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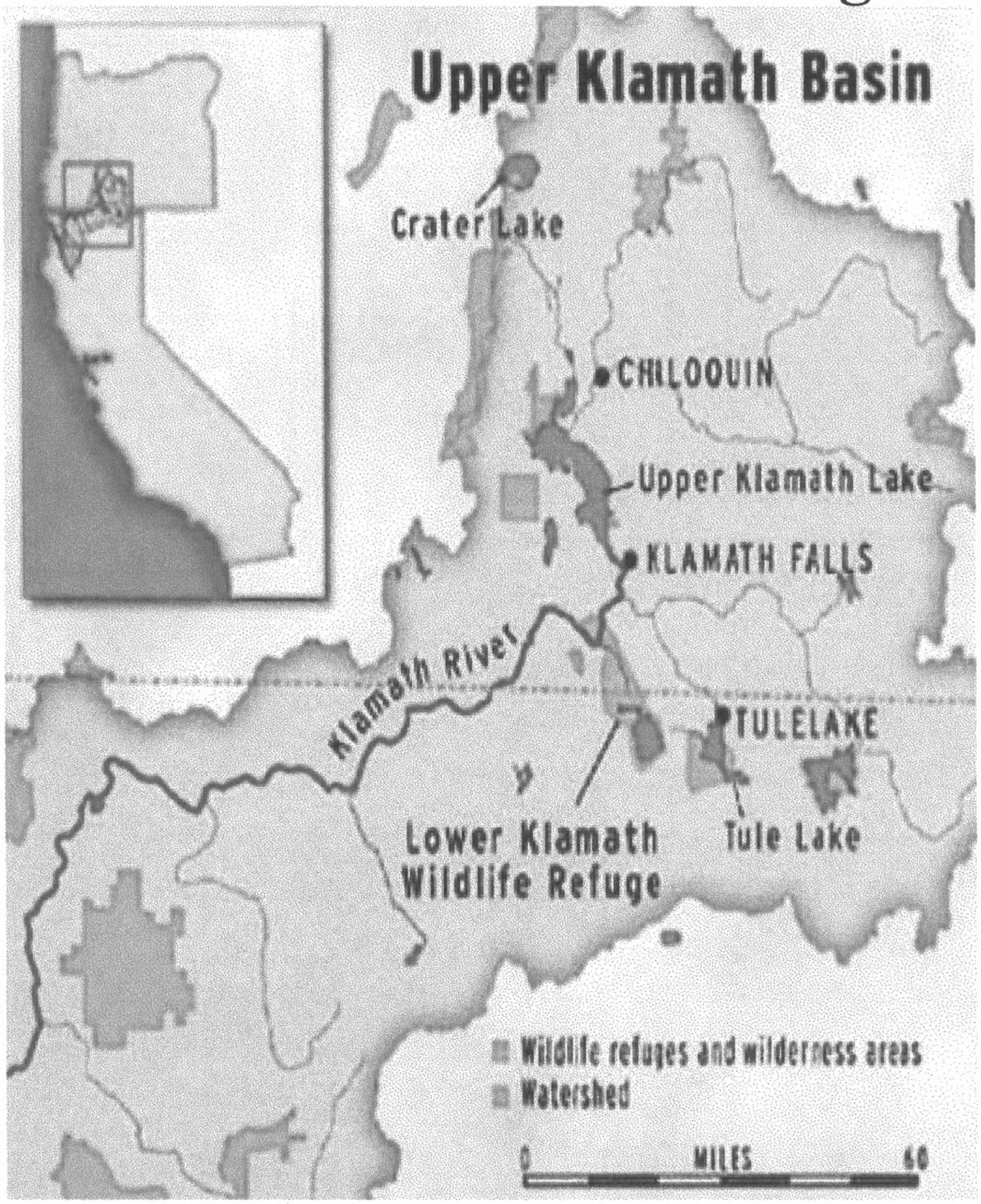
# Geology of the Water Supply for Klamath Falls and Surrounding Area





by
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Geology 202, Winter Quarter 2005

## INTRODUCTION

There is enough material on the social and political aspects available to fill several papers, and while it is tempting to include that here I have decided to concentrate the bulk of this paper on the actual geology of the water supply.

During the last hundred years, the Klamath Basin watershed has undergone gradual development into a Federally managed agrarian homesteaders' settlement interspersed with National Forests and Wildlife Refuges. At the time the "Klamath Irrigation Project" was undertaken, in 1905, there was no data to indicate that the water supply was finite. The increasing number and frequency of geological studies, since the first published study (by C.V. Theis in 1935), have served to underscore the actual fragility of this arid environment and the complexity of the water system that supports it. This report will summarize the findings of many of these earlier studies.

