REPORT

OF THE

Resources of the Land Grant

OF THE

ATLANTIC & PACIFIC R. R.

IN

MOHAVE COUNTY, ARIZONA,

and Adjacent Districts,

BY

PROF. G. E. BAILEY, EM., PH. D., ETC., IRRIGATION ENGINEER.

1893.

Published by the
Land Department of the Atlantic & Pacific R. R. Co.,
Chicago, Illinois.

CHICAGO:
RAND, McNALLY & CO., PRINTERS.
1893.

CHICAGO, August 30, 1893.

Gen. J. A. Williamson, Land Commissioner Atlantic & Pacific Railroad Co.

DEAR SIR: Inclosed please find report of my "Reconnaissance of the Resources of the Atlantic & Pacific Railroad Lands in Mohave County and Adjoining Territory, Arizona," accompanied by ten (10) maps.

It has been my endeavor to outline what may be done to make these lands productive, to show graphically the location of the various classes of land, the soil, climatic conditions, water-sheds, reservoirs, and crops best adapted to the various locations. It is a very difficult task to map this country correctly, owing to the absence of even township lines over the greater portion of the area. While all of June and part of July was personally spent in the field with my assistants, and while every pains has been taken to eliminate errors, I am aware that it is impossible to avoid them in a reconnaissance, and without making protracted and minute surveys.

It has been my object to point out the resources of the lands, and to furnish data to show on what lines and in what direction accurate surveys are warranted.

Prof. D. B. Thorner, who accompanied me, will present to you a special report on canaigre and fiber plants.

Hoping that the work, which has occupied my time from the 1st of May last to date, will be of service in calling attention to the value of your lands, I have the honor to remain,

Respectfully yours,

G. E. BAILEY.

SUMMARY OF REPORT ON THE RESOURCES OF MOHAVE COUNTY AND ADJOINING REGIONS, ARIZONA.

By G. E. Bailey, Irrigation Engineer.

Introductory.

Popular belief derogatory to the Territory. Fact is, it has the best of soil, excellent climate, and abundance of water for irrigation.

Topography.

Mohave County area 12,000 square miles. Mountain ranges running north and south with broad, plain-like valleys between. Ranges 3,000 to 9,000 feet high. Description of cañons, rivers, springs, and roads.

Water Supply.

Colorado River. Drainage area 242,065 square miles. Affording ample water for all possible irrigation. The waters fertilize the soil (see analyses). Navigable for 530 miles. From Bull's Head Cañon to the Gulf of California 432 miles.

FORT MOHAVE VALLEY.

Location.

From railroad bridge at Needles to foot of Bull's Head Cañon, thirty-five miles long by five to twelve miles wide, including part of Lower Sacramento Valley. Irrigable, 123,000 acres of railroad lands, or including Government lands about two hundred and fifty thousand acres, at cost of about $6 per acre. Three kinds of land: 1st, low lands near the river, partially or wholly overflowed twice a year; 2d, lower mesa lands, possibly irrigable by gravity ditch; 3d, upper mesa lands, only irrigable by pumping. Area overflowed lands, 20,000 to 25,000 acres; of lower mesa, 40,000 to 60,000 acres; and of upper mesa, 100,000 to 165,000 acres.

Immediately Available.

Overflowed lands for canaigre. Now covered with mesquite brush, etc., and will cost from $3 to $15 per acre to clear and prepare for canaigre-root planting.

Lower Mesa.

Especially adapted to citrus and all other California and sub-tropical fruits. Free from brush, plain-like, ready for irrigation. Objections to gravity ditch; pumping recommended.

Upper Mesa.

Especially adapted to fruits, canaigre and fiber plants, and cochineal.

Pumping.

Plan recommended utilizing the rapids at Bull's Head Cañon for power to pump water into canals for both lower and upper mesa lands.

BILL WILLIAMS DISTRICT.

AREA.

One hundred and twenty-seven thousand six hundred acres of Atlantic & Pacific Railroad lands and as much Government land up to 300,000 acres as may be desired.

BILL WILLIAMS RIVER.

Water-shed 4,000 square miles, the upper portion being high, snow-clad mountains with rainfall of forty-five to sixty inches a year. Rainfall of water-shed ten to sixty inches a year, from valley to highest summits. Supply ample for 600,000 acres.

RESERVOIR AND DAM SITE.

Just below junction of Big Sandy and Santa Maria creeks. With dam 110 feet high the reservoir measures six miles long, two miles wide, and sixty feet deep. With 300-foot dam the waters will be backed up twenty miles in length. Dam in the cañon of the Bill Williams River, 220 feet above lands to be irrigated.

TABLES OF LARGE RESERVOIRS AND DAMS.

LAND AND DISTRIBUTION.

Land suited to all California and sub-tropical fruits and plants. Ideal land for economical distribution of water. Sub-reservoirs easily built. Evaporation not necessary to consider. Accessibility excellent by wagon or for railroad.

SACRAMENTO AND HUALAPAI VALLEYS.

TOPOGRAPHY.

Like vast plains, unsurpassed lands in every way if irrigable. Area over one and one-half million acres. Not irrigable by ditches from the Colorado River. Possibly irrigable by utilizing the rapids of the river for power, transmitted to pumps. The plan discussed.

ARTESIAN WELLS.

The south half of the Hualapai Valley is an artesian basin, and wells for irrigation recommended.

SOILS AND GEOLOGY.

SOILS.

From eruptive rocks similar to Italy, and unrivaled elsewhere in the United States. Geology of country and analyses prove this.

SILT OF THE COLORADO.

A fertilizer that will maintain the richness of these soils.

CLIMATE.

ANNUAL RAINFALL.

Along the Colorado River four inches, in the Sacramento Valley six inches, in the Hualapai Valley ten inches, on the central and western ranges of mountains twelve to fifteen inches, on the eastern ranges twenty-five to forty-five inches, and on head of Bill Williams River forty-five to sixty inches.

TEMPERATURE.

General, excellent, not oppressive. Normal annual, along the Colorado River, 70° F.; Sacramento Valley, 65° F.; Hualapai Valley, 60° F. Lowest temperature (January), Fort Mohave Valley, 45° F.; Sacramento and Hualapai valleys, 40° F. Highest average

temperature (July), Fort Mohave Valley, 95° F.; Sacramento Valley, 90° F.; Hualapai Valley, 85° F. Equal to from 60° to 90° in the far East. Warm climate beneficial financially.

ADVANTAGES OVER CALIFORNIA.

No fog; six weeks earlier in ripening of fruits; better soil; more sunshine; twenty-four hours nearer Eastern market; cooler journey east for products.

FRUITS.

All citrus and sub-tropical fruits and fibers, especially raisin and wine grapes, canaigre, yucca, cochineal, and osage for silk-worms.

MISCELLANEOUS DATA.

Evaporation.

Units of water measure.

DUTY OF WATER.

One hundred and fifty to 250 acres for each cubic foot per second flowing in the canals.

Table of cost and duty of great canals.

Table of irrigated farms of the United States.

FIBER PLANTS.

Yucca, soap and paper making, cochineal, silk-worms, ramie, and canaigre.

MINING.

Brief outline of in the country.

Table of elevations.

Table of distances on the Colorado River.

Social and moral conditions, excellent.

List of books on Northwestern Arizona.

MAPS.

INTRODUCTORY.

Popular Belief.

Arizona is an olden land with a modern history. In the popular mind the very name has been so long associated with torrid heat, lawless whites, hostile Indians, venomous reptiles, and poisonous insects, that anything that may be said in its favor as an agricultural region is received with doubt that is not free from considerable prejudice. The popular idea is a relic of the days of '49. It was from the reports of the earlier travelers in this region that the common belief has become established that it is as rainless as the Sahara or the central plains of Australia, and that it is practically worthless from an agricultural standpoint, on account of this aridity.

Hunters and trappers in search of game, emigrants wearily accepting the deserts as the only path leading to the promised fatness of California, and prospectors seeking veins, placers, and pockets had neither time nor inclination to think of aught else but getting through this portion of the journey as soon as possible.

They found their road lying over sandy plains and barren mountains, where springs were far away, and where the sky was seldom clouded by rain. Carelessly, ignorantly, they called the land a desert; carelessly their hastily formed impressions spread; and now this impression, founded on ignorance and faulty and hasty observation, yields but slowly to the arguments of facts.

Facts.

It is a fact that to the masses this is an unknown land, but it is not a fact that it has not been carefully studied by some of the leading agriculturists and fruit-growers of America. It is a fact that its physical, topographical, and climatic peculiarities have been minutely and carefully studied by many of the leading scientists of the United States Geological Survey, the United States Department of Agriculture, the United States Signal Service and Weather Bureau, and many distinguished individuals who devote their lives to these economic problems. It is a fact that when irrigation water is turned onto the lands of Arizona they are found to possess so many advantages, such as salubrity of climate and productiveness of soil, that great and prosperous communities spring up and flourish in what so many consider only a desert.

