HISTORY OF WEATHER OBSERVATIONS
SACRAMENTO, CALIFORNIA
1849 - 1948

January 2005

Prepared By
Glen Conner
9216 Holland Road
Scottsville, Kentucky

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ACKNOWLEDGEMENT

The significant contributions of Joyce Fox Strand, University of California-Davis, to the research for this study must be recognized. In particular, her research abilities to identify and locate historic documents and records, knowledge of the libraries and archives in the area, and experience in preparing scientific papers were most valuable. With her enthusiastic assistance, the preparation of the study was both better organized and much more enjoyable. Nice things to remember.

Many thanks.

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Glen Conner
Kentucky State Climatologist Emeritus

INTRODUCTION

The relationship between climate and disease has long held a fascination for physicians. The medical doctors were a logical choice to perform observations to see if there was a connection between climate and disease. They were the most likely people to find it because they were trained as scientists, schooled in the importance of careful observations, and practiced in reasoned analysis. They were responsible people who could be trusted in this task just as they were in their medical tasks.

Perhaps it was for that reason that Dr. Thomas Logan left the gold fields of California and moved to Sacramento. The city was young having had its first building erected in 1849. According to Morse (1853) there were 45 wooden buildings, 300 cloth tents, and 300 camps in 1849. It had survived a flood in January 1850 that brought typhoid, encephalitis, and diarrhea. But the worst was yet to come. It was beset by a cholera epidemic that began about 15 October. By some reports, four-fifths of the population fled to other areas. Within a period of eighteen days about 1,000 people in Sacramento had died and that dreaded disease killed seventeen of the local physicians. Dr. Logan was one of those who survived while exposed as he treated patients during the epidemic. He began the first weather observations in the city soon thereafter.

The California Medical Gazette expressed concern that "with the exception of the contributions of Col. Williamson of the U.S. Engineers, Dr. H. Gibbons, of this city [San Francisco], and Dr. Logan, of Sacramento, nothing has been done in Meteorology." And they added, "It is our misfortune that there has been no concerted plan of observation to determine the laws of our climate, and the combinations that determine its peculiar modification. It is not that there are not capable observers, but for the want of cooperation and the habit of writing down the results of their observations, the facts are lost to the public, and perish."

Over the past one hundred and fifty years, observations have continued in Sacramento. However, the purposes for making the observations have changed as knowledge and understanding increased. Those primary needs have moved from medical to agricultural to aviation. Even with those changes in emphasis, there was a constant focus on climate induced or related problems throughout the years.

Goal of the Study

The goal of this study was to document the primary weather observational history in Sacramento, California that was part of the path to the current National Weather Service's observing program. Climatic data from the Sacramento stations that made weather observations throughout the period of record are readily available from the National Climatic Data Center, the Western Regional Climate Center, and the State Climatologist of California. The station's history since 1947 is well documented and also available through easily obtainable climatic records. The challenge of this study was to identify Sacramento's role in the development of the formal weather observational program and where it fit in the route from the Army surgeons, through the Smithsonian Observers, the Signal Service Observer Sergeants, the Weather Bureau meteorologists, to the National Weather Service observational network of today. Therefore, the focus of this study is on the period before 1948, the generally accepted start of the modern era of the documentation of weather observations.

LOCATION OF THE OBSERVATIONS

The map (Figure 1) of the City of Sacramento showing old and new streets from 1926 is a survivor from a different age. It was made from data showing the new street names in accordance with ordinance No. 249, (third series), that was adopted 8 December 1916. All the street addresses in this paper refer to those new street names rather than the original ones.

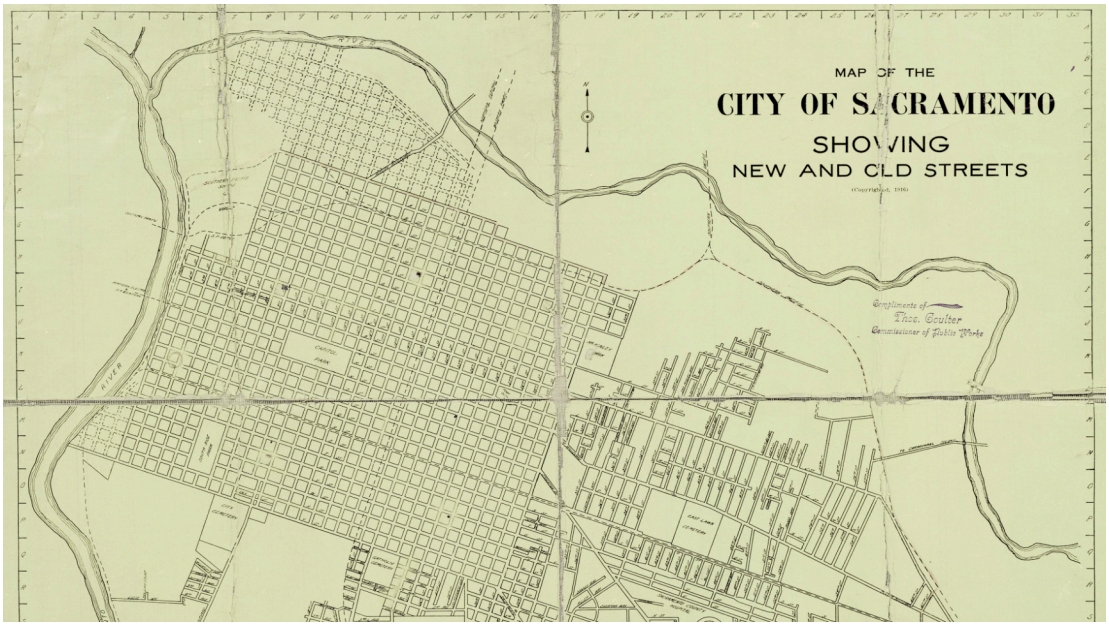


Figure 1. Sacramento, 1926
Source: Sacramento Public Library

Dr. Logan, the earliest observer, moved his offices frequently. In 1851, it was located at 928 South Side, 1853-184 at 303 K Street, 1854-186 at 225 K Street. Beginning in January 1856, the location of the earliest daily observations preserved from Dr. Logan were from 38˚ 34’ 42” north latitude, 121˚ 40’ 05” west longitude, at an elevation of 39 feet above the tide level.

His office was at 303 K from 1857-1862. In April 1857, the location was given as 38˚ 34’ 41” north latitude, 121˚ 27’ 44” west longitude, at an elevation of 41 feet. The April 1861 location was 38˚ 31’ 41” north latitude, 121˚ 27’ 44” west longitude, at an elevation of 52 feet. In January 1962, the station moved to 38˚ 38’ 41” north latitude, 121˚ 29’ 44” west longitude, at an elevation of 82 feet.

The office was at 231 K from 1863-1864 (Figure 2).

Figure 2. Dr. Logan was located in this building at 231 K Street, 1863-1864
Source: Sacramento Public Library

It was at 305 K in 1866, in the Morse Building at 2nd and K in 1869, at the corner of 2nd and K in 1870, and upstairs in the Fratt Building (Figure 3) on the southeast corner of 2nd and K from 1871-1876. In February 1872, the elevation changed to 65 feet, all else remained the same.

From 1 January 1863, the Wythe observations were made from the same location according to the entered latitude and longitude.

Figure 3. Fratt Building, 200 K Street, Sacramento. Dr. Thomas M. Logan's Office was on the second floor.
Source: Memories, Men, and Medicine, J. Roy Jones

Although not in the direct lineage of the current National Weather Service, Dr. Frederick W. Hatch was a contemporary observer in Sacramento. His first office in 1853 was at 56 K Street and his home at F and Eleventh Street. He moved his office to 46 K Street for 1854-1855, to the east side of Second Street near K Street in 1856, to 7 Court block in 1857-1858, and to 128 J Street in 1868-1869. His home was at 812 H Street beginning in 1857-1858.

The Signal Service years brought several moves. Their first location (Figure 4) was at 4th and J Streets in the St. George Building from 1 July 1877 to 27 November 1879. The office was located on the fourth floor.

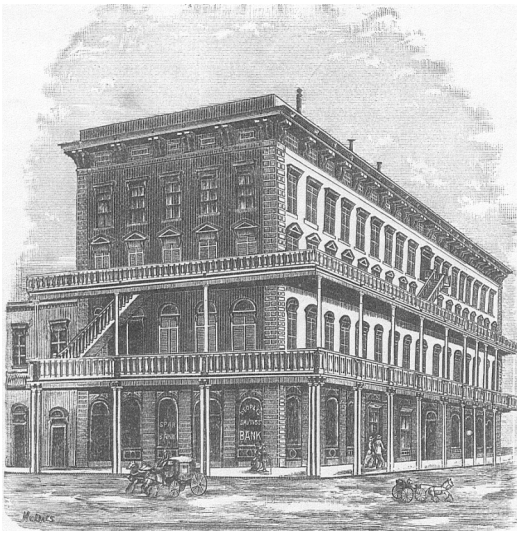


Figure 4. St. George Building, Sacramento, Fourth and J Streets
Source: Resources of Sacramento County

They moved to 2nd and K Streets in the Fratt Building (Figure 3) where they were located from 28 November 1877 through 31 May 1882. The office was located on the second floor. The next move was on 28 back to 1006 2nd Street in the Arcade Building (Figure 5) between J and K Streets. They remained there from 1 June 1882 through 31 January 1884. The station's location was at 38˚ 35' north latitude, 121˚ 31' west longitude, at an elevation of 49 feet.

Figure 5. The Arcade Building in 2005
Source: Author

In 1883, a Volunteer Observer began observations for the Signal Service. According to the front piece note in S. H. Gerrish's diary of 1861, his first observations in California were from 37˚ 47' 59" north latitude and 122˚ 23' 10" west longitude.

In February 1906, that cooperative observation site was at 1517 G Street at the home of S. H. Gerrish (Figure 6). The rain gage was on the north side of a greenhouse twenty feet from the house at a height of 7' 6" above ground level. That location would continue operation until 1911. Mr. Gerrish was a well known for his horticultural interests. The description that accompanied the engraving commented extensively about his banana, date, and orange trees. It also had comments that help define the conditions that would have existed at his observation site.

> The grounds about the residence of S. H. Gerrish at 1517 G Street, although not extensive, present for the size, one of the finest winter gardens in the county. Owing to the thickness of the foliage, the half-tone engraving does not do the scene justice. The photograph from which the engraving was made was taken on December 20, 1893. The front and corner of the building are covered with a thick mass of dark ivy. The remainder of the front of the house is almost hidden by tall seedling orange trees, heavily laden with the golden fruit. Between the oranges and the house are date palms and banana trees.

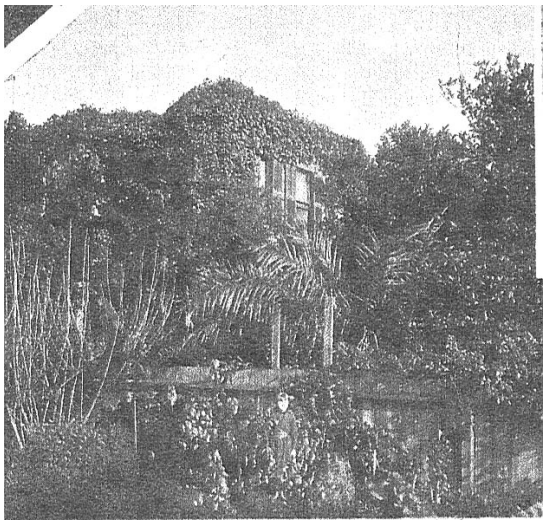


Figure 6. Samuel Howard Gerrish Home, 1517 G Street, Sacramento
Source: Sacramento County and Its Resources, 1894

The article also notes that the date tree was planted in 1868 and the banana tree in 1880.

The next move was to the Lyon and Curtis Building (Figure 7) at 117 J Street on 1 February 1884. In June 1886, the elevation changed to 35 feet. It remained there through 30 April 1894 and then moved to the Post Office Building. Note the instrument shelter and the weather vane on the roof.

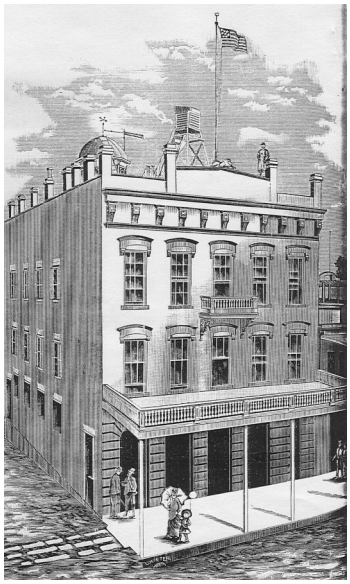


Figure 7. Lyon and Curtis Building (old Masonic building), Headquarters State Weather Service, 121 J Street Sacramento
Source: Barwick, Annual Meteorological Review 1891

The station moved to the Old Post Office on 1 May 1894. It remained there through 31 October 1933. In early 1905, there was a series of letters attempting to accurately determine the elevation of the Weather Bureau's instruments located on the roof of the Post Office Building (Figure 8).

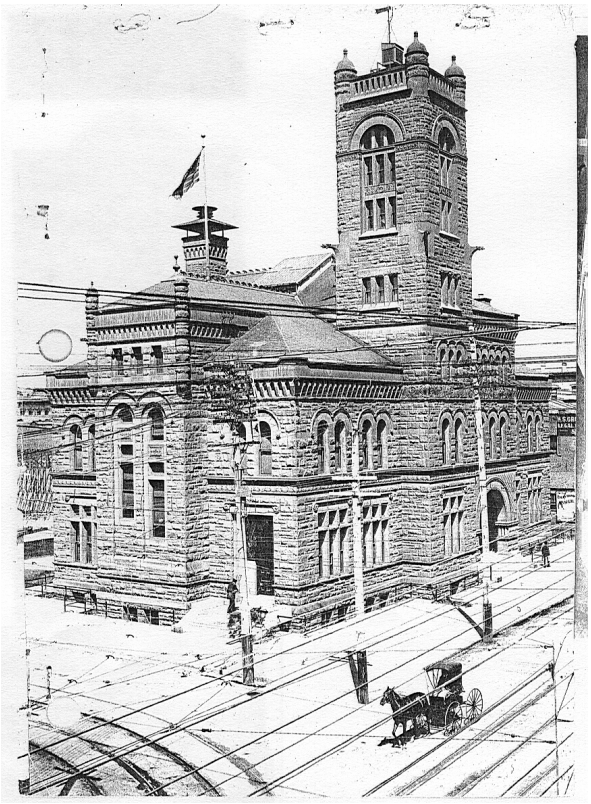


Figure 8. Old Post Office Building, 7th and K Street
Source: NWS Forecast Office, Sacramento

The Sergeant Observer in Charge, James H. Scarr included this description of the exposure of the instruments at the Old Post Office Building.

> All of the tower space except that south of the 'exit room' is floored with open slats nearly three feet above the tower floor proper, and on this floor the rain gauge supports rest with the top of the tipping bucket gauge just above the top of the broad stone coping surrounding the top of the tower wall. The 'exit room' is sheathed and roofed with copper, painted black, and the apex of the pyramidal roof is but a few inches below the bottom of the instrument shelter at the back side.

A close up of the roof portion the Old Post Office Building is shown in Figure 9.

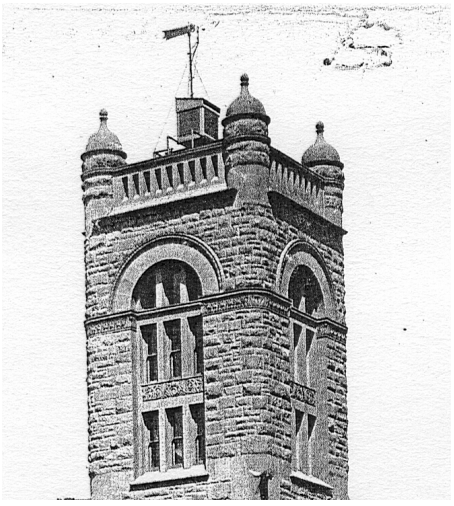


Figure 9. Old Post Office Building, Close up of the instrument shelter and weather vane on the roof.
Source: NWS Forecast Office, Sacramento

When the New Post Office Building (Figure 10) at 9th and I Streets became available, the weather office moved there on 1 November 1933. They remained there for fifteen years. The exposure of the rain gage changed dramatically with a significant increase in catch at the new location.