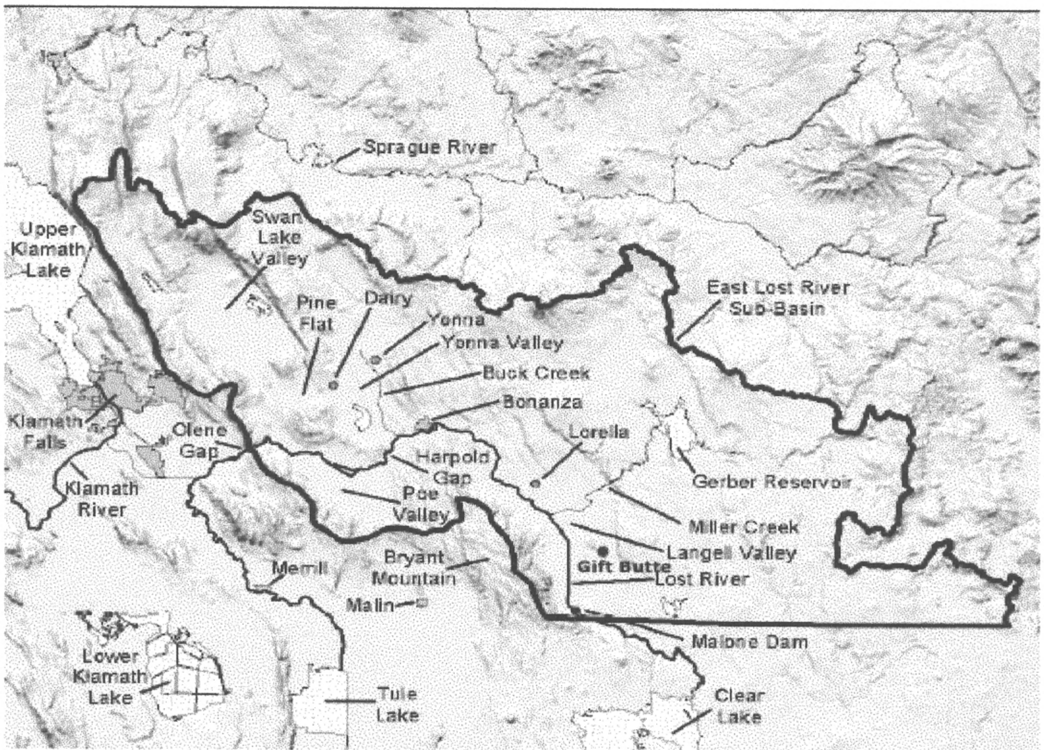

Figure 1, map of Lost River Sub-Basin with Klamath Falls to the right (source: Grondin, 2004, pg. 20)

## COVERAGE AREA

This report will concentrate on the Lost River Sub-Basin and the surrounding Upper Klamath River Basin. It includes the southernmost part of the old Klamath Indian Reservation. The extended areas beyond, including Silver Lake and Yamsay Mountain to the north, the Lower Klamath River Basin to the south, and Goose Lake to the east, will be mentioned occasionally to augment the main topic of discussion.

## GEOGRAPHIC SETTING

The Lost River Sub-Basin is outlined in solid black in the map on the previous page. It lies at the very northwestern tip of the Basin and Range province that extends into California, Nevada, Idaho, and several states beyond. Locally, it includes the Swan Lake valley plus the towns of Dairy, Buck Creek and Lorella, as well as the Gerber Reservoir. The Lost River Sub-Basin extends into the Upper Klamath River Basin from the southeast, which surrounds it on three sides. The town of Klamath Falls, as well as Upper Klamath Lake, is within the boundaries of the Upper Klamath River Basin.

The elevation of most of the valleys in the area is between 4500 and 4800 ft (Peterson and McIntyre, 1970), with Upper Klamath Lake being 4,050 ft above sea level. The peaks in the area, Gearhart and Yamsay Mountains, are 8390 and 8196 ft. a.s.l. respectively. The snow pack on these mountains, and the runoff from that during the spring, is the main source of new surface water within the valley.

### Climate

With the Cascade Mountain range to the west having a "rainshadow" effect on the area to the east, it is not surprising to find a semi-arid climate with rainfall averaging 13.7

inches a year. Temperatures in December and January are usually between 40°F and 29°F, and between 85°F and 50°F in July and August, with extremes around 105°F in summer and –24°F in the winter. (Argonne National Lab., 2003)

## GEOLOGY

There have been over a dozen major geologic studies of the Klamath area over the last 50 years, four of them since 2000, and each study only succeeds in adding to the complexity of the knowledge about the region. The Grondin report (2004) summarized many of the earlier reports into one presentation. The following historical paragraphs are condensed from details in the Grondin report unless otherwise noted.

### Miocene Era

Beginning in the Miocene era, about 8.18 million years ago, the area was flat with a comparatively uneventful topography. An eruption from an unknown volcanic vent covered the area with basaltic andesite – this as-yet-undiscovered vent is thought to have been in the vicinity of Gift Butte (within the Langell Valley, east of the Lost River), as that is where these dated samples were found, but the actual location has not been proven conclusively. Samples at Bryant Mountain (same latitude as Gift Butte, on the west side of the Lost River) indicate that another eruption followed that one - about 7.32 million years ago - which similarly covered the existing topography with thin horizontal layers of calc-alkaline basaltic trachyandesites.

