deep, current sluggish at low water.

Notice men working under cranes excavating rocks. Men are wearing hats, working under an active crane. Note similar photo on 30 Sept 1921

- What are the wind conditions?
- What is a "sluggish current"

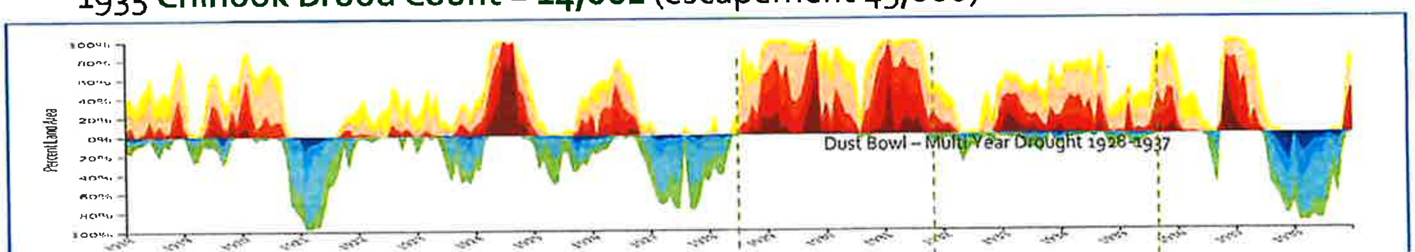
Drought Low Flows in Klamath River effect on Chinook Salmon?

Table 3. Chinook Counts and Egg Takes at Klamathon Racks, Klamath River, 1925 – 1961.

Year	Number of Fish Counted		Number of Eggs Taken
1925	10,420		6,735,000
1926	9,387		18,042,000
1927	No Count		11,797,000
1928	No Count		4,621,000
1929	4,031		5,016,000
1930	2,392		3,103,000
1931	12,611		13,643,000
1932	13,740	1931	4,085,000
1933	No Count	Brood	1,779,000 (a)
1934	10,340	returns	6,316,000
1935	14,061	age 3,	7,541,000
1936	10,398	4, &5	3,349,000
1937	33,144		7,334,000
1938	16,340		7,629,700
1939	No Count		7,056,000
1940	14,965		8,414,000
1941	11,204		3,760,000 (a)
1942	13,038		3,643,000 (a)
1943	No Count		3,640,000 (a)
1944	No Count		3,383,000 (a)
1945	No Count		4,682,706 (a)
1946	No Count		4,302,560 (a)
1947	No Count		798,765 (a)
1948	5,821		165,600 (a)
1949	11,504		165,600 (a)
1950	21,584		665,000 (a)
1951	17,857		1,261,000 (a)
1952	6,591		1,422,000 (a)
1953	6,267		1,097,080 (a)
1954	2,042		202,000 (a)
1955	14,946		3,271,750 (a)
1956	6,770		1,553,600 (a)
1957	2,436		260,572 (a)
1958	1,950		21,250 (a)
1959	3,546		1,404,600 (a)
1960	6,353		1,372,800 (a)
1961	9,021		3,704,000

(a) Eggs taken at Fall Creek, others at Klamathon.

- **THE MINIMUM RECORDED FLOW IN THE KLAMATH RIVER: 83cfs AT FALL CREEK ON 2 AUGUST 1931.**
- Chinook life-cycles are typically 4-5 years (minus jacks 2-3 yrs)
  - (Spawning in the Klamath River typically start in August – drought delays)
  - 1929-1934 was a the driest consecutive years recorded at that time.
- 1931 was a warm year with previous numerous years of dry conditions (meaning increased ET above the average with high likelihood of greater than 267,000AF of ET)
- **The Klamath Reclamation Project ADDED to the Klamath River** below Keno in WY 1931 from Lost River contributions.
  - River flows at Keno in June 1931 AVERAGED 97.6cfs.
  - River flows at Keno in July 1931 AVERAGED 114 cfs
  - River flows at Keno in August 1931 AVERAGED 202 cfs
  - River flows at Keno in September 1931 AVERAGED 334 cfs
- 1931 Chinook Brood Count = 12,611 (escapement 81,848)
- 1935 **Chinook Brood Count = 14,061** (escapement 45,000)



At 650 cfs UKL over Keno: Increased warm, nutrient-rich water raises temps (18-25°C+), lowers DO (<5 mg/L), boosts algae/nutrients, elevates C. shasta disease risk.
At 750 cfs UKL over Keno further exacerbates warming (to 26°C+), DO drops, nutrient loading/algae blooms, higher pathogen exposure/disease mortality.

The low flows associated with sustained drought did not destroy Chinook #s in the Klamath River; in fact, the driest year appears to have improved #s.

Low minimum flows (<300 cfs) in dry years correlate with high Chinook salmon returns, reduce redd scour, and promote larger 3yr old fish.

Spawning Year (Brood)	Estimated Spawning Numbers Sources: Fortune 1966 CDFW 2015	**Drought Condition during brood year**	Return Years	Total Return Numbers Estimates (Age 3,4,5) Sources: Fortune 1966 CDFW 2015	Returning Age Percentages (3,4,5)	Summer Flow Variations at Keno (mean/min/max cfs)	Adjusted Return Numbers (Age 3,4,5)
1931	12,611	Yes (1929-1937)	1934, 1935, 1936	10,340; 14,061; 10,398	30%; 40%; 30%	186/75/516	3,102; 5,624; 3,119
1990	564	Yes (1987-1992)	1993, 1994, 1995	29,185; 13,186; 2,539	65%; 29%; 6%	688/326/1050	18,970; 3,824; 152
1991	580	Yes	1994, 1995, 1996	29,578; 18,478; 457	61%; 38%; 1%	325/254/544	18,043; 7,022; 5
1992	600	Yes	1995, 1996, 1997	129,836; 132,474; 7,368	48%; 49%; 3%	206/131/574	62,321; 64,912; 221
2009	8,240	Yes (2007-2009)	2012, 2013, 2014	155,000; 108,799; 1,827	58%; 41%; 1%	1055/333/1170	89,900; 44,608; 18
2014	24,287	Yes (2012-2017)	2017, 2018, 2019	23,187; 5,567; 800	78%; 19%; 3%	698/396/1070	18,086; 1,058; 24

In drought broods with low spawner escapement (e.g., 1990-1992), reduced juvenile Chinook density, thus lowering competition for food and habitat, enabling faster growth and larger smolts that survive better and return stronger. Low-density conditions results in faster juvenile growth, which yields larger age-3 spawners that mature and return sooner.

A River Upside Down: Less flow reduces stress on Chinook fry with less nutrient loading and less temperature increases.

KLAMATH
IRRIGATION DISTRICT

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