It is a fact that, given good soil, good climate, and plenty of water, the financial results of irrigation in this sub-tropical country is remunerative in the highest degree.

It is a fact that in a report of the United States Geological Survey (Wheeler's) a comparison is made between Arizona and the Eastern portion of California and Southern Nevada, as follows:

	Arizona.	California and Nevada.
	Per cent.	Per cent.
Agricultural, irrigable, and arable lands	25	2
Timber	10	6
Grazing	30	88
Barren	35	4

And the experiences of the last decade will place a large portion of the California and Nevada lands under the head of barren so far as financial results are concerned.

It is a fact that Northwestern Arizona has the best of soils, an excellent climate, and that there is an abundance of water in the Colorado River and Bill Williams to irrigate hundreds of thousands of acres of land, converting them into districts as rich and prosperous as any in Southern California, and in many respects possessing decided advantages over the better known States.

Resources of Mohave County and Adjoining Regions.

TOPOGRAPHY.

Mohave County. Mohave County occupies the northwestern corner of the Territory, and is one of the four original political divisions into which Arizona was divided. The county was organized in 1864, but was but seldom heard of by the outside world, as its only method of communication was "overland," or by the Colorado River. It is bounded on the west by the Colorado River, on the north by Utah and Nevada, on the east by Yavapai County, and on the south by Yuma County.

Its area is about 12,000 square miles, composed of rugged mountain ranges and broad, smooth valleys. An inspection of the accompanying maps will show that the various mountain ranges are nearly parallel with each other, with broad, plain-like valleys between. Some of the mountain ranges, like the Hualapai and Music mountains, are fairly well wooded with pine, fir, juniper, etc., while the rest have but a sparse growth of timber. The ranges are different from Eastern mountains in being of eruptive origin, and springing abruptly from the plains, with no foothills. The ranges run from 3,000 to 9,000 feet in height as an average, with here and there higher peaks.

The vast valleys, starting sharply from the sides of the mountains, slope away so gently and uniformly as to appear to the eye like huge level plains. As a matter of fact, they slope all the way from ten to thirty feet per mile, and have an elevation ranging from 450 to 4,000 feet above sea-level. The principal ones are described in detail farther on. The Hualapai and Sacramento valleys extend north to the Colorado River, giving access to Utah and Nevada by wagon. The Colorado River is inclosed throughout the larger portion of its length, along the border of this county, by deep box cañons.

Canons. The Grand Cañon extends into the county to a short distance above Scanlan's Ferry (the old Lee Ferry), at the foot of the Hualapai Wash. From Scanlan's Ferry to Bull's Head Cañon, above old Fort Mohave, it is impossible to reach the river by wagon except at two points, one at Stone's Ferry, at the north end of the Sacramento Valley, and at Cottonwood Valley, above Bull's Head Cañon.

From Bull's Head to the Cañon of the Needles the river runs through a valley, and is everywhere accessible. The trails marked on the maps show the few places, besides those already mentioned, where access may be had to the river by pack-trains. The Colorado from below the Grand Cañon has many short box cañons where for from half a mile to several miles in length the waters are inclosed between huge perpendicular walls from 500 to 2,000 feet and more in height. Between these box cañons there are many beautiful valleys, often covering several hundred acres, but only to be seen after tedious and dangerous mule-back rides, or by going down the river in a skiff. From Bull's Head north to the mouth of the Virgin River is practically one cañon; excepting Cottonwood Valley, few

places where pack-trains can cross the Blue Ridge. The Grand Cañon is accessible by a fair wagon-road, eighteen miles long, from Peach Springs.

Rivers. Only one living stream, the Bill Williams River (described elsewhere), flows into the Colorado within the district examined. The Sacramento River is dry nearly all of the year, although it drains all of the southern portion of the Sacramento Valley. The Big Sandy and the Santa Maria rivers are described elsewhere.

Red Lake, in the Hualapai Valley, is dry the greater portion of the year, and the water which fills it after the rains sinks away in a few days.

Springs. As every one who travels this country, prior to the completion of extensive irrigation systems, is dependent upon the springs for water for himself and team, I have carefully located all I visited upon the map, as well as all the main roads and trails. The springs are found at the junction of the mountains and the plains as a rule, and fortunately occur about ever fifteen miles along the roads. As a rule, a cabin has been built near the road, and water-tanks, covered from the sun, erected, so that one is sure of a supply on producing cash enough to induce the guardian miner to unlock the tank. Springs are not abundant in the ranges themselves as a rule, and are not easy for "tender-feet" to find, and in exploring it is always advisable to take a guide who knows the range.

Roads. The vast valleys make it an easy matter to go to any part of Mohave County by wagon, and transport heavy loads. Difficulty is only met with in the higher ranges proper. Every town and mining-camp is easy of access for the heaviest transportation. The railroad crossing all the principal valleys, has made every point in the county easy to reach, either personally or for the heaviest and most bulky form of supplies.

THE COLORADO RIVER.

The Colorado River is formed by the union of the Grand and the Green rivers. The Green River rises in the Wind River Mountains of Wyoming, at an elevation of 12,000 feet above the ocean, a short distance south of the Yellowstone Park, and running south to the junction in Utah.

The Grand River rises near Long's Peak, Colorado, and runs southwest to the junction; thence the Colorado runs southwest to the mouth of the Grand Cañon, thence west to the head of Black Cañon, thence south to the Gulf of California. The river is navigable from the Gulf of California to Bull's Head Cañon, 432 miles, by stern-wheel steamers of light draft. In low water navigation is interrupted by the sand-bars above and below Yuma. During high water a few steamers have succeeded in going as high up the river as the mouth of the Virgin River, a short distance above the head of Black Cañon and ninety-eight miles above Bull's Head. The principal difficulty of the upper river is the frequent occurrence of swift rapids in the cañons. During low water the current runs from four to seven miles per hour, and in high water from five to fifteen miles. At Bull's Head Cañon the United States Government, I understand, has spent some $30,000 in improving the navigation of the rapids. The construction of canal head-works for the proposed irrigation of Fort Mohave Valley at that point could be so carried out as to aid in the navigation of the river instead of interfering with it.

The area of the land drained by the Colorado River and its tributaries, according to carefully conducted Government investigation, is 242,065 square miles. Its channel drains the heart of the greatest mountain region of the continent. In comparison with all other water-courses it is a mighty flood, the greatest river on the Pacific Coast, the Columbia alone excepted; flowing on undisturbed to the sea, past a vast desert which now challenges the power of men to convert it into a semi-tropical garden.

It is a river capable of affording, at all periods, an almost incredible amount of water for irrigation purposes, sufficient to bring hundreds of square miles of fertile lands under cultivation, and support thereby an enormous population.

One admirable feature is the fact that the Colorado reaches its highest dimensions in the months of June and July, the very time when water is most needed for irrigation.

The Waters Fertilize the Land.

Under irrigaton the sediment of the Colorado can be counted upon to restore the waste, whether it be the molecular waste of soil washed away or the elements of plant-food extracted by the crops. The fertilizing reddish mud of the river resembles that of the Nile and the Rio Grande. The quantity held in suspension varies from 0.1 to 0.5 per cent (1-1000 to 1-2000) of the water, so that it is good to drink even when heavily discolored by the mud. As compared to the Nile and the Rio Grande it is superior to both, containing less potash, more phosphoric acid and more carbonate of lime, as shown by the following analyses:

	Colorado.	Rio Grande.	Nile.
Chemically combined water	1.14	1.890	-----
Hygroscopic	3.27	3.122	-----
Potassa	0.103	0.284	0.166
Soda, or trace of lithia	0.074	0.064	0.022
Lime	-----	1.479	1.725
Carbonate of lime	12.50	5.190	-----
Magnesia	0.69	0.080	0.046
Oxide of iron	----	3.640	-----
Alumina	2.26	1.308	-----
Phosphoric acid	0.146	0.092	-----
Sulphuric acid	trace	trace	trace
Oxide manganese	trace	trace	trace
Insoluble in hydrochloric acid	78.1	82.55	-----

To the Aztecs the Colorado was as the Nile to the civilization which came to life the earliest of all in history, and spread its light all over Europe. From the early dawn of history it has supported the Aztecs and their descendants by feeding land with soil as well as water, and its annual rise was the only season about which grouped all the concerns of races now almost forgotten. The ruins of irrigation works along the Colorado and its lower tributaries, whose masonry shows their Aztec origin, are a mute testimonial to the success which would attend a repetition, on a grander scale, of these operations of an "uncivilized people."

THE FORT MOHAVE VALLEY.

Location.

By Fort Mohave Valley is meant the lands lying on the east side of the Colorado River, extending from the mouth of Bull's Head Cañon on the north to the Atlantic & Pacific Railroad bridge at the Cañon of the Needles. The tract extends from the river east to the west flank of the Blue Ridge Range, covering the larger portions of the low table-land known as the Black Mesa, and covering a portion of the lower part of the Sacramento Valley.

The tract along the river-front is about thirty-five miles long and from five to twelve miles wide, while the portion extending over the Black Mesa and into the Sacramento Valley covers the larger portions of about six townships.