There was a period of basin and range faulting that followed this (see the plate on the next page), with the first faultlines laying east-west and the subsequent ones trending northwest (though some in the northern end of Lost River Sub-Basin, around the town of Bonanza, trend northeast). The uplift from this normal faulting, combined with water erosion on the existing basaltic trachyandesites, created low-lying horsts and broad grabens. Sediment began to fill the valley over the top of the existing lava flows, leaving lacusrine mudstone and fluvial deltaic sandstone in the basins. The mudstone seems to have come from airborne volcanic ash.

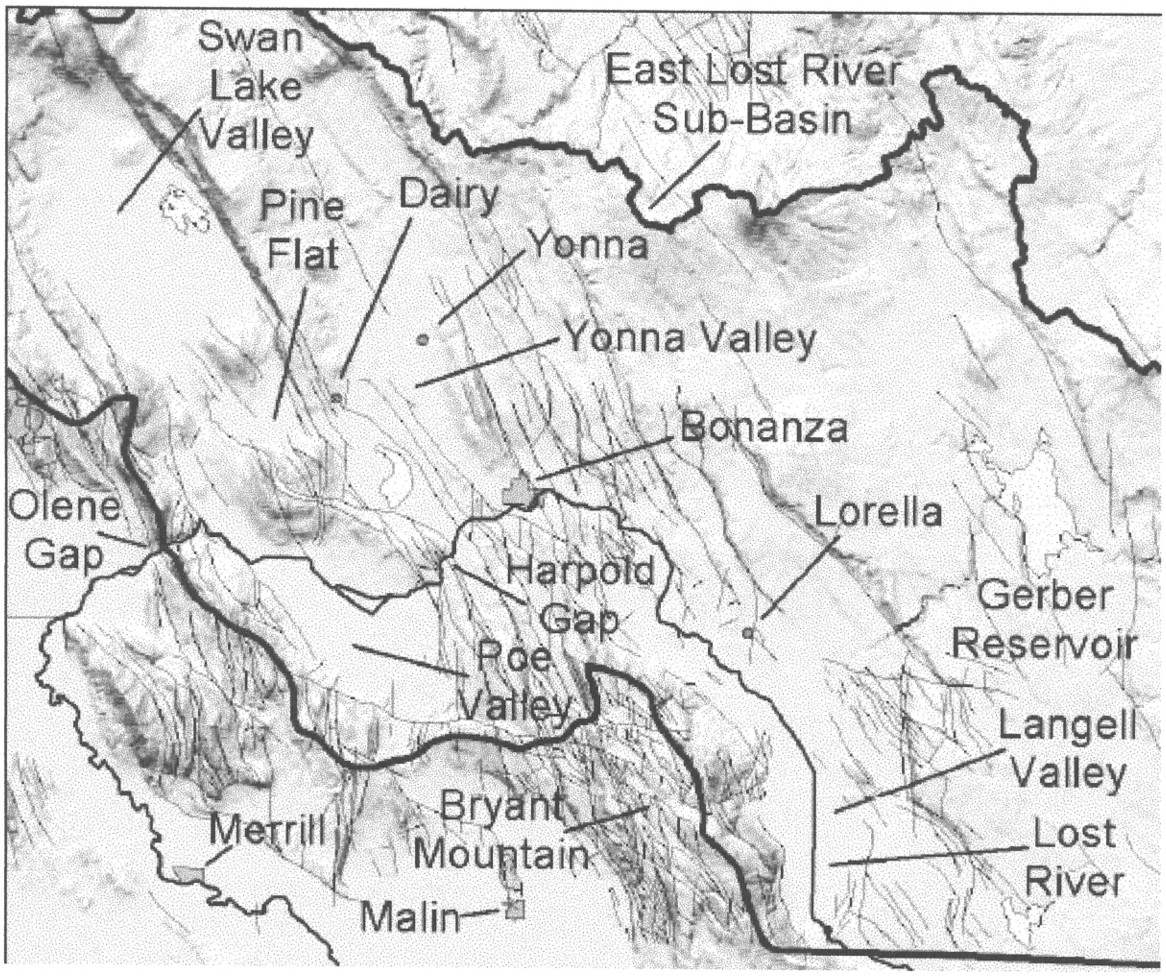


Figure 2: faultlines through the interior of the Lost River Sub-Basin (source: Grondin, 2004, pg. 43)

**Pliocene Era**

Local volcanic activity started again during the Pliocene era, beginning approximately 5 million years ago and lasting until 3.7 million years ago, with several eruptions occurring all around the area. Most of these were underwater at the time, emerging from known vents within the basins or on graben-bounding faults, so the deposits left behind are in the form of pillowed lavas and groundmass altered by interaction with water. This layer, at present, forms the most permeable aquifer under Klamath. Sedimentary deposition occurring after this was heavily laden with basaltic tuff and cinders.

