Report on the Little Colorado River

by

Hugh Stevens Bell

WR 1

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
Washington, D. C.
H. H. Bennett, Chief
W. C. Lowdermilk, Associate Chief

* * * *

A REPORT

on the

HISTORY OF THE CENTRAL AREA OF THE LITTLE COLORADO RIVER BASIN AND ITS RELATION TO FLOOD AND EROSIONAL CONDITIONS

by

Hugh Stevens Bell

* * * *

Sedimentation Studies
Division of Research
Cooperative Laboratory
California Institute of Technology
Pasadena, California

WR 2

TABLE OF CONTENTS

Introduction . . . . . 1 - 3
Little Colorado River. 4
Geological History of the Little Colorado 4 - 9
Early Occupants of the Little Colo. Basin 10-17
Little Colo. Basin Under Spanish Rule . . 17-28
Little Colo. Basin Under American Rule . . 28-47
The Sitgreaves Expedition 29-32
The Whipple Expedition of 1853-4 . . . 32-34
The Beale Expedition of 1857. 35-38
The Ives Expedition of 1857-8 39-42
The Basin After 1860 42-47
Mormon Settlements 43-44

Discussion of Precipitation Charts 48-51
Average Monthly Precipitation for Stations in the Little Colorado Basin. Table 1. 52
Discussion of Floods Since 1888. 53-85
The Super-flood of 1888 53-55
The Flood of November 1905. 55-57
The Flood of December 1908. 57-58
The Flood of July 1911. 58-60
The Flood of 1916 60-62
Precipitation Data for the Little Colorado Basin. 11/15 to 12/16. . . Table 2. 61
The Flood of 1919 62-64
Precipitation Data for the Little Colorado Basin. 1919. Table 3. . . 63
Floods of 1921 and September 1923 . . . 64-71
Precipitation Data for the Little Colorado Basin 6-9/21 and 7-10/23. . Table 4. 65
From 1923 to 1929 72-76
From 1929 to 1937 76-85
The Flood of February 11, 1932 . . . 79-81
Summary of Conclusions. 86
Brief Bibliography. 87-92
Plates 1 to 9 follow page 92.

LIST OF PLATES

PLATE 1.

The Little Colorado River Basin.
A map showing principal streams, routes of expeditions, location and elevations of weather stations, important ruins, etc.

PLATE 2.

Successive Courses of the Little Colorado River Near Cameron, Ariz.
Portion of an original map by Parry Reiche. 1936.

PLATE 3.

Effect of New Ways of Living on the Population of Northern, Arizona.
A graph. After Harold S. Colton. Science, October 16, 1936.

PLATE 4.

Annual Precipitation in the Little Colo. River Basin Above Grand Falls.
A graph covering the period 1900-1936. By the author.

PLATE 5.

Precipitation Accompanying or Preceding Recorded Floods Since 1900.
A graph. By the author.

PLATE 6.

Flood Situation, Leupp, Arizona. April 19, 1916.
A map. By H. F. Robinson.

PLATE 7.

Proposed Protection Work from Flood Waters, Leupp, Arizona. 1929.
Works indicated upon topographic map of August 1929 by Stover.

PLATE 8.

Leupp, Arizona, and Vicinity.
A map showing channels occupied by the Little Colorado River from 1929 to 1937; dikes, jetties, pilot channels, bridge, principal buildings, etc.; also topography as determined by Stover in 1931, dates of construction of protection works, surface levels since 1931, etc. Compiled by the author.

PLATE 9.

Leupp, Grand Falls and Tolani Lakes Area of the Little Colo. Basin.
A map prepared by R. M. Oaks from Fairchild Photo-mosaic and showing features of particular interest to this report.

CV-6417-201 NN001823

I N T R O D U C T I O N
(To be read!)

Like Topsy, this report "just growed". Many months ago we sat down to write a paper on the Misbehavior of Pilot Channels in the Vicinity of Leupp, Arizona. We felt that it might be both interesting and valuable to begin our presentation with a brief historical sketch in which we would point out the chain of events leading up to a situation which seemed to necessitate the construction of those channels. In short, we would prepare a background against which our report could be seen more clearly.

That the overgrazing following the arrival of the Hashknife and other cattle outfits in the late 1880's and the early '90's was almost entirely responsible for the erosional plagues which sicken the Little Colorado Valley at the present time, we had not the slightest doubt. We recognized that this condition had been aggravated within the Hopi and Navajo Indian Reservations by prolonged and flagrant violation of Nature's rules of the range on the part of native shepherds. The oldest living residents assured us that northern Arizona was a stockman's paradise in the early '80's, and that from Winslow to Grand Falls, or anywhere else, the grasping fingers of arroyos were unknown. Cattlemen assured us that sheep had ruined the country. Sheepmen were equally certain that cattle were to blame. Being neither the one nor the other we found it easy to remain neutral, and pronounced them both guilty.

We believed that they were truthful when they told us of that stockman's paradise which was the northern Arizona of the '80's. We believed them, too, when they said that overgrazing was responsible for the spoliation of the land. We concluded that before the coming of the vast hordes of livestock northern Arizona had always been a paradise, and that it would be so today had they never come.

With minor and unimportant reservations we still believe the stockmen, but we are confident that our conclusions were false! We no longer blame the greed of shepherds or the hooves of hungry creatures for all the grief which has befallen. Now we know the Little Colorado Basin has been ailing with chronic erosion for at least four centuries, and perhaps for that many millenia. In the early 1880's it was enjoying a season of rare good health. Today it is suffering from a major relapse. It has been quite as desperately sick many times before, and has recovered. It will again. History, written and unwritten, tells us that.

When we began to write we hoped to be able to go back 60 years with the story of the Little Colorado Basin. We have gone

back a hundred times that far, almost with confidence, and have had a glimpse of what took place 5,000 times that long ago! From lava flows and cinder beds, from ruined walls and broken jars, from tree rings and ancient legends, from diaries and wagging tongues, from musty files and stranded trees has come a wealth of history we thought was lost. It is as if the pieces of a gigantic picture puzzle had been scattered far and wide. A part of these we have gathered up, and fitted together. In the following pages we present to you our idea of what the original was like. We now find ourselves with a background, but no report to view against it! That paper, we trust, will be written at some later date.

Realizing, as we do, that our former ideas regarding the history of the Little Colorado Basin are widely held, and that those ideas are based upon a major premise which is, at best, only a half-truth, we feel that this paper is far more important than the one we set out to write. Erosion control in this area presents a problem which is not going to be solved by the mere elimination of the evil of overgrazing, as many would have us believe. Such beliefs are wishful thinking -- nothing more. Arroyos were cut time and again before stockmen came into the basin. How, then, are we justified in assuming that the reduction or even the complete removal of livestock will effect a permanent cure? Certainly it will help. Of that we have not the slightest doubt. But until we grasp the fact that overgrazing is only one factor, and possibly not the most important one, we have no adequate conception of the complexity of the problem which must be solved before an effective program of erosion control -- or flood control for that matter -- can be worked out.

The greatest flood of modern times followed upon the heels of the Little Colorado's "golden age". Arroyos were being cut when grass was magnificent. Vast areas were overrun by sand dunes, or but scantily covered with grass, nearly four centuries ago. Such are the facts which history presents. Because such information has not been readily available, much recent thinking has been shallow. In this respect we have been as guilty as any. By concentrating in this paper a mass of historical evidence, both old and new, we hope to supply a foundation upon which clearer, deeper thinking can be done. We have been chiefly interested in that part of the valley which lies below Holbrook, and most particularly in the region immediately surrounding Leupp. Much of our material, however, will be found to be of far more general interest than these limitations seem to imply.

Particular pains have been taken in piecing together climatological data gathered since 1900, and an attempt has been

made to discover the underlying causes of all recent major floods. Our studies have proved conclusively that the cutting of arroyos in the Corn Creek Basin resulted in the formation of a ~~delta~~ fan in the valley of the Little Colorado River above Leupp, and that this delta has been the largest single contributor to the flood danger at Leupp. We hasten to add, lest we be misunderstood, that this fact has been recognized by practically every investigator for the past ten years. We have been able to show for the first time just how important this delta is by presenting evidence which proves that during the last seven years, when Leupp has been repeatedly menaced by floods, the annual precipitation has been below normal five times and slightly above only twice. Before July 1929 floods of approximately 30,000 cfs passed almost unnoticed. Since that time floods of less than 10,000 cfs have looked really dangerous. With the probable exception of the flood of February 11, 1932, and the possible exception of those of August 1936 and February 1937, Leupp has had no floods, since it has been protected with dikes, which would have been even slightly dangerous before 1927. We believe it entirely possible that even these floods would have passed harmlessly.

For reasons which we have presented fully in this report we believe that, while it now appears it would have been wise to have abandoned Leupp in 1929, that is not necessarily the case today. Improved communication, changes in the course of the river, more adequate protection by dikes, and an understanding of the conditions which result in floods all contribute to the relative safety of the town and its people.

We wish to acknowledge our indebtedness to the United States Indian Service personnel at Window Rock and Leupp for most generous help and unfailing cooperation. To the United States Weather Bureau at Albuquerque, New Mexico, and Phoenix, Arizona, we are heavily indebted for climatological data. Our thanks are due librarians at the University of Arizona, California Institute of Technology, The Southwest Museum, and the Pasadena Public Library for the interest they have taken in making available many rare volumes for our use. To Dr. Parry Reiche, Mr. John C. McGregor, Mr. William S. Young, Mr. William Williams and Mr. David Ward we owe thanks for many helpful suggestions and much valuable information. The 9 plates presented with this volume have been drafted, often under considerable difficulties, by Mr. Robert M. Oaks whose skill and keen interest we deeply appreciate.

H. S. B.
Soil Conservation Service
California Institute of Technology
April 29, 1937

[illegible] "[illegible] which have been added [illegible] the volume. H.S.B.

CV-6417-201 NN001826

THE LITTLE COLORADO RIVER

The Little Colorado River is one of those streams so typical of the more arid parts of the Southwest -- a raging torrent today, almost dry tomorrow. Throughout its entire length from the Continental Divide in northwestern New Mexico to the Grand Canyon in northcentral Arizona its course is northwesterly. Its tributaries reach northward to the Kaibito Plateau, Black Mesa and the Defiance Plateau, southward to the San Francisco, Mogollon and White Mountains, and eastward to the Chuska and Zuni Mountains.

The drainage basin of 25,900 square miles is, in general, a high plateau which lies more than 4,000 feet above sea level. Average annual precipitation varies widely from station to station within the basin. Tuba City, the driest, has slightly less than seven inches, while Flagstaff, the wettest, has almost twenty-three. The average for the entire basin is about twelve inches. Although much of the area drained is composed of rolling plains, run-off is excessive because of thin soil, scanty vegetation and exceedingly severe storms. Huge quantities of silt are carried away in the brief but violent floods which follow every period of heavy precipitation, a characteristic which lead Oñate to call the stream the Rio Colorado in 1604. (33a)

Geological History

There seems to be no doubt that the Little Colorado River occupied much the same course in Pleistocene times that it occupies today, despite numerous local changes in its channel due to uplifting, faulting, and several invasions of its earlier entrenchments by flows of lava.

Dr. Parry Reiche, Regional Geologist with the Soil Conservation Service, has generously pointed out to us some of the major changes which have taken place immediately below Cameron, Arizona, where the river is now entrenched more than 100 feet in a sheer-walled canyon. Here for several miles a former canyon of the river was filled with a flow of lava from an undetermined source toward the south. Into this lava was cut a new channel about 60 feet in depth before uplifting and extensive faulting created a small graben valley which intersected this second channel practically at right angles. Subsequently the present gorge was formed, probably by the union of several former tributary ~~streamcourses~~ gorges.* The entrenchment of the channel in the lava may have been accomplished in pre-Pleistocene times. In places it has been completely filled with gravels produced by the disintegration of the Shinarump Conglomerate, a formation of the Upper Triassic. In 1934 bones of an elephant -- tentatively identified by L. F. Brady of the Museum of Northern

* Correction in order of events made at suggestion of Parry Reiche

CV-6417-201 NN001827

Arizona as E. columbii -- were taken from these gravels, making it quite certain that the filling was Pleistocene. (41a) Plate 2.

In more recent times a flow of lava entered the canyon of the Little Colorado between Leupp and Cameron. This flow came from the west through a tributary canyon (19a), formed a dam over a mile thick in the main canyon and then overshot it about half a mile. The depth of the canyon then, as now, was approximately 125 feet (19a), and it extended upstream for an undetermined distance. There is, however, evidence to support the belief that it reached at least to Leupp where the domestic water supply comes from four wells sunk to depths of from about 70 to slightly more than 100 feet in what seems to be this former channel. Two miles below Leupp the Canyon Diablo Bridge was built on a site where bedrock could not be found, although the neighboring Ashurst Bridge has abutments which rest on Kaibab limestone. Certainly this indicates the presence of a former canyon. Traces of even deeper entrenchment have been found as far east as Gallup (19b), but this does not justify the assumption that the canyon was unbroken from the Grand Canyon to the New Mexican headwaters.

It would be interesting to know the exact date of the flow which created Grand Falls. It is one of utmost importance in the history of the site of Leupp, and possibly of those of Winslow and Holbrook as well. Had there been no such flow, there would be no flood or silting problems to attract our attention at Leupp today.

Geologically we may safely date Grand Falls as Recent. We have been able to discover no legends among neighboring Indian tribes dealing with their origin. The flow which formed them, therefore, must have taken place in prehistoric times. We admit that such answers are too vague to give much satisfaction.

However, we may attack the problem from another angle. What changes, let us ask, have taken place since the lava dam was formed? There are two conspicuous ones. Above the falls the former canyon has been completely obliterated by silting as far as Holbrook, with the conspicuous exception of a short section which was entrenched through an anticline in the Kaibab limestone immediately below Tolchaco, and again less conspicuously between this anticline and the falls. Observations of silting in modern reservoirs makes it appear that this would have taken no great length of time even if the Little Colorado of earlier days had carried only a small portion of its present burden of silt. While it is probable that such "clear water" periods did exist formerly, it is certain that there have been times when erosion was quite as rapid as it is today. During the present century the river has been rather steadily aggrading, but it would be dangerous to assume that this process has continued unbroken since the damming of the canyon.

Reiche calls this final sentence "pure helium" i.e. "balloon juice". I still insist that it there had been no lava flow there would be a canyon over 100' deep at Leupp today, and ∴ no flood problem. all

Reiche has since accepted the ancient canyon as something more than my own "wild-eyed hypothesis" as he once called it. Such acceptance is tough on his "pure helium" statement.