Figure 10. Federal Building, view from the south.
Source: California State Library

The eight inch rain gage, the tipping bucket rain gage, the instrument shelter with the other instruments, and the anemometer on a tower were located on the roof as shown in Figures 11 and Figure 12.

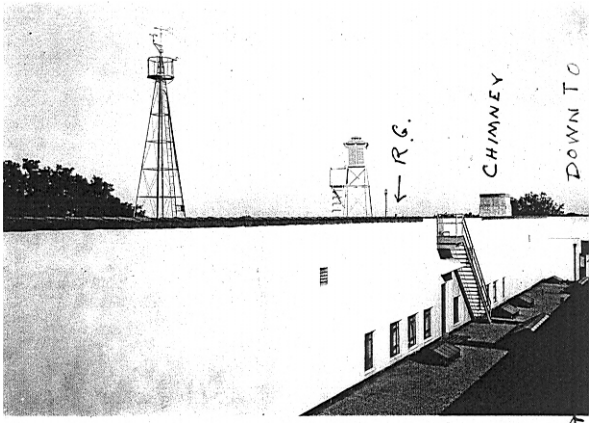


Figure 11. Federal Building roof looking eastward.
Source: NWS Forecast Office, Sacramento

Figure 12. Federal Building Roof, looking south.
Source: NWS Forecast Office, Sacramento

Observations were begun at the Municipal Airport at 6151 Freeport Blvd on 1 December 1937. The office continued at the Federal Building until it moved to the State of California Building at 1725 23rd Street. There were two more moves afterward, one on 29 September 1964 to the Resources Building at 1416 9th Street and a subsequent one to Weather Service Office at 3310 El Camino Avenue on 15 August 1995.

INSTRUMENTATION

When Dr. Logan first arrived in Sacramento, he had an "ordinary ship barometer, the only one to be had then, which was used, appears to have ranged entirely too low." On the earliest extant observation form from Dr. Logan in January 1856, he described his weather instruments. His barometer then was a siphon tube type designed by J. L. Gay-Lussac and modified with a Bunton air trap made in Paris, perhaps like the one in Figure 13.

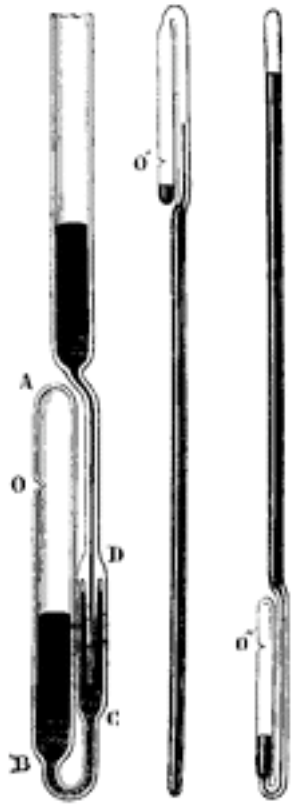


Figure 13. Gay-Lussac Barometer with Bunton Modification

The Gay-Lussac's barometer had two scales with a common zero point from which was graduated in opposite directions. The true height of mercury was the difference between the two levels. It was preferred by travelers who needed something light weight and compact. It was mounted about 45 feet above the level of the sea as measured at San Francisco. All his other instruments were procured from James Green. Those included an attached thermometer on the barometer, a psychrometer, and an open air thermometer.

In the 1856 Tenth Annual Report of the Smithsonian Institution, Dr. Logan wrote about his instrumentation and observational routine. It is included here because it gives insight into the instrumentation, the observational procedures, and the care with which he maintained the meteorological record.

The following observations and tables have been carefully drawn up and verified for future comparative reference. As the initiative of a series of more comprehensive and perfect observations, which it is proposed to prosecute for several successive years, they are now presented for record among the reports of the Smithsonian Institution. The increasing rigor which advancing physical science exacts before generalizations can be reliably deduced, especially requires the adoption of such a course, in a new country like this, possessed as it is of one of the most extraordinary climates known. In frequent instances discrepancies will be found between the present tables and those published in the reports for 1854, originating in errors of copy and typography, and which are now corrected. The barometric and thermometric computations are the result of three daily observations. Prior to April, 1854, they were made at 8 a.m., 3 p. m., and 10 p. m.; since that date, at sunrise, 3 p.m., and 10 p. m. Henceforth they will be continued, in accordance with the uniform system of observation adopted by the Smithsonian Institution, at 7 a. m., 2 p. m., and 9 p.m. The course of the wind was also noted three times a day, corresponding with the above periods, as well as the state of the weather in relation to clearness, cloudiness, and rain. By clear days, is meant entirely clear - i.e., no clouds whatever being visible at the time of observation; by cloudy, that some clouds were visible when it did not rain; and by rainy days, that more or less rain then fell without reference to quantity. The dew point was taken at the driest time of the day only, (3 p. m.,) from July 1854 to November, 1855, with Daniels' hygrometer; since then, it has been calculated from three daily observations with the wet and dry-bulb thermometer. The three tables of hourly observations for twenty-four successive hours, are the first of a series to be repeated four times every year, at or about the period of the solstices and equinoxes, for the purpose of determining the corrections to be applied, in order to render comparable with each other, the records made at different periods of the day. It will be perceived, in these" term observations," that the horary oscillations of the barometer present in a marked degree the two diurnal maxima and minima which obtain within the tropics. From a register kept with an extremely sensitive open-cistern barometer for six months, from the 1st of April, 1855, to September following, inclusive, for the express purpose of testing the regularity of ebb and flow of the aerial ocean, it is

ascertained that the mean monthly range between the sunrise and the 9 1/2 a. m. readings, amounted to 1.07 inch plus, in favor of the latter hour; whereas, between 3 p. m. and the 9 1/2 p. m. readings, the mean monthly range was 0.46 inch plus, in favor of the last hour. These observations will be continued for six months longer, in order to determine whether the fluctuations of atmospheric pressure occur as regularly in the same ratio and degree during the rainy season. The instruments employed were all placed in the open air on the north side of the lower story of a brick building, in a sheltered projection, and protected against the effect of either direct or reflected insolation, as well as against nocturnal radiation. In consequence of the care exercised in this respect, the figures of the thermometer ranged generally lower during the summer than those of other observers in the city. It is necessary to add, before proceeding to the special remarks for each year, that according to recent observations by the Aneroid barometer, the altitude of the city may be put down at thirty-nine feet above tide-level. The latitude is 38° 34' 42" north, and the longitude 121˚ 40' 05" west.

During his years as a Smithsonian observer, Dr. Logan may have used their recommendations for making the observations. His reference above to a "sheltered projection" was probably a window shelter to house the thermometers as shown in Figure 14.

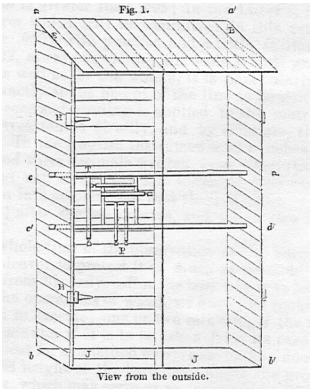


Figure 14. Window Instrument Shelter Recommended by the Smithsonian Institution
Source: Smithsonian Tenth Annual Report, 1856

The window shelter was designed to provide convenient viewing from within the room without exposing the observer to during inclement weather. A wooden shutter on the window side was closed except at the time of observation. The shelter was painted

white to reflect the sun's rays to reduce the amount of heat absorbed by the shelter. The thermometer was placed "exactly perpendicular" and attached to the small cross bars. It would hang ten to twelve inches away from the window pane, the screen, and any other part of the window.

The instructions were to read the thermometer without opening the window because "otherwise the temperature of the chamber will inevitably influence the thermometer in the open air."

The Smithsonian also recommended the use of a rain gage like that in Figure 15. Note that the funnel's top was essentially level with the ground surface. That was to minimize the under catch caused by the wind induced perturbations.

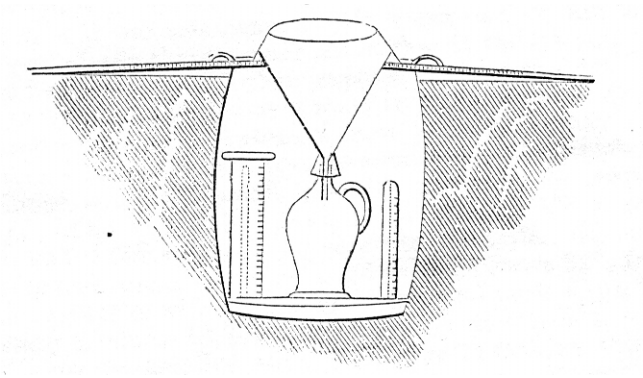


Figure 15. Ombrometer (rain gage) Recommended by the Smithsonian Institution
Source: Smithsonian Tenth Annual Report, 1856

The instructions for rain measurement noted that "Trees, high buildings, and other obstacles, if too near, may have a considerable influence in increasing or diminishing the quantity of rain that falls into the funnel. The surface of the receiver should be placed horizontally about six inches above the ground." The funnel top had an opening of 100 square inches and the water collected in a container below. To make the measurement, the container was emptied into the measuring glass that had divisions of one hundredth of an inch etched on the glass. That produced the ten to one ratio needed to measure to hundredths of an inch.

The Wythe observations during portions of 1863 show that he had a thermometer, a hygrometer, and a rain gauge.

The Signal Service from July 1877 through April 1894 used a window shelter to house the thermometers. When the station moved to the Old Post Office Building, a shelter was placed on the roof. On 1 September 1902, a tipping bucket rain gage was mounted on top of the shelter,

An article in the Sacramento Bee on 4 January 1902 described the instruments then in use. The drawing shown in Figure 16 shows the weather recording instruments as the newspaper called them. They are posed on a desk for this drawing, not in their usual operating position. The anemometer cups for example would have been on the roof.

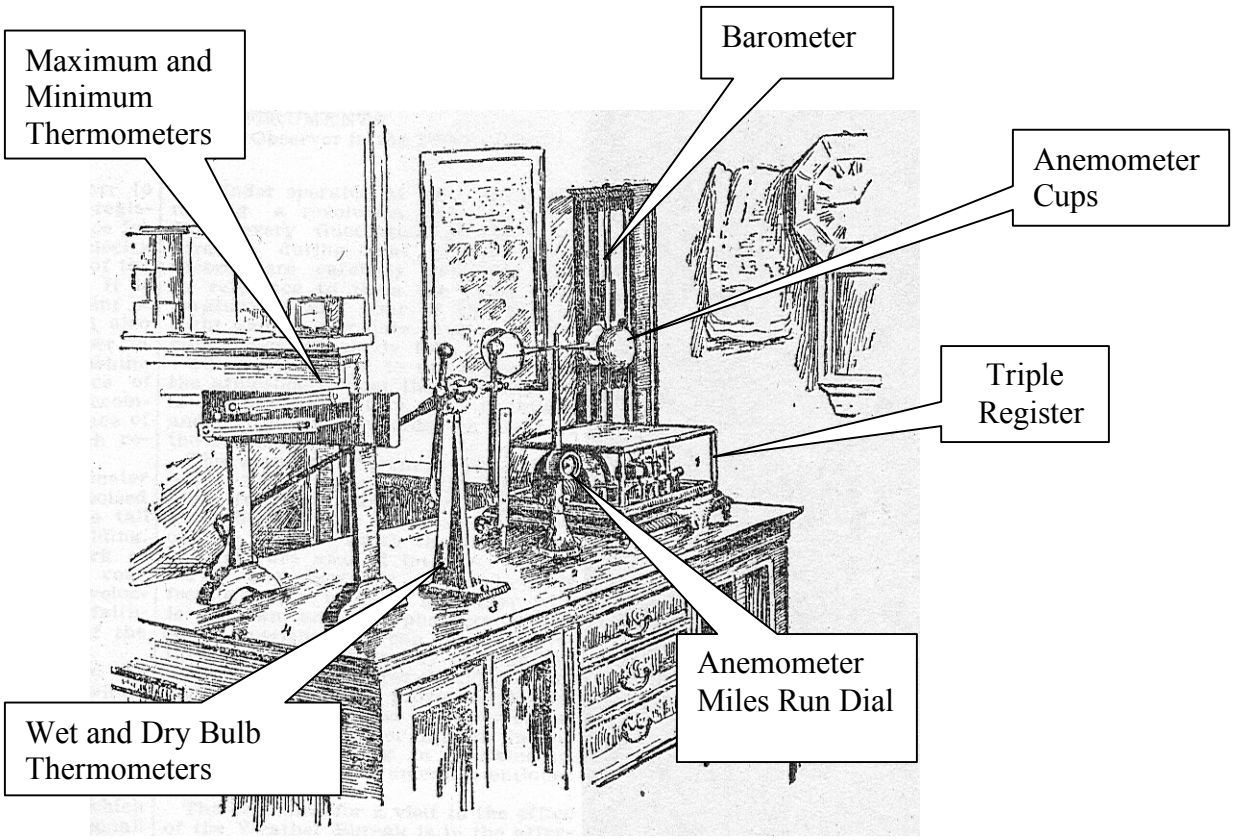


Figure 16. Signal Service Weather Instruments at Sacramento
Source: Sacramento Bee, 4 January 1902

The Triple Register was an electrical device that recorded the direction and velocity of the wind each minute, the amount of rainfall as it fell, and the accumulated hours and minutes of sunshine. The information was recorded by pens on graph paper wrapped around a drum that rotated once per week. The working parts of the Triple Register were made of brass and the unit was covered by a glass case to protect the device from dust. It was quite an impressive part of the meteorologist's equipment.

Wind was measured in two ways. The wind direction was determined by a wind vane that was mounted on the roof. It swiveled toward the direction from which the wind came. It was not shown in the drawing. Also mounted on the roof were the anemometer cups. The wind rotated those cups that in turn rotated the shaft to which they were attached. Each time the shaft rotated 500 times, in the office below, one mile was added to the "total miles run" and displayed on the dial. That is to say, the dial displayed the total number of miles of air that had passed since the anemometer dial was reset. Both the

wind direction and the wind speed were electrically connected to the triple register were they were registered on the graph.

A tipping bucket rain gage was mounted on the roof. A funnel directed rainfall into a small “bucket” on one end of a seesaw like device. The seesaw tipped when the bucket filled with one hundredths of an inch of rain. The tipping emptied that bucket and placed the bucket at the other end of the seesaw under the funnel to be filled next. Each time there was a tipping of the buckets, an electrical signal marked another 0.01” of rain on the triple register.

The triple register also recorded sunshine. A glass tube with a large bulb at either end was located on the roof. One end was clear, the other coated with lampblack. The tube was partially filled with mercury. In the middle of the tube were two wires. When exposed to sunshine, the lampblack would absorb solar radiation causing the mercury to expand and cover the ends of the two wires. The electrical circuit between the two wires would be completed. That connection would be recorded on the triple register until cooling (as the sunshine ended) caused the mercury to contract and uncover the two wire ends thus breaking the connection.

The wet and dry bulb thermometers shown in Figure 16 were used to determine humidity. The wet bulb thermometer had a wet linen “sock” over the bulb. The dry bulb thermometer was bare. Those two thermometers were twirled using gears connected to a crank. The evaporating water from the sock caused the twirling wet bulb thermometer to cool. On a table in a handbook at the intersection of the dry bulb temperature and the difference between the temperature of the wet and dry bulb thermometers was found the relative humidity. The greater the difference, the lower the relative humidity.

The maximum and minimum thermometers determined the two extremes since they were last reset. Each had markers that stuck at the extreme positions. Tilting the minimum thermometer reset the marker. The maximum thermometer needed centrifugal force to reset it.