How thick is this layer? There was a test-drilling for oil done by the Humble Oil Company (Peterson & McIntyre, 1970), at a well located north of Goose Lake (off the map, just to the east of the Lost River Sub-Basin), that came close to finding out: the test-well went 12,093 feet down without hitting the bottom of the layer. After this, the full depth to the first major eruption has been estimated as being 13,000 feet, but no one knows this for certain.

**Pliestocene Era**

The Pliestocene era saw glaciation at the peaks of Gearhart Mountain, Yamsay Mountain and Deadhorse Rim (off the map to the east, north of Goose Lake). Volcanic activity came to a halt in this era. What is now referred to as Lake Modoc – a lake large enough to flood what later became the current valleys and sub-basins - crested at 4,240 feet above sea level during this period (leaving its high-water mark on surrounding rocks now below ground). A gravel delta was formed where Miller Creek flowed into Lake Modoc. Lacustrian deposition of varying thickness, in the form of mud and fine sands, is present all around this area. Fish bones have been found within the sub-basins, and coquina was discovered near the east shore of Summer Lake.

## Holocene Era

The modern lake and river pattern was established when this lake yielded to deposition and receded approximately 6,000 years ago. Upper Klamath Lake, Tule Lake, Alkali Lake, and Swan Lake are separate remainders of what was once a much larger body of water. The Lost River valley was also formed during this period of Modoc recession. Deposition since then has consisted of colluvium, landslide and playa deposits, windblown sand, and stream alluvium.

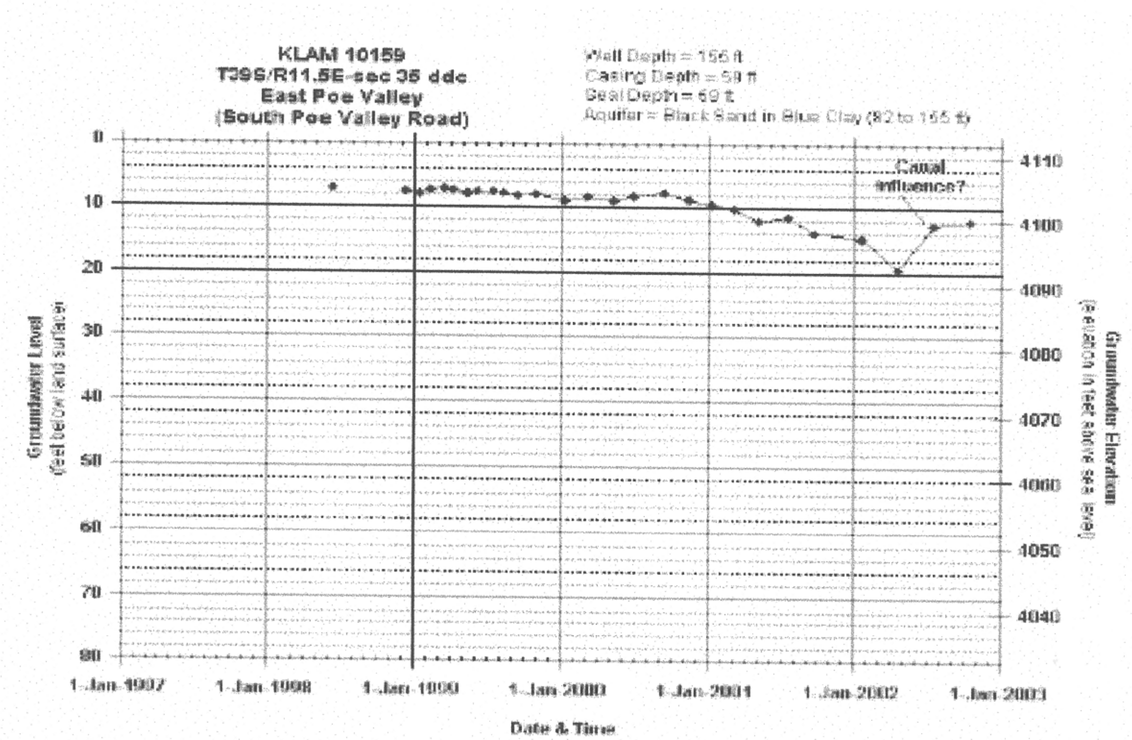


Figure 3: example of groundwater elevation change from 1998-2003, typical of most wells (source: Grondin, 2004, pg. 69)

## GEOLOGY OF WATER SUPPLY

According to data gathered from nearly every well tapped from the basalt layer, both within the Upper Klamath Basin and the Lost River Sub-Basin (the above graph from Grondin 2004 being typical), all wells with one or two exceptions have efficient hydraulic connection – that is the level changes of one well coincide with level changes in the others. Leakage from the canals or lakes will affect some wells and not others depending on the depth of the well and the faulting in the area. The wells in the South Poe Valley seem to be isolated from the rest, however, as the water levels there will drop further and faster than the others will. This implies some underground barrier exists that interferes with transmitivity. The cross-section shown below shows a unique combination of faulting which may help explain this anomaly (i.e. that aquicludes have shifted and blocked this portion of the aquifer off from the other underground sections – note well #KLAM51131 particularly – the graph for that well is shown on the next page).