WR

What proof, on the other hand, is there that present agradation is not the culmination of that primary silting cycle? Pottery sherds are fairly abundant throughout the length of the Little Colorado. From these it is possible for the trained student to assign rather accurate dates for the occupation of any particular site. Thus we learn that the area surrounding Leupp, for instance, supported a small population during the eighth and ninth centuries, and a considerably larger one in the twelfth and thirteenth. The people who lived there were farmers, and it is obvious that the arable lands of those days bordered the river closely on both sides, being the more abundant on the northeast. From this we may conclude rather confidently that the former canyon had silted up to approximately the present level before the eighth century, otherwise the water-table would have been entirely too low for successful farming. Low mounds and slightly elevated benches in the vicinity are plentifully supplied with sherds, and allow us to assume that they were occupied because they afforded protection from floods since they could have given no possible protection from enemies. It is interesting to note, in passing, that the flood of February 8, 1937, inundated a small area in which eigth century sherds are common on the surface, indicating that modern bed levels may be slightly higher than those of twelve centuries ago.

From approximately 700 to 900 A. D. we may picture the most favored spots along the Little Colorado as being green with small fields of corn, beans and squash. A few centuries later, when the agrarian population was much greater, there sprang up many villages and "corn camps" on neighboring natural mounds and low terraces -- the homes of industrious farmers who may have depended partially upon occasional floods to insure a sufficient supply of moisture for their crops. The lava flow which created Grand Falls also made this miniature "Nile Valley" possible.

As we shall see later the most recent period of violent volcanic activity took place in this area at about 885 A. D. Lava flows of that outburst did not come within a dozen miles of Grand Falls, but volcanic ash from this eruption did reach them and entered a small dwelling where it was recently discovered by John C. McGregor of the Museum of Northern Arizona. (37a) This building is so situated that it can be definitely stated that it was constructed after the lava flow created the falls, while the ashes it contained gave equally positive proof that it was built before the eruption of 885.

We may say, then, with certainty that the lava flow which created Grand Falls took place before 885 A. D.; that it took place early enough for the canyon it blocked to become silted to the point of complete obliteration, making farming possible in the Leupp

G.F. Lava Flow elevation is almost 4600' The Little Colo again averages a 5'/m drop. I still think I'm right. RMW

Reiche expresses doubt that Grand Falls Lava Flow had much to do with silting as far east as Leupp. Winslow to Leupp via the river is about 30 miles. Winslow elev. 4848. Leupp 4700. Little Colo. drops 5'/mile. Leupp to G.F. via L.C. 20 mi. Drop about 100' since

WR 10

Reiche wants names. We have no desire to embarrass anyone. Bell

area as early as 700 A. D.; that since this silting is known to total approximately 125 feet at Grand Falls and at Leupp, probably not less than one nor more than five centuries were required to accomplish it. By such reasoning we arrive at the conclusion that the falls were formed not later than 600 A. D. and possibly as early as 200 A. D. We are assuming, however, that farming was carried on in the Little Colorado Valley just as soon as it became possible, and in proof of this assumption we have not one shred of evidence. As a matter of fact we believe that farming was possible long before the birth of Christ.

We have stated that there are two conspicuous changes which have taken place since the formation of Grand Falls. Silting and obliteration of the former canyon is the first of these. The second is far less spectacular, but, since it is continuing today, could be made to yield far more dependable results. ("hypotheses", Reiche)

Reiche objects that "the conclusion" is based on too many "probablys" to mean anything. We are inclined to agree wholeheartedly. Bell

It has been pointed out above that the Grand Falls lava flow extended for about half a mile beyond the canyon it filled. The river was thus forced to find a new course around this obstruction. Almost immediately the new channel reached bedrock, which happened to be the rather resistant Kaibab limestone. At the present time entrenchment has progressed to a depth of approximately 5 feet. We are informed that it has been estimated, supposedly by geologists, that this entrenchment is taking place at the rate of approximately 1 foot in a thousand years. Allowing for an error of 50% either way in such an estimate, (which might be more accurately termed "guesstimate") we may date the formation of the falls as not earlier than 8,000 B. C. nor later than 600 B. C.

Whatever the date, it seems reasonably certain that floods in the valley of the Little Colorado are of long standing, from the viewpoint of the average citizen. As we shall see later, events of the past two or three decades have resulted in serious, although definitely localized, flood problems. This situation might lead to the belief that the flood history had recent beginnings, instead of being almost as old as the falls themselves.

Herbert E. Gregory has written, "From a point near Winslow to Tolchico the valley is flat and broad and the flood plain attains a width exceeding a mile. The form of the valley in this meandering stretch is doubtless due to the anticline bisected by the river at Wolf Crossing." (19a)

This anticline is the one to which we have previously referred as containing the only section of the former canyon above Grand Falls which has not been obliterated or rendered inconspicuous by silting. At first glance the statement quoted above may seem to contradict our contention that the lava flow which dammed the canyon six miles below the anticline is the factor of greatest importance in determining the levels of today's channel. We are

CV-6417-201 NN001830

justified, we believe, in going into the matter in some detail so that a rather clear picture may be presented.

In the first place let us recall that 5,000 years, more or less, have been required for the Little Colorado to cut through about five feet of Kaibab limestone at Grand Falls. The anticline is also of Kaibab limestone, and yet the entrenchment here is certainly not less than 100 feet and may be more than twice that figure.* As we look at the area today the river seems suddenly to enter a canyon, but a canyon through a hill which rises above the surrounding country. It is almost as if we had placed a loaf of bread upon a table, then cut a single slice from the center of the loaf. Through the place where the slice is missing, the river runs. The slice, however, is rather narrow and during the greatest flood of modern times water was forced around the end of the "loaf". That being the case, we naturally ask why the river should have cut through the anticline instead of having cut around it.

It has been assumed by some that the anticline is still forming, and that the river has been able to cut through it just as rapidly as it forms, and thus has not been forced to detour. The chief objection to this very fascinating theory is that it isn't true. There has probably been little if any change in that anticline since Cretaceous times -- and that was a long time ago even to a geologist. (41b) If the anticline is still forming as rapidly as it is being cut away it becomes rather difficult to explain the origin of two gravel hills of Pleistocene age which stand on the flood plain about three or four miles below Leupp, and minor difficulties arise in explaining why the ancient channel at Leupp should be quite as deeply entrenched as the modern one below Grand Falls.

If, however, we assume that the anticline was completed during the Cretaceous, we are confronted by no particular difficulties. For the sake of simplicity let us assume that the river actually does cut through the Kaibab limestone at the rate of a foot in a thousand years, and that at the anticline it has cut through approximately 200 feet of that formation. That allows us to picture the Little Colorado as working at the task of clearing away the fairly soft Moencopi formation, about 200,000 years ago, when it laid bare the top of our anticline of Kaibab limestone, which was relatively very hard. It was already firmly entrenched in the Moencopi, and was therefore forced to go to work on the Kaibab. Give a stream enough abrasive and sufficient water and the things it can do to even the toughest of limestones are amazing. Upstream from the anticline were great areas of Shinarump Conglomerate which would make excellent abrasive material. Upon this fine supply the river seized, but even so, the task required much time and patience. Gradually the broad valley which Gregory has described was created as the river searched incessantly for more

* More recent field investigation makes it appear that this entrenchment may be very close to 300 ft. Rail

material with which to cut away the anticline. At the end of 200,000 years it had cut 200 feet through that anticline and was grinding its way along the bottom of a canyon cut through what seemed to be a hill. So great had been its demands for materials that the softer formations upstream had been carried away until the remaining canyon walls were little more than half as high as those at the anticline. Then came the great flow of lava which filled and overshot the canyon, creating Grand Falls. Silts quickly filled and obliterated most of the former canyon. Today we see only the top portion of the canyon through the anticline, two hills of Shinarump gravels abandoned below Leupp, and an anticline laid bare by the wind and the rain of the ages so that great floods may go around as well as through it. The river is now "hung up" at Grand Falls quite as it was by the anticline in the long ago.

It is apparent from all the information we have been able to gather that there have been no changes of gr at physiographic importance in the Little Colorado Valley during the entire Christian era. To be sure there seems to be ample evidence for the belief that the present orgy of exceedingly rapid arroyo formation in tributary streams is only a repetition of one or more similar periods since the birth of Christ. During such times extensive aggrading in the channel of the major stream would be expected, followed by prolonged periods of much slower degradation. We see no reason to doubt that periods of accelerated erosion in the past resulted in local flood situations similar to the one at Leupp at the present time. It is entirely possible that bronzed farmers in the tributary valleys found their farmlands worthless because of lowered water-tables, while their brothers along the main stream had their crops drowned by floods or smothered with silt. We know that check-dams were constructed, possibly to destroy the all-devouring appetites of the demons of erosion who create arroyos. Such dams still exist in both Arizona and Colorado.

As history repeats itself today we find ourselves better armed for the battle, an advantage which is largely offset by the greater size of our communities, and a seeming lack of ability to choose sites wisely. Holbrook, Joseph City, Winslow, Leupp -- all are dangerously, almost foolishly, located. Such conditions are not limited to the valley of the Little Colorado, as recent history in the Middle West and along the Pacific Slope has amply demonstrated.

EARLY OCCUPANTS OF THE LITTLE COLORADO BASIN

Wild and woolly have been the guesses as to when man first entered the great Southwest. As yet there is no really definite answer to the closely related problem of when the first adventurers from Asia crossed to the dim American shores. Dr. N. C. Nelson has recently pointed out that they probably arrived somewhere between 5,000 and 10,000 years ago, and brought with them the partially developed culture of the Neolithic period. (38a) Dr. Aleš Hrdlička also makes it clear that this event was probably a post-glacial one, and that it was accomplished most probably by water rather than by any bridge of land connecting Asia and America. He is convinced, also, that there was no one great migration of man to America, but a great many minor migrations over a long period of time. (25a) Dr. H. J. Spinden indicates that this migration took place during Neolithic times, and shows that all great civilizations of the New World sprang up after the development of dry land agriculture, somewhat less than 6,000 years ago. (48a)

While it is granted that recent discoveries, including those at Folsom, New Mexico, and at Lake Agassiz, Minnesota, may eventually alter these views we are inclined to accept them, at least for the present.

In any event it is ~~It becomes~~ obvious, ~~then,~~ that man, having originated in Asia, could not have appeared in northern Arizona without first having arrived in America, an event which took place in the not too dim and distant past. In a recent letter to the author, Mr. John C. McGregor of the Museum of Northern Arizona said, "The first people that I know of, either in the washes or the main river, (Little Colorado) are B. M. III. They (Basket Makers) were only semi-sedentary, but certainly practiced a casual sort of agriculture. Actual dates from this period are the most vague of all, (for the Little Colorado below Winslow) but I can place their occupation as probably late in the sixth century." (A. D.)

Spinden shows that this culture seems to have made its appearance along the Colorado River in the area in which the Arizona-Utah border is intersected by the river, and up the San Juan, at about 2500 B. C. (48a)

In Dr. Nelson's article, cited above, is this interesting description of the cultural attainments of the Basket Makers: "The remarkable thing about this culture stratum, as now known, is that although it may be 3,000 or 4,000 years old, and is at least part devoid of pottery, and almost if not quite devoid of maize, positively lacking in bows and arrows, in chipped stone arrow points, grooved axes, etc., it is at the same time rich in basketry, in textile work -- especially ornate sandals; in wood work --

CV-6417-201 NN001833

including spears and spear throwers; in ordinary bone work; in polished and drilled stone work, as for example beads, pipes, etc.; and lastly in ordinary flaked and chipped stone work taking the form of lance points and knives. To these accomplishments may be added the possession of the domesticated dog and possibly the turkey. All in all, such are the taste and skill displayed by these primarily hunting folk that, however distant they may have lived in time, their achievements rest on long prior developments not yet discovered. Moreover, from the manner in which maize culture and ceramics gradually developed among them and their successors, the Pueblos, it seems probable that the Basket Makers were from the start subject to influence from more advanced cultures in the south." (38a)

It is at least probable that Basket Makers had reached the Little Colorado Basin at the beginning of the Christian era, and possibly a century or two earlier. Since they were essentially hunters they must have been few in number. From studies made long since by Sir John Lubbock, (58a) Schoolcraft and others, it has become apparent that in a semi-arid country approximately 75 square miles of land are required for the support of each individual if hunting comprises the sole means of subsistence. If such is actually the case, then the entire watershed above Grand Falls could have supported only about 300 hunters!

Dr. Harold S. Colton, Director of the Museum of Northern Arizona, has made an extended study of the prehistoric population in the area under discussion. Pointing out that the numbers doubtless fluctuated with the relative abundance or scarcity of the game supply, he estimates that during the early centuries of occupation the population varied between two and four people to each 100 square miles. (8d) Such figures would be possible only if the food supply was supplemented by some feeble attempt at agriculture, if we are to accept the land requirements as stated by Lubbock and Schoolcraft.

Throughout the sixth century, and for the next 500 years or slightly more, the population was increasing rapidly in Northern Arizona. During most of this period the rate was between one and two per cent per year. Only one thing could make this possible -- the introduction of agriculture. As Mr. McGregor has pointed out, it was only "a casual sort of agriculture", but sufficiently effective to allow a rapid increase in population.

"Our studies show us", says Dr. Colton "that the population of Northern Arizona increased seven fold between 600 A. D. and 1100 A. D. This was (made) possible by the introduction of agriculture, together with the custom of families living in isolated houses."

The coming of corn, beans and squash allowed the use of lands which were not plentifully supplied with game. Between 700 and 800 A. D. corn was being grown on both sides of the river in the immediate vicinity of Leupp, if the testimony of the pottery fragments collected in that area is true. There is little reason to doubt that similar farms were scattered from Grand Falls to Holbrook and beyond. Barely a half mile above Grand Falls there was built, during this period, the small dwelling already referred to as so recently excavated by Mr. McGregor.

Dr. Colton points out that the sites at this time, and for nearly a century longer, were clustered close to the peaks -- the San Franciscos -- and that at the close of the ninth century they spread from the peaks to the Little Colorado River, for reasons which we shall consider shortly. (8b) It is interesting that during the three centuries from 600 to 900 the stone type of house, as well as other characteristic features of later centuries, were being perfected. (44a)

This architectural progress seems to have lagged far behind in the Little Colorado Basin immediately above Grand Falls and the neighboring mountainous area. Mr. McGregor, let us recall, says that the Basket Maker III culture reached the Little Colorado late in the sixth century, at about the time Dr. Frank H. H. Roberts, Jr., indicates Pueblo II culture began in the San Juan drainage. (44a) Thus it seems that the people in this area were 300 years -- an entire cultural stage -- behind the times. They were the "hill-billies" of their age.