The mercury barometer was mounted on the wall. The height of the mercury standing in the barometer’s tube was measured in inches from the top surface of the mercury in the well at the bottom was the atmospheric pressure.

The station had two recording instruments that were not shown in the drawing. One was a thermograph. It continually marked with a pen the temperature on a graph wrapped around a clock driven cylinder that rotated once per week. The other recording instrument was a barograph that recorded barometric pressure in the same way.

In 1906, Mr. Gerrish, the Volunteer Observer, was equipped with a Maximum and Minimum Thermometer made by C. J. Tagualin form New York. It was mounted on the north facing porch eight feet above clear ground. His rain gage was a Stratton from the Smithsonian Institute.

The data produced by the tipping bucket rain gage during the period between May 1894 and November 1933 were questioned in the WB 500-1 Form dated 14 September 1951. It was stated that the four towers on top of the Old Post Office Building could have produced turbulence around the gage and disturbed the catch. After the office was moved, a comparison of the old and new location data over a 5.5-year period revealed that there was an 11.5% increase in the catch at the new location. The conclusion inferred that the catch at the new location was a better measurement.

The move to the New Post Office building on 1 November 1933 greatly improved the instrument exposure, except for the wind equipment. The wind equipment was 35 feet above the roof but the sloping edges of the roof caused strong vertical currents when the wind was southerly and above 25 mph.

The move to the airport in 1937 provided good exposure for all the instruments including the wind equipment. The meteorologists believed that the airport wind record was more representative for wind climatology.

THE OBSERVERS

The Smithsonian Years

Thomas Muldrup Logan

Figure 17. Thomas M. Logan, M.D.
Source: Memories, Men, and Medicine. J. Roy Jones.

Thomas M. Logan (Figure 17) was born in Charleston South Carolina in 1808 and graduated from the medical college there in 1828. He practiced medicine in Charleston for a period and it was while there that he published an article that set the tone for his interest in climate and medicine. The article in 1836 was titled "The Climate and Health of Charleston." In it, he first presented his interest in the relationship between mortality and climate. Although he seemed intent on presenting Charleston as a "salubrious city," he showed his concern for yellow fever, malaria, and influenza as diseases that he considered related to climate.

He moved to New Orleans and practiced there for a short period. He eventually sailed to San Francisco, arriving there on 26 January 1850. In April, he closed his practice in San Francisco and went to Coloma, California to regain his energy and to search for gold.

In August 1850, he left the gold fields of Coloma and moved to Sacramento to resume his medical practice (Figure 18). The cholera epidemic erupted in October and the weather instruments that he brought from New Orleans became vital to the climatological, meteorological, and necrological studies that he began to make.

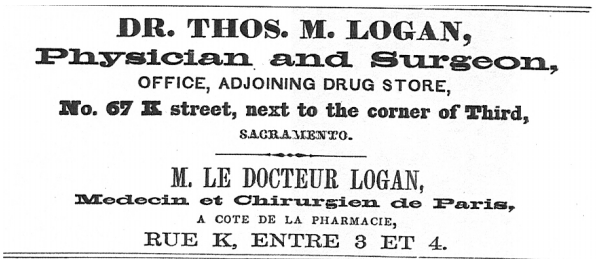
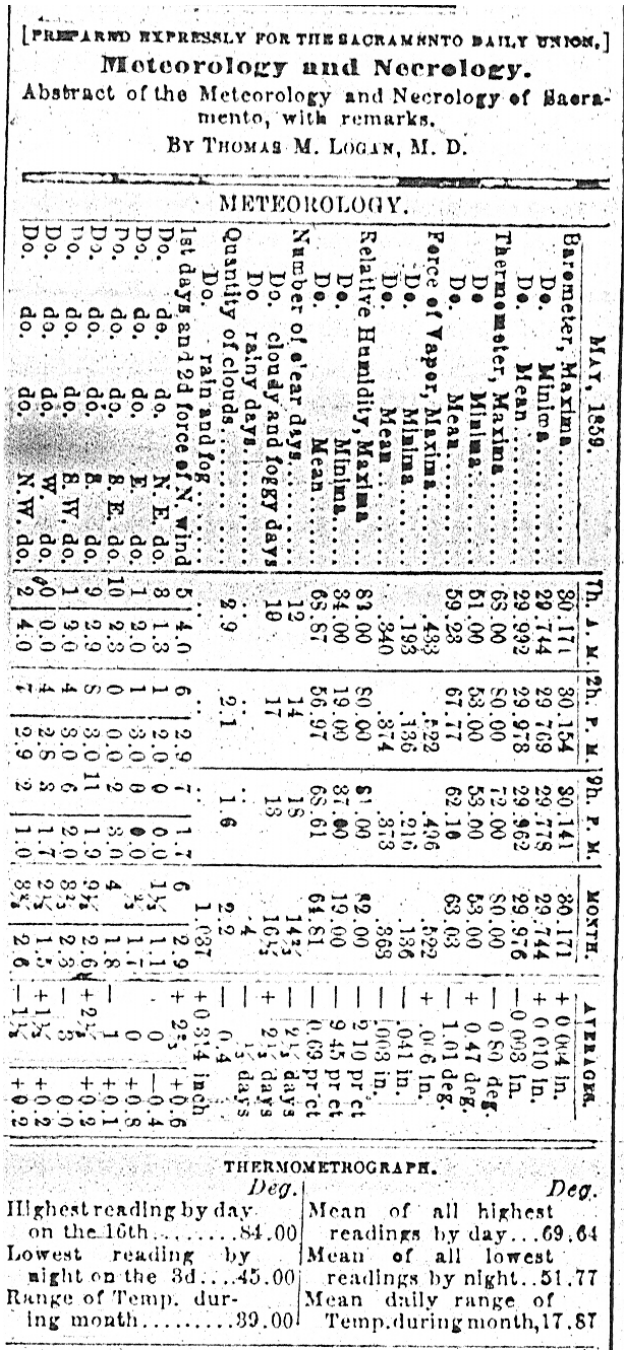


Figure 18. Dr. Logan's Ad for his medical practice in Sacramento
Source: Sacramento Directory for the Year 1853-1854, Morse

The daily observations he made were said to be the first systematic collection of climatological data made west of the Rockies. A plaque next to his tombstone in Sacramento says, "He was California's first meteorologist and kept the first detailed mortality data on the west coast." According to Jones, he collected necrological records from undertakers from 1850 to January 1858 to establish a baseline for comparisons with weather, climate, and topography.

He published the both the meteorological and the necrological monthly data after the end of each month in the Sacramento Union daily newspaper. The June 1856 data were in the 2 July 1856 issue. The monthly publication in the newspaper continued through at least October 1859. The newspaper article shown in Figure 19 had meteorological statistics from May 1859, followed by a long narrative of the month's weather, and another table that contained the necrology statistics by cause of death. That kind of report was published at the beginning of each month in the local newspaper for several years.

In later years, 1873 for example, he published annual statistical summaries of both meteorology and necrology. Those were very detailed and filled most of a newspaper page.



[PREPARED EXPRESSLY FOR THE SACRAMENTO DAILY UNION.]

Meteorology and Necrology.

Abstract of the Meteorology and Necrology of Sacramento, with remarks.

BY THOMAS M. LOGAN, M. D.

METEOROLOGY.

MAY, 1859.		7h. A. M.	2h. P. M.	9h. P. M.	MONTH.	AVERAGE.
Barometer, Maxima		30.171	30.154	30.141	30.171	+ 0.004 in.
Do. Minima		29.744	29.769	29.778	29.744	+ 0.010 in.
Do. Mean		29.992	29.978	29.962	29.976	— 0.003 in.
Thermometer, Maxima		68.00	80.00	72.00	80.00	— 0.80 deg.
Do Minima		51.00	53.00	53.00	53.00	+ 0.47 deg.
Do. Mean		59.23	67.77	62.10	63.03	— 1.01 deg.
Force of Vapor, Maxima		.433	.522	.406	.522	+ .006 in.
Do. Minima		.193	.136	.216	.136	— .041 in.
Do. Mean		.340	.374	.373	.363	— .003 in.
Relative Humidity, Maxima		81.00	80.00	81.00	82.00	— 2.10 pr ct
Do. Minima		84.00	19.00	87.00	19.00	— 9.45 pr ct
Do. Mean		68.57	56.97	68.61	64.81	— 0.69 pr ct
Number of clear days		12	14	18	142/3	+ 2 1/3 days
Do. cloudy and foggy days		10	17	13	163/4	+ 2 1/3 days
Do rainy days		..	2.1	1.6	.4	— 1/3 days
Quantity of clouds		2.9	..	..	2.2	— 0.4
Do. rain and fog		..	..	..	1.037	+ 0.314 inch
1st days and 2d force of N. wind		5 4.0	6 2.9	7 1.7	6 2.9	+ 2 5/6 — 0
Do. do. N. E. do.		8 1.3	1 2.0	0 0.0	1 1/2 1.1	+ 2 1/3 days
Do. do. E. do.		1 2.0	1 3.0	0 0.0	3/4 1.7	— 1/3 days
do. do. S. E. do.		10 2.3	0 0.0	2 3.0	4 1.8	— 0.4
Do. do. S. do.		9 2.9	8 3.0	11 1.9	9 1/2 2.6	— 1
Do. do. S. W. do.		1 9.0	4 3.0	6 2.0	8 3/4 2.3	+ 2 1/2
Do. do. W. do.		0 0.0	4 2.5	3 1.7	2 1/2 1.3	— 3
Do. do. N. W. do.		2 4.0	7 2.9	2 1.0	8 1/4 2.6	+ 1 1/2 — 1 1/2

THERMOMETROGRAPH.			
	Deg.		Deg.
Highest reading by day on the 16th	84.00	Mean of all highest readings by day	69.64
Lowest reading by night on the 3d	45.00	Mean of all lowest readings by night	51.77
Range of Temp. during month	39.00	Mean daily range of Temp. during month	17.87

Figure 19. One of Dr. Logan's Monthly News Releases, 2 June 1859
Source: Sacramento Union

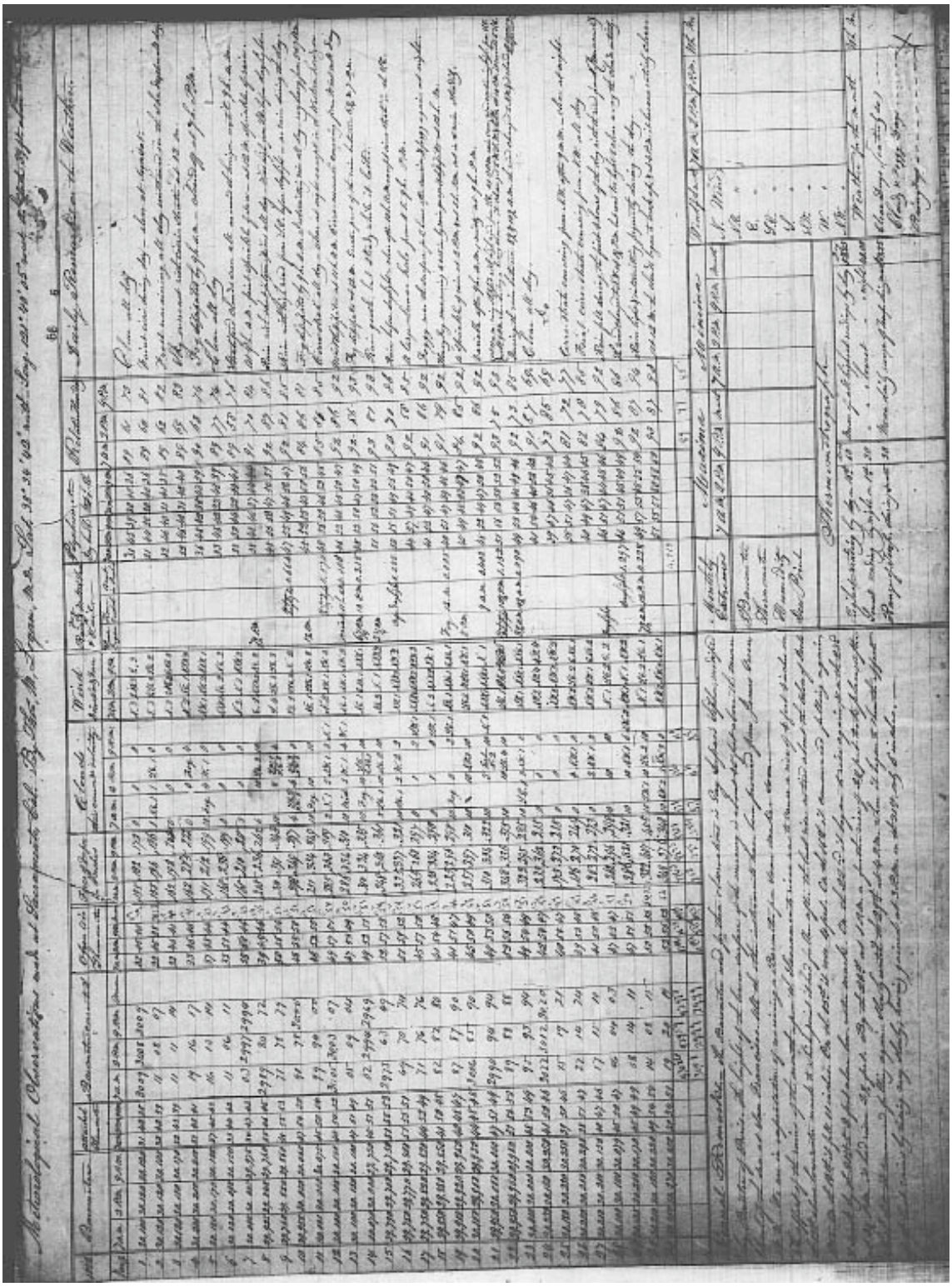


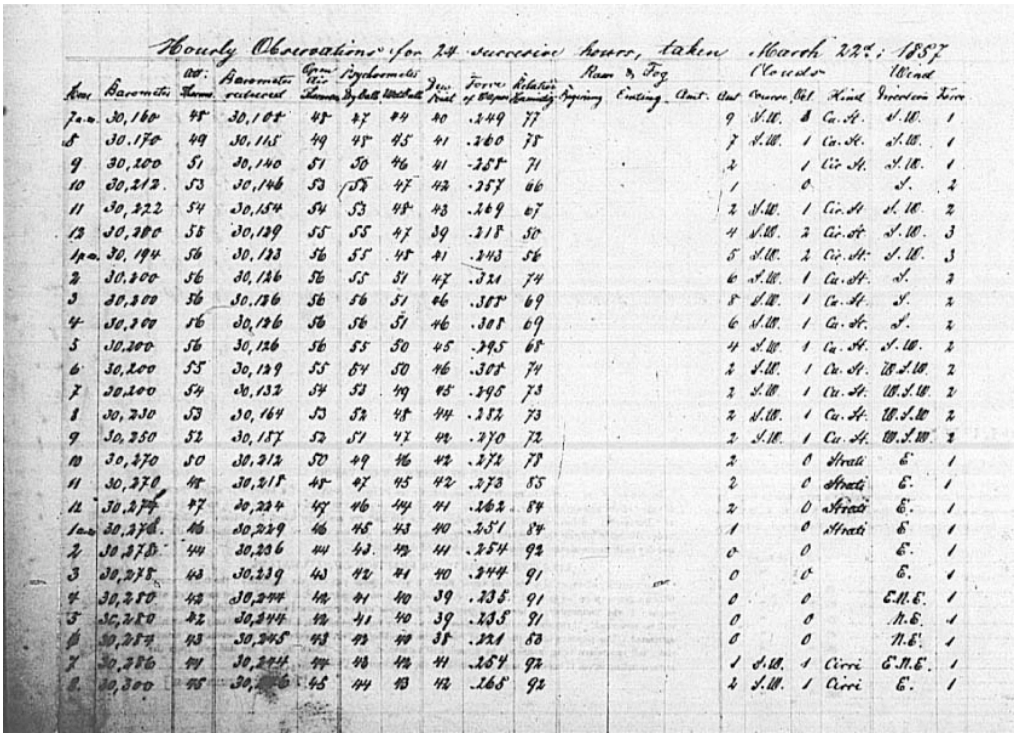
Figure 20. Dr. Thomas M. Logan's observations from Janaury 1856.
Source: Original record, National Climatic Data Center

The earliest extant daily observational record from Sacramento is from January 1856 (Figure 20). The hand drawn form tells us that he had not yet received the printed forms from the Smithsonian Institution to whom he sent that monthly report. The columns on the form inform us about his instrumentation and the summary blocks on the lower right of the form show his interest in climatology.