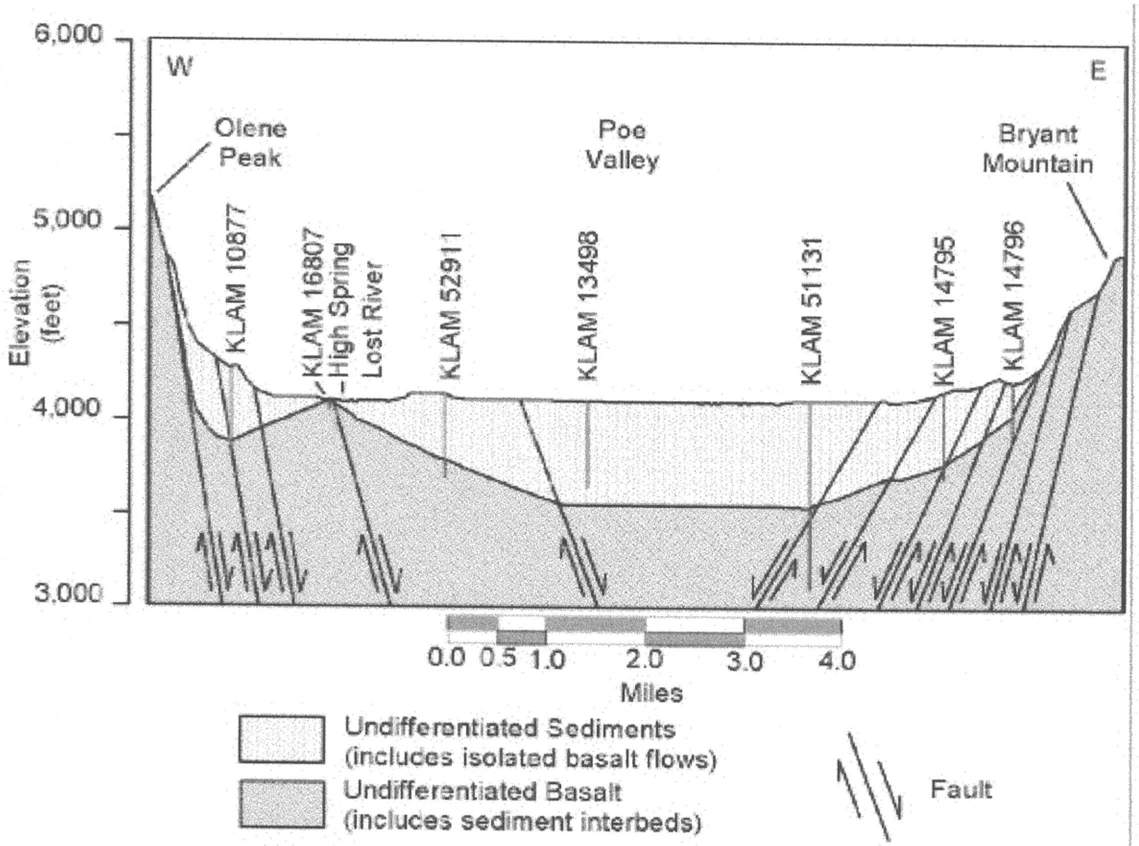


Figure 4: fault lines through the Southern Poe Valley, with focus on area that has lost transmitivity with other wells (source: Grondin, 2004, appendix 9, pg. 10)