There must have been good and sufficient reasons for this cultural lag -- reasons which were far more obvious then than now. It has been shown by numerous investigators that Pueblo agriculture was and still is essentially "dry farming", although irrigation in its various forms has been used in numerous instances almost from the beginning of farming in the Pueblo country. In either case the best results were obtained in a very light or a definitely sandy soil -- soil particularly well suited to the principal crops, as well as to the methods used.

Where conditions were most favorable, progress along agricultural lines might be expected to be most rapid. Where agricultural progress was most rapid, the population could and probably would speedily increase. This increase in numbers might soon necessitate improved housing. Instead of 75 square miles being required to support a single hunter, one square mile might support 75 farmers in comparative ease. Gaining their subsistence more easily, living closer together so that the interchange of ideas would be facilitated, the farmers would have both time and opportunity for cultural advancement which would be denied to their hunting brothers.

We are tempted to infer, then, that conditions in the Little Colorado Basin were less favorable than were those along the San Juan. An investigation bears this out in areas close to the two rivers, for the alluvial deposits along the Little Colorado are frequently extremely heavy, and definitely unsuited for dry farming. Yet, as we approach the San Francisco mountains, the last stand of Basket Maker culture, we find rapidly increasing precipitation coupled with a light and sandy soil. On every hand we find traces of a very great population which occupied the area for the two centuries from 900 to 1100 A. D. while nearby are the ruins of Wupatki, Citadel, Fewke's Ruin J, Turkey Hill and other pueblos of the Twelfth and thirteenth centuries. An area which had been able to support only a score of people when Christ was born, and perhaps only 50 or 60 in the sixth century after hundreds of years of crude attempts at agriculture, apparently was supporting a population of more than 4,000 in the early years of the eleventh century, while the population of the whole of Northern Arizona in the same period had increased from less than 1000 to more than 23,000. (8d) The beginning of the twelfth century found the Arizona "hillbillies" still trailing culturally, but in architecture, at least, the lead had been cut in two. The builders of Wupatki were only a little more than a century and a half behind those pioneers who built Pueblo Bonito in Chaco Canyon.

It is not possible to notice such great changes without asking what caused them. Naturally we think first of improved agricultural methods, then of climatic changes involving increased precipitation and more favorable temperatures. The truth is that neither of these factors was of any great importance in this case, but that almost overnight Northern Arizona received approximately 1000 square miles of new soil, practically "custom built" to the specifications of the dry farmer.

How? We know not only how, but, thanks to the tree ring studies of Dr. Douglas and Mr. McGregor, we also know when. After several years of study Mr. McGregor has arrived at the conclusion that in the year 885 A. D. (± 25 years) a volcano now know as Sunset Crater, burst suddenly into action and spread a layer of ashes, volcanic sand and small cinders over an area of nearly 1000 square miles. Much of this area had previously been bare Kaibab limestone, or this same formation covered all too sparingly with soil, so that, for centuries the run-off had been exceedingly rapid. Agriculture had been quite impossible except in a few small areas.

The eruption of Sunset Crater changed all this. The thirsty volcanic soil drank up every drop of rain which fell upon it. There was no longer any run-off. But the new soil had another advantage. It was both a sponge and a mulch which prevented the rapid evaporation of the moisture it imprisoned. It was black and thus was able

to make the most of the heat which fell upon it. Small wonder that farmers came even from far away southern Arizona to revel in this new paradise, or that the story of the eruption survives today in Hopi legends.

According to Dr. Colton, "Pottery studies show us that between 950 and 1100 people flocked into this area from all about, and a survey of sites indicates that for two centuries the Flagstaff area held one of the densest rural populations in northern Arizona. Although some people seem to have come in from the west, the major migrations were from the north and from the southeast. These newcomers almost swamped the original settlers of the region. They brought in new ideas and methods of making things. -- The population of the San Francisco Mountains area between 1100 and 1200 must have formed a very cosmopolitan group." (8d)

In the opinion of Mr. McGregor the eruption also brought about a very brief increase in the population in the Tolchaco area below Leupp. This, he points out, was due to a rather thin blanket of ashes which, during the short time it remained, made agriculture possible along the river. As soon as the ashes had blown or washed away there was doubtless a migration of a few miles to the more heavily covered areas in the foothills. The Hopi or Tusayan Washes seem to have been sufficiently favored with soil and moisture to have retained their farmers against the pull of the new lands, but the less attractive areas along the river were doubtless soon abandoned, and only a few of the finest sites held their people.

Despite the fact that large communal dwellings were being constructed in New Mexico as early as 919, the Indians of northern Arizona continued to live almost wholly in scattered houses only large enough for single families until the middle of the eleventh century. In other words they lived very much as the Navajos live today, and so long as they did they increased mightily in numbers. Then came the pueblo type of dwelling, and an essentially rural people found themselves suddenly leading the life of city slums, without the faintest ideas about sanitation. Almost immediately population fell off at a rate practically equal to the one at which it had increased for at least five centuries, a decrease which continued almost to the beginning of the present century, at which time there were fewer Peublo Indians in northern Arizona than there had been Basket Makers in 600 A. D. It was not drought, or migration, or war which caused all this. It was disease -- disease made possible by a change of architecture! (8d)

This rapid decrease in population quite naturally brought about a shrinkage in the occupied area due to the abandonment of peripheral sites -- marginal lands, if you prefer. There was, very

truly, a rush of the rural population into the fashionable apartment houses of the 12th century. Social life and elaborate religious ceremonies served as flames to attract the moths. Those pestilential pueblos grew by accretion -- not by healthy increase from within themselves, but by steady additions from surrounding rural districts. Their growth was essentially the same as the growth of American cities in the 19th century when urban populations were maintained and increased in the face of plague and pestilence only because they could draw heavily upon rural reservoirs of humanity.

A study of tree rings allows the archaeologist to say with reasonable certainty that Wupatki Pueblo, a few miles from Grand Falls, was started in 1087 and completed in 1197. Thirty years before it was begun the population of northern Arizona was nearly 25,000. Thirty years after it was completed there were about 12,500 people in the same area.

Slowly but surely the strong winds and violent rains, characteristic of the Little Colorado Basin, managed to bring about the destruction of large sections of the volcanic blanket which had made agriculture so successful in the area between Leupp and the San Francisco mountains. Millions of tons of this vital top-soil were blown or washed into deep canyons and carried away to the Little Colorado -- a process which continues to this day. In other areas the light sands were whipped relentlessly into dunes which swept northeastward into the valley of the river.

Possibly the arrival of these dunes in the Leupp area sometime after 1100 accounts for the apparently dense population of this region from approximately 1150 to 1250 by making agriculture temporarily successful there. Dozens of acres of pottery, chiefly along the northeastern bank of the river, tell us that such a population was certainly there. As yet we have had no sufficient opportunity to study the evidence which is presented by the pottery sherds, and the dates suggested above must not be accepted as definite. Walls are as lacking as broken pottery is abundant, a fact which suggests that these sites were occupied largely, if not entirely, as "corn camps" during the growing season, and that the farmers had pueblo homes situated nearer an abundant fuel supply for use during the inclement months.

Eventually the conditions which made farming in the Leupp area so attractive were changed, possibly by the migration of dunes, decreased precipitation, or a shift in the course of the river. Perhaps further decrease in the total population made more desirable lands available, and the Leupp area was abandoned for that reason, rather than because of any major change in local conditions.

This we do know. In the year 1277 there began one of the most terrible droughts northern Arizona has ever known -- a drought which cursed the country until 1300. The main population left the river and migrated into the tributary valleys or toward the headwaters and the southeast. Before normal precipitation returned again the magnificent pueblos now known as Betatakin and Keet Seel were abandoned even as they were nearing completion. Betatakin was begun in 1260 and work stopped with the beginning of the drought in 1277. Keet Seel was started in 1274 and probably abandoned soon after building was halted in 1284. No finer cliff dwellings were ever constructed in northern Arizona.

It now seems almost certain that these two groups moved southward into what we now call the Hopi Country. According to Dr. Colton's estimates the population of the Hopi area increased almost four fold between 1275 and 1400. As the 15th century opened at least 3,500 people, one half the total population of northern Arizona at that time, were concentrated in this small area. (8d) In 1370 Oraibi was begun, and twenty years later building was started at Shipaulovi and Shongopovi. In 1410 Kokopynyama began to rise in the Jeddito drainage near Kawaiku which was already 125 years old. (8d) Mishongnovi, Hoyapi, Walpi and Chuckovi all were enlarged by additions from pueblos far to the north. "The Jeddito pueblos", writes Dr. Colton, "were swelled by accretion, perhaps from the Chinlee Valley, Rio Pueblo Colorado and Puerco drainages, so that from Kokopynyama to Awatovi 5 great towns flourished with a total population of over 3,000.

"By 1400 the only settlements north of the Tonto Rim were on the Hopi Mesas, in the Jeddito, in the Hopi Buttes, in the Petrified Forest, in the White Mountains, in the Verde Valley, besides those on the Little Colorado near Winslow and in Chavez Pass. These were great towns, many of which must have had hundreds of persons each. It was a period in northern Arizona of an artistic revival. It was then that the finest textiles and the best pottery was made. Except on the outskirts it was not a period of decadence, as Kidder and others maintain.

"But the shrinkage of the population continued. After 1400 and before 1540 another big migration occurred, marked by the abandonment of the Verde Valley, Chavez Pass, Winslow Pueblos and the probable absorption of the remnants by the Hopi.

"Hopi tradition still remembers this migration, for they tell how the people of Homolovi, by the Little Colorado near Winslow, were driven out by the mosquitoes and when they arrived at Shungopovi the people stood on the housetops and said, 'Here come the "mosquitoes"'. They finally settled at Shipaulovi, and Shipaulovi, meaning the place of the mosquitoes, commemorates that migration of the 1400's." (8d)

So it was that the Spaniards found these people in their little cluster of towns in 1540, when in July of that year Don

Pedro de Tovar sought them out at the command of the great Francisco Vasquez Coronado, and killed a few of them by way of impressing them with the might of Spain. He found them growing much cotton, beans, corn and squash. The Spaniards were impressed with the neatness and cleanliness of the Hopis. In view of the fact that the decline in population of the pueblos continued at about the same rate it had previously, we are inclined to wonder if the incident does not tell more about the contemporary ideas on sanitation in Spain than it does about the Hopis.

In 1583 Antonio de Espejo visited the villages and was given a present of three or four thousand cotton blankets, and other cotton goods. (16a) We shall find it profitable to review the history of the Spanish in northern Arizona rather carefully.

THE LITTLE COLORADO BASIN UNDER SPANISH RULE

In May, 1539, the Little Colorado River was discovered by Estevancic, possibly the most famous negro traveler the world has ever known. In the middle 1530's he had accompanied Álvar Nuñez Cabeza de Vaca on an astonishing journey from the Atlantic coast of Florida to the Pacific coast of Mexico.

Stirred by the tales of the great cities of Cíbola of which Cabeza de Vaca had brought word, Mendoza, first Viceroy of Mexico, had sent Fray Marcos de Niza, an Italian who had become Vice-Commissioner General of "New Spain", to search for them in the spring of 1539. Estevancio accompanied the friar as guide and interpreter. After a time the negro went ahead of the Italian to search out the route to Cíbola. Ignoring all orders to wait for Niza, Estevancio hurried on and reached the Zuñi village of Hawikuh about the 10th of May. He was forbidden to enter the pueblo under pain of death, and robbed of all he possessed. The following day he was captured as he attempted to escape, while several of his Indian companions were killed, and others wounded. Later he was put to death, shortly before Niza arrived at a point from which he look down upon Hawikuh. The friar had been informed the day before of Estevancio's death, and made no attempt to reach the pueblo. He erected a cross and immediately began his return journey to report to Mendoza. The date was about May 25, 1539.

More than a year passed, and then with horsemen, footmen, negro slaves and Indians from Mexico, Francisco Vasquez de Coronado arrived at and successfully stormed Hawikuh on July 7, 1540. Surrounding the pueblo with his horsemen Coronado advanced on foot with his infantry to the attack. The inhabitants, after a preliminary show of hostility, had taken positions upon the housetops and watched the troops advance. Most conspicuous of all was Coronado

CV-6417-201 NN001840

in guilded armor with a plume on his helmet. He soon found himself the target of marksmen whose missles were not arrows but stones thrown with surprising accuracy. Knocked to the ground he regained his feet and continued the advance. Again he went down, stunned by the force of the blow according to his own account of the battle. He was twice wounded in the face and an arrow pierced his right foot. Using his own body as a shield Garcia Lopez de Cárdenas, recently appointed army master, protected Coronado from the hail of stones, helped him to his feet and guided him to safety. (9a)

Wearied by forced marches through inhospitable country, weakened by lack of food, their horses a sorry lot, their bow strings broken, the Spaniards realized they must take the pueblo or starve. They took it, and found within quantities of corn, beans, pinon nuts and turkeys, things which they "wanted more than gold" one of them wrote in a letter a few weeks later.

While he was recovering in this pueblo, which he had renamed Granada, Coronado did his utmost to convince the Indians of his friendly intentions. His success was slight, but, perhaps out of their desire to have him move on, the Zuñis told him of several great villages which he would find to the northwest. Although he doubted the truth of what they told him, he immediately gave orders for Don Pedro de Tovar to investigate. According to Castañeda, an ordinary soldier with an extraordinary education, Don Pedro took with him seventeen horsemen and three or four footmen, and was accompanied by Fray Juan de Padilla, a former Spanish soldier.

Don Pedro returned to Granada, after a brief visit among the Hopi towns, during which time he killed a number of the inhabitants, to report to Coronado that the region "contained nothing to attract the Spaniards". He had been told, he said, that there was a mighty river which flowed in a great gash in the earth beyond the villages toward the west, and that upon its banks there lived giant people.

About August 25th Don Garcia Lopez de Cárdenas started out with Coronado's authority to explore for a period of eighty days. With twelve companions he went first to the Hopi villages, probably crossing the Rio Puerco near Navajo Springs, and secured guides to take him to the mighty river and the land of the tall men. He was warned that the country to be crossed was without water, and that about twenty days would be required to reach the river.