A thorough search for his daily observations from the years prior to 1856 proved fruitless. However, the mystery was solved when Mr. Barwick, in his letter of 1895 to the State Engineer's office, added a postscript.

> Mrs. Dr. Logan has all the Dr's records but will not let anyone see them. She is angry because the State would not buy them, & also angry with the Signal Service because they will not buy them. The mean temperature published by myself from 1853 to 1883, from 1853-1875 was from Dr. Logan that a former observer (surreptitiously Mrs. Logan says) obtained from her.
>
> Respectfully
>
> B

That postscript solves the mystery of where they were in 1895 but not where they are located now.



Hourly Observations for 24 successive hours, taken March 22d, 1857

Hour	Barometer	Att. Therm.	Barometer reduced	Therm. Wet	Psychrometer Dry Bulb	Wet Bulb	Dew Point	Force of Vapor	Relative Humidity	Rain & Fog Beginning	Ending	Amt.	Clouds Amt.	Direction	Kind	Wind Direction	Force
Jan.	30,160	48	30,104	43	47	44	40	.249	77				9	N.W.	8	Cu. St.	N.W.	1
8	30.170	49	30.115	49	45	45	41	.260	78				7	N.W.	1	Cu. St.	N.W.	1
9	30,200	51	30,140	51	50	46	41	.255	71				2		1	Cir St.	N.W.	1
10	30,212	53	30,146	53	50	47	42	.257	66				1		0		N.	2
11	30,222	54	30,154	54	53	48	43	.269	67				2	N.W.	1	Cir. St	N.W.	2
12	30,200	55	30,139	55	55	47	39	.218	50				4	N.W.	2	Cir. St	N.W.	3
1p.m.	30, 194	56	30, 133	56	55	48	41	.243	56				5	N.W.	2	Cir. St.	N.W.	3
2	30,200	56	30, 126	56	55	51	47	.321	74				6	N.W.	1	Cu. St.	N.	2
3	30,200	56	30.126	56	56	51	46	.305	69				8	N.W.	1	Cu. St.	N.	2
4	30,200	56	30,126	56	56	51	46	.308	69				6	N.W.	1	Cu. St.	N.	2
5	30,200	56	30, 126	56	55	50	45	.295	68				4	N.W.	1	Cu. St.	N.W.	2
6	30,200	55	30, 129	55	54	50	46	.305	74				2	N.W.	1	Cu. St.	W.N.W.	2
7	30,200	54	30,132	54	53	49	45	.295	73				2	N.W.	1	Cu. St.	W.N.W.	2
8	30, 230	53	30, 164	53	52	48	44	.282	73				2	N.W.	1	Cu. St.	W.N.W	2
9	30, 250	52	30, 187	52	51	47	42	.270	72				2	N.W.	1	Cu. St.	W.N.W.	2
10	30, 270	50	30, 212	50	49	46	42	.272	77				2		0	Strati	E.	1
11	30, 270	48	30, 218	48	47	45	42	.273	85				2		0	Strati	E.	1
12	30, 274	47	30, 224	47	46	44	41	.262	84				2		0	Strati	E.	1
1a.m.	30, 270	46	30, 229	46	45	43	40	.251	84				1		0	Strati	E.	1
2	30 270	44	30, 236	44	43	42	41	.254	92				0		0		E.	1
3	30, 278	43	30, 239	43	42	41	40	.244	91				0		0		E.	1
4	30, 280	42	30, 244	42	41	40	39	.235	91				0		0		E.N.E.	1
5	30, 280	42	30, 244	42	41	40	39	.235	91				0		0		N.E.	1
6	30, 284	43	30, 245	43	42	40	38	.224	83				0		0		N.E.	1
7	30, 286	44	30, 244	44	43	42	41	.254	92				1	S.W.	1	Cirri	E.N.E.	1
8	30, 300	45	30, [illegible]	45	44	43	42	.265	92				2	S.W.	1	Cirri	E.	1

Figure 21. Hourly Observations in Sacramento on 22 March 1857
Source: Original record, National Climatic Data Center

Included in his March 1857 report to the Smithsonian was a table (Figure 21) of hourly observations taken on 22 March 1857, The motivation for these hourly data collections was Dr. Logan's scientific leanings and his search for the factors influencing the spread of disease. He intended to make these hourly collections four times each year, on the dates of the equinox and the solstice. Those data could be used as a baseline for observations at other times of the year that had either more or fewer hours of daylight. Those other observations could then be corrected for the difference in day length. A result of those four days in 1855 were published in the Smithsonian's Tenth Annual Report.

Dr. Logan published papers often. His 1858 paper had several pages of his monthly meteorological data and several pages of narrative description of the climate of Sacramento. In his 1859 paper, six years of his meteorological observations were presented as comparative statistics to the mortality numbers for the Sacramento area. He noted that the peak of mortality occurred during autumn. But he concluded that cholera, diarrhea, typhoid fever, etc. depended greatly on the hygiene of the inhabitants. Climate and weather were considered to be contributing causes.

His 1869 paper, written as the Visiting Physician to the Small Pox Hospital in Sacramento, included a narrative summary of the weather in California and strongly advocated vaccinations for small pox during infancy.

When he published the 1873 paper, he was the President of the American Medical Association and the paper was his address to its convention in St. Louis. Again he reviewed the previous 25 years of the organization and recommended that a Secretary of Public Health be established in the Federal Government.

He died on 13 February 1876 shortly after visiting the Senate chamber on State Board of Health business. His meteorological work did not die. Dr. Logan's summarized data have appeared in virtually every discussion of Sacramento's climate that has been published to date.

Joseph H. Wythe

In 1863, the climatological record of Sacramento became muddled by the addition of another observer in town. The Civil War brought that observer, Major Joseph H. Wythe, to Sacramento in January 1863. He had been appointed the Staff Assistant Surgeon in General Wright's unit on 11 September 1862. He was promoted to Surgeon on 4 December 1862. As a weather observer and a surgeon, he was participating in an Army climate observation network begun many years before.

The Surgeon-General of the Army, James Tilton M.D., first conceived of a climate network in the United States in 1814 during the War of 1812. He issued a directive to his Army hospital, post, and regimental surgeons to record the weather. Although this beginning was encouraging it was dropped between 1815 and 1817. The effort to collect climate data was renewed by his successor, Joseph Lovell, M.D. in 1818. He ordered

each Army surgeon to ".... keep a diary of the weather...." and to note ".... everything of importance relating to the medical topography of his station, the climate, diseases prevalent in the vicinity...."

The motivation for the new task was to determine if there was a cause and effect relationship between climate and the health of the soldiers. Dr. Lovell said the purpose was to ascertain if "in a series of years there be any material change in the climate of a given district of the country; and if so, how far it depends on cultivation of the soil, density of population, etc."

Major Wythe's first two observation reports were entered on hand drawn forms that he signed as "Asst, Surg. U.S. Vols." From March through August of 1863, he used the Army Surgeon General's printed form titled "Meteorological Register." The word "Army" was lined through on it and above it he wrote "Vols."

In May and June 1863, records from both Dr. Logan and Dr. Wythe exist with Logan reporting to the Smithsonian and Wythe to the Surgeon General. Dr. Wythe's September report was again entered on a hand drawn form and it is the last extant report from him. As soon as the danger passed for the succession of California from the Union, he resigned from the Army on 26 October 1863. Thereafter, he was pastor of the Methodist Episcopal Church in Sacramento and President of Willamette University in Oregon.

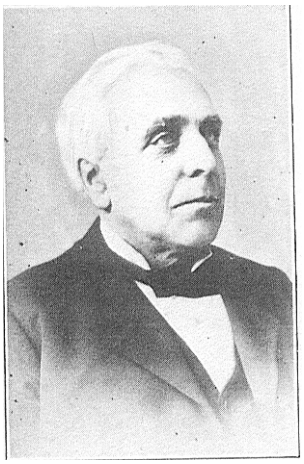


Figure 22. Dr. Joseph H. Wythe
Source: Memories, Men, and Medicine, Jones

Dr. Wythe (Figure 22) published frequently both as a physician and as a minister. He was the author of a widely used medical textbook, a medical professor for twenty-five years in what later became Stanford University, and an author of twelve volumes on biology, geology, medicine, and religion.

A substitute observer recorded the data for Dr. Logan for December 1863. He was Charles Croft who was a Hospital Steward at Dr. Logan's hospital. This month was the only such substitution that was noted.

In June 1864, the extant records continue with Dr. Logan as the observer. It seems likely that there was no actual gap in daily observations because he never commented about resumption. As meticulous as he was, one would have expected an explanation if a gap in fact existed. Lacking one, it seems likely that the forms were mishandled. In any case, the monthly data have survived.

A Ten Year Data Gap in Logan's Record

Dr. Logan's daily record ends after March 1867 and doesn't resume until June 1877. He attended the American Medical Association meeting in Cincinnati in 1867 and then sailed to Europe to attend the International Medical Congress that was meeting in Paris. Afterward, he spent a few months visiting medical institutions in France, England, and Germany. When he returned, he moved to San Francisco and opened an office there in early 1868. However, he moved his practice back to Sacramento at the end of that year.

Frederick Winslow Hatch

Figure 23. Dr. Frederick Winslow Hatch
Source: Memories, Men, and Medicine, Jones

Dr. Frederick Winslow Hatch (Figure 22) was another observer in Sacramento who was contemporaneous with Dr. Logan. They had several similarities. Both married in Charleston, South Carolina, both migrated to Sacramento (Hatch in 1853 three years after

Dr. Logan), both were members of the local branch of the American Medical Association, both were involved with the Sacramento Board of Health, and both published meteorological articles. Dr. Hatch was elected Superintendent of Schools in April 1855, was the first president of the City Board of Health in 1862 and a member of that board for twenty-two years, and was a professor in the Medical Department of the University of California for several years. He died on 16 October 1884 while still serving as the Secretary of the Board of Health.

In 1855, he published "Meteorological Observations at Sacramento, California" that appeared in the Ninth Annual Report of the Smithsonian Institution. In it, he presented his daily observations from April 1854 through March 1855. They included for his four observation times of sunrise, meridian (noon), sunset, and 10 p.m., the temperature as the time of observation, the maximum and minimum for those times, the barometer, the attached thermometer reading, and the thermometrograph with its extremes; the hygrometer's reading of maximum and minimum dew point and moisture in the air (in percent), the psychrometer with both wet and dry bulb; the wind direction and the wind force; the weather including days clear or cloudy; days with precipitation and amounts; and days with fog.

In July 1855, he published "On the Climate of the Valley of the Sacramento, California" in the New York Journal of Medicine. That forty-one page climatology was based on his own observations during 1854-1855. His article had lengthy narrative descriptions of the seasons, the extremes in each, and what he perceived to be relationships between climate and diseases. There were tables of monthly data for each of the observed climate elements. He also included a table of mortality at Sacramento for 1854 that the Board of Health had collected. After a presentation of temperature data, he explained his interest.

> We have devoted thus much to the subject of the daily variation in temperature to which we are exposed, and its influence upon the health, from a conviction that to this single cause many of the diseases met with in this valley are to be attributed in its direct or secondary relation. In concluding the subject we cannot forebear to repeat the expression of surprise, that, under the atmospheric agencies alluded to, there should not be found a far greater and more general impairment of health than facts or the records of mortality exhibit.

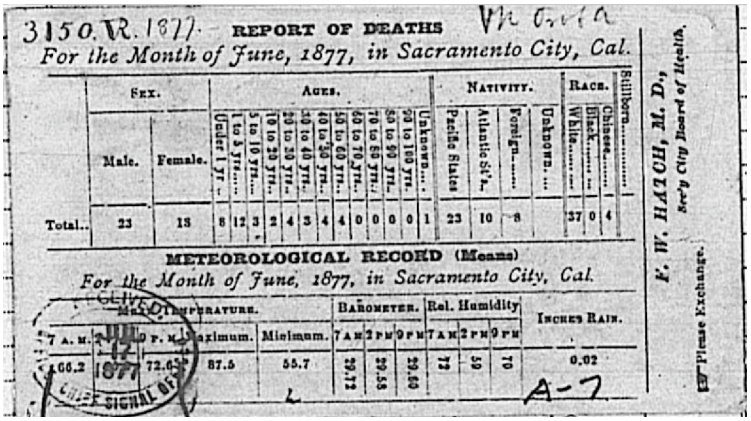
Two of the more interesting tables in that article showed data not usually collected by observers. One was the "proportion of observations when the sky was perfectly cloudless." The data from 23 March through 31 December showed that condition at ten percent of the observations with September leading with twenty-six percent. The other unusual table (Table 1) was the "color of the sky" that was prepared from August observations.

	Vapory	Light-Blue	Blue
Sunrise	20	5	2
Meridian	11	14	4
Sunset	14	10	5
10 p.m.	14	15	14[1]

Table 1. Days with Color of the Sky at Observation Time, (two days omitted)
Source: On the Climate of Sacramento Valley, Hatch, 1855.

He wrote that even when the sky was cloudless, there was often a vapory condition that obscured the natural sky color. He collected these data to investigate that occurrence.

> We have observed this condition much less frequently when the wind was west or northwest, and when a fresh breeze was blowing. At such times it would seem as if the vapor in its ascent would be collected into light masses of clouds, revealing an atmosphere above which rivals, in its deep, clear blue, the sky of the tropics.



3150. R. 1877.

REPORT OF DEATHS

For the Month of June, 1877, in Sacramento City, Cal.

	Sex.		Ages.											Nativity.			Race.			Stillborn.
	Male.	Female.	Under 1 yr.	1 to 5 yrs.	5 to 10 yrs.	10 to 20 yrs.	20 to 30 yrs.	30 to 40 yrs.	40 to 50 yrs.	50 to 60 yrs.	60 to 70 yrs.	70 to 80 yrs.	80 to 90 yrs.	90 to 100 yrs.	Unknown.	Pacific States	Atlantic St's.	Foreign.	Unknown.	White.	Black.	Chinese.	
Total..	23	13	8	12	3	2	4	3	4	4	0	0	0	0	1	23	10	3		37	0	4	

E. W. HATCH, M. D., Secy City Board of Health.

METEOROLOGICAL RECORD (Means)

For the Month of June, 1877, in Sacramento City, Cal.

Temperature.				Barometer.			Rel. Humidity			Inches Rain.
7 A.M.	2 P.M.	Maximum.	Minimum.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	
66.2	72.6	87.5	55.7	29.72	29.53	29.60	72	50	70	0.02

Please Exchange.

Figure 24. Newspaper Clipping of Report of Deaths by Dr. F. W. Hatch
Source: June 1877 Sacramento Data Files, National Climatic Data Center

He provided data to the local newspaper similar to those provided by Dr. Logan. There is a newspaper clipping (Figure 24) in the files of Sacramento meteorological data presented by Frederick Winslow Hatch. At that time he was the Secretary of the City Board of Health. Note that it included weather data in addition to the necrological data.

[1] There appears to be a typographical error in the Blue entry for 10 p.m.

His articles clearly showed the depth of his interest and understanding of weather and his strongly held belief that it induced or influenced the occurrence of diseases. The monthly data published by Barwick in 1891, attributed the Sacramento record 1849-1890 to the combination of Dr. Logan, Dr. Hatch, and the Signal Service without distinguishing among them. Another Sacramento observer, S. H. Gerrish mentions in a 6 December 1882 newspaper clipping that Dr, Logan observed from 1849 to 1862 and Dr. Hatch from 1862 to 30 June 1877. Those dates seem to be correct.