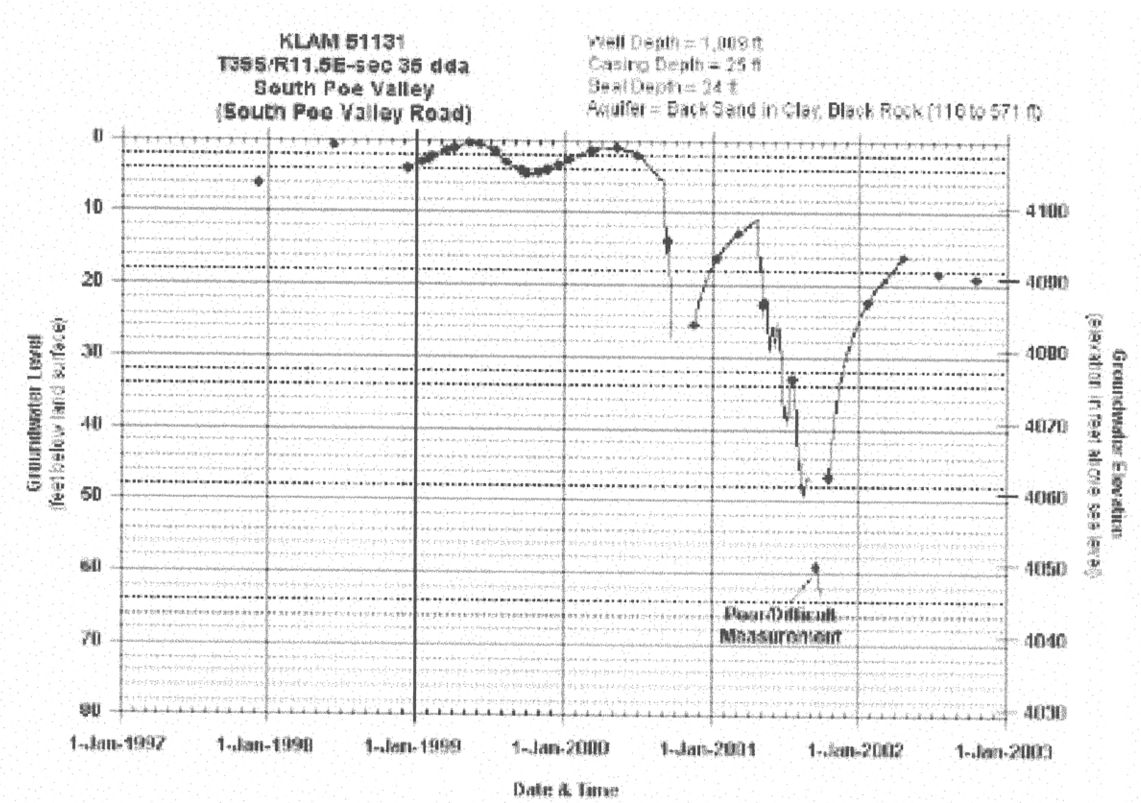


Figure 5: loss of groundwater elevation in Southern Poe Valley well (source: Grondin, 2004, pg. 69)

The other water source that is isolated from the others seems to be the hot springs, the only trace of volcanism remaining in the area, and these are found mostly on the NorthEastern side of the town of Klamath Falls where they are used as the source of heat for both commercial and residential buildings. Other towns such as Lakeview to the east, along Highway 395, also have hot springs. These vary in temperature between 140 and 235 degrees, and the availability of water from these springs does not seem to fluctuate as the wells do. Its source of water is still unknown, and is probably very deep.

## SETTLEMENT HISTORY

From 1864, when the treaty was signed with the Klamath Indian Tribe making 880,000 acres of this land their reservation, there was no development of this Federal land until 1905. Then, making a decision that would have import far beyond that moment, the Federal Bureau of Reclamation started the “Klamath Irrigation Project” which would reclaim the desert below Upper Klamath Lake and make it into farmland. Completed in 1957, it involved the building of dams and canals and gradually opening up the area to homesteading through a lottery. A schematic of the water supply grid, as proposed at the time, is reproduced below.