Surveys.

The only existing surveys in this region are the surveys of the railroad line, the determination this year of the junction of the Nevada State liue and the Colorado River, and the survey of the base line, which reaches the river not far below Bull's Head Cañon. There is no recent or accurate survey of the Colorado River along

this front, and none of the township lines have been surveyed within this tract. Under these conditions it is impossible to present more than a sketch-map of the district, so as to give an approximate idea of the area, distance, and conditions of the valley. The areas are roughly ascertained by projecting the lines of the surveyed townships, lying some forty miles east, to the river line, as taken from the best accessible sources.

Areas.

Under these conditions, the area possible to irrigate is estimated at 123,065 acres of railroad lands, or, including the Government lands, a total of 246,130 acres. In round numbers, it is estimated that the lands of the Fort Mohave Valley which it is possible to irrigate cover 250,000 acres.

Kinds of Land.

An inspection of the land naturally divides it into three portions: First. The lowlands near the river, which are wholly or partially overflowed once or twice a year. Second. The lower mesa lands, which may be possibly irrigated by gravity from a canal taken from the river at Bull's Head Cañon. Third. The upper mesa lands, which can only be irrigated by raising the water into a canal starting at the Bull's Head Cañon.

THE OVERFLOWED LANDS.

(See Map.)

Area estimated to be 20,000 to 25,000 acres.

As the river was at nearly its highest stage during all the time my party was in the field, and as the flood was the highest known for many years, there was a good opportunity to see the eastern extent of the overflow. In many places the water covered the lands for a width of over five miles, leaving, however, islands that were from two to four feet above the water. The lands so overflowed are covered with a dense growth of mesquite trees, cat-claw, etc., and after the water goes down a large portion of the tract is covered with wild canaigre. A few Hualapai Indians have their gardens scattered over the submerged lands immediately around old Fort Mohave, and their success in raising vegetables and fruits without irrigation gives excellent testimony as to richness and fertility of the soil.

Land Immediately Available.

This land can be made immediately available by clearing off the growth of mesquite, cat-claw, etc., and planting the tract in canaigre. As some of this land is covered only with grass, and on others the growth of brush and trees varies widely in density, it is difficult to estimate, without special survey and examination, what it will cost per acre to clear the land and prepare it for planting. The cost will run from about $3.50 per acre for the easier ground to $15 per acre for that of dense growth and hard grubbing. When cleared, no soil is richer or better watered for canaigre than this.

The overflow coming in the spring, when the crops need it most, saves other irrigation. In all ordinary years the overflow, lasting a week to ten days, will not injure the plants. The soil being porous, there is no danger of souring or rotting of roots by long-standing water. The moisture retained in the subsoil is sufficient to maintain the full vitality of the canaigre and insure a full, high-grade crop of tanning material.

Using the Brush.

In order to maintain the integrity of these lands, and to enable the company to control, if so desired, the amount of flooding, it will be advisable to use the brush taken from the land as brush-matting along certain portions of the river. I advise a careful examination of those portions of the river liable to erosion, especially the initial points for the entrance of the water above and at old Fort Mohave, and the heads of the old channels, so that the necessary rip-rapping and brush-matting may be completed at the same time that the lands are cleared. As all the material is on he ground, this can be done economically and without special expense.

THE LOWER MESA LANDS.

Area (estimated), forty to sixty thousand acres.

The lands are free from all growths except grass and cacti. The lower mesa lands cover what is known as the first bench lands. Judging from careful reconnaissance, but without a full line of levels and cross-sections, it seems possible to irrigate a large portion of these lands by a ditch taken directly from the Colorado River at the foot of Bull's Head Cañon. As discussed farther on, under the head of "The Upper Mesa Lands," I doubt if it is advisable to seriously consider the question of a direct ditch for these lands from the river. If it were not possible to irrigate a vast tract of still higher lands by other means, there is no question as to the value of watering this tract by a direct gravity ditch. As it is considered feasible to handle the upper lands, that problem should be settled first, and thereby avoid unnecessary expense in connection with the lower mesa. If watered by a direct gravity ditch, it will be necessary—

1st. To carry the ditch for several miles close to and parallel with the river before it would emerge onto the bench lands.

2d. The fall of the river from Bull's Head Cañon to the bridge at the Needles is slight, about three feet per mile, requiring a large ditch to carry the water with its low velocity.

3d. The system suggested farther on will enable the lands to be irrigated by more cheaply constructed canals than the direct gravity canals.

4th. It will avoid the difficulties the direct gravity would have near its head in crossing some of the washes from the Blue Ridge Mountains.

Towns, Etc.

I have on the map maintained, however, the integrity of this lower mesa, as it is the most desirable ground for orchards, citrus fruits, vineyards, and for towns, etc. The fruits, etc., adapted to this and the other lands are shown on the fruit map.

UPPER MESA LANDS.

Area (estimated), one hundred and eighty to one hundred and sixty-five thousand acres.

As mentioned elsewhere, there are no foothills proper to these mountains, but the valley lands separate sharply from the abrupt flanks of the mountains and slope at first rapidly, and soon almost imperceptibly, away from the range. This makes the construction of ditches close to the mountain and commanding the most laud an easy and not expensive matter, avoiding drops and falls in order to maintain grade. With a high-line canal, as suggested, the natural grade of the mesa is well adapted to the rapid, economical, and thorough irrigation of all the lands, and providing a perfect drainage. With extraordinary rich soil, a climate especially adapted to sub-tropical growth, and vast mesas ready for the water, requiring but little leveling and no clearing of brush or vegetation, the question at once arises, "What is the best method of getting the magnificent and unrivaled water supply of the Colorado River onto these lands?" The only answer is, "By pumping."

Pumping.

There is nothing in the answer to alarm an irrigator if he will carefully examine the conditions. An examination of the lands shows that if water is raised about one hundred feet high from the river at Bull's Head Cañon, it can be carried by canal a short distance, about three miles, along the side of the mountain, and then pour into the high line irrigation canal, and begin at once its work of making the mesa blossom and bloom. Such a ditch carried along the head of the mesa could be brought onto the large plain — locally known as the "Black Mesa" — which forms the southern termination of the Blue Ridge, and from there swing around into the Sacramento Valley, irrigating it down to the old river-bed near the track. The power to do this pumping is to be

obtained from the vast volume of the Colorado itself, at the rapids at the foot of Bull's Head Cañon, making it raise a small portion of its own waters into the canal. Before describing the river at this point let me say a few words about pumping for irrigation. The value of pumping for irrigation has been recognized in the older European and Asiatic countries for ages. In fact, a very large proportion of the irrigation of Europe, China, Japan, India, and Egypt is by means of lifting the water. Near Tucson, Arizona, water is raised from a 70-foot well by a steam-pump, and waters 600 acres. The first cost of this plant was $8.50 per acre, and the annual cost is only 70 cents per acre, prices that will compare favorably with any system of irrigation. In several places which might be quoted irrigation water is being raised from twenty to eighty feet by centrifugal pumps worked by steam, the first cost running from $8 to $15 per acre, and the annual cost from 70 cents to $2.50 per acre, according to the area watered, the smaller area being proportionately much higher. One tract of 1,000 acres is being watered at the annual cost of 75 cents per acre, the plant costing $10,000, or $10 per acre. I am examining every style of pump that seems adapted to this purpose, and collecting data from their manufacturers, and have placed myself in correspondence with irrigators who pump in many parts of the world, and will be prepared to give plans and specifications later on if desired. One pump in particular seems to fulfill all the requirements for a plant for the Mohave Valley, full particulars of which can be furnished you when desired.

BULL'S HEAD CAÑON.

The Colorado River, after passing through the Grand Cañon, runs through a series of smaller cañons to the mouth of the Virgin River. There it turns south into the long, dark Black Cañon, and continues its course between high, almost perpendicular walls nearly all the way to Bull's Head. This cañon proper is only a few miles in length. The sides are heavy granite precipices, reaching the water's edge. The bottom of the river is evidently granite. At the foot of the cañon, where the river emerges onto the plain, the converging of the waters has made a rapid known to be one of the most troublesome to navigation on the upper river. The river is apparently about 600 to 800 feet wide (high water), but how deep I was unable to ascertain. On the east and on the west side of the river are granite points projecting above the water, the only visible portion, in high water, of the reef that obstructs the channel. During high water there is a distinct low cascade in parts of the reef, and elsewhere the waters rush and boil between the rocks, showing a decided fall in the level of the water. I have not seen the river at low water at this point since 1881, but remember distinctly the savageness of the rapids at that time, being nearly wrecked by crushing my boat on these rocks.