Castañeda, who did not accompany Cárdenas, wrote a brief account of the journey nearly twenty years later. We have found no one translation of this version which seems entirely satisfactory, and have taken the liberty to combine two, adding parenthetical

CV-6417-201 NN001841

remarks of our own. "After they had gone 20 days they arrived at the gorges of the river which, (when) standing on the expanse thereof, would seem to be more than three or four leagues (roughly 10 to 14 miles) wide in an air line. (The canyon, not the river, was apparently that wide.) This country was elevated and full of low twisted pines (piñons?), very cold, and lying open toward the north, so that, this being the warm season (mid-September), no one could live there on account of the cold. They spent 3 days on this bank looking for a passage down to the river, which looked from above as if the water was 6 feet across, although the Indians said it was half a league (a mile and three-quarters) wide. It was impossible to descend, for after 3 days Capt. Melgosa and one Juan Galeras and another companion, who were the three lightest and most agile men, made an attempt to go down at the least difficult place, and went down until those who were above were unable to keep sight of them." (55a & 10a)

Late in the afternoon the three climbers returned to report that stones which, from the rim, had appeared no higher than a man were actually higher than the great tower of Seville.

Another excellent account by an anonymous writer who undoubtedly accompanied Coronado on his New Mexican campaign gives the following version. (53a) We have used Winship's translation and have added a few parenthetical remarks for the sake of clarity. "He (Cárdenas) was conducted beyond Tuzan (the Hopi country: Tusayan on modern maps) by native guides (Hopis, probably from Awatobi.), who said there were settlements beyond, although at a distance. Having gone 50 leagues (170 miles) west of Tuzan, and 80 from Cíbola (Zuñi), he found the edge of a river down which it was impossible to find a path for a horse in any direction, or even for a man on foot, except in one very difficult place, where there was a descent for almost two leagues (7 miles). The sides were such a steep rocky precipice that it was scarcely possible to see the river, which looks like a brook from above, although it is half as large again as that at Seville (the Guadalquivir), according to what they say, so that although they sought for a passage with great diligence, none was found for a long distance, during which they were for several days without water which could not be found, and they could not approach the river, although they could see it, and on this account Don García Lopez (de Cárdenas) was forced to return. This river comes from the northeast and turns toward the south-southwest at the place where they found it, so that it is without any doubt the one that Melchior Diaz reached." (Diaz reached Colorado near its mouth early in 1541, found the natives carrying torches to warm themselves during the cold weather, named the stream Rio del Tizon -- River of the Firebrands.)

Fifty years ago it was believed that Cárdenas discovered the Grand Canyon at the junction of the Colorado and the Little Colorado,

then went up the river approximately to Lee's Ferry before returning to the Hopi pueblo from which he had started out. In an interesting footnote Bancroft states, "A westward course from Moqui would have led to the Colorado at the junction of the Colorado Chiquito, where the main river turns abruptly to the N. of W. As no crossing of the branch (Little Colorado) is mentioned, and as the course of the river is given as N. E. to S. S. W., it would be much more convenient to suppose that Cárdenas went N. W. to the river, and followed it southward, but not much importance can be attached to the matter." (1a)

To us, however, the route which Cárdenas followed is of some importance. To our way of thinking "it would be much more convenient to suppose that" Cárdenas did almost exactly what the Spanish documents say he did, and by so doing allow him to arrive at the place he said he reached, where the Grand Canyon answers his description of it, where the vegetation is as he said it was, and where the river very conspicuously follows the course he described. In other words, we prefer to suppose that he crossed the Little Colorado and failed to mention it.

By air the distance from the Hopi villages to the junction of the rivers is about 75 miles, and to Lee's Ferry not over 90. Either place could have been reached by trail in 30 leagues, instead of 50. There is no doubt that the Hopis visited the junction of the rivers to obtain salt from a sacred saline near the mouth of the Little Colorado, and there are very good reasons for believing that not more than two days were required to reach that place. Yet the accounts state definitely that Cardenas traveled 20 days, and 50 leagues.

From the point of land between the rivers the Colorado is easily seen, seems to be almost beneath one's feet, and would never be mistaken for a brook 6 feet wide. Furthermore this spot is low, rather than elevated, and without timber of any kind instead of being "full of low twisted pines". Aside from the direction of the river, the Lee's Ferry area is much farther from the description of the Spanish authors than is the junction. Had Cárdenas gone there he would have been able to reach the river, and might possibly have discovered the crossing used by Escalante in 1776.

The south rim of the Grand Canyon fits the Spanish texts like a glove. From Kanab Creek to Diamond Creek, the Colorado River follows the course recorded, and it does so very conspicuously, and in its southward course points almost as straight as an arrow to that part of itself which Melchior Diaz explored. "So it is without any doubt the one that Melchior Diaz reached", says the ancient record.

From the Hopi towns to the point where the river turns conspicuously toward the south is approximately 145 miles in a straight line; roughly 43 Spanish leagues. But the character of the country did not allow straight line travel, and 50 leagues is certainly a reasonable estimate.

F. S. Dellenbaugh, who accompanied Major Powell on his memorable voyage through the Grand Canyon, long ago concluded that Cárdenas made his discovery at the spot we have chosen, but was so troubled by the period of 20 days taken to reach it that he concluded Cárdenas could not have started from the Hopi towns, but must have been guided northwestward from some group of pueblos in the Four Peaks area of New Mexico. (13b) He argues, further, that there would have been absolutely no good reason for the Hopis to have taken Cárdenas so far to the west before allowing him to look into the great chasm which he sought.

There are several facts which need to be considered. The account which gives the distance as 50 leagues was written about 1541, but Castañeda wrote in 1560 that they journey to the river had required 20 days. Surely it would have been easier for him to make a mistake than for the earlier author. Furthermore the first author was with Coronada at Zuñi at the time of the discovery, whereas Cantañeda did not reach Zuñi until months later.

Because no mention is made of the crossing of the Little Colorado, Bancroft assumes that it was not crossed. It is true that all subsequent Spanish expeditions which crossed the Little Colorado below Winslow did record the fact in more or less detail. "Circumstances alter cases", is an old saying which fits here. Cárdenas had been commanded to seek a large river, flowing in a huge gash in the earth. We believe that he crossed the Little Colorado late in August. We know his expedition was almost continually in need of water. We assume, then, that either the rainy season had passed or that it simply did not arrive in the summer of 1540. The Water-Supply Papers of the U. S. Geological Survey furnish abundant evidence that even in normal years there may be fairly long periods when the river is dry in late August or early September. Furthermore, about sixty years after the discovery of the Grand Canyon, Farfan crossed the Little Colorado and described the river as having "level banks". Is it strange, then, that an explorer who searched for and found the greatest canyon on the face of the earth should fail to mention the fact that he crossed an insignificant, dry streambed?

We are confident that Cárdenas was the first European to cross the Little Colorado between Winslow and Grand Falls. Because of the desperate shortage of water which he experienced, we are inclined to the belief that his route was north of the San Francisco

Peaks, and around the head of Havasu Canyon, as we have indicated on our map of the Little Colorado Basin. Plate I.

As to the motive which prompted the Hopi guides to take him on so long a ride before showing him the canyon he sought, several suggest themselves. Perhaps they liked to travel with such distinguished guests. Possibly they were receiving some sort of daily pay, and were guilty of a "boondoggle". The upper end of the Grand Canyon was believed to be the place where Hopi spirits entered the after-world, and possibly the guides were not anxious to meet any of their dear departed friends or relatives. Near the junction of the rivers was a salt deposit, as we have pointed out above, and it was particularly sacred. Perhaps they did not want their guests to know of this shrine.

Although Cárdenas crossed the Little Colorado late in August, 1540, he left us no record of what the river was like at that time. Not until May 1, 1583, was the river crossed again by a European westward bound. Then Antonio de Espejo, a wealthy citizen of Mexico, crossed with four companions and some Hopi guides. Espejo did very little writing until he had returned to Mexico. He tells of having crossed "dos rios razonables" (two rivers of moderate size) upon the banks of which there grew Castillian (!) flax. (16a) Coronado and others state that flax grew along the Little Colorado in 1540. A letter which he wrote to Mendoza (First Viceroy of Mexico) on August 3 of that year stated" ---there was flax, but chiefly near the banks of a certain river, which therefore we called 'El Rio del Lino'". "The River of Flax" it still was in 1858, for we find it on a map accompanying Lieut. Joseph C. Ives' report on the Colorado River of the West, where it is labeled "Flax River or Colorado Chiquito". (27a)

Diego Pérez de Luxén accompanied Espejo and kept a day to day diary, for which we may give thanks since Espejo was so careless. We quote from Hammond's translation, adding remarks in parenthesis. "We the five companions left the pueblo of Aguato (Awatobi, destroyed by irate Hopis from Oraibi, Walpi and Mushongnovi in Nov. 1700.) for the mines on the last day of April (1583), taking along with us the necessary guides. On this day we marched five leagues to a water hole which was insufficient for the horses, so they were two days without water. We named this place El Ojo Triste. (The Sad Eye. Could it have been because the spring was so small that only "tear" drops came from it?) We left this place on the first of May and marched two hours before daybreak. Overcome by drowsiness and out of consideration for the guides (!) and because of the bad road we halted midway for the siesta. We traveled ten leagues (34 miles) on this day and reached a fine, beautiful and selected (important) river, almost as large as the Del Norte, containing many groves of poplars and willows. (Still true after 1900). This river flows

from the south toward the north. It is settled by warlike mountainous people.

"We left this place on the second of the month and marched six leagues and camped at a deep stream (In a deep canyon?) where there were many large pools of rainwater which would be sufficient for a whole year. This route is rich in abundant pasture and cedar forests. These cedars bear a fruit the size of hazel nuts, somewhat tasty." (35a)

Espejo wrote, "With the four others whom I took with me I went directly west for forty-five leagues (154 miles), in search of some mines there of which they told me, with guides whom they furnished me in this province (Hopi) to take me to them. I found them and with my own hands I extracted ore from them, said by those who know to be very rich and to contain much silver." (10a)

Dr. Colton says that they crossed the Little Colorado somewhere below Leupp, and probably spent nights at Turkey Tanks, Mormon Lake and Oak Creek, then crossed the Verde and visited the present mining region of Jerome. (8a) Luxán says that the ore contained no silver, but only copper. The expedition returned in disappointment to Awatobi, and then continued to New Mexico.

Over 15 years passed before, on November 17, 1598, the great Juan de Oñate, while visiting in the Hopi villages, also learned of those same mines and gave orders for Captain Marcos Farfan de los Godos to go with eight others in search of them. We quote from Dr. Bolton's translation of the sworn statement which Farfan made upon his return to report to Oñate at Zuñi, under date of December 11, 1598. " -- he had set out with the said eight companions from the province of Mohoqui (Hopi) at the order of his Lordship in the month of November of this year. They traveled six leagues towards the west through a land of sand dunes without timber, and where the horses could not drink, although there was plenty of water for the men. (El Ojo Triste again?) Next morning they set out from this place in the same direction, and having traveled about three leagues they found a river which flowed towards the north, of moderate width and carrying considerable water, with many cottonwoods, level banks, and little pasture.

"And traveling on in the same direction they reached the slope of a mountain range in time to camp for the night, having gone about another three leagues. They camped without water, and the next morning they set out from this place; and after going two leagues they arrived at a grove of small pines and a very deep pool, which was ample to water all the horses and more if there had been more." (17a)

There can not be the slightest doubt that Farfan crossed the Little Colorado somewhere near Leupp. The description might have been written only yesterday, by the sound of it, and seems to prove rather conclusively that the conditions now are much the same as they were when Farfan crossed during the afternoon of November 18, 1598. It is interesting to note, in passing, that Farfan reached the river in 9 leagues, Espejo in 15; and that he reached the mines in 30 leagues, although Espejo went 45. It seems to be agreed by most authors that the two expeditions reached the same mines over nearly identical routes. These mines, if near Jerome, as Dr. Colton states, were a very little more than 30 leagues by air from the Hopi town of Awatobi. But our courageous explorers were not traveling by air. The fact seems to be that Farfan was very conservative in his estimates of distance, that his leagues were over five miles in length, while those of Espejo and Luxán were quite possibly a little less than the standard 3.4245 miles.

Farfan named the Little Colorado "Rio de la Alameda" -- River of the Cottonwood, (literally Poplar) -- but when his illustrious superior, Juan de Oñate crossed at about the same place in October 1604, he named it the "Rio Colorado". "They called it thus", wrote Zárate-Salmerón in 1626, "because the water is nearly red; the river runs from southeast to northwest, and they say it enters California." (57a) The place where they crossed, we are informed by the same authority, was called San José.

That was not the first time the red color had been recorded. In 1540 Juan Jaramillo, accompanying Coronado, wrote of the Rio Vermejo -- the "Red" or perhaps "Vermillion" River -- and Castañeda used the same name. It seems probable that they were referring to the branch we now call the Zuni River, and that the main branch of the Little Colorado was meant when Castañeda wrote, "From here we went to another river, which we called 'el rio Frio' on account of its water being so". (24c)

What's in a name? Sometimes there is little or nothing. Again, as here, names may speak volumes. Castañeda and Jaramillo with their Red River in 1540, and Onate with his in 1604, by the mere act of naming the streams tell us that accelerated erosion of some sort was invading the Little Colorado Basin four centuries ago, for without a burden of silt there would have been no red rivers.* Had Farfan left no other record of the Little Colorado than his name for it, "Poplar River", we could have been certain that cottonwoods grew there in 1598, and the "Flax River" of Coronado and Espejo tells its story, too.

Were there arroyos, fingering gullies cutting into the land then as now? In all the early records we find no mention of

"Not so sure. Surely the Chinle + Moencopi stretches have been barren (normally) for centuries, and no 'accelerated erosion' is indicated, since summer floods from these areas must always have been red". Reiche

them, no positive evidence. But there is one phrase in Farfan's description of the Little Colorado which gives us a reason for wondering just a little. "Level banks". Could it be that he was impressed by these level banks because they were not typical of the streams of that day? We have been told by eyewitnesses that arroyos were unknown in the Hopi valleys or along the river from Winslow to Grand Falls in 1880 and for nearly 26 years afterward. Yet [redacted]*, Mr. John C. McGregor and others have pointed out that there is [redacted] evidence of arroyo cutting and subsequent filling during Pueblo times, cycles which required less than three centuries for completion. Such evidence is not without interest in the case at hand. Farfan traveled "through a land of sand dunes without timber", to reach a river "of moderate width, and carrying considerable water", flowing through a region in which there was "little pasture". If there is anything lacking in a stage setting where a drama of rapid erosion is to take place, we fail to detect it.