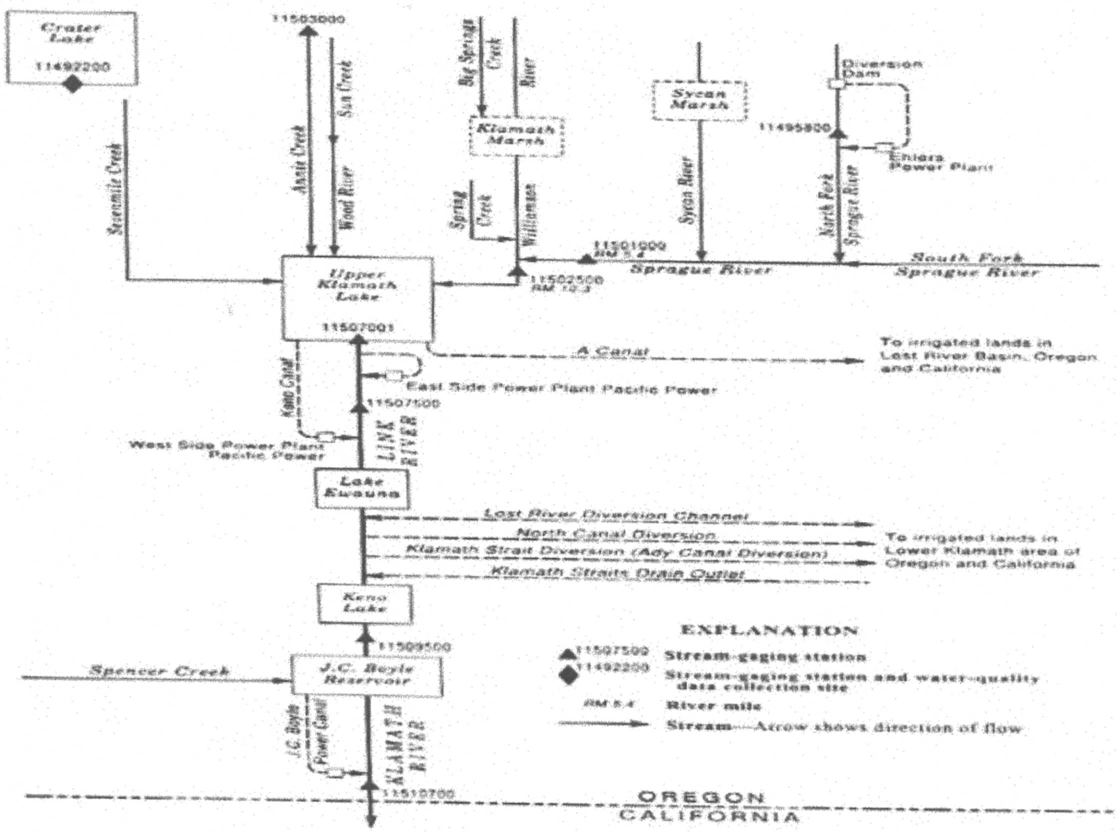


Figure 6: schematic of water sources and routes (source: Argonne National Laboratory, 2003)

The Klamath Indian Reservation, mentioned above, was “terminated” in 1954 to open up more land – some for settlement, but most of it was made into National Forest and Wildlife Refuge. The Tribes were reinstated to a small portion of their original reservation in 1986 – 190,000 acres out of the original 880,000 – and have been working since then to restore the rest of it to their control.

Two sub-species of Mullet fish, specifically the Short-nosed Sucker and the Lost River Sucker, were the traditional food source for the Indians and were considered sacred. The diversion of water toward agriculture had made these fish very scarce. Both fish were added to the California Endangered Species list in 1974. The Endangered Species Act in 1986 added these two fish to a Federal list. The stage had been unknowingly set for a coming battle over proper water resource usage.

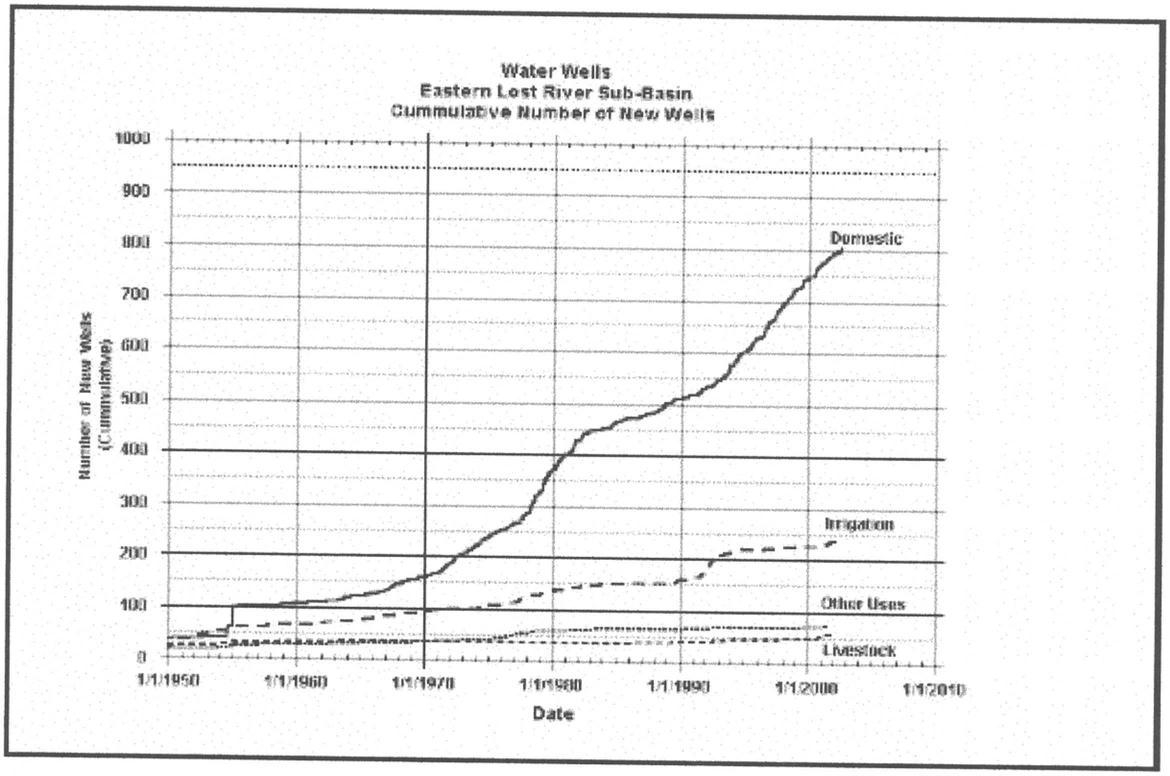


Figure 7: permits for new wells, data beginning in 1955 (source: Grondin, 2004, pg. 27)

## WATER USAGE

If the application for new wells is any indication, as seen in the plate above, the greatest growth in the demand on the water supply has been in the domestic (i.e. residential) sector. From the time that permits were first sought, beginning in 1955, the line on the graph representing non-commercial usage has been increasing exponentially. Most of the non-farming usage of water taps the relatively low-yield permeable zones from the sedimentary layers (Grondin, 2004). These layers also carry the greatest amount of total dissolved solids (TSDs), which have seen measurements from 600 to 800 mg per Liter (State of California, Bulletin 118, 2004). Federal limits on TSDs in drinking water are exceeded at 500 mg/L (Todd Jarvis, guest lecture on WOU campus, 3/2/05).