It seems feasible to place at this point turbine wheels that can be made safe from floods, and by them move pumps to raise the water twenty feet into a canal for the lower mesa and 100 feet or more for the upper mesa. The water supply is most abundant. The water power seems ample for every desired purpose of pumping or factory power, electric lighting, etc. All rock necessary for head-works is abundant on the ground. The connection between turbines and pumps is short and would be direct, and Nature has done a large portion of the work of preparing for a plant of this kind that would be safe from the heaviest floods. The natural advantages offered for head-works, in connection with the rare tracts of land described, certainly warrant the extended and minute surveys that are necessary to formulate plans for work on the lines suggested. There are no new features of engineering involved, and while it would be a work of magnitude, there is nothing especially bold or formidable about it, and the construction of such head-works could be made so as to improve instead of interfering with the navigation of the river.

General. The statements above cover the more important facts connected with the Fort Mohave Valley. There are many others of minor importance upon which I shall be pleased to report at your request.

In the areas mentioned no allowance has been made for the land included in the United States reservations of old Fort Mohave. The fort has been abandoned several years, and these lands will soon be thrown open. They cover all told about 300 acres. The old fort buildings have been turned into an Indian school, which will be permanent. These occupy about 160 acres. Good roads make the entire valley easily accessible from the railroad. A steam-ferry connects the valley also with the town of Needles, on the California bank.

BILL WILLIAMS DISTRICT.

(*See Map.*)

Location. The Bill Williams District lies immediately south of Mohave County, in Yuma County, extending from the junction of the Big Sandy and Santa Maria rivers west to the Colorado and south for an indefinite number of miles. The region south of the Bill Williams is one of extensive plains sloping south and west, with here and there rugged mountain ranges similar to those in Mohave County. The amount of Atlantic & Pacific Railroad land is estimated at 127,600 acres. The amount of land capable of being irrigated depends upon the amount stored in the proposed reservoir, as the land slopes gently south all the way to Yuma, over 100 miles distant, and the land can be irrigated as far as the water will reach. At present the land is wholly unproductive, being covered only with coarse gieta grass and stunted shrubbery and cacti.

Surveys. No township or section lines have as yet been surveyed in this district. In the estimates on the proposed reservoir and dam I use the figures of John F. Blandy of Prescott, who made the surveys.

Water Supply. The Bill Williams River is formed by the junction of the Santa Maria and Big Sandy rivers, both strong living streams. The Santa Maria rises in the elevated plateau known as Peoples Valley, at an elevation of 10,000 feet, lying north of the Antelope Mountains; thence it flows north, and is locally known as Kirkland Creek, and is soon joined by Sycamore Creek, coming from Mount Hope Range; thence it turns west to the junction with the Big Sandy. The Big Sandy rises in the Cottonwood Mountains, 9,000 feet above sea-level. The principal branches of the Big Sandy are Trout, Burro, Cliff, Spencer, Boulder, and Rock creeks. The elevation of the mountain ranges around the heads of these rivers is from 8,000 to 12,000 feet above sea-level. The area drained by the Bill Williams is over 4,000 square miles. The rainfall in the lower portion of this area, for example around Signal, is from seven to ten inches per year, and in the higher ranges from forty-five to sixty inches per year. Enough water passes annually down the Bill Williams from this water-shed to irrigate about 600,000 acres, allowing one second foot of water to 100 acres during the irrigation season. Unlike the Colorado, this river is at its lowest stage during the season when water is most needed for irrigation, and the flood-waters must be stored in a reservoir so as to be made available. The water is clear and pure and free from silt, excepting during high floods.

Reservoir Site.

The reservoir site selected for this purpose begins at a dam across the Bill Williams River where it cuts through the Aubrey Range, and extends back up the stream to the junction of the Santa Maria and the Big Sandy, provided the dam is built 110 feet high (Blandy), or farther still up each stream if the height of the dam is increased.

With a dam 110 feet high across the cañon of the Bill Williams, a reservoir six miles long by nearly two miles wide is obtained, having a depth of sixty feet, capable of watering over 300,000 acres of land. The reservoir site is a broad, flat valley having a fall most of the way of from twelve to fifteen feet per mile, and surrounded by high mountains. The character of the formation of the bottom of the basin and of the surrounding geological formations is such as removes all danger of loss by leakage or undue absorption. In fact, it is an almost ideal reservoir site, being broad and flat, with tight bottom and high mountain-sides.

The Dam.

Six miles below the junction of the Santa Maria and Big Sandy the Bill Williams River cuts through the Aubrey Mountains at right-angles, forming a narrow, precipitous cañon some eight miles long. The proposed dam site is in the cañon about 1,500 feet from the head. At this point the gorge is about sixty feet wide at the bottom, and a dam 110 feet high would have a crest about 175 feet long. Mr. Blandy reports that the test boring showed bed-rock twenty to thirty-five feet below the surface. The dip of the quartzite, lying next to the granites, is up-stream. The formation is hard, firm, close, and a dam can be anchored securely in it. The cañon is from 300 to 500 feet deep, with very precipitous sides, and a dam 300 feet in height can be built, backing the water up into the valleys above for a distance of twenty miles, if so desired. As the cañon winds in and out in sharp reverse curves, it will be possible to protect any dam to a large degree, if not wholly, from the floods which rush through this channel two or three times a year. No matter what height the dam may be built to, it will be necessary to build it in the form of a weir, so as to stand any possible flood that may come. It would be easier to protect a high dam, say 300 feet, from floods than the lower one, as it would require less cutting through or across the curves of the cañon in order to secure an ample waste-way. I emphasize this point, as the lands to be irrigated need only to be seen to be appreciated. The water supply is ample, and the most important point to be guarded against is danger to the dam from floods. Draining as it does an area of 4,000 square miles, it is to be expected that cloud-bursts will discharge their floods sometime every season into this channel. The following storms are quoted in order to give some idea of the importance and amount of these floods: In Bear Valley, California, in February, 1891, seventeen inches of rain fell in twenty-four hours, taxing the Bear Valley Dam almost to its limit. Around Yuma, Ariz., the annual rainfall is only about three inches, but in February, 1891, two and one-half inches of rain fell in twenty-four hours. On Salt River the average discharge of the stream is about 1,000 cubic feet per second, and the average flood 10,000 cubic feet per second, yet in 1891 the river had a flood of 140,000 cubic feet per second, and in 1892 one of 350,000 cubic feet per second.

Local cloud-bursts around Signal, on the Big Sandy, have shown a fall of from three to five inches in an hour. At the time of my examination of the Bill Williams dam site, June, 1893. I measured to where recent floods had left their débris on the walls of the cañon thirty-five and forty-five feet above the ordinary surface of the stream. The floods from the sudden melting of snows, or from heavy and protracted rains, are easily guarded against, and if proper precautions are taken the floods from sudden cloud-bursts will be welcomed rather than looked upon with dread. With this exception of provision for handling, and protection against unusual floods, there are no engineering features unusual to work of this magnitude. There is an abundance of rock at the dam site, good sand, and safe foundation for the largest dam desired. For the sake of comparison, I quote the following data of

LARGE RESERVOIRS AND DAMS.

NAME.	LOCATION.	MATERIAL OF DAM.	CAPACITY IN ACRE-FEET.	HEIGHT OF DAM.	LENGTH ON TOP.	COST PER ACRE-FOOT STORED.
Sweetwater	California.	Masonry.	18,000	94	380	$40.90
Bear Valley	"	"	40,550	64	300	5.30
Hemet Valley	"	"	138,000	150	250	9.98
Walnut Grove	Arizona.	Loose Rock.	7,000	110	420	16.10
Periar	India.	Masonry.	160,000	155	1,230	4.65
Bhatgar	"	"	126,500	127	4,067	3.20

The low cost per acre-foot (water enough to cover one acre one foot deep during the irrigation season) of the large dams will be appreciated from a study of the above table. With the water supply of the Bill Williams it is well worth while to study the proposition of a dam 300 feet high, capable of storing waters to irrigate half a million of acres of land.

Distribution of Water.

From the outlet at the dam to the low pass south of the Bill Williams, where the initial point of distribution is located, is about eighteen miles, according to Blandy's report. Mr. Blandy recommended a pipe line from the 110-foot dam through the cañon; then to carry the water by ditch onto the lands. As the fall from the dam to the initial point is some 220 feet, I suggest the plan of building a low diverting dam just below the cañon to turn the water into the canal, and using the natural channel of the stream to that point. The diverting dam would be six or seven miles below the first, and the loss of water too small to notice.

There is very little irrigable land in the valley of the Bill Williams proper, the irrigable lands beginning about eight miles south and southeast of the river, and extending 100 miles south. The initial point is about eighteen miles east of the Colorado River. The land slopes so gradually to the south and west as to make the distribution of the water easy and economical, and provides excellent drainage.

Sub-Reservoirs.

There are many places in these plains where natural basin-like depressions may be used as temporary reservoirs if so desired.

Evaporation.

Evaporation is to a large extent a bugbear to those unacquainted with irrigation in these regions. While the loss by absorption and percolation sometimes rises as high as 40 to 60 per cent of the volume entering the head of the new canals, yet, as it will take several years to complete so large a system of canals, and the upper or first lands have an opportunity to become saturated, the loss by absorption becomes of little moment. The reservoir being located in the mountains, and the water supply being so large, the question of evaporation need not be considered.