When Oñate returned in 1605 from his trip to California he is said to have followed the same route he had used on his westward trip, so must have again crossed the river near Leupo. For more than a century afterward there seems to have been no Spanish explorative work carried on in northern Arizona. The Hopis accepted Christianity sometime before 1625, and three missions are known to have been built. We know that Fray Francisco Porras worked for many years among them, only to be poisoned at Awatobi in 1633. Thirty years later Governor Peñalosa visited the villages. In 1680 the four Franciscan missionaries resident there met death in the great revolt of that year. Never again were the Hopis brought under Spanish or Christian rule, although those of Awatobi did permit a friar to baptize a few children in 1700, a concession which lead to the destruction of the entire village the following November, as we have pointed out above. (1a)

During the following 75 years records are meager. There was a military expedition under Governor Cubero in 1701, and another under Captain Holguin in 1706, followed by a third in 1715. In '42 two friars visited the villages and 441 Tewas returned with them to New Mexico. Three years later two padres and a soldier visited all the towns and counted (?) 10,946 inhabitants. (1a)

It was in June 1775 (possibly '74) that Padre Silvestre V. Escalante spent eight days in the villages in a vain attempt to go beyond to the Rio Grand de Cosninos -- the Colorado. (1a) He is said to have counted 7494 Hopis at that time, and 30,000 sheep. (1ga) Evidence seems conclusive that this and subsequent journeys kept him well to the north and east of the Little Colorado.

* "Damn you anyway!" Reiche.

CV-6417-201 NN001848

Our search through the historical records of nearly two centuries is at last rewarded with the following entry in the diary of the great and good Padre Francisco Garcés, under date of June 28, 1776. "I traveled three and a half leagues ---- and I arrived at the Rio Jaquesila, and I called it the Rio de San Pedro. (Lieut. A. W. Whipple, in a brief word list from the Yuman language gives "Ha-qua-si-cel" as the name for the Gila River. Elsewhere this same word has been written "Hah-qua-si-il-la". The similarity between these two and the padre's "Jaquesila" is striking. He had recently been among the Yumas and had with him a few Indian servants. The name is definitely not Spanish except in spelling. We believe, therefore, that it is Yuman; its meaning we have not ascertained.* Padre Font's map of 1777 gives Jaquesua; Bancroft, Jaquevila.) It was running water enough", Garcés continues, "but very dirty and red, that could not be drunk; but in the pools of the border of the river there was good water. This river runs to the westnorthwest, and unites with the Rio Colorado a little before this passes through the Puerto de Bucareli. (Grand Canyon.) The bed of this river, as far as the confluence, is a trough of solid rock, very profound and wide about a stone's throw (!), and on that account impassable even on foot; wherefore with much travail did I enter into said bed of the river, following down a trough not so profound, (The graben valley discovered by Reiche, and mentioned earlier in this report?) in the direction eastnorthwest. (He had lost his compass several weeks earlier, and his directions are not always accurate.) In the afternoon, having crossed the river, and entering another similar cajon (the Moenkopi Wash) I traveled eight leagues north and east ---." (18a) Garcés seems to have been using a league of about 2.75 miles.

Padre Garcés must have left the wash and cut across country, eventually reencountering the Moenkopi, down which a sudden flood was running so that he mistook it for his Rio de San Pedro (Little Colorado). He reached the site of the present pueblo of Moenkopi, found that the Hopis from Oraibi had corn fields there, and took note of the ruined pueblo on the mesa on the south side of the wash. From there he went by way of the Hopi trail to Oraibi, where he was most unwelcome, and was refused food and lodging. He describes the Indians returning from their fields with "hoes, hatchets and and dibbles", mentions a corral in which were "about three flocks of sheep", and speaks of the great length of the Oraibi valley, with extensive fields of corn.

It is interesting to note, in passing, that Garcés began the long return journey to his San Xavier Mission, near Tucson, on July 4, 1776, on which day the Hopis requested him to depart immediately, thus declaring their independence from Spanish and Christian rule at almost the same instant that the thirteen

* "Salt River". (54b) The river is slightly brackish.

CV-6417-201 NN001849

colonies were declaring their independence from England and establishing a new nation in which there could be religious freedom.

November of the same year found Escalante returning from exploring Utah in an attempt to find a new route to the California Missions. He received food but no shelter from the Hopis.

In September, 1780, Juan Bautista de Anza, Governor of New Mexico, having heard that the Hopis were in desperate straights, set out from Santa Fé to give them aid and make an earnest effort to obtain their submission to the Spanish crown. Word had come that forty families were willing to be moved to New Mexico if he would personally supervise their migration. Accompanied by Fathers Fernandez and García and a military escort, he visited all the towns, finding two of them completely abandoned. Upon his arrival he learned that, just fifteen days before, the forty families had been driven by hunger to go into the Navajo country. The men were killed; the women and children enslaved. Conditions in the villages were almost unbelievably bad. For three long years there had been no rain. Of the 7494 people Escalante had counted in 1775, there remained only 798. Deaths were said to have totaled 6698 because of the combined inroads of famine, small pox and Navajo-Yuta raids. Only 300 sheep were left from an estimated 30,000. There were five horses, and no cattle. (20a) Although the Hopis expected to harvest less than 800 bushels of corn and beans, the proud chief of Oraibi refused to surrender to either a foreign king or a foreign god. He would not accept the food offered since he had nothing to give in return, and firmly maintained that since his people seemed doomed to annihilation they preferred to perish in their own homes while still loyal to their own gods. He said that he would stand in the way of no one who cared to leave the country, and consequently some thirty families returned with Anza and were settled in New Mexico. It is said that the Hopis blamed their unkind treatment of Garcés for all their misfortunes, and that their present hospitality, for which they have become famous, is thus accounted for. From the time of Anza's visit until the end of Spanish and Mexican rule little or nothing more is known of Hopi history. (1a) & (20a)

Our study of the history of the Little Colorado from 1540 to 1780 leads us to the conclusion that the stream throughout the entire Spanish period carried large quanitities of silt, a fact which is thoroughly impressed upon us by early names bestowed upon it, as well as by the definite statements of the writers of the day. Although Cárdenas, first to cross it in historic times, left no record of the river which has as yet been discovered, Coronado, Castañeda, Jaramillo, Espejo, Luxán, Farfán, Salmerón and Garcés all mention it, and four of the eight call attention to the redness of the Little Colorado or one of its principal tributaries.

See next page for this deleted note.

We doubt that the farming of the Hopi or the Zuñi can be blamed for the rapid erosion during those centuries of Spanish rule. Methods of farming then were essentially those in use by Hopi, Zuñi and Navajo today. The plow, unless used with almost infinite wisdom, is one of erosion's most potent allies -- but plows were unknown to the farmers of the Pueblos and, quite fortunately, are little used by them even now.

For centuries the Little Colorado Basin has been sick with a severe case of chronic erosion, an illness which has frequently become acute after prolonged drought or an overdose of animals.* Today we are obviously witnessing the nearly disasterous effects produced by a combination of these two irritants.

THE LITTLE COLORADO BASIN UNDER AMERICAN RULE

There is little to be said about the Little Colorado Basin from Governor Anza's brief visit to the Hopis in 1780 until Sitgreaves expedition of 1851. Spanish rule was definitely on the wane in Arizona and New Mexico as early as 1811, and finally ceased entirely with the end of the Mexican war for independence in 1821.

Just 4 years later, in the fall of 1825, American trappers entered northern Arizona. First among these were James Ohio Pattie and his father, but before long they were followed by such famous individuals as Kit Carson, Antoine Leroux, Ewing Young, and "Old Bill" Williams who was one of the best trappers and greatest travelers in a restless age. Northern Arizona, including the tributaries of the Little Colorado, seems to have been abundantly supplied with beaver and bear, while otter and other valued fur bearers also tempted these hardy explorers to persue their illegal trapping in a very dangerous land. Their business called for fortitude -- intestinal and otherwise -- rather than for literary genius, and their records, with rare exceptions, have not come down to us because they were never written. Perhaps the finest collection of notes any of these men ever made was destroyed in a St. Louis fire as they were being prepared for publication. They were the work of Jedediah Smith who had already met death on the Cimarron in northern New Mexico, the victim of Comanches.(34a)

In 1834 a trapping party of some 200 men working for the Rocky Mountain Fur Company may have crossed the river just below Leupp as they made their way from Bill Williams Fork to the Hopi villages, where they plundered the gardens and shot 15 or 20 Hopis who objected. (1a)

* "I look on active erosion in a region which has been subject to 4000-5000 ft. in comparatively recent times as the normal regime not a diseased condition. You and de Kruif!" Reiche.

And I rec'ly that many people, like the Little Colo. country, are normally sick.

Bell

WR 32

Long before any of our government-financed scientific expeditions reached northern Arizona every river and mountain in the area was intimately known by trappers. What a vast store of pertinent information they could have left us about conditions during the second quarter of the last century! Since they failed to do so, we are forced to skip ahead to the 1850's before we again find careful records.

In 1846 the United States began a war against Mexico for the acquisition of new territory. In '48 New Mexico and northern Arizona came under the American flag. The gold rush of '49 brought thousands of people across the state, but the majority of them passed southwest from Zuñi into the upper Gila and consequently merely cut through the edge of the Little Colorado Basin. Occasional parties seem to have become confused, or for other reasons followed down the river as far as Leupp, where a few of them left their names carved in soft sandstone a few miles west of that town.

The Sitgreaves Expedition

On September 24, 1851, an expedition set out from Zuñi under Captain L. Sitgreaves with orders to follow the Zuñi, Little Colorado and Colorado Rivers to the Gulf of California, and to determine the head of navigation. Sitgreaves was thoroughly discouraged with the first of these streams, and entered in his report the first day the following: "The Zuñi is a mere rivulet, and not entitled to the name river; in most parts of our country it would not be dignified with that of creek".

The Captain's diary was brief and allows us to quote it almost in full from the time the expedition reached the region of the Petrified Forest on September 28 until it passed Grand Falls on October 8. As usual we have seen fit to add a few parenthetical remarks. The one included in the next paragraph, however, is not ours but Sitgreaves'.

"September 28, Camp No. 5. -- Proceeding down the valley, it widens out into a broad plain, which the recent profuse rains had made soft and muddy. To avoid this we turned off from the river, and made our way across the high land, but gained little by the exchange, for the soil was so light and thinly covered with grass that the mules sank to their fetlocks at every step. The ground was strewed with pebbles of agate, jasper, and chalcedony, and masses of what appeared to have been stumps of trees petrified into jasper, beautifully striped with bright shades of red, (the predominating color,) blue, white and yellow. The rocks were gray sandstone, sometimes of a slaty structure.

"September 30, Camp No. 7. -- The river here runs through

a deep and rocky canyon, which we skirted and crossed below it to the south bank, finding the ground much broken by ravines, which were only visible when we came directly upon them. (This sounds strangely like fingering arroyos to us.) The surrounding scenery resembled that of the northwestern prairies, the country being bare of trees and the horizon unbroken, except in one direction, where a high conical peak, that had served us several days as a landmark, varied the uniformity of its outline. (Camp made a few miles below Silver Creek.)

"October 1, Camp No. 8. -- The river, winding to the north, gave us a straight course across the high land, soft and sandy, as usual, and frequently intersected by deep ravines, until we again encountered it, flowing now between bluff sandy banks fringed with cotton-wood trees, and presenting at length the appearance of a river, but still with little water in its bed. (By taking the cut-off Sitgreaves had missed the junction of the Puerco with the Little Colorado just above Holbrook. This tributary was, of course, largely responsible for the increase in the size of the river which the captain noticed.) * * * In the course of the day's march the San Francisco mountains became visible to the west, and to the north several singular volcanic peaks. (Castle Buttes, or Hopi Buttes on present maps.)

"October 2, Camp No. 9. -- The river here receives a tributary known among trappers as Chevelon's Fork, from one of that name who died upon its banks from eating some poisonous root. Their confluence produces an intricate labyrinth of sloughs, in which we became involved, and were forced to encamp, not finding an outlet until late in the day. (They camped on the east bank of Chevalon Creek, and not far from the Little Colorado.) In several places veins of fibrous gypsum were seen, looking like the ice-crystals that burst open the ground in spring.

"October 3, Camp No. 10. -- Our course was here interrupted by a deep bayou thickly overgrown with rushes, and which, on attempting to turn it, was found to lead to a rocky ravine or cañon utterly impassable. (Clear Creek. The pueblo of Homolovi, abandoned by the Hopis in the 1400's, was located close to this place. Mosquitoes drove the Indians out. The "bayou", consequently becomes more interesting.) We retraced out steps, therefore, and with much difficulty recrossed the river, which, making a bend to the north, winds through a broad plain resembling the bed of a great lagoon from which the water had just subsided, leaving it slimy and intersected with fissures and channels that often impeded our progress. Here and there only a bush of the wild sage dotted its surface, and the surrounding hills appeared equally destitute of vegetation. (Evidently Captain Sitgreaves was following in the wake of a considerable flood. On September 28 he had referred to "the recent profuse rains". Note particularly his reference here to "fissures and channels". Cottonwood Wash was passed unnoticed, and soon afterward the party crossed

CV-6417-201 NN001853

to the east side of the river, making a camp a few miles below the Cottonwood's junction with the Little Colorado.)

"October 5, Camp No. 12. -- The country on the north bank presenting the same appearance of desolation as far as the eye could discern, we again crossed the river, and, passing on to higher ground, encamped on a bayou near the edge of the valley. (Possibly the Hopi Crossing was used, and the "bayou" may have been the lake shown on many maps about 12 miles southeast of Leupp, but was more probably the area known later as "Slough Bend", ten or twelve miles up the river from Leupp. This camp was No. 11, made October 4. On the map accompanying Sitgreaves' Report it is shown on the north bank of the Little Colorado. Either the cartographer is in error, or Sitgreaves failed to mention another crossing of the river.) The grass upon the hills was invariably better and more abundant than on the river bottom, but the absence of wood and water in such places generally obliged us to make our camps near the river. The mules, particularly those of Major Kendrick's command, already began to show signs of fatigue, and their backs to become galled by the saddles." (There follows a paragraph discussing pack saddles. Camp No. 12 seems to have been a short distance below Leupp, possibly at the mouth of Canyon Diablo. This tributary seems to have been dry, and was not included upon the map of the expedition, nor mentioned specifically in the notes. Those referred to in the following notation were below Tolchaco.)