The Signal Service Years

Congressman Halbert E. Paine from Wisconsin adopted the idea of Professor Increase A. Lapham of Milwaukee for a national service to collect and distribute weather information. He gained the support of Colonel Albert J. Myer, Chief of the Signal Service and introduced a resolution that required the Secretary of War to "to provide for taking meteorological observations at the military stations in the interior of the continent and at other points in the States and Territories...and for giving notice on the northern (Great) lakes and on the seacoast by magnetic telegraph and marine signals, of the approach and force of storms." The resolution passed and President Ulysses S. Grant signed it into law on February 9, 1870.

Because of the Signal Corps' telegraph network, the new function was given to it and the head of than unit, the newly promoted Brevet Brigadier General Albert J. Myer. The weather network of twenty-four stations telegraphically transmitted their first reports at 7:35 a.m. on November 1, 1870 to the central office in Washington. That network would evolve into the Weather Bureau and the National Weather Service.

Robert Bruce Watkins

The first Sacramento observer of the newly formed Signal Service was Observer Sergeant Robert B. Watkins. A Virginian, he had been an Army Cadet from 1 July 1870 to June 1873 but he became a Private in the Signal Corps on 3 October 1873.

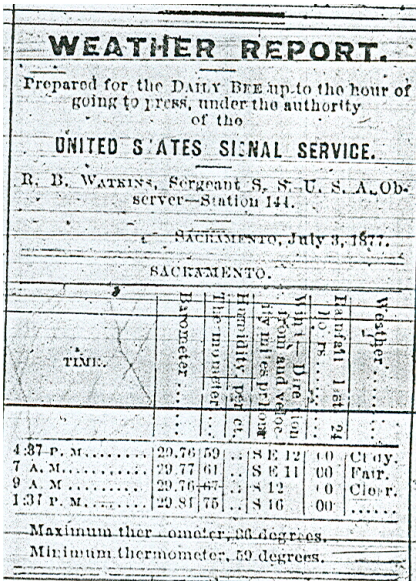
Sergeant Watkins may have been a product of a relatively new Army school of meteorology that had been established at Fort Whipple (later Fort Myer) in Virginia. He was stationed there for two years. There, the new Observer Sergeants received instruction in signaling, telegraphy, telegraphic line construction, electricity, meteorology, and practical work in meteorological observation.

Sergeant Watkins was transferred from Washington to Virginia City, Montana Territory. After about two years there, he moved to Sacramento to open the first Signal Service office there. According to Masters-Bevan, the first message, of the then Sergeant, Watkins was sent to Washington on 23 June 1877. It said "Arrived." His arrival prompted this retraction that appeared three days later in the Sacramento Daily Record.

A few days ago we announced that J. H. Lewis Depty Postmaster at Sacramento had been appointed to send weather reports to the Chief of the Signal Service at Washington. However, the station had been upgraded to first class station, one of 148 in the U.S.

According to the Sacramento Bee of 30 June 1877, Sergeant Watkins wanted to lease an office in the State Capitol for one year with the option to retain it indefinitely. The Capitol Commissioners could not grant him that option for longer than their term of office. His second choice for an office in Sacramento was in one of two rooms on the fourth floor of the St. George Building, at 4th and J Streets. He lived in the other room. His first report of meteorological observations was on 1 July 1877 and his first report was for July 1877 on the War Department's Form 22. The report included the barometer, thermometer, maximum and minimum thermometers, precipitation amounts, temperature means, wind direction, and maximum wind velocity. According to the newspaper article, he made observations seven times per day. Four of those were made at 4:37 a.m., 9:02 a.m., 1:37 p.m., and 8:02 p.m. local time to coincide with 7 a.m., 2 p.m. and 9 p.m. of Washington D.C. Mean Time. The other three observations were made at 7 a.m., 2 p.m., and 9 p.m. local Sacramento time. He was quite a busy man for seven days per week.

He submitted weather reports to the Sacramento Bee newspaper (Figure 25). Those reports also included data from other stations in the western United States.



WEATHER REPORT.

Prepared for the DAILY BEE up to the hour of going to press, under the authority of the

UNITED STATES SIGNAL SERVICE.

R. B. WATKINS, Sergeant S. S. U. S. A., Observer—Station 144.

SACRAMENTO, July 3, 1877.

SACRAMENTO.

TIME.	Barometer reduced to sea level.	Thermometer.	Humidity. Dew point.	Wind—Direction and velocity per hour.	Rainfall last 24 hours.	Weather.
4:37 P. M.	29.76	59	..	S E 12	00	Cloudy.
7 A. M.	29.77	61	..	S E 11	00	Fair.
9 A. M.	29.76	57	..	S 12	00	Clear.
1:37 P. M.	29.81	75	..	S 16	00	.....

Maximum thermometer, 86 degrees.
Minimum thermometer, 59 degrees.

Figure 25. Sergeant Watkins' Weather Report for Sacramento
Source: Sacramento Bee, 3 July 1877

Sergeant Watkins was transferred away from Sacramento in July 1879 to Cincinnati. At the time of his departure, there were 284 Signal Service weather stations each reporting three times per day.

Sergeant Watkins was promoted to 2nd Lieutenant on 26 April 1883. There was an examination that was required before promotion to officer rank. The examination topics (Figure 26) were quite varied. The stations were provided with a library for use in preparation for the examination. 1st Lt. Watkins retired on 27 August 1896.

II. An examining board will meet at this office, at such time as may be necessary, for the purpose of examining such sergeants of the Signal Corps as may be ordered by the Chief Signal Officer to appear before it. The examination will be made for the purpose of selecting two sergeants for promotion to 2d Lieutenants in the Signal Corps of the Army.

Each sergeant will be examined in the following subjects:

First. English grammar, and ability to read and write with facility and correctness.

Second. Arithmetic, and ability in the application of its rules to practical questions; the use of logarithms, and ability to apply them to questions of practice; algebra, to the solution of quadratic equations; knowledge of plane geometry, and the elements of surveying.

Third. Geography, particularly in reference to the northern continent of America; ability to solve the usual problems on the terrestrial globe, and popular astronomy.

Fourth. History, particularly in reference to the United States.

Fifth. The constitution of the United States, the organization of the Government under it, and the general principles which regulate international intercourse.

Sixth. The minimum course as laid out in the second edition of Howison's Analytic Geometry; differential and integral calculus, as much as is contained in Peck's or Davies' Calculus.

Seventh. Dechanel's Natural Philosophy, 6th Ed., 1883, complete, and Stewart's or Maxwell's Treatise on Heat.

Eighth. Examination into physical and moral qualifications should cover the history of the person examined, and establish for a successful candidate, a continuously sound mental and physical condition, excellent moral character, a good character for sobriety and fidelity, as well as an intelligent, energetic, judicious, and faithful performance of such duties as may have been assigned him in the Signal Corps of the Army.

Each candidate will be required to submit to the board a short, original essay on some previously assigned topic, and will be required to make an original investigation of some problem in one of the various branches of meteorology.

The ability to read French and German scientific books is desirable; but, unless two candidates receive equal marks in the other subjects, will not be considered in the examination.

Figure 26 . Examination topics for promotion from Sergeant to 2nd Lieutenant. 1885 Source: General Order No. 25, War Department

Figure 27. Samuel Howard Gerrish

Samuel Howard Gerrish was a major contributor to our knowledge of Sacramento climate although he began long before the Signal Service existed. In the beginning, he kept temperature records in his diary. He began keeping diaries on 1 January 1860. The location of the first entry isn't identified in the diary but his entry on 5 June records his departure by ship from New York. He recorded his latitude and longitude each day along with the high temperature. He arrived in Panama City, Panama on the 13th, departed on the 15th, and arrived in San Francisco on the 28th. His 1862 diary recorded his location as Vallejo. His list of expenditures for October of that year included a purchase of a thermometer on the 2nd. It was a "Peregorie" (spelling uncertain) and cost $1.25. He resumed entering three times per day temperature readings on the same day. According to his diary his last observation at Vallejo was 28 February 1866 and his first in Sacramento was 6 April 1866.

Fifty-two volumes of his diaries are available at the U.C. Berkeley's Bancroft Library. These are actual diaries of his daily activities but they began each day with temperature observations. For example, on 1 January 1860, he recorded the temperature at -15˚F at 7 a.m., -5˚F at 1 p.m., and 0˚F at 9 p.m. There followed on most days a comment about the weather conditions, i.e., clear, foggy, rain, etc. The diary entries for each day contain comments about his work day with the Navy as an engineer, with the railroad as a machinist (ten hours each day usually), his horticultural activities, his service with the California National Guard, and other personal activities. There are also lists of his outgoing letters, expenditures, and other notes at the end of each volume.

During the period 1861 through 1885, Mr. Gerrish kept a scrapbook of newspaper clippings using an old 874-page book and pasted clippings on 425 of those pages. All of the clippings were weather observations or articles about weather events. One clipping was on "eclipses, auroras, prospects of collision with a comet." His own reports were published in the paper from about 1875. He mentioned in a 6 December 1882 clipping that he had been a private rain gage observer for many years. The first mention of rainfall

measurements appeared in his diary on 31 October 1875. He mentioned in the same article that Dr, Logan observed from 1849 to 1862 and Dr. Hatch from 1862 to 30 June 1877.

One of his contributions to the Sacramento Union points out that there was an error in the Signal Service record in the rain amount for December 1875. He said that it should be 5.025" and the seasonal total should be 26.510". It seems certain that the Signal Service was not offended by that correction. In the autobiography in his personal papers, he wrote that "General Hazen, Chief Signal Officer of the U. S. Army, appointed me Voluntary Observer at Sacramento. I began on January 1, 1883, to send my reports to Washington, D. C. to his office."

Mr. Gerrish made temperature entries at 7 a.m., 2 p.m. and 9 p.m.; maximum and minimum temperature; rainfall and snowfall amounts; prevailing wind direction, character of the day; and snow depth during the 1893-1900 period. Subsequently from 1901-1911, the Form 1009 that he used was revised. The new form had maximum and minimum temperature, beginning and ending time of precipitation, rainfall and snowfall amount, depth of snow, prevailing wind direction, character of the day, and remarks. In all but the final month, there were remarks that enhanced his numerical data.

His observations were published in January 1897 as a Cooperative Observer for the Signal Service in what would become the Climatological Data for California. His diary recorded that first submission as well.

A Weather Bureau Form 4000, Description of Cooperative Observer's Station, dated 8 February 1906 noted that the rain gage had been at the same spot for thirty-one years. That means that Mr. Gerrish had been an observer both before and after his work with the Signal Service. His observations were made at 9 a.m. from his home.

In December 1911, the Weather Bureau was listed as an observational site in Sacramento with a length of record of 34 years in addition to Mr. Gerrish's site with a period of record listed as 58 years. It was to be the last mention of Mr. Gerrish. Located in the California State Library in Sacramento are the original monthly Weather Bureau's Voluntary Observers' Meteorological Record forms prepared by Mr. Gerrish. The entries were made in pencil and cover the period from 1 January 1893 through 30 September 1911. In the front is a note that these forms were a donation from Edward L. Gerrish in 1932. The note says that the reports were "discontinued after September 1911 because of failing health of Samuel H. Gerrish." The forms have his post office address as 1517 G Street in Sacramento.

Even after he discontinued making entries on an official form, he continued to made temperature entries in his diary. The last entry on 14 March 1912 had the maximum, minimum, and mean temperature and then this entry:

"It is painful for me to sleep in my chair but I hope I will get through with it sometime and be relieved of the asthma…."

He died shortly thereafter.

Marion M. Sickler

Observer-Sergeant Marion M. Sickler served at the U. S. Signal Service Station at Sacramento from l6 April 1879 to 15 March 1881. His function as part of the Weather Department of the Signal Service was to record various meteorological measurements and give warning to farmers of the approach of storms, floods, frosts, and cold waves.

Although there is a collection of his letters from his stay in Sacramento, they don't amplify the comments on his observation forms. His tour ended on 14 March 1881. His replacement was his opposite regarding documentation and publication.

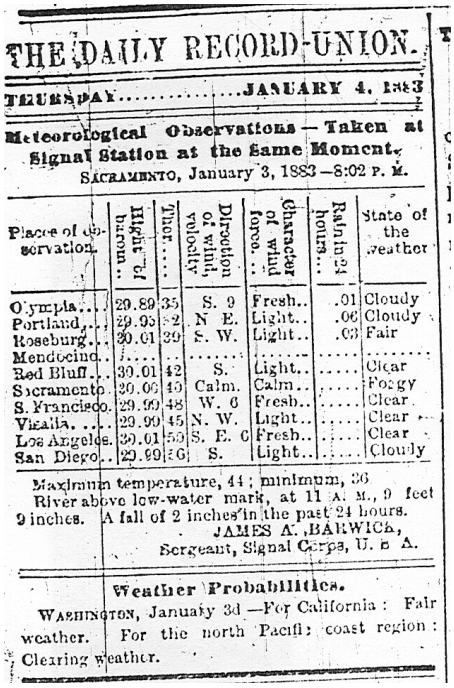
James A. Barwick

The replacement was Observer Sergeant James A. Barwick (Figure 28), a Maryland native who arrived in Sacramento in March 1879. He would serve until 1901. During that period, dramatic changes occurred in the office and in its public service role.

Figure 28. James A. Barwick, Signal Service Observer Sergeant
Source: Barwick's Annual Meteorological Review California 1890

He contributed articles to the Sacramento newspapers. Those articles served the public but they also assured that the Signal Service's presence was frequently affirmed. Not inconsequentially, they also inserted Sergeant Barwick's name into the public's memory. For example, he contributed an 1849-1881 monthly rainfall table to the Sacramento Record-Union on 1 January 1885 that included the data from Dr. Logan and Dr. Hatch.

When use of a common observation time for the Signal Service stations began, his articles served a new function. They gave readers an understanding of how Sacramento weather compared to other California locations (Figure 29).



THE DAILY RECORD-UNION.

THURSDAY.....JANUARY 4, 1883

Meteorological Observations — Taken at Signal Station at the Same Moment.

SACRAMENTO, January 3, 1883—8:02 P. M.

Place of observation.	Height of barom...	Ther.....	Direction of wind, velocity	Character of wind force...	Rain in 24 hours...	State of the weather
Olympia...	29.89	35	S. 9	Fresh..	.01	Cloudy
Portland...	29.95	32	N. E.	Light..	.06	Cloudy
Roseburg...	30.01	39	S. W.	Light..	.03	Fair
Mendocino..	.....	..	.....	.....	.....	.....
Red Bluff...	30.01	42	S.	Light..	.....	Clear
Sacramento.	30.06	40	Calm.	Calm..	.....	Foggy
S. Francisco.	29.99	48	W. 6	Fresh..	.....	Clear.
Visalia. ...	29.99	45	N. W.	Light..	.....	Clear
Los Angeles.	30.01	50	S. E. 6	Fresh..	.....	Clear
San Diego..	29.99	56	S.	Light..	.....	Cloudy

Maximum temperature, 44; minimum, 36

River above low-water mark, at 11 A. M., 9 feet 9 inches. A fall of 2 inches in the past 24 hours.

JAMES A. BARWICK,
Sergeant, Signal Corps, U. S. A.

Weather Probabilities.

WASHINGTON, January 3d.—For California: Fair weather. For the north Pacific coast region: Clearing weather.

Figure 29. Barwick Article with Observations Taken at the Same Moment
Source: Sacramento Daily Record-Union, 4 January 1883

Not everyone shared the Observer Sergeants' enthusiasm for the weather mission. The famous Civil War General William Tecumseh Sherman was one of those detractors. According to Goodwin's study, he thought that the Observer Sergeants were

> …. No more soldiers than the men of the Smithsonian Institute. They are making scientific observations of the weather, of great interest to navigators and the country at large. But what does a soldier care about the weather? Whether good or bad, he must take it as it comes.