The soils of this district are mainly alluvial sandy loams, with here and there clays. It is a noticeable fact that the evaporation from such soils is comparatively small. Careful experiments recently made show that the evaporation from sandy surfaces is only about one-fourth or one-fifth that from water surfaces, the tests giving for water twenty inches loss, for earth nineteen inches, and for sand $3\frac{7}{10}$ inches.

Fruits, Etc.

All the citrus and sub-tropical fruits raised in Southern Arizona and Southern California can be raised on these lands. As the conditions of climate and soil are nearly similar in all the districts embraced in this report, the products of the soil are described elsewhere as a whole.

I understand that the railroad-bed has been graded from Prescott to Congress. From Congress to these lands, a distance of about thirty-five miles, the wagon-road lies over a plain over which it would be easy to build a railroad. A railroad could also be constructed, but at much greater expense, from Yucca, on the Atlantic & Pacific Railroad.

Accessibility.

The survey of the proposed railroad from Prescott to San Diego passes diagonally from northeast to southwest through these lands. Along the west edge of the tract there are numerous good steamboat-landings on the Colorado.

At present the lands are reached most readily by an excellent wagon-road from Yucca, on the Atlantic & Pacific Railroad, about fifty-five miles north.

SACRAMENTO AND HUALAPAI VALLEYS.

The Sacramento and Hualapai valleys have been well described as "exasperatingly beautiful." Beautiful they are indeed, stretching from the railroad on the south clear to the Colorado River on the north; level as a floor to the unpracticed eye; covered for miles, on many portions, by grass and flowers for a short time after the winter rains. With a mighty river of water rushing past their northern outlets, it is exasperating to think that there is no quick way of getting water onto their million and a half acres of richest soil. A most careful survey demonstrates the fact that it is an impossibility to get water onto these lands from the Colorado River by gravity ditches. The reasons are evident from an inspection of the accompanying tables of elevation. Both valleys slope to the north and to the south. The pass or highest point in the plain of the Sacramento has an elevation of 3,363 feet above the ocean, while its northern end, at Stone's Ferry, on the Colorado, is only 900 feet above sea-level. This pass is also located near the middle of the valley, some forty miles south of the river. From this pass the valley also slopes south to the Sacramento River. The Hualapai Valley Pass is about three miles south of Gold Basin mining-camp, or twenty-one miles south of the Colorado at Scanlan's Ferry. The elevation of this pass is 3,156 feet above sea-level, while Scanlan's Ferry is only 950 feet.

Topography.

From this pass the Hualapai slopes south to Red Lake. In fact, the valley south of the Pass No. 3 (see map) slopes in all directions, from Music Mountains, from the Cerebat, and from the railroad, toward Red Lake, and the rainfalls all converge there and sink into underground channels.

Both valleys reach the Colorado by way of slopes, by which I found no difficulty in reaching the river by wagon. The two valleys are connected by a grassy plain, lying between the Cerebat and White Hills mountains, and known as Dolan's Pass. The lowest point of this pass has an elevation of 3,997 feet above the ocean. If water could be brought to these three passes, there is no question as to the ease with which it could be distributed over every portion of both valleys, for the lands are admirably adapted for the cheap construction of ditches and the economic distribution of water.

The high character and beauty of these valleys, stretching like a plain for 100 miles north of the railroad, and having a width of from fifteen to over twenty miles, and endowed with perfect soil and climate, led me to examine very closely whether there might not be some possible way to overcome the difficulty. The water supply of the Colorado is more than ample, but the elevation of 2,000 feet and over to be overcome was most formidable.

The work of gathering the data on this point has delayed this report somewhat, but there is a possibility of watering one of the largest and richest tracts of land in America that is worthy of consideration and investigation.

It is possible to raise the waters of the Colorado River so as to irrigate all of the lands of both the Sacramento and Hualapai valleys; the only question is, "Will it pay commercially?" "Is it a business proposition?" This can not be answered either affirmatively or negatively at this date, but if work is carried on at Fort Mohave Valley, or at Bill Williams, I earnestly recommend that investigation be carried on and data obtained so as to settle this question. If successful, while the work would be heavy, the results would be of the greatest importance to the whole world.

The Plan.

A careful examination of the accompanying map will show the relative position of the river, the borders of the valley, and the three key passes. It will also show that all along the river are a series of rapids. Several of the most important of these, in fact the largest on the whole Colorado, are situated between Scanlan's Ferry and the mouth of the Diamond Wash, north of Peach Springs. The distance of these rapids from the pass to the head of the Hualapai is from fifteen to twenty miles. Power can be obtained, by turbines, from these rapids and transmitted by electricity over the mountains to the pumps.

The slope of both the Sacramento and Hualapai valleys to the river is such that any desired plan for handling the water can be utilized. It could be carried along the gradual incline by relay pumps; raised by steps and carried on by ditches to other pumps; or, if desired, raised at once up the precipices at the river to the desired height and then forwarded by canals.

Electricity.

The questions in regard to power, turbines, and pumps can be answered; the greatest difficulty is the electric plant and the transmission. Some of the ablest manufacturers of pumps and some of the best electricians in the world are now studying this problem for me, and I shall be pleased to give the results later on. The main difficulty so far is that the test of practical operation in long-distance transmission of power by electricity has been applied in but very few cases, and the severer test of continued operation over a considerable length of time is of rare occurrence. The latter is the crucial test, and of the highest importance commercially.

There are two plants in the United States which have successfully met the following conditions: Long distance, rough country, difficult climate, continuity of service, and a pressure above that ordinarily used. The first is that of the Willamette Falls Company, Portland, Ore. They utilize the power of the Willamette Falls, fifteen miles from Portland, using Victor wheels of 300 horse-power, geared to horizontal shafts with which the dynamo belts are connected. Two alternating current dynamos are driven by each wheel. The current at the high pressure of 4,000 volts passes direct to the line of No. 4 B. & S. wire, which is carried on ordinary double-petticoat glass insulators across the country to Portland. There the current is received at 3,300 volts by transformers and reduced to 1,100 volts for distribution.

Another plant, at Telluride, Colo., operates the Gold King mill. Here the wires are carried over mountain-peaks steep and rough, the line in some places being perpendicular, in others having an angle of forty-five degrees, and during the winter the snow is occasionally level with the top of the poles, and in the summer the lightning arresters are kept peculiarly busy, as high as forty-two discharges being noted in one minute on one occasion. The generator and motor are similar to those at Portland. On both the Portland and Telluride circuits the line loss is 20 per cent. At Portland the line has been in successful use for two years. At Telluride the line had been in operation (at the time of my notes) 127 days, with a loss of 19½ hours, or an average of nine minutes in a day of twenty-four hours. These

results are valuable as showing what has been accomplished with new types of machinery in countries where line construction and maintenance are peculiarly difficult, with practically continuous service, with attendants who are not electricians, with a high voltage, a long distance, and large power; places transmission beyond the stage of experimental trial, and gives it the stamp of commercial success. The same type of apparatus which has been successful in them is available for larger capacities.

An interesting test of long-distance transmission was made last year in Germany. Dynamos of large capacity, operated by turbines in the River Neckar at Lauffen, were connected by wire with motors at Frankfort-on-Main, 108 miles distant; 225 to 250 horse-power was generated at Lauffen, and 175 to 200 delivered at Frankfort; that is, 70 to 75 per cent of the power was transmitted and from 25 to 30 per cent lost, this including an initial loss of 8 to 10 per cent in the generating dynamos, which might be somewhat eliminated by more perfect construction. The actual loss of energy during the triple process of transferring a current of over 200 horse-power into a current of small voltage but high intensity, transmitting this 108 miles over naked copper wires hung on ordinary telegraph-poles by oil-trough porcelain insulators, and re-transmitting it into a current of ordinary pressure, at a loss of only 20 per cent (not including generating dynamos), was remarkable.

These examples are sufficient to show that the industrial value of long-distance transmission has been demonstrated fully.

Along the Colorado River, with water-power plant once in place, the cost of maintaining the power would be almost nothing compared with fuel, and the loss in transmission not large.

It is well worth while, therefore, to seriously investigate the cost of the necessary plant in relation to the value of the lands when irrigated; the abundance of water for irrigation and power and the value of the lands being beyond question.

ARTESIAN WELLS.

A careful study of the geological features of the Hualapai Valley, the character of the strata, dip and strike, satisfy me that valuable artesian waters can be had by wells 500 to 700 feet deep along portions of the valley just south and southwest of Red Lake. I do not believe that the waters would overflow with more than a low pressure, but an abundance would raise to the surface, or near to it, so as to be readily pumped in large quantities and several thousand acres irrigated. The expense of fuel for pumping would not be great, owing to the short distance from the railroad and the excellent roads.

I will not burden this report with the geological reason and the proof of the existence of these waters, but this evidence was carefully gathered, and is sufficient to warrant, without fear of failure, the sinking of a test well in an area which I shall be pleased to give to you personally.

SOILS AND GEOLOGY.