"October 7, Camp No. 13. -- Many precipitous cañons were passed, enclosing within their walls of yellow sandstone (Kaibab limestone) clumps of small cottonwood trees. Ridges of lava and a black dust, the detritus of the lava, (c)overing the ground in many places, indicated our approach to a volcanic region. (The black dust was composed of small volcanic cinders - scoriae - rather than decomposed lava.) Near our camp, on the bank of the river, were the ruins of several stone houses, which our guide, Mr. Leroux (Antoine Leroux, the trapper), said resembled those of the Moqui (Hopi) Indians. (Possibly one of these is the one which Mr. McGregor excavated, to which we have previously made reference.) Camp No. 13 was a short distance above Grand Falls.)

"October 8, Camp No. 14. -- About a mile below the last camp the river falls over a succession of horizontal ledges of sandstone (Kaibab limestone), forming a beautiful cascade (Grand Falls) of one hundred to one hundred and twenty feet in vertical height, and continues on a course through a cañon of that depth, the general level of the banks remaining the same." (47a)

The Sitgreaves Expedition continued westward, leaving the canyon of the Little Colorado, discovering Wupatki and Citadel ruins, and passing along the north and west sides of the San Francisco Peaks. The account of the journey from Grand Falls to

CV-6417-201 NN001854

the junction of the Gila and the Colorado is brief, but filled with exciting incidents and decidedly worth reading.

Dr. S. W. Woodhouse, surgeon and naturalist to the expedition, in writing of the conditions along the Little Colorado from Holbrook to Grand Falls stated, "The vegetation along this stream varies but little. As we approached the San Francisco mountain, the cotton-wood (P. monilifera) became more abundant; also cedars along different portions of our route. * * * Gramma-grasses were found along different portions of the valley, in some places quite abundant." (56a)

The Whipple Expedition of 1853-4

Only two years after the Sitgreaves Expedition journeyed down the Little Colorado there came another government-financed group of explorers, engineers and scientists, this time under the command of Lieut. A. W. Whipple. The purpose was to discover a railroad route from the Mississippi to the Pacific, following as nearly as possible the 35th parallel.

On May 14, 1853, Secretary of War Jefferson Davis gave Whipple his instructions, a small section of which we quote. "Great attention will be given to collateral branches of science which more or less directly affect the solution of the question of the location for the proposed railway: the nature of the rocks and soils; and means of obtaining water on arid plains -- whether by tanks or artesian wells; the products of the country, animal, mineral and vegetable; its population and resources; its supply of timber and other material for the construction of a railway; the location, character, habits, tradition and language of the Indian tribes." It was suggested that Whipple should submit his report "on or after the first Monday of February next". He was, therefore, expected to organize an expedition, survey more than a thousand miles of line for a railway -- least difficult sections being skipped -- and in addition collect in nine months information which a score of men could not have obtained in as many years. His report was not ready on February's first Monday, but in an astonishingly short time it was submitted. It is surprising to find it a rich mine of information in all the departments he was expected to investigate.

"The Colorado Chiquito", he wrote in his preliminary report, "is a stream smaller than the Gila (Which Whipple had explored a few years earlier), but similar in many respects. The banks are fringed with cotton-wood; the valley is wide, the soil rich, and the gravelly ridges covered with fragments of pottery among ruins

of ancient Indian pueblos. Driftwood here is abundant, indicating occasional freshets, and plenty of timber near the sources of the river "

The expedition reached the Little Colorado near its junction with the Rio Puerco on December 3, 1853. Whipple's enthusiasm for the country continually pops out in his report, a part of which we quote here, with our own remarks in parenthesis. We find them in the Holbrook area.

"December 3, Camp 77. -- * * * From the entrance to the wide valley referred to (Little Colorado) we turned westward * * * (and) finding numerous lagunas of fresh water and good gramma, we camped. * * * The advantages of this country for grazing cannot well be surpassed. With two hundred mules, besides beef-cattle and sheep, we are able to camp where we please, without fear of the want of grass. Formerly New Mexico, according to Gregg, exported annually 500,000 sheep for mutton alone. * * * there scarcely need be a limit to the number that may graze upon this region. Nature has furnished grass, sufficient water, and a climate favorable to this purpose."

On December 5 they camped upon and named "Leroux's fork", just west of Holbrook, and received news of a horrible epidemic of smallpox which had swept nearly every male adult from three Hopi pueblos. "In one remained only the cacique (Chief.) and a single man from a hundred warriors. They were dying by fifties per day; and the living, unable to bury the dead, had thrown them down the steep sides of the lofty mesas upon which the pueblos are built." (Until very recent years the Hopis frequently, if not habitually, did not bury their dead.)

"December 6, Camp 78. -- Our Zuñi guides left us this morning to return and the survey proceeded along the right bank of the river for fifteen miles. Several dry ditches were crossed, the banks of which it was necessary to cut down, thus creating a few hours' detention. (Arroyos are often dry ditches.) * * * ~~The stream is now small, but rapid; its waters are fresh and clear~~, * * * The stream is now small, but rapid; its waters are fresh and clear, and sufficient for the irrigation of a considerable portion of the low lands that border it. (The Mormons developed this in the '70's in the Joseph City region.) Its sinuous course through the bottoms is marked by a small line of alamos (Cottonwoods). The gravelly prairies that bound the valley are in places thinly spread with gramma; in others, barren. (It seems possible that the presence of permanent water in this section may have caused native animals to overgraze this area during some particularly severe drought.)

"December 7, Camp 80 -- * * * Sand and light soil, like ashes, rendered the journey heavy for the wagons. Finding a favorable spot we camped early, having made 8 1/2 miles. * * *

"December 8, Camp 81 - - Plodding along through sand and light soil -- sometimes threading the wide valley, at others crossing gravel ridges that bounded it -- we made five miles and encamped. We had crossed the deep bed of a well-wooded tributary flowing from the northeast, called Cottonwood creek. Nearly opposite could be seen the junction of an affluent from the southeast. (Clear Creek?) The Colorado Chiquito here branches into a net-work of channels, all bordered with alamos. Below camp is quite a forest, extending about four miles down the valley. From a high hill two miles back from camp the river can be seen making a great bend, and sweeping northward. * * *

"December 9, Camp 82 -- At the usual hour we left camp, and proceeded a mile and a half, near to the great bend in the river where we encamped. Near by is the remnant of a ruin as extensive as any yet seen. An isolated hill of sandstone is the foundation of this ancient pueblo." (54b) This ruin was doubtless Homolovi. In Hopi the name means Place of the Breast-like Elevation. (24a) Whipple made note of an ancient acequia - irrigation ditch - on the south side of the valley, and described the Little Colorado at its junction with the Cottonwood as "50 feet wide, two and a half feet deep, and flowing between clayey banks about 10 feet in height".

The mules stampeded on the night of December 9, causing a considerable delay. But on the 13th an exploring party went westward across Tucker Flat and before rain stopped their progress had almost reached Canyon Diablo, which gorge they discovered and named the following morning. We shall rejoin them there.

" * * * But, finding no means of crossing the canon with our pack-mules, we followed the right bank for a passage, proceeded to its junction with the Rio Colorado Chiquito, and encamped about twenty-five miles northwest from where we left the wagons. (Down the river a few miles from Cottonwood Wash.) The valley is here wide, and thickly covered with good-sized alamos. (True at the time Leupp was founded in 1905.) The river, which we crossed in order to find a better camp-ground, is two and a half feet deep, and from ten to twenty yards wide. It flows rapidly, furnishing plenty of water for irrigation. (Sometimes!) The cañon which interrupted our march today has been named Cañon Diablo. Near its junction with the river valley was seen a great quantity of dark volcanic ashes, (They are still to be seen.) and it is possible that the channel, seemingly cut in a level bed of dolomite, may have resulted from the decomposition of a trap dike." (54b) (But that is not the case.)

On the 15th as they made their camp in the foothills Whipple wrote, "Gramma grass has been excellent and abundant over nearly the whole of the route traversed today". They had gone from Canyon Diablo's mouth to the foothills.

CV-6417-201 NN001857

The Beale Expedition of 1857

The most bizarre expedition which ever reached the Little Colorado Basin was probably the one headed by Edward Fitzgerald Beale to whom the Secretary of War assigned the task of laying out a wagon road from Ft. Defiance to California. He left Zuñi Village on August 31 and arrived at the mouth of Canyon Diablo September 8, 1857. In his outfit were at least 14 camels, each of which was carrying a load of practically 775 pounds of corn which had been purchased in Zuñi for the use of the horses and mules on the long journey to California. There were more than 50 men on the expedition, and in the wagon train was a fiery red ambulance in which anyone who took sick or was injure might ride, and thus avoid delays to which earlier expeditions had been subjected.

As the party headed toward the San Franciscos from the mouth of Canyon Diablo on September 9 Beale did not fail to notice his surroundings with the usual care he gave to such things, and when camp had again been made he wrote the following descriptions. "After ascending from Canon Diablo, we came to a plain of vast extent, and only bounded by San Francisco mountain ahead, and more distant ones to the southward. To the north nothing obstructed the view. This great plain seemed to ascend by a gradual slope to the westward until it met the base of the great mountain of San Francisco. As we travelled over it, we found it occasionally breaking into gentle valleys and small ravines, but all easy and rolling, and between them level floors of extensive table-land; the whole covered thickly, as far as the eye could reach, with the richest crop of the most luxuriant gramma grass. The entire plain is covered with stones and loose pebbles, and parts of it with small pieces of lava, and occasionally masses of it in rocks, which sometimes reach the altitude of fifteen or twenty feet. Altogether the view, the rich green grass, the distant mountains, and our moving camp wagons, sheep, horses and camels made up a beautiful picture." (2a)

May Humphreys Stacey, a Pennsylvania lad of only 19 years, accompanied Beale. He kept a journal in which he made almost daily entries. In it, under date of September 9, he wrote, "Our road lay over a most beautiful rolling country upon which there was plenty of grass, enough to supply the wants of an unlimited number of cattle". (49a)

It is not often that fortune has favored us with two records of a single expedition into the Little Colorado country. Here, however, we have the daily impressions set down by a seasoned traveler, side by side with those of a boy in his 'teens

CV-6417-201 NN001858

who was making his first long journey. We wish that we might quote, in full, the diaries of these two writers. They saw the valley from Holbrook to Leupp with the grass at its very best. Beale's enthusiasm was unbounded, despite clay which gathered on the hooves of his mules "like snowballs". Eight months later Lieut. Ives and Dr. Newberry came over much of the same ground, and gave a very different picture. We feel that we must treat the accounts of these four writers rather fully -- wish that we might present them here in their entirety.

Writing of the Little Colorado at its junction with the Puerco, just above the present town of Holbrook, Beale said, "It was a discolored and shallow stream, some one hundred yards or so from bank to bank; but the water not wider than as many feet, and not over a foot in depth". (Stacey wrote, "From bank to bank it measures about two hundred yards. The stream itself is about twenty yards wide and very muddy".) Beale continued, "The valley of this river is three miles across, and grass plentiful in the bottoms, as well as on the hills, which are quite low. There is abundance of large cotton-wood trees in the bottom, which resembles very nearly the bottom of the Rio Grande."

Continuing northwestward the following day they found wood abundant on the river but none on the hills. "We travelled this morning nearly five miles on a course about north northwest, and cut down two arroyos to admit passage of our wagons. We left our breakfast camp (This was on Manila Wash, near Joseph City.) at noon and travelled until 5, crossing over many arroyos draining to the river. (The underscoring is ours.)

"The road was perfectly level, with the exception of the gullies, which we worked down with difficulty." Next morning, approaching Cottonwood Wash, "Our trail was over a perfect level, but the rains had rendered the stiff clay soil of the consistency of tar, so that it stuck to the wheels in large pieces, and to the feet of the mules like snow balls. * * * The valley of the river bottom here is about six miles wide. On either side the hills slope gradually to the meadow land of the bottom, and, ascending them, extensive plains spread out for great distances, all covered with fine grass." Beale found the Cottonwood swollen by the recent rains, and about six feet deep, but rightly surmised that it would be nearly dry after the rains ceased. Not being able to cross it, they followed to the junction with the Little Colorado, which they forded with very little difficulty, and after going a mile or two down stream "encamped near a singular stream coming in from the south. This stream gives no notice of its existence until you arrive directly on its banks, having neither cottonwood trees nor willows to warn one of its whereabouts. I explored it for some distance up, and found it issuing out of

CV-6417-201 NN001859

a rocky cañon with precipitous sides. The water is clear, * * * (There can be no doubt Beale had reached Clear Creek.)

Beale seems to have been an unusually keen observer, and his deductions are very frequently excellent. As he camped on the bank of Clear Creek he made a rather serious mistake when he concluded, "The climate of this country is exceedingly pleasant, and from the vast quantity of rain that has fallen on us, I should suppose crops might be easily raised without irrigation." Again he mentions that grass was excellent and most abundant.

The next day, camped midway between Winslow and Leupp, on the south side of the river, and several miles from its banks he wrote, "We have seen indications of the greatest abundance of game for the past three days. (He had traveled from just above Holbrook to this camp in that time. From Holbrook to Cottonwood Wash he was on the north side of the river. Then he crossed to the south side.) Elk, antelope, and deer, besides beavers and coyotes in large numbers." A little later he writes. "The grass throughout the day has been most abundant, and we have constantly exclaimed, "What a stock country! I have never seen anything like it; * * * The river is in sight on our left (He must have meant right.), well wooded with cottonwood; and as far as one can see, a level country extends to the southward and westward, covered with gramma and bunch grass." In a succeeding paragraph he says, "We have seen deer and elk (today), and the fresh tracks of them are innumerable all over the valley."

His course from this point to Canyon Diablo was "over a succession of level valleys, divided from each other by gentle ridges of very easy grades, generally a mere swelling in the prairie. All of them were filled with fine grass, with the exception of bald places, called by the Mexicans playas. These are always of clay, perfectly flat and smooth, and for the most part hard and firm". These playas are still very conspicuous in this section. An attempt to encourage plants to grow upon them by building miles of contour dikes has been made near Leupp.