The sheer volume of water used by the agricultural sector, however, has dwarfed the residential usage consistently. Data from the California side of the border, as published in their Bulletin 118 (updated 2004) suggests a 10:1 usage ratio, with agriculture using approximately 8,700 acre-feet and municipal/industrial demands being around 830 acre-feet. The well application rate for agricultural use has been relatively steady, seeing a spike in the early 90s (coinciding with the drought) but remaining essentially flat before and after that. The water for this usage has had to come from the lava rock layers, below the sediments, which has greater flow rates than the sedimentary layers above. They also have a much lower TSD rate than the higher wells, averaging from 150 to 270 mg/L. (State of California, Bulletin 118, 2004)

As bad as the early 90s drought was, reflected in the jump in permits for new wells as shown on the graph on the previous page, it was exceeded in intensity by a similar drought in the mid 1930s (see the graph on the next page). This earlier lack of rainfall did not have the effect of the later drought because there were fewer farmers in the valley. Droughts of this magnitude in the Klamath Basin are not uncommon – in fact, average rainfall can be seen by this graph to vary widely from one year to the next. This affects the snow pack, which is the only real source for new water in the valley, and as a result the abundance of water cannot be counted on from year to year.

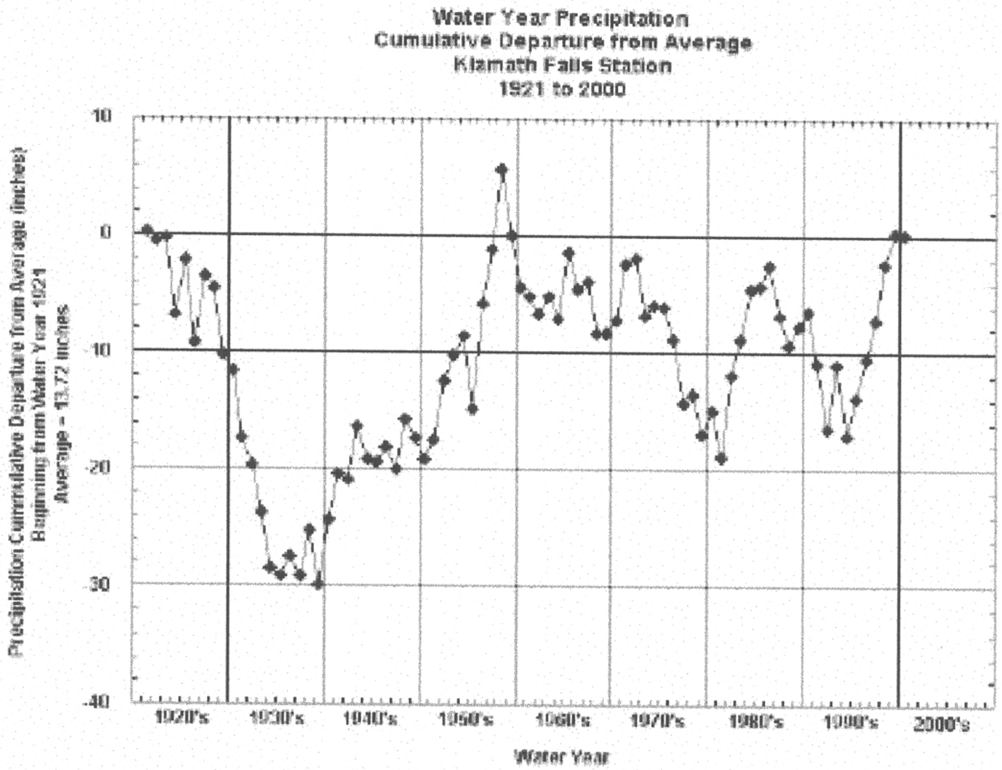


Figure 8: cumulative departure from average rainfall, from 1920s to 2001 (source: Grondin, 2004, pg. 22)

## CONCLUSION

The history of settlement and agriculture in this area was problematic from the beginning, though there was never any hint that water might be scarce when the Klamath Irrigation Project was opened to homesteading as early as 1908. The increasing human demands on the water supply have combined with droughts and ecological concerns to create a political firestorm as well as a looming economic and environmental disaster.

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