The study of the geology of the district gives the key to the character and composition of the soils, for the rocks of the mountains determine the composition and texture of the

soils. Rich as the Arizona soil is, it is always a sad disappointment to the eye of the man who views it with the prejudices born of familiarity with the deep, rich, grass-grown loams of the Eastern prairies. At first sight he can only compare it with nothing but the sands of the sea-beach; that it could be made to bear a scanty crop of some hardy grass is almost beyond his comprehension; that it will bear enormous harvests of grain, that it is the rival of every vineyard soil of the whole world, and that it is especially adapted to the successful culture of citrus and semi-tropical fruits in general, are facts which have to conquer unbelief in his unwilling mind.

An examination of the accompanying geological map shows that the mountain ranges run in a general north and south direction; that a large limestone mesa covers the northeastern portion; that the core of the ranges is granite; that this is surrounded by a belt of eruptive rocks, generally rhyolite, which decomposes readily, furnishing clay to the soils; and that these rocks in turn are surrounded by a belt of limeshales which furnish both lime and clay to the soils.

The character of the soft rocks along the flanks of the ranges and the absence of foothills make the digging of canals unusually economical, there being scarcely any rockwork even on the proposed high-line canals. The rocks and the raindrops are the parents of agriculture here, and it is but the part of man to assist nature. The alluvial wash of the mountains produced the rich plain-like valley lands, and the causes at work in the past are still in operation. Owing to the absence of heavy annual rainfall, the soils are unleached, and therefore exceptionally productive, and the fertilizing waters of the Colorado will maintain this quality. The soils washed from the mountains contain all the elements of plant-food.

It is the decomposed lavas and eruptive rocks of Italy that make that land famous for its grapes, and it is a fact that the lands of Mohave County are far richer, from the same class of rocks, than those of far-famed Italy, and with water can be made the banner raisin and grape lands of the country.

The soils are strong, substantial, and durable from the lavas, limeshales, and limestones. There is no troublesome alkali, and the grade and porosity is such as to prevent water-logging or souring.

For general purposes it is acknowledged that limestone soils are the best. Here, as the farmer would say, the lands are already marled. The soils are of remarkable depth, and there is no raw subsoil near the top for the farmer to fear turning up.

With irrigation every square mile of these lands is capable of producing prolific crops of grains, and all the semi-tropic fruits and plants, even to cotton and sugar-cane. The wonderful fertility of the lands is established beyond question by actual experiments on small holdings along the flanks of every mountain range, and especially at Kingman and Fort Mohave, and along the Big Sandy River. The soils of the mesas and valleys are warm, airy, and especially adapted to the cultivation of citrus fruits, canaigre, and fiber plants. These are reddish-gray in color, and loose enough in texture to stand irrigation without baking. While of a loamy nature, they are also sandy, and looser, and better adapted than the California lands to the cultivation of the fig, olive, and various varieties of wine-grapes. In fact, it is asserted by several of the most experienced of California wine-growers that these lands are better calculated for the production of true port and sherry wines than those of their own State, and for raisins are unrivaled at home and abroad. In fact, these soils for depth, richness, quality, quantity, and variety of products under irrigation are equal to any in the world.

Silt a Fertilizer.

The value of silt-bearing waters as a fertilizer is well-known, and it is well established by foreign countries that the longer this class of lands is cultivated and fertilized by the river sediment the more productive they become. The silt of the Colorado River at this point is especially valuable

as a fertilizer. Emerging as it does from a long series of cañons cut through the heart of great mountain ranges, the waters are not so heavily charged with sand as they become after passing through the plains farther south. As shown by the analysis already given, the silt contains some lime and clay, a considerable amount of phosphates and potash, and some nitrogenous matter. It is estimated that an application of water fifteen inches deep in one irrigation season will supply phosphates, potash, and nitrogenous matter to the value of $3.62 per acre, estimating these at their market value in the East to-day. It is certain that the Colorado water will enrich and keep up the fertilization of the soil as well as supply moisture to the growing crops. The following examples will show the value of silt. In the Valley of Moselle, France, a land with a natural poor soil, and absolutely barren and worthless without fertilization, the alluvial matter deposited by irrigation from the turbid waters renders the soil capable of producing two crops per year. In the Valley of Durance, France, the turbid waters of that stream bring a price for irrigation twelve times as great as that paid for the clear waters of the Sergues River. The Calloway Canal, California, gives 18 per cent better results with its muddy water than the clear artesian-well waters of the same district. Examples could be multiplied from our own land, from India, and along the fertile Nile, but a little examination of this question is all that is necessary to show that the silt carried by the Colorado River is most valuable for increasing and maintaining the natural richness of the soils of Mohave County.

CLIMATE.

(*See Map.*)

Rainfall. There are two rainy seasons, in the winter and summer months, respectively. The summer, or "shepherd" rains, as they are locally known, are brief in duration and limited in area, being seen in the mountains rather than felt in the valleys, and are of no value whatever alone for agricultural purposes, but taken in connection with irrigation will have their value. The most important effect of these rains at present is the maintaining of a host of springs that are indispensable to the traveler, and to all workers in the land at present. These rains also sometimes develop into local cloud-bursts, sending huge volumes of water down some of the gulches, as mentioned under the head of the "Bill Williams District." Wherever canals along the foothills cross the dry washes from the mountain cañons, the possibility of these floods must be provided against by protecting the canals.

An inspection of the map will show that the region along the river has an annual rainfall of four inches, the Sacramento Valley six inches, and the Hualapai and Lower Sandy ten inches. The western mountain ranges have an annual rainfall of twelve to fifteen inches; the eastern of from fifteen to twenty-five inches; while the middle and upper portion of the Bill Williams water-shed has an annual precipitation of from twenty-five to forty-five inches.

TEMPERATURES.

Among the many errors concerning Arizona which for many years have received the sanction of general acceptance, there is none greater than that relating to temperature.

To most uninformed people, and the believers in the yarns of the festive newspaper space-filler, the very name "Arizona" is suggestive of desert wastes, devoid of vegetation, scorched by the fierce rays of a southern sun, whose blinding glare neither man nor beast can withstand. A region where the temperature during the summer is unbearable, where "bacon is eaten with a spoon, chickens lay hard-boiled eggs, bad dead men send their ghosts back for their blankets, and the bones of all the mules rattle in their sun-shriveled hides." Even a short personal experience in this land will be sufficient to prove to the most skeptical that it has been the fashion in the East to malign the climate of Arizona, and the visitor will return to praise the land of bright skies, pure air, cloudless days, brilliant star-lit nights of refreshing coolness, and pure, dry, health-giving air, and will testify that while the thermometer may have read higher in actual degrees, he or she felt far more comfortable in the dry, bracing climate of Arizona than in the moist, enervating climate of the East, where the thermometer stood nearer 90°.

Normal Annual Temperature. (*See Map.*)

The normal annual temperature along the Colorado River is 70° Fahrenheit; that of the Sacramento Valley, 65° Fahrenheit; that of the Hualapai Valley, 60° Fahrenheit; and farther east, on the elevated plateau followed by the railroad, 55° Fahrenheit. As one ascends any of the mountain ranges along these valleys of course the temperatures fall rapidly with increase of elevation. The temperatures given on the maps are those of the valleys, with no allowance for local variation in the mountain ranges. This range of normal annual temperature needs no comment as to its importance to health, or to fruit-raising.

Lowest Normal Temperature.

The lowest average temperature is found in the month of January, being 50° Fahrenheit west of the Colorado, 45° Fahrenheit in the Fort Mohave Valley, 40° Fahrenheit in the Sacramento and Hualapai valleys, and 35° Fahrenheit farther east. This insures the safety of the most delicate sub-tropical plants. and sustains the claim of the citizens that their land is one of the best of winter resorts in America.

Highest Normal Temperature.

The highest average temperature is found in July, the Colorado Valley being 95° Fahrenheit, the Sacramento Valley 90° Fahrenheit, the Hualapai Valley 85° Fahrenheit, and east of Hackberry 80° Fahrenheit. It is true that the thermometer has been known to reach 118° and 120° Fahrenheit in the shade in the Fort Mohave Valley, but I and my party can personally testify that we drove in the sun all day, and worked in the open air without other sun-shade than our hats, and felt less discomfort than in Chicago, on our return, where the thermometer stood at from 93° to 95°. It is a fact that in the dry air of Arizona these apparently high temperatures are equivalent to 88° to 95° in the East, where the air is saturated with moisture. Here the heat is not as oppressive as in Southern California even, where the ocean moisture is felt.

After being acquainted with this climate more or less for over twenty years, I can personally describe it as simply superb for nine months out of the twelve, and not as disagreeable as that of New York during the highest temperatures of the other three months.

Financial Benefits.

The financial benefit of the climate is shown in the fact that these lands have an earlier and warmer spring, the trees have an earlier start, and the higher temperature ripens the fruit earlier than in California. Oranges, for example, ripen about the first of December, instead of the middle of January as in Southern California, and are never subject to injury by low temperatures in the winter, as is sometimes the case in the neighboring State.

Sunshine.