At a point about ten miles southeast of Leupp, on a large mesa, he found the grass so tempting that he determined to camp there for breakfast, which had to be cooked with greasewood because there was no other fuel at that distance from the river. After a rest of four hours, during which the stock had a chance to make the most of the excellent grass, the journey was continued ten miles in four and a half hours, to the mouth of Canyon Diablo, where the party encamped. "This point", wrote Beale, "is well marked by four little red sandstone buttes, which rise from the meadow near its mouth, and cannot be mistaken, as they

are of peculiar form and isolated in position. They are thirty or forty feet in height. * * * Today the soil of the table-lands has been the same as that of yesterday. (Clay and gravel, mixed.) That of the bottom is sand and clay mixed. * * * Water, wood and grass abundant."

Of this same day's trek young Stacey wrote rather briefly. "Left camp twenty minutes past five; the road generally good and grass abundant, watered from a pond on the line of march. Saw some antelopes. Camped this afternoon near the Cañon Diablo and Rio Colorado Chiquito. Grass not very good. Distance nineteen miles." The underscoring is ours. Since both writers agree that grass was abundant during the day, it seems obvious that Stacey was referring to the grass immediately surrounding the mouth of Canyon Diablo. Since the topography of the region forced travel to this point, we wonder if the condition there might not be traced to a resulting concentration of livestock over a long period of years. Beyond any doubt mounted Indians had used the ford at that place for a century or more.

As we pointed out earlier, Beale and Stacey saw the Little Colorado Basin with the grass at its best. They were both Pennsylvanians, in fact from the same town, and therefore their ideas of what good grass was must have been very similar. Today the citizens of northern Arizona often speak of the grass being good in an area which seems utterly desolate to an easterner. We feel, therefore, that the grass really was excellent from Holbrook to Leupp and beyond, in September 1857. And such being the case, we are convinced that the presence of numerous deep arroyos between Holbrook and Winslow become particularly significant to the student of erosion. There are many who have assumed that where there is a good cover of vegetation, especially of grass, such accelerated erosion can not exist.* Perhaps it can not, but certainly Beale's observations seem to indicate that it can.

Having followed Beale down the valley and westward toward the San Franciscos, we shall now come eastward from the edge of the timber to Canyon Diablo's mouth, and then make our way by a devious route, up the river to Winslow with Ives and Newberry. As we find them, late in April 1858, only eight months have passed since Beale and Stacey worked westward across a country where "there was plenty of grass, enough to supply the wants of an unlimited number of cattle."

*"Arroyos do not necessarily indicate accelerated erosion". Reine. Not necessarily, to be sure, but if one is just naturally suspicious one is apt to suspect accelerated erosion when gullies are growing like gizzard out of an area. I grant that accelerated erosion may be suspected where only exceedingly rapid erosion exists. Reine's point is well made.
Bell

WR 12

The Ives Expedition of 1857-8.

On May 2, 1583, Espejo and Luxán reached the Little Colorado. On May 2, 1858, -- exactly 275 years later -- Lieut. Joseph C. Ives and Dr. J. S. Newberry reached that same stream at about the same place. Coming from the east on May 1, Espejo and Luxán had stopped for a siesta, being overcome by drowsiness. Coming from the west on April 28, Ives and Newberry were nearly frozen by a belated blizzard which overtook them between the foothills and the river; and kept them snowbound for more than a day. Space permits only occasional very pertinent paragraphs from Ives' Report to be given here. Parentheses are ours.

"Camp 85, Flax river, May 2. -- (Camp 85, according to Appendix B, was located at Latitude 35°17'51.4", Longitude 110°58' 55.5". That, according to recent Fairchild air maps, is the junction of the Little Colorado and Canyon Diablo. Flax River is, of course, the former.) The wide valley of Flax river could be recognized a long way off by the line of cottonwoods that skirt the banks of the stream. The river is smaller than the Colorado, but at this season, when the water is becoming high, much resembles the other at its low stage. There are the same swift current, chocolate colored water, shoals, snags, sand bars, and evidences of a constantly shifting channel. The width opposite to camp is fifty yards, and the depth five or six feet. The banks and bottom are composed of quicksand, and we have been unable to find a ford. The bottom lands are in places several miles wide. Here and there are to be found patches of a coarse grass, which at this season is green and nutritious. (Several varieties of Sporobolis grow even now in this area.)

"Before proceeding with the examinations northward, it became necessary to look into the condition of the train and supplies. The inspection developed unsatisfactory results. Most of the mules are in such a state as to preclude the possibility of their going much further. * * * The sudden and severe snowstorms, coming in the midst of hot weather, the scarcity, and, at times, absolute deprivation of food and water, the difficult country and rocky surface, have reduced them to a sorry plight. They look and move like slightly animated skeletons.

"The stock of provisions is nearly gone."

By means of a portable canvas boat, provisions and men were ferried across the river, and the best of the mules swam over. The party was divided into 2 sections, the stronger to go to the Hopi villages, the other to follow Whipple's trail to Zuñi. The latter party did not cross the river. The following day Ives, Newberry and a few others waved farewell and started for the Hopi country. "The direction taken was a little east of north. The alluvial earth was soft and difficult to traverse; the slope that

CV-6417-201 NN001862

followed composed of material still softer, and when, after crossing several ridges, the top of the plateau was reached, the soil became so light and friable that every step of the way was attended with labor and fatigue. The day was the hottest that had been experienced. (The present road from Leupp to Oraibi may follow rather closely the route taken, but is probably too far to the east. The plateau they reached is now known as Newberry Mesa, while the next one to the southeast is called Ives Mesa.)

"The summit being attained, a vast extent of country -- sweeping from Flax river around to the northeast -- was brought into view. It was a flat table-land from which wide tracts had been eroded to a moderate depth, leaving exposed lines of low bluffs and isolated fragments of the removed stratum. The scene was one of utter desolation. Not a tree nor a shrub broke its monotony. The edges of the mesas were flaming red, and the sand threw back the sun's rays in a yellow glare. (An excellent view of these flaming mesas and their yellow dunes may be had from Red Lakes Trading Post.) Every object looked hot and dry and dreary. The animals began to give out. We knew that it was desperate to keep on, but felt unwilling to return, and forced the jaded brutes to wade through the powdery impalpable dust for fifteen miles. The country, if possible, grew worse. There was not a spear of grass, and from the porousness of the soil and rocks it was impossible that there should be a drop of water. A point was reached which commanded a view twenty or thirty miles ahead, but the fiery bluffs and yellow sand, paled somewhat by distance, extended to the end of the vista. Even beyond the ordinary limit of vision were other bluffs and sand fields, lifted into view by the mirage, and elongating the hideous picture. The only relief to the eye was a cluster of blue pinacles far to the east (Castle Buttes or Hopi Buttes on modern maps.) that promised a different character of country. It was useless, however, to take the r sk of proceeding directly thither. The experience of the day had demonstrated the hopelessness of trying to drive the mules for any length of time through an untrodden and yielding soil, and it was determined, as a last chance, to go back to Flax river and ascend (follow up) the bank, at the hazard of having to make a long circuit, till some Indian trail should be encountered leading in the desired direction, and affording a beaten way practicable to be followed."

The scene which seemed so terrible to Ives actually forms part of one of the most beautiful panoramas northern Arizona has to offer, when one is not overly worried about jaded mules, scanty provisions, and no water. We are frankly suspicious that the mirage which elongated the hideous picture was nothing more nor less than Tolani Lakes. Many a desert traveler has been lured to his death by a mirage. Few, indeed, have thirstily turned their backs upon a cluster of beautiful lakes!

CV-6417-201 NN001863

"The night spent upon the desert showed that this condemned region was not entirely devoid of life. As the sun declined and a pleasanter atmosphere succeeded to the oppressive heat, scorpions, spiders, rattlesnakes, and centipedes emerged from their retreats to enjoy the evening air. A collector in that department of natural history could have reaped a harvest of these reptiles (!) in almost any part of our camp-ground.

"The next day we went back to the river, striking it ten miles above the place where we had left it. The return was attended with the same difficulties as the march of the day before, and I think nothing but the knowledge on the part of the thirsty mules that they were approaching water could have made them hold out till the distance was accomplished. The valley seemed like an Eden, in contrast with the region that had just been visited, though a sorry looking place if compared with the more favored parts of the continent. During yesterday we have traveled up the river twenty-five miles,(And had arrived to a point just above Cottonwood Wash.) The valley is much cut up by ravines and sloughs. (The underscoring is ours.) There are indications that, at some seasons, there are storms which send torrents of water from the plateau across the alluvial lands. The soil in many places is impregnated with alkalies and the surface covered with an efflorescence.

"The blinding glare of the sun upon the white ground seriously affects the vision, and it has been found necessary to screen the eyes with muslin shades. (!)*

"The bottom is filled with black-tailed deer. A buck was killed today measuring six feet from the nose to the base of the tail. The venison was of delightful flavor, and, though not in season, quite tender. Ruins of ancient pueblos have been passed. (Homolovi, once more.) These vestiges of a former race of inhabitants, which are found so widely scattered over the table-lands of New Mexico, may be taken as evidence either that the country where they exist can or that it cannot now sustain a population; depending upon the theory adopted to account for the disappearance of the previous residents.

"At noon today we came to the object of our search -- a well-beaten Indian trail running towards the north. Camp was pitched at the place where it strikes the river, and it is the intention to make the second attempt tomorrow to penetrate the unexplored region. Near by are several salt springs, and scattered over the adjacent surface are crystals of excellent salt. This accounts for the position of the trail, for it is doubtless here that the Moquis obtain their supply of that article." (27a)

Following this trail the party eventually reached "Mooshahneh" (Mishongnovi?), where there were great numbers of sheep -- almost all black -- but practically no grass at all. They were very well received, and were escorted from here to Fort Defiance,

* "Why the exclamation, you confounded ordinatist? The preceding remark in such a tone is (sic)." Reiche.

I still prefer exclamation points & impropriety.
Bell

after having attempted a trip in the direction of Tuba City into a waterless desert country in which there was some grass, better, in fact, than any they had seen since leaving the valley of the Little Colorado.

It is to this expedition that the Painted Desert owes its name. Dr. Newberry named it thus, and the first section encountered by him seems to have been not far north of Leupp, where the colors are not particularly brilliant. Of the trip from the foothills to the Little Colorado, Dr. Newberry said that most of the last ten miles was made over a virtually naked stretch of buffy limestone. He also states that they first reached the river about 15 miles above Grand Falls. The mouth of Canyon Diablo is exactly fifteen miles in an air line from the falls. The party had some difficulty due to encountering the numerous canyons of the Diablo-Padre system, which would indicate an attempt to remain entirely too far south. (40a)

Certainly the impressions of Ives and Newberry, when everything was going wrong, were vastly different from those of Beale and Stacey when all was running smoothly. Aside from the fact that the Ives party was in serious difficulty, they were traversing the country during one of its most unpleasant seasons, while Beale and his companions saw it at its very best. Such differences account largely for the widely divergent reports given of the same general area at no widely separated times. It is our belief that all these gentlemen gave remarkably honest pictures of what they observed.

The Basin After 1860.

The epidemic of expeditions financed with Federal funds was confined to the 1850's. Sitgreaves had proved that the Zuñi and Little Colorado were not navigable streams. Whipple had shown that a railroad route was feasible along the 35th parallel. Beale had laid out a wagon road from Ft. Defiance to California which he felt certain was destined to be the principal route of the future. Ives had convinced himself that the lower Colorado was of great importance to commerce, and incidentally had followed more or less closely the overland routes of Whipple and Beale.

As to what conditions were in the 1860's we have been able to learn nothing at all beyond the fact that in '67, during the summer, 800 cattle were feeding in the valley under the constant protection of cowboys. Grazing obviously was good. (34a) Perhaps it was during this decade that Samuel W. Cozzens spent his three years of wandering in Arizona and New Mexico, eventually reaching Zuñi. Of the land of the Hopis he wrote, "It is arid, barren country, deeply eroded by floods, and largely formed of steep mesas, volcanic peaks, and rocky cañons with a few fertile

CV-6417-201 NN001865

valleys interspersed among them". (11a) This description he obtained from a Zuñi Indian, not from personal exploration. His writings are delightfully entertaining rather than scientifically accurate.

Mormon Settlements.

In 1873 the first group of Mormon settlers entered the valley from Utah. Most of them got no farther than Grand Falls, but a small scouting party was sent to explore for about 100 miles above that point, and returned to say that no suitable farm land could be found. The entire group turned back toward Utah, and most, if not all, recrossed the Colorado and returned to Kanab or Fredonia. But the church officials were determined that the Little Colorado must be conquered, and eventually others succeeded where the first party had failed miserably.

Just a century after Garcés had visited the Hopi villages, Mormon settlements dotted the Little Colorado Valley from Winslow to Holbrook and beyond. Like Garcés they, too, were brought into this country by a desire to win the Indians to a new faith, and also like him, they failed in this purpose. But Brigham City, Sunset City, Obed, Taylor and Allen found a place on the map, and Holbrook, Woodruff, Snowflake, Joseph City, Pinedale, Springerville and St. Johns were soon established. In 1870 the settlers of Obed and Allen (Across the river from the present Joseph City.) constructed a dam at a cost of $5,000. It raised the height of the water 12 feet and went out with the first flood. In '77 a new dam was completed a mile and a half upstream, only to be carried away. In '81 a dam was again built at the first site and almost immediately destroyed by the river. In '82 a pile dam was constructed and spoiled by floods. By 1894 the settlers in that vicinity had completed their eighth dam across the river. (36a)

From a hand-book published in 1878 we learn that the Colorado-Chiquito in the vicinity of Winslow was two to four feet deep, about eighteen feet wide, and that it abounded in otter, beaver, turtle and fish. From the same source we discover that, "The main road from Prescott to Fort Wingate crosses the Colorado-Chiquito near Cañon Diablo", and that, "The habitations of the Moqui Indians * * * (are) surrounded by a wide, barren, sandy region where grass is found but sparingly and in small patches, but plentiful when the rain is more than average". (23a)

A Mormon settler writing from the Winslow area in the middle '70's to the Deseret News said, "Our land was all covered with rabbit and grease brush, and large, dry cottonwood logs that had fallen to the ground, intermixed with large quantities of driftwood from the river." (23a)

About this same time Lot Smith, leader of a company of Mormons who settled Sunset, near the present Winslow, wrote, "This is a strange country, belonging to a people whose lands the rivers have spoiled". And again he wrote" * * * though the river shows it would be a mighty rushing torrent when rains commence in summer, with the appearance of being 25 miles broad, and the Indians told us that if we are indeed to live where we are encamped, we had better fix scaffolding in the trees". (36b)

"In August, 1878, a correspondent of the Deseret News wrote from Sunset that for a week the rain had been pouring down almost incessantly, that the whole bottom was covered with water, that some farms were submerged and grain in shocks was flooded, grain at Woodruff was entirely destroyed, the grist mill at Brigham City inundated and the grain stacks there were deep in water, with the inhabitants using boats and a raft to get around their farms." (36b) The Indian prophecy had been fulfilled, and, although Sunset was occupied for many years after this event, it was completely abandoned in 1888, after the great flood of that year. Lot Smith was the last to leave.