It isn't surprising that the Army's responsibility for weather observations was transferred to the new Weather Bureau that was created within the Department of Agriculture on 1 October 1890. Congress, at the request of President Benjamin Harrison, passed an act that transferred the weather service from the Signal Service to a new Weather Bureau created within the Department of Agriculture. According to NOAA history, the new law prescribed that:

> ...the enlisted force of the Signal Service, excepting those hereinafter provided for shall be honorably discharged from the Army on June 30, 1891, and such portion of this entire force, including civilian employees of the Weather Bureau shall, if they so elect be transferred to the Department of Agriculture...

James Barwick made the election to be transferred and in 1890, he left the Army and became the Meteorologist to the State Board of Agriculture. In California, the State Agricultural Society published annual reports from 1882 to 1891 through an arrangement that Mr. Barwick had initiated. Those statistical monthly summaries were intended to include data from the other Signal Service observers in California. He commented in the report for 1888 that only the San Diego observer submitted data, the other two did not. He wrote, "I must confess that I myself am greatly disgusted and discouraged at the small amount of interest taken by its people in the climatic conditions of this State…." He envied the creation of the State Weather Service of Nevada and of Oregon. He apparently got his wish because, the following year, there were inputs from the other stations.

After a bill to create the State Weather Services was defeated, the U.S. Weather Bureau under Mr. Barwick established the State Weather Service and took over the publication of data from the forty Voluntary Observers active at that time. The State Agricultural Society published its reports through the State Printing Office. By January 1893, the number of observers had increased to ninety. By the beginning of 1897, there were 143 volunteer observers.

On 1 January 1897, Volume I Number 1 of the new Climate and Crop Service publication's California Section was issued by the Weather Bureau. That publication was an attempt to standardize the monthly weather reviews being published by the various state offices. Mr. Barwick authored that first Climate and Crops publication for California for the Weather Bureau.

Difficulties in obtaining a sufficient printing budget may have contributed to the transfer of the Service to San Francisco on 1 July 1897. After that time, the Sacramento office reverted to serving the weather needs of the local community. Mr. Barwick stayed until 18 August 1901 when he was transferred to Camp Douglas near Denver, Colorado. The Sacramento Record-Union had a banner article on the following day about his departure and noted that he had served for twenty-one years, five months, and two days. It noted fondly that "he will be missed by hundreds, many of whom look upon him as an old crony, and all regard him as a good fellow." It also stated that "Mr. Barwick remained in charge of the station in this city longer than any man in the bureau in any other state…"

James H. Scarr

James H. Scarr (Figure 30), a native of Michigan, was reassigned from being the head of the station in Helena, Montana to Sacramento as Mr. Barwick's replacement. He had taught school while earning his law degree. He was admitted to the bar but never practiced. Instead, he was appointed to the Weather Bureau from Oklahoma. He began as an observer-printer in St. Louis and worked there for two years. The assignment as an assistant in Helena followed. During that time, he also worked temporarily at the stations in Cairo, Illinois and Havre, Montana.

Figure 30. James. H. Scarr, U.S. Weather Bureau, Sacramento
Source: Sacramento Chronicle, 21 August 1901

To fill Mr. Barwick's shoes required a politician. Mr. Scarr was just that having run for election as School Superintendent in Guthrie, Oklahoma years earlier before his joining the Weather Bureau.

He continued the contributions to the local newspapers and wrote at least one major article each year. One such article described the instrumentation (Figure 16) in great detail and invited the public to visit his "weather factory." The tour he promised would be entertaining and instructive and suggested that between two and four o'clock would be the best time to visit. He made a special invitation to teachers and pupils from the public and private schools.

In the 10 April 1903 issue of the Sacramento Record-Union, there was one of his articles "Anemometers, Barometers, and Other Paraphernalia." It was essentially a transcript of his tour of the office with descriptions of the weather instruments and their functions. He also announced that a new employee had reported on 1 April 1903. Carlos V. Brown, a ninth grade student at the Sacramento Grammar School passed the Civil Service examination and was appointed with a job title was "Messenger" at a salary of $360.00 per year. He assisted Mr. Scarr in the functioning of the office until 20 December 1905. He was replaced on 1 February 1906 by Hugh O. Grant who passed the Civil Service examination but gave up the job to continue his High School studies. He was replaced by Westby W. Jeune who began work on 1 May 1906.

Plans were that the Sacramento office would assume a local and supplement forecast responsibility. In particular, the vineyards and orchards needed special attention during the spring frosts and fall rains. The office space in the Federal Building was enlarged to accommodate the new responsibility that began on 1 July 1904. Roy L. Fisher

was assigned to the station to assist with the production of weather maps.

The Latter Years

The Station Memorandum Weather Bureau lists two subsequent leaders of the Sacramento station. N. R. Taylor served from 3 May 1908 to 1 July 1932. He was followed by E. H. Fletcher who served until May 1950. On 1 November 1933, the Sacramento Weather Bureau Office was moved to the New Federal Building. On 1 December 1937, an observation station was opened in the Administration Building at the Municipal Airport located at 6151 East Freeport Boulevard.

Figure 31. Administration Building, Sacramento
Source: NWS Forecast Office Sacramento

Figure 31 shows the Administration Building at the airport in Sacramento on 7 June 1939 where the Weather Bureau Office was located. In the foreground, the instrument shelter was visible. It contained a thermograph in addition to the thermometers. The wind instruments were on the top of the CAA Control Tower.

Figure 32. Instrument Shelter Sacramento Airport , 7 June 1939
Source: NWS Forecast Office, Sacramento

Figure 32 is a view of the shelter from atop the Administration Building. Note that there was a tipping bucket rain gage, an eight-inch rain gage, and one shielded rain gage on the far right. The photograph was taken from the top of the beacon tower

Figure 33. Wind Instruments Sacramento Airport, 7 June 1939
Source: NWS Forecast Office Sacramento

The wind vane and anemometer on the 12 foot tower on top of the Administration Building is shown in Figure 33.

THE RAILROAD WEATHER OBSERVATION NETWORK

During the research for this history of Sacramento weather observations, the 1886 publication of William Hammond Hall on "Physical Data and Statistics of California" was found to contain weather observations. The expected records of Mr. Gerrish, Dr. Logan, and the Signal Service were included for Sacramento. However, tables of data from 1870 to 1884 showing observations made by the Central Pacific Railroad in Sacramento were an unexpected find. The following paragraphs contain preliminary information about the network and were placed in this study to entice others to study the network more thoroughly.

The Beginning

In 1862, Theodore Judah published the results of his survey of a route for the Central Pacific Railroad of California to cross the Sierra Nevada Mountains from Sacramento to the Eastern Boundary of California. His survey report was an engineer's report and did not include climate data. However, he estimated winter accumulated snow depth using surrogate data. His innovative assessment was a reminder of the impact of weather on railroad construction and operation that may explain the motivation for the establishment of a weather observation network by the railroad company.

> …. The trees are generally covered with moss down to the level of the snow, and thousands of them can be seen entirely free of moss up to a certain height, and almost entirely covered with moss from that height….
>
> Frequent marks (made by persons on showshoes) during the winter by axe marks chopped in the tree at the level of the snow….
>
> …. limbs lying beneath the snow maintaining their original or natural position, while those above the snow line are almost universally bent downwards and not unfrequently (sic) broken by the weight of the snow….
>
> …. These observations lead to the conclusion that the greatest depth of undisturbed snow is 13 feet at the summit.

The Network

The California State Engineer, William Hammond Hall and his assistant C. Ewald Grunsky, collected rainfall data for several years beginning in 1880. This collection includes Signal Service data as well as data from sites reporting to the Central Pacific Railroad.

An 1878 newspaper article in the San Francisco Bulletin contained an address to the California Academy of Science by B. B. Redding. It reported on the network that had been established by the Railroad Companies.

> The temperature of the air, course of the wind, rain and snowfall, are taken daily at 7 a.m., 2 p.m., and 9 p.m. at 83 stations of the Central Pacific and Southern Pacific Railroads and their branches, extending from San Francisco to Ogden, Lathrop to Fort Yuma, San Francisco to Soledad, Sacramento to Redding, Sacrament to Willows, and Vallejo to Calistoga and Petaluma. The temperature of the water is also taken at several points, including five stations on the Sacramento and San Joaquin rivers.
>
> In addition to the observations made by the United States Signal Service, the Coast Survey and those made at the military posts, we thus have three daily observations recorded at 83 stations on the Pacific coast, extending through eight degrees of latitude and 12 degrees of longitude. These have been kept for the use of the companies, and for the benefit of the people residing the vicinity of the various stations. As each new station is reached in the construction of a railroad, the agent is supplied with proper instruments and the record required to be kept. On all the roads first constructed the record has been kept for more than ten years. On the new road over the Colorado desert from the San Bernardino mountains to Fort Yuma, of course, the record is only for the past year. The record of these three daily observations, for even 50 stations for two years, makes an army of figures that is almost appalling to attack; yet, when reduced and the mean obtained, the results are of great importance, not only to the farmer, but to every citizen.

The Redding paper also discussed the climatology of California based on the railroad and the other available data.

The Railroad Data

The Railroad data for Sacramento (Figure 34) was summarized in the Hall's book. It is presumed that similar data were available from other Railroad weather stations.

PRECIPITATION TABLE, No. 106. COMPILED BY THE

Monthly: Rain and Melted Snow. SACRAMENTO.

AUTHORITY: Central Pacific Railroad Co. } In Inches.

YEARS.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.
1870–71	0.02	0.02	0.58	0.98	2.42	1.84	0.98	1.05	0.56	0.00	0.00	0.00
1871–72	0.00	0.29	1.24	10.37	3.49	4.34	1.74	0.61	0.28	0.01	0.00	0.00
1872–73	0.00	0.20	1.87	5.44	1.11	3.83	0.46	0.50	0.00	0.00	0.00	0.00
1873–74	0.00	0.31	1.87	10.12	5.30	1.86	3.05	0.89	0.37	0.00	0.00	0.00
1874–75	0.05	2.26	3.80	0.44	8.81	0.03	1.26	0.00	0.04	1.06	0.00	0.00
1875–76	0.00	0.04	6.20	5.52	4.99	3.75	4.15	1.10	0.15	0.00	0.21	0.02
1876–77	0.00	3.45	0.30	0.00	2.77	1.04	0.56	0.19	0.64	0.00	0.00	0.00
1877–78	0.00	0.64	1.46	1.35	8.68	5.89	3.23	1.13	0.17	0.00	0.00	0.00
1878–79	0.29	0.38	0.42	0.47	3.88	3.15	4.33	2.66	1.31	0.13	0.00	0.00
1879–80	0.00	0.76	1.77	3.38	1.52	1.76	2.13	12.29	0.81	0.00	0.00	0.00
1880–81	0.00	0.00	0.03	9.27	4.75	4.79	1.21	1.59	0.00	0.50	0.00	0.00
1881–82	0.30	0.30	1.72	2.81	1.41	2.25	2.81	1.61	0.35	0.16	0.00	0.00
1882–83	0.21	1.33	2.66	0.54	1.65	1.03	3.48	0.73	2.69	0.00	0.00	0.00
1883–84	0.65	0.76	0.58	0.52	2.71	3.85	6.50	3.60	0.00	1.35	0.00	0.00
Means	0.11	0.77	1.75	3.66	3.82	2.81	2.56	2.00	0.52	0.23	0.02	0.00

Figure 34. Central Pacific Railroad Observations at Sacramento
Source: Physical Data and Statistics of California, Hall

The Hall Papers in the Sacramento Archives include some data as well. One special group of papers are the Grunsky collection of precipitation data. Those data were apparently the result of letters sent by Mr. Grunsky to people who were believed to be weather observers. Some of the responding letters are in the collection. Mr. Barwick, the Weather Bureau Observer, provided data from Sacramento as did observers from other locations. The data were collected for two water years (September through August) of 1884-1886 from 80 stations. The data are included here as Appendix 2.

The Railroad data were collected under observation instructions that they provided as shown in Appendix 3 and reported on a form for that purpose as shown in Appendix 4.

The National Archives has two collections of the railroad data. One is the "Records of Observations Made at Stations of the Central and Southern Pacific Railroad" and is in SEC-CLASS: U, MLR CTRL # 35073. The other is "Observations Made by Employees of the Northern Pacific Railroad," SEC-CLASS:U, MLR CTRL # 35071. Those records are being imaged and will be available for viewing through the National Climatic Data Center.

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APPENDIX 1

METHODOLOGY

The primary sources of information for this study were the Sacramento observers' daily weather records themselves. Copies of their monthly reports and the data digitized from those reports were available from the Midwestern Regional Climate Center in Champaign, Illinois, or the National Climatic Data Center in Asheville, North Carolina. The monthly reports can be considered original sources because they were written by the observers and not altered by subsequent readers.

There were a variety of secondary sources that held information about Sacramento, its history, and its people. The author visited and collected information from the holdings of the National Climatic Data Center at Asheville, North Carolina; Sacramento Archives & Museum Collection Center; California State Library; California State Archives; UC Davis' Library; UC Berkeley Bancroft Library ; Library California Historical Society ; Sacramento Public Library; The Sierra Sacramento Valley Museum of Medical History; the Library at the California Military Museum; the National Weather Service Office, Sacramento; and the LDS Family History Library in Salt Lake City, Utah. The National Weather Service Office headed by Elizabeth Morse and her Meteorologists John Juskie and Jim Matthews were particularly helpful.

The tertiary sources were reference materials that are available on-line. Among those were the metadata prepared by the Office of the State Climatologist of California, the Western Regional Climate Center, the National Climatic Data Center substation histories, and the Office of Medical History in the Office of the Surgeon General, U.S. Army. Two genealogical research sources, Ancestry.com and Genealogy.com were used to provide some of the personal information about the observers. For location analysis, the interactive maps available from TopoZone.com were used.

There was an attempt to glean information from all these sources that would allow a glimpse into the lives of the observers, the location of the observation site, and the historical environment that produced the climatic history of Sacramento. Maps, drawings, and photographs were included when appropriate to illustrate the information.

Throughout the research for and preparation of this study, the objective was to produce a document that future studies can use to evaluate the validity of the data that were collected here, judge the trustworthiness of the observers who collected them, and determine the climatological significance of the whatever variability may be discerned.