Letting 100 represent continuous sunshine, the percentage of cloudless days for the different months is as follows: January, 69; February, 72; March, 72; April, 79; May, 80; June, 85; July, 63; August, 65; September, 82; October,

80; November, 78; and December, 74. The value of these cloudless days in ripening and curing fruits, especially in ripening wine-grapes and curing raisins, is evident to every fruit-raiser.

Advantages over California.

This land is free from the fogs that hang over portions of Southern California. The average spring, summer, and autumn temperatures is about 10° higher than at Riverside, Cal., explaining the fact that citrus fruits, small fruits, vegetables, etc., will ripen here from a month to six weeks earlier than in the great fruit-growing State across the river.

In the element of sunshine for ripening and curing of fruit it has a great advantage. It has a better soil, and produces fruit with better color and flavor. It is a fact that citrus fruits improve in quality when transported here from California, the skin becoming thinner, the flavor finer, the perfume stronger, and the seeds fewer, and being ready for the market six weeks earlier they command a better price. An examination of a map will show that after leaving these valleys the Atlantic & Pacific Railroad crosses the Territory at an average elevation of over 5,000 feet above sea-level. The fruit leaving these valleys is a few hours traversing the elevated Colorado plateau, in a cool climate, and has a cool trip all the way east. It is one day's journey nearer the East than California. California fruit has either one day's travel more over the hot Mohave Desert west of the Colorado, or it has to cross the hot regions of Southern Arizona for their full length, then across Southern New Mexico, and through Texas, before reaching market. These advantages will be appreciated at their full value by every shipper of fruit.

FRUITS.

The questions what to grow, how to grow it, how to prepare it for market, and where to find a market, have already been answered by the citizens of Mohave Valley. The experiments at Kingman, Beale's Springs, Fort Mohave, Scanlan's Ferry, and along the Big Sandy leave no question as to the great future success of fruit-raising here.

While the yield on irrigated land of wheat, oats, rye, barley, and other farm produce is greater than that of the best grain regions of the East, the irrigated lands are altogether too valuable to be used for the production of small grains, corn, or even alfalfa, except for home consumption, and I do not, therefore, consider these products. Northwestern Arizona can be made one of the greatest fruit-raising sections of this continent in a comparatively few years by the conservative use of capital on a large scale.

Oranges, lemons, and limes find these soils and the climate exceedingly congenial, and yield in abundance large clean, thin-skinned, and exceedingly juicy fruit, coloring handsomely, and containing the requisite sweetness and acidity. The fig and pomegranate offer a character of fruit that stamps them as indigenous. The grapes attain a great size, cluster lightly on the bunches, are firm and high colored, and possess exquisite flavor. Heavy wines and brandies of superb excellence can be produced. The olive grows luxuriantly, and will be a leader. The mulberry grows luxuriantly also, and produces a large sweet fruit. Plums and prunes of unsurpassed excellence can be raised. The raising of dates has passed beyond all conjecture. The apricots and peaches are simply superb. The field of fruits is too large to attempt to cover in this report, but there is abundant evidence to show the great success in this direction that awaits the irrigator, for nowhere on the Atlantic Slope can be found a district more favorable to all kinds of fruits than Mohave and the surrounding counties. The following will show the time of maturing of a few fruits: Strawberries, January 15th; apricots, April 1st to 21st; mulberries, April

10th to 20th; figs, April 20th to May 1st; grapes, June 1st to 7th; watermelons, May 15th to 20th; peaches, June 15th; pomegranates, June 15th; lemons, September 15th to 25th; limes, September 15th to 25th; dates, September 1st to 5th; and oranges. November 25th to December 1st.

MISCELLANEOUS DATA.

Evaporation.

As mentioned in connection with the Bill Williams lands, evaporation is to a large extent a bugbear to those unacquainted with irrigation in these regions. It is true that in many places the value of waste water when stored in reservoirs depends upon the amount of evaporation. On the lands where the water is taken direct from the Colorado, the supply is so ample and the distance to the lands so small that evaporation cuts no figure.

The reservoir of the Bill Williams is so large and the water supply so abundant that it need not be considered.

In the distribution over the lands attention has been called (Bill Williams, page 17) to the fact that the evaporation from sandy surfaces is only about one-fourth or one-fifth that from water surfaces, so that the duty of the water will not be lowered by evaporation.

The only place where it will be necessary to take this into account will be at local valley distributing reservoirs, such as may be built in the Sacramento and Hualapai valleys and in the Bill Williams lands. In such reservoirs it will be found that the evaporation is most rapid in June; that the possible evaporation will rise to or exceed 100 inches a year, 5 per cent occurring in January, 14 per cent in June, and 4 per cent in December; that a fair allowance will be seven feet for evaporation during the irrigation season, or one-half an inch a day.

Units of Water Measure.

ACRE-FOOT.— The amount that will cover one acre of land one foot deep during one irrigation season = 43,560 cubic feet, and is ample for average crops.

SECOND-FEET.— Number of cubic feet of water passing a given point in one second of time.

One second-foot = 450 gallons per minute.

One cubic foot = 7.5 gallons.

One second-foot = 2 acre-feet in 24 hours (approximate).

One second-foot = 59½ acre-feet in 30 days.

Duty of Water.

The duty of water from new canals and on new land is always low for the first two years, but rises rapidly as the land becomes more thoroughly saturated down to a subsoil. The cultivation and planting of the soil causes it to require less water. The duty of water depends largely upon the thoroughness of the system for delivering and measuring water, of the water company, and upon the intelligence of the land-owner. The following shows the duty of one second-foot of water during the irrigation season, for various places:

One second-foot irrigates each season —

Northern India	250 to 300 acres.
Valencia, Spain	200 to 325 "
Southern California, by surface irrigation	159 to 399 "
Southern California, by sub-irrigation	300 to 1,000 "
Arizona, generally imperfect	100 to 225 "

The duty of water on the lands in this report should be from 150 to 250 acres per second-foot, and on citrus lands by sub-irrigation it should be brought to 500 and over.

COST AND DUTY OF SOME GREAT CANALS.

Name of Canal.	Locality.	Area Commanded. Acres.	Length in Miles.	Capacity. Second-feet.	Grade.	Bed Width. Feet.	Depth, Feet.	Cost per Acre. Irrigated.	Cost per Sec-foot Used.
Lower Ganges	India.	2,435,000	564	6,500	1 in 10,560	216	8	$ 9.00	.....
Ganges	"	1,820,000	456	6,700	1 in 4,224	170	10	5.25	$290 00
Soane	"	1,000,000	367	5,956	1 in 10,565	180	9	8.70	.....
Sirhind	"	800,000	503	3,500	1 in 4,800	190	6	13.00	121 00
Cavour	Italy.	490,000	53	3,250	1 in 4,000	66	12	30.60	.....
Idaho Irr. Co.	Idaho.	350,000	70	2,585	1 in 2,640	40	10	2.16	190 00
Bear River ...	Utah.	200,000	150	1,000	1 in 5,280	50	7	5.00	125 00
Pecos.....	N. Mex.	200,000	75	1,100	1 in 6,707	45	6	5.00	690 00
Turlock.....	California	176,000	93	1,150	1 in 5,280	70	7.5	14.50	730 00
Arizona.....	Arizona.	60,000	41	1,000	1 in 2,640	36	7.5	10.00	.....
Yuma	"	207,000	241	.....	.....	....	....	6.31	.....
So. Gila.....	"	12,000	22	.....	.....	....	....	3.75	.....
Mohawk	"	40,000	35	.....	.....	....	....	3.75	.....

It will be noticed in the above table that the cost per acre irrigated, in the American canals, run from $3.75 to $14.50. This depends largely upon the cost of the dam, or of the head-works of the canal. Without more data than that secured at present, I estimate the cost of irrigating in the Fort Mohave Valley at about from $8 to $10 per acre, and on the Bill Williams at from $6 to $8, according to the size of the dam and method of reaching the lands.

The table following is taken from the United States census of 1890, and is quoted so as to give some idea of the extent and cost of irrigation in general. As there is so much irrigable land devoted in parts of the West wholly to agriculture, the effect is to raise the average size of the farms and to lower the value of the water per acre. The size of the fruit farms runs from one acre to twenty as a rule, and the value of a water-right from $10 to $100 per acre, often even more.

AMERICAN IRRIGATED FARMS—PER UNITED STATES CENSUS 1890.

STATE.	Crops Irrigated. Acres.	Average size of Farms. Acres.	Average first cost water per acre.	Average value water per acre.	Average annual cost of water per acre.	Average cost of preparing land for cult. per acre.	Average value of irr. land per acre
Total in U. S.....	3,564,416	67	$ 8.15	$26.00	$0.99	$12.12	$ 83.28
Arizona	68,821	61	7.07	12.58	1.55	8.60	48.68
California	1,004,233	73	15.84	52.28	1.60	22.27	150.00
Colorado	890,735	92	7.15	28.46	.79	9.72	67.02
Idaho	217,005	50	4.74	13.18	.80	9.31	46.50
Montana	350,582	95	4.63	15.04	.95	8.29	49.50
Nevada	224,403	192	7.58	24.60	.84	10.57	41.00
New Mexico.....	91,745	30	5.58	18.30	1.54	11.71	50.98
Oregon	77,944	56	4.64	15.48	.94	12.59	57.00
Utah	263,473	27	10.55	26.84	.91	14.85	84.25
Washington	48,800	47	4.03	13.15	.44	10.27	50.00
Wyoming	229,676	119	3.62	8.69	.44	8.23	31.40

FIBER PLANTS, ETC., ON IRRIGATED LANDS.

The flora of this Territory has never yet been properly classified, and many of its most interesting and valuable varieties are unknown to the botanist of the East. I recognized as native of these lands many varieties of cacti that I have seen used in Mexico and Central America for fiber, and for paper-manufacturing. A long list of these plants might be given, but I leave this to my associate, Professor Thorner, and call attention to only a few that are of special commercial importance.

The Yucca. There are several species and many varieties of the yucca growing wild all over the lower portion of the mountain ranges, and the supply can be made a certain one by planting. The *Yucca filamentosa* is the famous "soap plant" of Mexico and the Southwest, the large tuberous roots yielding a fine article of soap that is already being placed on the market on a large scale by manufacturers. Other varieties of the yucca yield fibers in abundance, long, strong, and of all grades, from the coarse material for ropes and cables to those soft as silk and weaving into choice satines.

For Paper-Making. For paper-making the supply of cacti is large and of the best quality.

Cochineal. It may surprise some, but it is true that this industry may be carried on successfully in the Fort Mohave and Bill Williams districts, where the low altitude and the temperature of winter and summer enable the cactus to thrive, upon which the insect lives. The *Opuntia cochinillifera*—or cochineal cactus—thrives in a wild state on these lands, and may be profitably cultivated without irrigation.

Silk-Worms. It has been proved by the Mexicans that the osage is even better than the mulberry for food for silk-worms. Nowhere can this be grown to better advantage than on the mesas of Mohave County.

Ramie. Besides the native fibers, there are many others that will do well in this climate, at this altitude, and in these soils. Among others the ramie (*Urtica nivea*) should prove very profitable on account of its great beauty of fiber and almost unlimited commercial demand. The long growing season of these districts will permit three or four cuts to be made annually.

Mining. Every mountain range, hill, and isolated peak contains valuable minerals. Gold, silver, copper, lead, iron, and nearly every mineral of value known to the miner is found within the borders of this district. Mines were opened in Mohave County soon after the excitement of '49, and some of them have been steady producers for many years. The accompanying map shows the location of all the recorded mining districts of Mohave County. There are many mines outside of these districts, and several unrecorded districts are not shown. Among the well-known mines is the McCracken mine of Owens District, near Signal, which at one time was considered one of the largest silver mines in America. The names of Cerebat, Gold Basin, Lost Basin, and Stockton Hill are well-known to all mining-men.

No country has suffered more than this from incompetence, ignorance, mismanagement, and lack of capital on the part of investors, and there are many mines which could be worked and made productive if there were irrigated farms near at hand from which to draw supplies.

The greatest drawback of all has been, and is to-day, lack of water. If any plan is put in operation by which water is brought onto the Sacramento and Hualapai valleys, it will, by supplying also the mills and smelters, make Mohave County one of the largest bullion producers in the United States. There are sampling-works at Kingman which buy and ship ores, but the miners make no attempt to sack and ship anything less than $100

per ton ore, allowing the lower grades to accumulate in the mines or on the dump. Prospecting is kept up, and new districts are being opened every year. The comparatively recent discovery of the White Hills has given a new impetus to prospecting.

ELEVATIONS.

ATLANTIC & PACIFIC RAILROAD LINE, TRACK AT STATIONS.

	Feet.
East line of Mohave County	4,980
Peach Springs	4,780
Truxton	4,197
Hackberry	3,544
Hualapai	3,300
Old Beal Siding	3,495
Kingman	3,326
Drake	2,608
Yucca	1,796
Franconia	1,098
Mellen	547
Powell	444
Beal	552
Needles	575

SACRAMENTO VALLEY.

Pass No. 1, head	3,363
Foot, near Powell	435
North end, near Stone's Ferry	900

HUALAPAI VALLEY.

Head Pass No. 3, near Gold Basin	3,156
North end, two miles west of Scanlan's Ferry	935
Scanlan's Ferry, low water	950
South rim, at Hualapai	3,300
Dolan's Pass, between Sacramento and Hualapai	3,997
Union Pass, Blue Ridge Mountains	2,795
Camp Hualapai	5,321
Cottonwood Springs	4,170

FORT MOHAVE.

Hualapai Springs	4,258
Peach Springs, Music Mountains	6,208
Tin-na-ha Springs	4,080
San Francisco Peak	12,561
Bill Williams Peak	9,080
Mount Union	9,000
Hualapai Range	7,000 to 8,500
Cerebat Range	7,000 to 8,000
Music Mountains	8,000 to 9,000

	Feet.
Head of Bill Williams River	9,000 to 11,000
Blue Ridge Range	5,000 to 7,000
White Hills Range	5,000 to 7,000
Aubrey Mountains	4,000 to 7,000

COLORADO RIVER.

Grand Wash, North Peach Springs	1,000
Scanlan's Ferry	950
Stone's Ferry	930
Mouth of Virgin River	920
Head of Black Cañon	900
Bull's Head Cañon (foot), high water (about)	575
Bull's Head Cañon (foot) low water (about)	555 to 560
Old Fort Mohave	515
Railroad Bridge, low water	420
Mouth of Bill Williams River	380
Fort Yuma	200

BILL WILLIAMS RIVER.

Junction of Bill Williams and Santa Maria, bar	1,277
Dam site on Bill Williams, bar	1,187
Initial point on irrigated lands, bar	970

DISTANCES.

COLORADO RIVER BY WATER (Approximately).

	Miles.
Mouth of river to Yuma	150
Yuma to mouth of Bill Williams River	190
Mouth of Bill Williams River to the Needles Bridge	51
Needles Bridge to Bull's Head Cañon	41
Bull's Head to head Black Cañon	98
Total	530

SOCIAL AND MORAL CONDITIONS.

Social and moral conditions in Arizona are far different from what some might suppose, judging from the shafts of alleged wit fired by the newspapers of the eastern coast. Mohave County as a law-abiding, intelligent, and prosperous county will challenge comparison, in proportion to the population, with any county in the East.

The common-school system is firmly established and well maintained, giving the settlers the same advantages for their children as they enjoyed in the East. In Northwestern Arizona there are no Indian troubles, and there have been none since the early days of long ago. The few Hualapai and Mohave Indians in the region are industrious, and make excellent farm hands. So far Arizona has been notably free from contention between labor and capital.

In general, the settler will be as well pleased with the social and moral conditions as he could be east of the Mississippi River.

BOOKS OF REFERENCE ON NORTHWESTERN ARIZONA.

Bancroft, H. H. Agriculture and Irrigation of Arizona, 1889.

Black, J. A. Arizona, 1890.

Blake, William P. 1889.

Citizens' County Report of Yuma. Tucson, 1889.

Dutton, C. E. Cause of Arid Climate. American Journal Science. New Haven, vol. 22.

Gila Bend Reservoir Irrigation Co. E. J. Horton, Tucson, 1890.

Greeley, Gen. A. W. House Ex. Doc. 287.

Gulley, F. A. Arizona Experiment Station. Tucson, 1890.

Hamilton, P. Arizona Resources, 1885.

Hancock, W. A. Agua Fria Enterprise, 1891.

Hazen, W. B. Our Barren Lands. Cincinnati, 1875.

Hill, J. R. Arizona's Development. San Diego, 1888.

Hinton, R. J. Handbook, 1878.

Irrigation Age. Salt Lake, 1890 to 1893.

King, C. H. Citrus Fruit Belt, 1887.

Loomis, E. American Journal Science, New Haven, vol. 25.

Mowry, S. American Geographical Society, 1859 to 1863.

Newell, F. H. Census Bulletins, 1891.

O'Neill, B. Ancient Irrigation in Arizona, 1891.

Report Phœnix Chamber of Commerce, 1887, 1889.

Sorrin, T. R. Handbook. Tucson, 1880.

Schott, C. A. Rain Tables, Arizona. Smithsonian contributions, No. 353.

Smith, Hon. M. A. Speech and Report Arizona Legislature report, 1888.

Smith. Report United States Congress, 1889.

United States Weather Service Reports.

United States War Department Secretary, 1888–1889.

Widney, J. P. Colorado Desert. Overland Monthly, 1875.

United States Reports on Irrigation.

United States Department Agriculture. Reports on Irrigation.

United States Geological Surveys, Tenth Annual Report.

Eleventh Census, United States.

Report Secretary War, 1890.

Hilgard. United States Agricultural Arid Land of the Pacific Coast.

Martindale, M. A. American Irrigation Systems, 1883.