APPENDIX 2
GRUNSKY PRECIPITATION DATA

Monthly Rainfall at C. P. R. R. Stations

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
		1884					1885					
Brentwood	×	1.20	00	2.69	1.19	.11	.72	.51	00	.35	×	00
		1885					1886					
Brentwood	00	00	6.40	2.58	4.16	.03	1.51	2.04	00	00	00	00
		1884					1885					
Byron	00	1.23	00	3.33	1.23	.18	.35	1.02	00	00	00	00
		1885					1886					
Byron	00	00	6.70	2.04	4.09	00	1.79	2.23	00	00	00	×
		1884					1885					
Martinez	.13	1.13	00	4.76	1.66	.17	.05	4.75	00	00	00	00
		1885					1886					
Martinez	.06	.15	8.08	4.11	5.39	.05	1.53	3.44	.25	00	.07	.00
		1884					1885					
Borden	00	.16	00	11.74	.60	00	.78	.75	00	00	00	00
		1885					1886					
Borden	00	00	8.69	.93	3.98	.08	1.66	2.93	.00	00	00	00
		1884					1885					
Fresno	00	.35	.08	3.98	.45	00	.53	1.11	.15	00	00	00
		1885					1886					
Fresno	00	.06	7.92	1.90	2.38	.58	1.21	2.07	00	00	00	00
		1884					1885					
Kingsburgh	00	.26	.09	4.56	.60	00	.69	1.12	00	00	00	00
		1885					1886					
Kingsburgh	00	.70	6.22	2.44	2.04	24	1.03	2.45	00	00	00	00
		1884					1885					
Caliente	00	.22	.25	3.25	.25	00	42	3.00	1.05	00	.05	00
		1885					1886					
Caliente	00	.05	3.88	1.33	1.59	.66	2.62	2.65	00	00	×	00
		1884					1885					
Delano	00	00	.16	2.16	.13	00	.36	4.15	.03	00	00	00
		1885					1886					
Delano	00	.15	3.40	1.60	.95	.20	.80	1.54	00	00	00	00
		1884					1885					
Keene	×	2.55	.36	5.22	.36	.13	.65	1.47	.11	.10	.06	×
		1885					1886					
Keene	00	.28	8.73	4.16	2.02	.64	2.28	2.84	00	00	×	.02
		1884					1885					
Mojave	00	.13	×1	×1	.00	00	00	.61	.14	00	71	00
		1885					1886					
Mojave	00	00	1.25	1.16	1.49	00	1.22	Blank	00	×	×	00
		1884					1885					
Summer	00	00	4.40	3.35	00	.02	1.50	2.30	.05	00	.05	00
		1885					1886					
Summer	00	.43	1.94	1.23	.85	.20	.30	.94	00	35	00	00

Monthly Rainfall at C.P.R.R. Stations

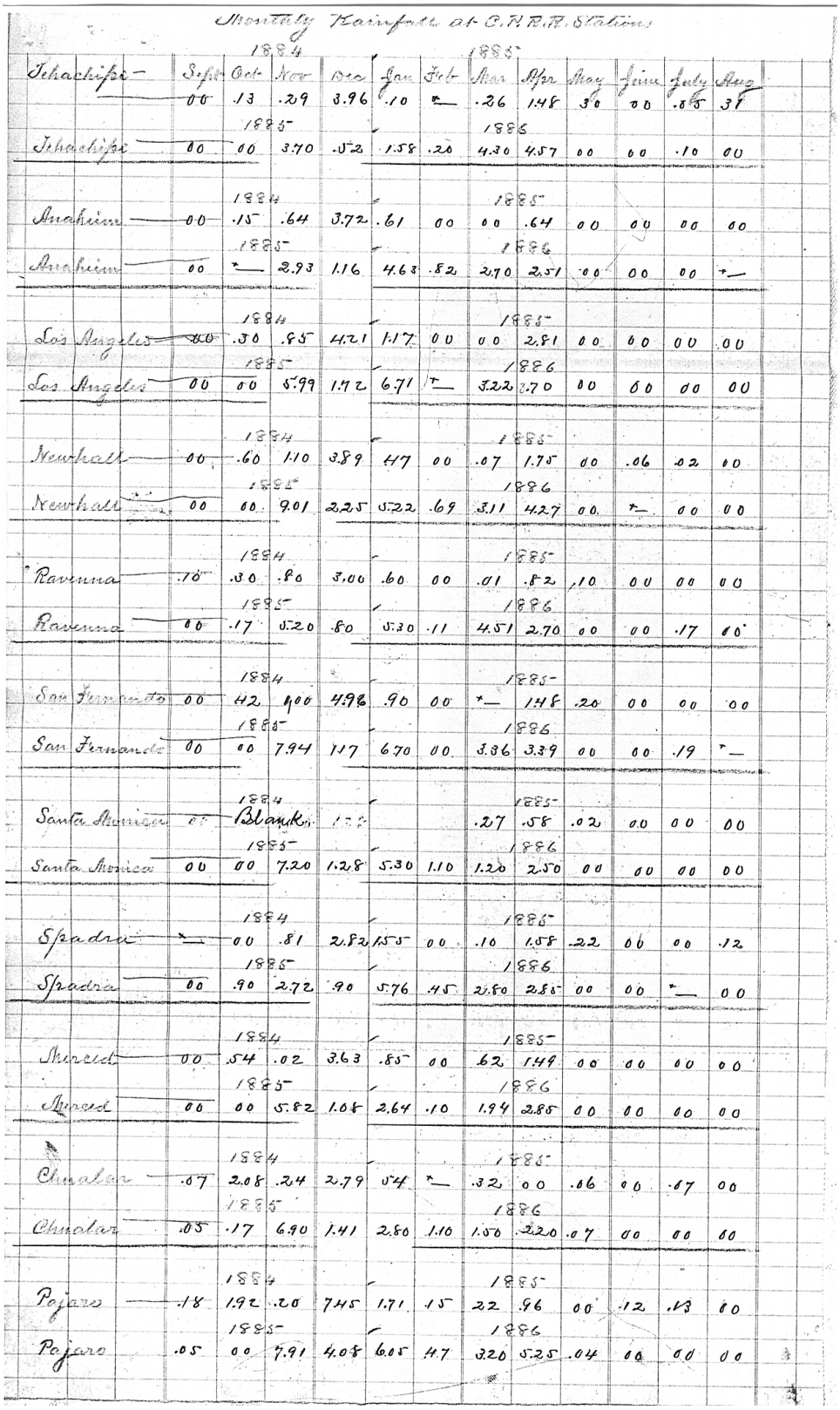
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Salinas	.14	1.81	.18	4.28	1.07	00	.19	1.36	.15	00	.09	00
		1884					1885					
Salinas	00	.08	6.37	1.17	5.18	1.16	2.16	4.03	.08	00	—	00
		1884					1885					
Soledad	00	1.78	.30	1.74	.92	00	.47	.59	00	00	00	00
		1885					1886					
Soledad	00	.20	6.22	1.02	2.44	1.20	1.69	1.93	00	00	.02	00
		1884					1885					
Calistoga	.19	1.83	.05	15.08	2.05	1.59	.71	.95	00	00	00	00
		1885					1886					
Calistoga	.12	.78	15.67	5.36	9.39	—	2.23	7.12	1.05	00	00	00
		1884					1885					
Knoxville		No Report										
		1885					1886					
Knoxville												
		1884					1885					
Napa	—	.70	.00	10.16	1.96	.40	.43	1.57	00	00	00	00
		1885					1886					
Napa	.05	.61	8.51	4.35	8.09	00	1.81	4.42	.38	00	00	00
		1884					1885					
Boca	—	.80	00	8.20	1.00	.16	.10	1.50	00	.30	00	00
		1885					1886					
Boca	00	00	2.40	2.53	8.35	.85	.44	1.30	.50	00	1.00	00
		1884					1885					
Truckee	.78	1.00	00	13.24	1.80	.84	.56	2.04	.08	00	00	00
		1885					1886					
Truckee	.47	00	6.95	2.22	7.08	.50	2.90	1.75	.60	.56	.89	00
		1884					1885					
Alta	.12	1.00	00	14.08	1.50	.60	.10	2.46	00	1.00	Discontinued	
		1885					1886					
Alta				Discontinued								
		1884					1885					
Auburn	.56	2.25	00	16.37	1.74	1.27	.87	2.10	00	.70	00	00
		1885					1886					
Auburn	.64	00	15.24	4.05	8.25	00	4.10	9.38	.65	00	00	00
		1884					1885					
Cisco	1.40	2.32	00	25.05	2.30	1.28	2.20	3.95	.30	.95	00	00
		1885					1886					
Cisco	.50	00	17.05	4.87	4.55	2.40	7.40	7.50	1.45	00	00	00
		1884					1885					
Colfax	.80	2.55	—	23.60	2.85	1.66	.68	2.29	00	1.18	00	00
		1885					1886					
Colfax	.62	00	15.48	6.77	12.17	.34	3.69	16.86	1.08	00	00	00

Monthly Rainfall at C.P.R.R. Stations

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Livermore	.30	.99	.62	6.22	1.72	.36	.78	1.29	.08	00	00	00
Livermore	.05	00	6.56	1.94	4.20	.24	1.18	2.36	00	00	40	00
Midway	.37	No Report										
Midway												
Niles	.34	1.30	00	5.75	1.58	.15	.66	92	00	00	00	00
Niles	00	.35	8.78	1.92	6.17	.63	1.72	4.18	.18	00	00	00
Oakland	.20	2.77	00	6.10	1.68	.25	.86	2.75	00	00	00	00
Oakland	.02	.38	9.73	3.46	6.77	.30	2.00	3.90	.19	00	.08	00
Pleasanton	.08	.99	00	4.47	1.78	.22	1.14	1.09	.04	.16	00	00
Pleasanton	00	.05	7.33	2.17	4.25	.29	1.34	3.08	.39	00	00	00
Lone	00	1.82	00	8.22	1.74	00	00	1.55	00	.43	00	00
Lone	00	00	8.45	2.17	5.15	.07	2.40	6.06	.84	00	00	00
Chico	.86	1.40	00	5.28	2.26	1.01	.30	.75	.55	.58	00	00
Chico	.30	.27	8.99	5.42	4.44	.75	2.29	4.17	36	00	00	00
Orland	.20	.80	.00	4.08	1.34	.58	.05	.57	.82	.80	00	00
Orland	.22	00	9.41	3.03	4.45	.50	1.01	2.70	64	00	00	00
Williams	.33	.45	00	4.27	1.38	.58	.15	1.26	00	.20	00	00
Williams	.18	.70	6.51	3.10	3.83	00	.89	3.01	00	00	00	00
Willows	.13	.69	00	4.18	1.19	.24	.05	.94	.20	00	00	00
Willows	.30	.30	7.28	3.37	4.04	00	.35	2.45	00	00	00	00
Antioch	+	1.25	+	2.89	1.16	.12	.35	.96	00	00	+	00
Antioch	+	00	4.87	2.19	3.60	00	.56	2.03	+	00	00	00

Monthly Rainfall at C. P. R. R. Stations

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
		1884						1885				
Needles		Discontinued										
		1885		No Report				1886				
Needles												
		1884						1885				
Mammoth Tank	00	00	~~.87~~ .00	.87	~~.00~~	~~.02~~	00	00	00	.00	~~.62~~ .62	
		1885						1886				
Mammoth Tank	00	00	1.01	00	.57	.20	.25	.05	00	00	00	00
		1884						1885				
Whitewater		No Report										
		1885						1886				
Whitewater												
		1884						1885				
San Francisco	?	Call at Railroad Office										
		1885						1886				
San Francisco	?											
		1884						1885				
Ellis		No Station										
		1885						1886				
Ellis												
		1884						1885				
Farmington	.09	1.15	00	6.21	1.03	00	.16	.46	00	.17	00	?
		1885						1886				
Farmington	?	00	6.95	1.37	4.20	.41	1.87	5.81	.19	00	00	00
		1884						1885				
Latterop	.10	.82	00	2.97	.78	?	.19	31	.02	.20	.02	00
		1885						1886				
Latterop	00	00	6.46	.99	3.51	.01	1.08	2.46	00	00	00	00
		1884						1885				
Stockton	.08	1.58	.00	~~5.48~~	1.11	.05	.23	95	00	00	00	00
		1885						1886				
Stockton	00	00	Blank	.74	4.36	.05	1.60	3.25	00	00	00	00
		1884						1885				
Tracy	00	.82	00	2.49	.93	.10	.10	.37	00	00	00	00
		1885						1886				
Tracy	00	00	5.60	.85	2.55	.35	1.40	1.55	?	00	00	00
		1884						1885				
Shells Park	.04	1.86	.27	4.92	1.89	.12	.50	1.98	04	00	00	00
		1885						1886				
Shells Park	.02	.09	6.22	2.17	4.97	.37	1.65	3.34	.08	00	.24	00
		1884						1885				
San Shales	.17	1.78	.21	7.59	2.36	.19	.52	4.20	.05	.10	00	00
		1885						1886				
San Shales	.02	.13	6.88	2.34	6.20	.35	2.28	4.80	.15	00	.07	00



Monthly Rainfall at S.P.R.R. Stations

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
		1884					1885					
Tehachipa	00	.13	.29	3.96	.10	T	.26	1.48	30	00	.05	31
		1885					1886					
Tehachipa	00	00	3.70	.52	1.58	.20	4.30	4.57	00	00	.10	00
		1884					1885					
Anaheim	00	.15	.64	3.72	.61	00	00	.64	00	00	00	00
		1885					1886					
Anaheim	00	T	2.93	1.16	4.63	.82	2.70	2.51	00	00	00	T
		1884					1885					
Los Angeles	00	.30	.85	4.21	1.17	00	00	2.81	00	00	00	00
		1885					1886					
Los Angeles	00	00	5.99	1.72	6.71	T	3.22	2.70	00	00	00	00
		1884					1885					
Newhall	00	.60	1.10	3.89	.47	00	.07	1.75	00	.06	.02	00
		1885					1886					
Newhall	00	00	9.01	2.25	5.22	.69	3.11	4.27	00	T	00	00
		1884					1885					
Ravenna	.70	.30	.80	3.00	.60	00	.01	.82	.10	00	00	00
		1885					1886					
Ravenna	00	.17	5.20	.80	5.30	.11	4.51	2.70	00	00	.17	00
		1884					1885					
San Fernando	00	.42	1.00	4.96	.90	00	T	1.48	.20	00	00	00
		1885					1886					
San Fernando	00	00	7.94	1.17	6.70	00	3.86	3.39	00	00	.19	T
		1884					1885					
Santa Monica	0?	Blank					.27	.58	.02	00	00	00
		1885					1886					
Santa Monica	00	00	7.20	1.28	5.30	1.10	1.20	2.50	00	00	00	00
		1884					1885					
Sfradra	T	00	.81	2.82	1.55	00	.10	1.58	.22	00	00	.12
		1885					1886					
Sfradra	00	.90	2.72	.90	5.76	.45	2.80	2.86	00	00	T	00
		1884					1885					
Merced	00	.54	.02	3.63	.85	00	.62	1.49	00	00	00	00
		1885					1886					
Merced	00	00	5.82	1.08	2.64	.10	1.94	2.85	00	00	00	00
		1884					1885					
Chualar	.07	2.08	.24	2.79	.54	T	.32	00	.06	00	.07	00
		1885					1886					
Chualar	.05	.17	6.90	1.41	2.80	1.10	1.50	2.20	.07	00	00	00
		1884					1885					
Pajaro	.18	1.92	.20	7.45	1.71	.15	.22	.96	00	.12	.13	00
		1885					1886					
Pajaro	.05	00	7.91	4.08	6.05	.47	3.20	5.25	.04	00	00	00

Monthly Rainfall at C. P. R. R. Stations

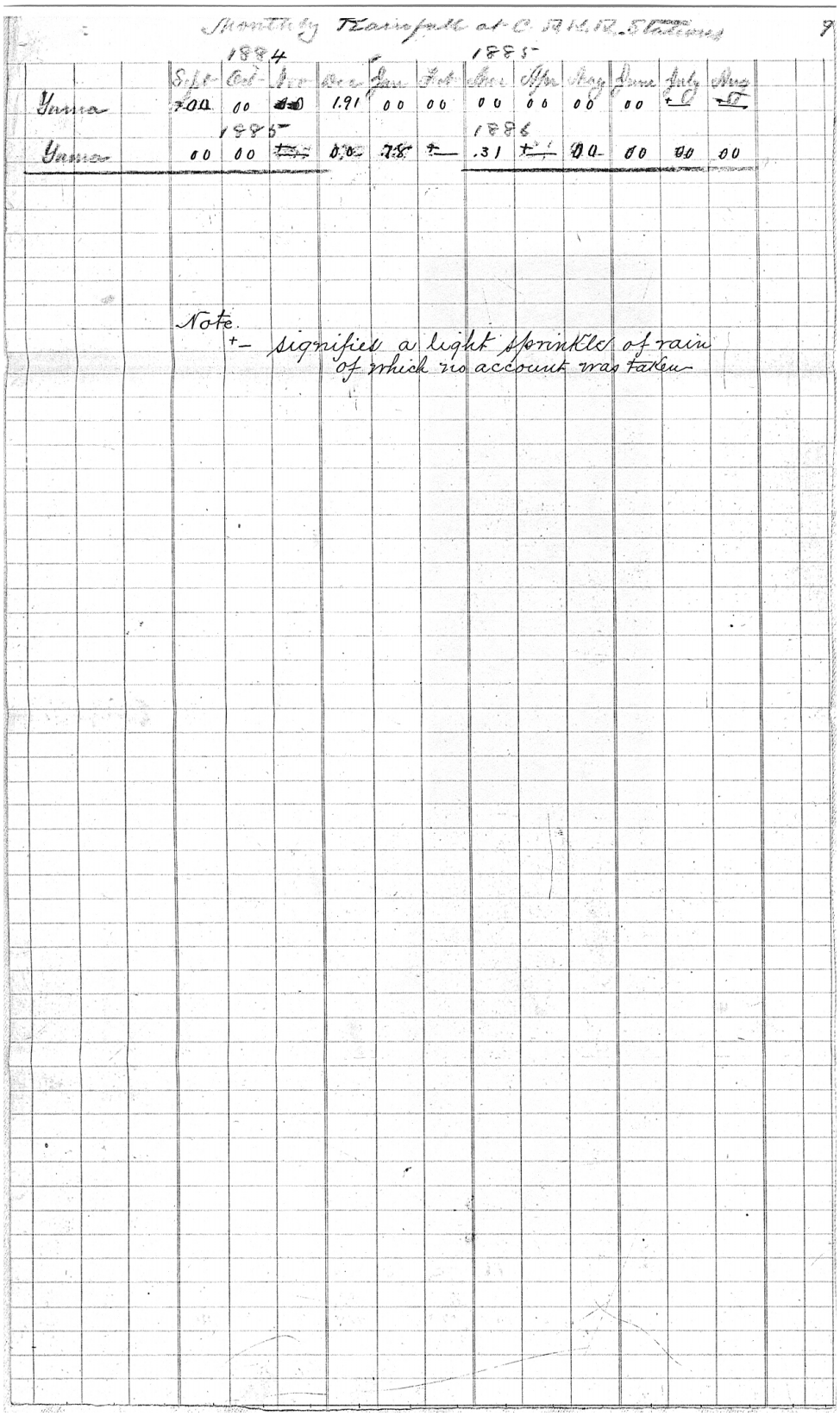
		1884			1885						
Emigrant Gap	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
	.51	1.93	1.00	31.19	2.68	2.15	48	3.89	.20	4.85	00	00
Emigrant Gap		1885					1886					
	.53	00	18.69	7.38	18.28	1.97	6.90	11.94	2.73	+	00	00
		1884						1885				
Rocklin	.10	1.85	00	7.75	1.36	40	00	.82	.11	18	00	00
Rocklin	.03	1885	9.32	3.96	5.84	.34	3.61	1886	.16	00	00	00
		1884						1885				
Summit	1.10	3.13	00	10.43	1.40	.58	.10	4.88	1.00	.80	00	+
Summit	.05	1885	13.60	3.00	13.90	1.40	7.80	1886	.95	00	00	00
		1884						1885				
Brighton	.23	1.42	00	6.17	1.61	44	00	.54	00	00	00	00
Brighton	00	1885	7.76	2.84	5.49	.07	3.05	1886	.10	00	00	00
		1884						1885				
Galt	00	1.31	00	6.06	1.30	.12	00	.82	00	00	00	00
Galt	00	1885	5.56	2.33	6.04	00	1.69	1886	.15	00	00	00
		1884						1885				
Sacramento	.48	1.80	00	7.40	1.89	.43	.10	.53	00	.10	00	00
Sacramento	.07	1885	8.58	5.41	5.00	.10	2.53	1886	.05	00	00	00
		1884						1885				
Hollister	00	1.30	00	3.62	.58	.17	.35	45	00	.23	.27	00
Hollister	00	1885	4.91	1.12	3.93	.65	1.29	1886	.15	00	00	00
		1884						1885				
Colton	00	.25	.12	3.93	1.00	00	00	2.08	.22	00	00	00
Colton	00	1885	1.92	.52	2.78	.40	3.54	1886	.50	00	00	00
		1884						1885				
Daggett				No Report								
Daggett		1885						1886				
		1884						1885				
Fenner	00	Discontinued		No Report								
Fenner		1885						1886				
		1884						1885				
Indio	00	00	00	.70	00	00	00	.10	00	00	00	00
Indio	00	1885	.96	00	00	00	00	1886	00	00	00	00

Monthly Rainfall at C.P.R.R. Stations

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
		1884					1885					
Gilroy	.12	1.73	.06	8.83	2.03	.09	.28	1.48	0.0	12	.05	00
		1885					1886					
Gilroy	x	00	6.77	2.40	6.09	32	1.17	4.32	22	00	00	00
		1884					1885					
San Jose	.08	1.50	.06	3.90	1.83	.18	.86	2.75	11	—	00	00
		1885					1886					
San Jose	00	.06	7.39	2.11	3.59	1.12	1.89	4.47	00	00	.03	00
		1884					1885					
Tennant	.27	1.78	.12	8.11	1.31	00	1.56	2.72	00	.04	00	00
		1885					1886					
Tennant	00	00	Discontinued									
		1884					1885					
Santa Cruz	.33	1.37	.32	8.91	2.11	41	47	2.43	.05	00	08	00
		1885					1886					
Santa Cruz	.07	.10	10.25	2.90	7.60	.80	3.05	7.60	.30	00	00	00
		1884					1885					
Delta	1.03	6.01	.56	16.24	2.91	2.53	37	2.54	.67	1.60	00	00
		1885					1886					
Delta	00	.60	29.38	13.94	9.95	.00	3.52	10.19	8.16	00	00	00
		1884					1885					
Redding	.02	1.36	00	14.57	2.32	1.38	00	3.63	00	1.23	00	00
		1885					1886					
Redding	x	x	11.90	9.00	10.30	x	2.90	8.41	2.32	00	00	00
		1884					1885					
Berryvale				No Report								
		1885					1886					
Berryvale												
		1884					1885					
Fairfield & Suisun	x	.70	00	7.46	1.06	1.25	.64	1.52	.02	00	00	00
		1885					1886					
Fairfield & Suisun	.05	.22	10.38	4.43	8.18	00	1.87	4.02	.15	00	00	00
		1884					1885					
South Vallejo	00	1.09	00	6.03	1.75	.26	.24	1.85	00	00	00	00
		1885					1886					
South Vallejo	00	.50	7.87	4.50	6.25	00	2.20	4.82	.22	00	00	00
		1884					1885					
Petaluma	.13	.94	.12	8.07	1.34	.76	1.39	2.08	.04	.14	00	00
		1885					1886					
Petaluma	.04	.86	11.33	3.26	6.09	.18	2.30	4.47	.54	00	00	00
		1884					1885					
Woodards	00	1.20	00	2.62	.90	00	.70	.98	00	00	00	00
		1885					1886					
Woodards	00	00	5.05	.85	2.60	.10	1.46	2.79	00	00	00	00

Monthly Rainfall at C. P. R. R. Stations

	Sept.	1884 Oct.	1884 Nov.	Dec.	1885 Jan.	1885 Feb.	1885 Mar.	1885 Apr.	1885 May	1885 June	1885 July	1885 Aug.
Surlock	.05	.85	00	2.46	1.22	00	.32	1.14	00	00	00	00
Surlock	+	1885 00	6.63	1.10	2.52	1886 .08	1.75	3.01	00	00	00	00
Red Bluff	.20	1884 1.00	00	8.40	1.85	1.50	1885 00	.90	.57	1.42	00	00
Red Bluff	2.50	1885 .20	17.22	4.35	5.07	00	1886 1.38	4.63	.93	00	00	00
Tehama	00	1884 .69	00	6.16	1.67	.60	1885 .05	.70	.73	.72	.00	00
Tehama	48	1885 +	10.42	3.00	4.08	00	1886 .98	4.00	.18	00	00	+
Gerber	00	1884 .36	00	3.75	.37	.00	1885 1.42	1.38	.16	00	00	00
Gerber	00	1885 .05	4.24	1.43	1.74	.43	1886 1.06	1.67	00	00	00	00
Lemoore	00	1884 .25	.20	3.87	.87	00	1885 .60	1.15	.10	00	00	00
Lemoore	00	1885 .03	8.16	1.20	3.16	.20	1886 1.21	3.35	00	00	+	00
Tulare	00	1884 .16	.08	2.61	.28	00	.86	1885 1.44	.13	00	.05	00
Tulare	.00	1885 .06	3.36	1.48	1.41	.15	1886 .80	1.94	00	00	00	00
Davisville	.28	1884 1.48	00	5.25	1.32	.14	.10	1885 1.22	00	00	00	00
Davisville	.05	1885 00	7.87	4.56	5.82	.20	1886 1.70	4.75	05	00	00	00
Dunnigan	.04	1884 1.28	00	7.16	1.66	.32	.13	1885 1.10	00	00	00	00
Dunnigan	05	1885 1.45	10.47	3.68	8.37	00	1886 1.69	3.61	18	00	00	00
Grafton or Knights Landing	.35	1884 1.45	00	5.56	1.42	00	1885 .48	1.59	00	00	00	00
Grafton	00	1885 00	8.00	4.93	5.53	00	1886 1.37	4.25	00	00	00	00
Woodland	+	1884 1.00	00	4.63	1.43	.12	.10	1885 1.44	00	00	00	00
Woodland	00	1885 .20	8.70	3.75	4.78	00	1886 1.31	4.10	00	00	00	00
Reno	00	1884 00	00	.77	00(?)	00	00	1885 .80	00	00	00	00
Reno	00	1885 00	.55	.60	8.00	.20	1886 .70	00	.10	00	.15	00



Monthly Rainfall at C. [illegible] Stations 7

	1884 Sept	Oct	Nov	Dec	1885 Jan	Feb	Mar	Apr	May	June	July	Aug
Yuma	.00	00	[illegible]	1.91	00	00	00	00	00	00	+0	[illegible]
1885 Yuma	00	00	[illegible]	0.0	.75	+	1886 .31	+	00	00	00	00

Note.
+ signifies a light sprinkle of rain of which no account was taken

State Engineers Wm. Ham. Hall Papers, Rainfall Records, Box 8, Folder 90, California State Archives, Sacramento.

APPENDIX 3

RAILROAD OBSERVER INSTRUCTIONS

CENTRAL PACIFIC RAILROAD.

METEOROLOGICAL OBSERVATIONS.

Instructions for Setting Up and Reading the Rain Guages.

The Rain Gauge is composed of two cylinders of brass, of different diameters, screwed together, one cylinder of wood. a guage stick and a scale of metal.

Place the cylindrical piece of wood in the ground, in a vertical position, leaving about four inches above, and in this insert the guage.

The place chosen for the Rain Guage should be at least 100 feet foom any building, so that the currents of air may not carry into it more or less rain than the actual fall.

The top of an isolated post is not objectionable, nor the top of a house, where an eddy of wind will not be formed.

The Guage Stick and Scale should be kept dry.

In measuring the rain fall, insert the Guage Stick carefully, touching the bottom, and measure the wetted portion with the Scale.

The numbers on the Scale stand for or represent tenths and the smaller divisions hundredths of an inch.

Should the water rise above the top of the smaller cylinder, pour the surplus into a vessel and measure the remaining portion, after which throw out the measured water, and pour the water from the vessel holding the surplus, and measure it also ; repeating the operation until it is all measured.

When snow falls, measure carefully each day, with an ordinary carpenter's rule, the amount fallen during the day, and enter it in its appropriate column.

Be careful to select a place where the snow has not drifted.

If the snow melts as it falls, the Guage will show the amount of water, which you will enter in your book as rain fall, making a side note stating that fact.

Instructions for Setting Up and Observing the Thermometer.

The Instrument should be suspended in the center of a small box, having apertures in its sides to admit the air freely, which should be placed where it will not be subjected to the direct or reflected rays of the sun at any hour of the day.

An awning or porch, on the north side of a building, affords the most suitable location for the thermometer, and it should be so placed as not to be affected by currents of warm air issuing from a door or window.

The observations MUST BE made regularly and promptly at the hours indicated in the Record Book, and the temperature entered in the book at the time. Any variation in the time of observing should be noted in the proper column.

Observations of the direction and force of the wind (especially in stormy weather) should be made frequently during the day, and any sudden changes noted.

The value of these observations depends upon the regularity and care with which they are taken, and it is expected that all Agents, or others, to whom they are entrusted, will attend to them promptly.

All entries in the Record Book should be made with ink.

At the end of each month, copy carefully on the blanks furnished herewith, the records of all observations made during the month, and send the same to the Chief Engineer's Office, Sacramento.

NOTE.—Paste this inside the cover of Record Book.

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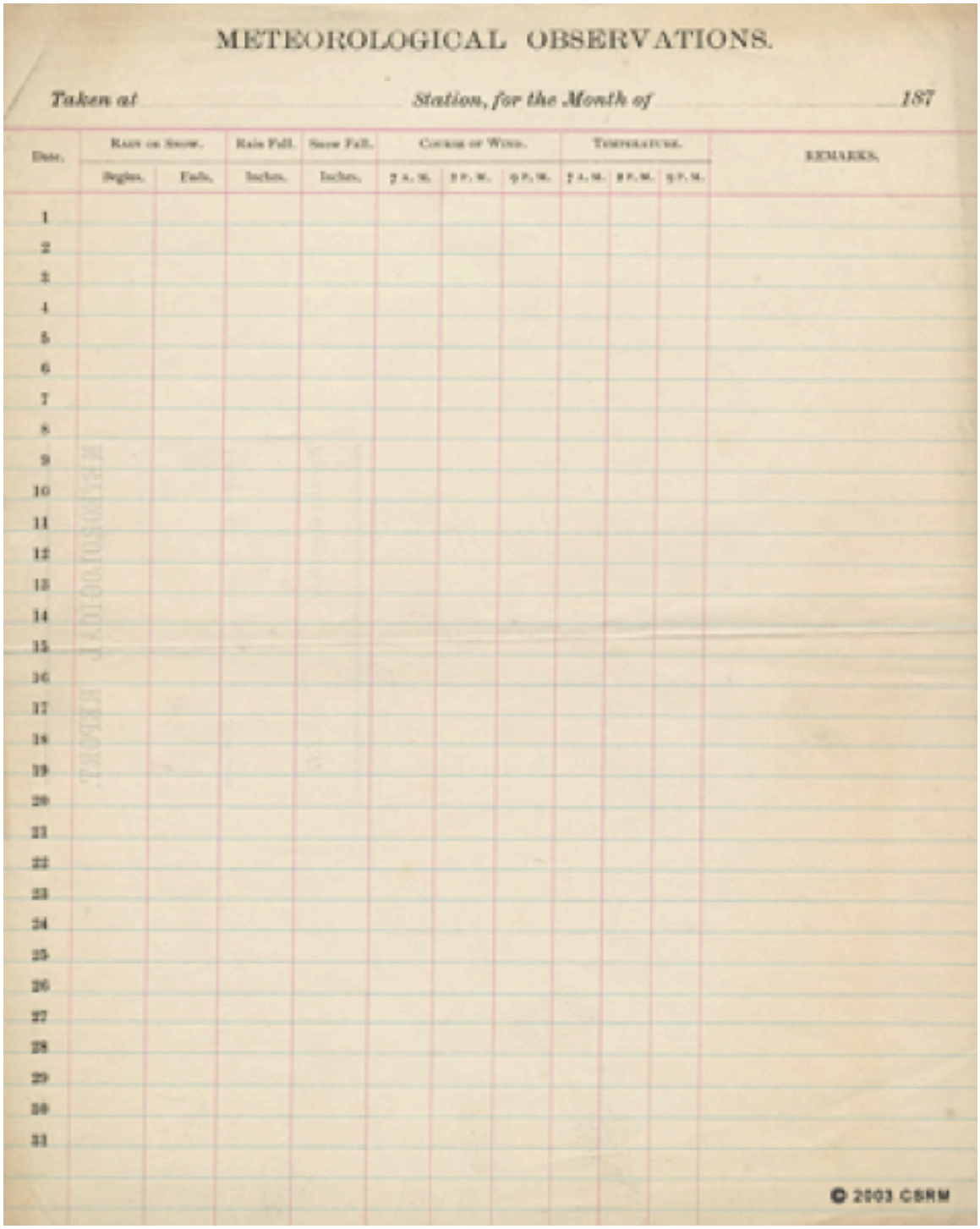
APPENDIX 4

RAILROAD OBSERVER FORM



METEOROLOGICAL OBSERVATIONS.

Taken at *Station, for the Month of* *187*

Date.	Rain or Snow.		Rain Fall.	Snow Fall.	Course of Wind.			Temperature.			Remarks.
	Begins.	Ends.	Inches.	Inches.	7 A. M.	2 P. M.	9 P. M.	7 A. M.	2 P. M.	9 P. M.	
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