With the coming of the railroad to Winslow in 1881 and its completion across the state (territory) in May 1883, northern Arizona found itself upon a stage which was set for rapid action, with the grazing industry playing the leading role of combined hero and villian. Really accurate statistics are not available even for the entire state, let alone for the Little Colorado Basin. We shall present such figures as are available, and point out the most obvious weaknesses.

"In 1860", writes one authority, "the statistical returns of the territory list only 803 sheep, but the growth of the industry was so pronounced after the settlement of the Apache trouble, that the ranching industry rapidly developed. Even before the last of these wars Hamilton's Statistics of 1883, place the total number at 680,000, and the wool clip is valued at $2,380,000". (42a) Obviously the figure for 1860 is absurdly low, and ignores completely sheep owned by Indians. Whipple in '53 had with him a Mexican who had been a Navajo slave. He said the Navajo wealth consisted of immense flocks and herds. "Some of the rich men own one thousand horses each, besides mules, cattle and sheep." (54b) On May 11, 1858, Ives wrote of passing large flocks of sheep in the Hopi country. During the early 1860's huge losses of stock among the Navajos induced them to sue for peace with the Americans. A few years later Kit Carson brought them under control by killing their sheep in great numbers. Figures for 1883 seem to have the same omissions. In 1884 Navajos alone are supposed to have had a million sheep and 35,000 horses, a considerable part of which were certainly in Arizona. (1a)

Again we read, "In 1883, there were reported in Arizona 145,000 cattle and 602,000 sheep. Within ten years the number of cattle advanced to over 800,000 and the sheep numbered nearly a million". (34a) Since the Indians were in possession of comparatively few cattle, figures regarding them are probably far more accurate than those for either sheep or horses.

"Arizona was an open range country in all that the term implies during the period from 1880 to 1890", writes Bert Haskett. "Its mountains, mesas, uplands and valleys were covered with a wealth of plants and grasses that seemed forever inexhaustible, all open and free to the cattleman, the sheepman or whoever cared to use them. Except for the Indian reservations, one could go with his flocks wherever he would." (20a)

We are assured by Mr. Billy Williams, of Winslow, that his earliest impressions of the Little Colorado Valley below Winslow fit this glowing description quite exactly. From the river to the San Francisco Peaks there was one glorious sea of grass in 1880. He pictures a land so perfect that it could easily have lured a steer from a clover patch or a heifer from a field of young corn. From Winslow to Grand Falls and from Winslow to Blue Canyon there was not a single arroyo. His testimony is verified by that of a traveler of the early '80's who returned to Tolchaco in 1908 and lamented to Mr. David Ward (of whom more anon) that some of the most beautiful country he had ever seen had been ruined.

The repeated destruction of Mormon dams in the '70's indicates that there was no shortage of rain during the 5 years immediately before 1880, and we are of the opinion that the range was as good or better than when Beale and Stacey crossed it nearly a quarter of a century before. We believe this while still remembering that Lot Smith had written in 1775 of "lands the rivers have spoiled".

With the completion of the railroads across Arizona stockmen literally swarmed into the territory. Those already there imported stock from neighboring states or from Mexico. Enormous bands of sheep spent their summers in the northern highlands, their winters in the southern valleys. Clashes between sheepmen and cattlemen were inevitable as the range became more crowded. Until 1886 stock could be fattened on the range and sent directly to eastern markets. From then on it was necessary to send it elsewhere to be finished before it could be marketed. (34a) A devastating drought in neighboring states only served to force more and more stock into Arizona, where there was not "grass for an unlimited number of cattle".

When Tolchaco was founded in 1900 the Little Colorado Basin was the home of choking dust storms, and cutting sand, and no longer a sea of grass. When Leupp was founded in 1905 conditions were no better. There seems to have been no real opposition on the part of the stockmen to the withdrawal of a large area from their crowded domain so that a new reservation for Indians might be set aside. Surely they must have considered it utterly worthless, or the Leupp Extension would not have been surrendered without a bitter struggle.

Outside the reservation bankruptcy and federal and state regulations combined to bring about some marked improvement more than a quarter of a century ago, although powerful organizations of stockmen fought Forest Service grazing regulations with entirely too much success until after the turn of the century. Within the reservation conditions seem to have gone from bad to worse. Navajo sheep and goats had to be counted in millions. In 1930 a quarantine for scabmites was put into effect against all Navajo sheep and for three years none could be shipped. When it was raised in 1933 prices were so low, only $1.00 a head, that the majority of Indians preferred not to sell. A program of government buying was inaugurated and resulted in some relief during 1934 and '35, when great numbers of goats and much scrub stock was destroyed. This program has had to fight almost constant Navajo opposition.

In addition to overcrowding due to quarantine and natural increase, the Little Colorado Basin has recently been experiencing more than a dozen years of abnormally dry weather, which has made a bad matter definitely worse. We have made a careful and extensive study of precipitation within the basin during the present century. This investigation was made with the hope that it might throw additional light upon the problem of controlling floods at Leupp. We feel that it may profitably be discussed here, as may also the floods of the last half century. Since space will be given to the discussion of the present cycle of arroyo cutting as we consider individual floods, we have omitted such information from the historical sketch we have just presented.

Before passing on to this new material we wish to restate our conviction that for at least four centuries ~~the well-being of~~* the Little Colorado Basin has been cursed with chronic erosion which has repeatedly become acute in times past, and which is at present malignant because of a combination of drought and overgrazing. We wish to point out, too, that even in Beale's paradise of 1857 there were large numbers of arroyos, that Lot Smith thought of the land as ruined in 1875 or '76, and that violent floods were not unusual before the stockmen came. History fairly screams the warning that we are sadly mistaken if we believe the

* Deleted at the request of Reiche. "They make the sentence absurd," he states, and then adds comfortingly, "which it may be anyway." I have a family largely composed of M.D.'s and can understand the sentence.

WR.

mere reduction of stock will drive the gouging fiends of erosion* from the country. Help it will, and help it must, but obviously it is foolish to trace all our present ills to the coming of the stockmen in the '80's. Had there never been a railroad in northern Arizona, never a White Man with his flocks and herds, there would probably be arroyos eating away the valleys of the Little Colorado Basin today. Unless we are conscious of this fact we are not apt to appreciate the magnitude of the problem which is to be solved. To deny that it is a fact is to ignore history.

* "Put-put Howell has found his master! Tsk." Reiche.

THE PRECIPITATION CHARTS

It is our belief that the amount of precipitation has been a relatively unimportant factor in the flood situation at Leupp since 1920, but to prove this to the complete satisfaction of the most skeptical is not an easy task.

In such a case one naturally turns to the available climatological data, confidently expecting to find there the evidence desired. In the Little Colorado Valley difficulties are encountered almost immediately.

For example, we want to know the average rainfall for the entire drainage area each year since 1900. To get that we need only pick out a reasonable number of stations, nicely spaced throughout the region, which have reported continuously for the past 36 or 37 years. A dozen or fifteen will do nicely. We have only one! Flagstaff -- the wettest station in the entire basin.

The U. S. Weather Bureau says in its "Climatological Summary of the United States", Section 25, p. 2, "The average precipitation over the Colorado Valley is less than 11 inches; in the Little Colorado Valley it increases to about 12 inches, -- ".

The average at Flagstaff is 22.80 inches! Obviously it is anything but a typical station.

If we take the average precipitation for all stations reporting each year, and from these determine a normal for the basin we might obtain a satisfactory yardstick with which to measure the relative wetness of any year. Having done this we soon discover that we have a very inefficient tool. It is almost literally true that in no two years are the reporting stations identical. Therefore the comparative wetness or dryness in any given year can be found only by determining the normal for the particular combination of stations reporting in that particular year. This does not necessarily give us accurate information regarding the average for the entire basin. We have used reports from 25 stations during the period, yet in four years only four stations reported. Sadly mistaken ideas might result if we compare the average for these with a standard normal prepared from reports of 25.

Our stations may, however, be rather readily divided into four regional* groups -- eastern, northern, central and southern -- in which the respective normals show great variation: eastern 14.37", northern 12.65", central 9.14", and southern 17.84". This gives us a normal for the Little Colorado Basin of approximately 13.5", which is 1.5" higher than the average as stated by

* Reiche suggests "district".

CV-6417-201 NN001871

the U. S. Weather Bureau as quoted above. Our computations have purposely excluded the northwestern and extreme western sections of the basin since run-off from these enters the river far to the west and in no way effects our problem at Leupp. These two areas are known to be dryer even than the one we have designated as central. Had they been included our normal would have closely approximated the twelve inches called for by the Weather Bureau's statement. If, on the other hand, the average is figured for all stations reporting without first dividing them into groups, our normal becomes 14.7" -- entirely too high.

This wide variation in averages from identical data can be readily explained. For several years the southern section was represented by more than half of all stations reporting. In 1920, for example, 10 of 18 reporting stations were southern, thus giving the wettest section of the drainage area 56% of the total representation -- 10 votes, let us say, where only 4.5 are allowable, leaving only 8 for the remaining three sections in place of the 13.5 to which they were entitled. If, however, we determine the average precipitation for the stations of each region, add these and divide by four, each area exerts its rightful influence on the final average. Thus we find that in 1920 the average precipitation for all stations reporting was 14.64", while that for the Little Colorado Valley, as determined from sectional averages, was only 13.03" -- a difference of exactly 11%.

While group treatment thus gives bright promises of allowing us to determine a reasonably accurate average for any or every year, there are difficulties. The year 1905 is a case in point. Only five stations supply us with records. In the eastern area there were two, while other sections were represented by only one each. Now 1905 was, by all odds, the wettest year ever recorded since records have been kept in northern Arizona. The five reporting stations had an average precipitation of 22.16" -- startlingly high. But the average by sectional treatment is 22.95" -- higher by almost .7". Inquiry shows that Flagstaff is the sole representative of the southern section. Its total precipitation that year was 34.53", as compared with a normal of 22.8".

It is absurd to allow the wettest station in the entire Little Colorado Valley to represent the southern section, but what can be done about it? We can determine the normal for all other stations in this southern group, and thus learn that it is only about 75% of Flagstaff's normal. Therefore we may feel free to take 75% of Flagstaff's 1905 precipitation as a more probable average for the southern section. We arrive in this way at a basin average of 20.79" -- closer to actual, perhaps, and surely much easier to believe.

In a similar way it is possible to interpolate an average for a section which is unrepresented in any year. In 1901, 1902 and 1903 there were no reports from the central section; from 1925 to 1929, inclusive, no reports are available for the northern section. The normal for the central section is only 61% of that for the rest of the basin. Normal for the northern section is 92% of that for all others. Probable rainfall can thus be readily interpolated from reports of other sections. Where necessary this has been done.

In Plate 4, which shows annual precipitation in the Little Colorado Valley, the figures for 1904, 1912 to 1924 inclusive and 1929 to 1936 inclusive are computed from unaltered sectional averages. All others have been weighted by one or both of the methods described.

In the case of monthly precipitation for major flood periods, Plate 5, we present only the averages as computed for the stations reporting in those particular months. For comparative purposes the group normal has been determined in each case, and the ratio of actual to normal precipitation is expressed in percent of normal.

We willingly admit that there are inaccuracies present. The charts are not presented as precision instruments, but merely as reasonably accurate tools with which to do the work at hand. To be sure many minor alterations might still be made which would apparently increase the accuracy of the averages obtained -- improvements probably more apparent than real, and certainly not worth the effort they would require. We have here just one more example of an almost overwhelming array of unknowns and variables -- one more chance for a scientifically minded student to "avoid innumerable minute errors in order to arrive at a major fallacy".

During the present century floods have occurred at Leupp in '05, '08, '11, '16, '19, '21, '23 '29, '33 and '37. Expenditures for flood-protection have been made each year since 1929, usually during or immediately after high water had frightened the residents.

A glance at Plate 4, shows clearly that all recorded floods, up to and including the one of September, 1923, took place in years with more than average precipitation. Four years ('05, '11, '19 and '23) were conspicuously wet, and the other two ('08, '21) had considerably more than normal precipitation. In 1921 more than 60% of the total came in July and August. Not a single year since 1923 has been as wet as 1921, and in the same period only floodless 1927 was wetter than 1908.

CV-6417-201 NN001873

It will be noticed also that only two years ('31 and '36) have received more than normal precipitation since 1927, while two others ('29 and '35) very closely approach it. Four years ('28, '30, '32 and '34) are conspicuously dry.

From 1923 to 1935 only four years are on the wet side of the line, and the wettest of these exceeded the normal by a little more than 14%. The average for the period is 9% lower than that for the previous 24 years, and 10% below the normal for the previous 12 years. The normals for the three periods are 1900-11, 13.75"; 1912-23, 14.01"; 1924-35, 12.63". Normal for the entire 36 years is 13.46".

With these facts in mind, it is surprising to find, as we later shall, that the final seven years of the driest period have witnessed recurring floods at Leupp. Is it not strange, also, that 1929, dry by a hair, should have had two nearly disasterous floods, while nowhere do we find records of previous floods at Leupp in approximately normal years?

It is admitted that concentration of precipitation in the driest of years might be such as to cause serious floods. By coincidence such conditions might prevail twice in a single year, or in consecutive years. Again and again Leupp has been threatened by floods since 1929, yet only 1931 and 1936 had more than average precipitation. Interestingly enough, 1931 was the wettest year in the period, and the only one without a flood! Precipitation is shown for July, August and September in Plate 5 for comparative purposes.

We shall attempt, with the aid of these precipitation charts, to point out the factors which brought about the principal floods of the present century. But the greatest flood of modern times came in 1888, and was of such proportions that we feel we must include it in our discussion.

CV-6417-201 NN001874

CV-6417-201

STATIONS IN ARIZONA	Elev.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Bly	6800	2.31	1.67	2.03	1.81	.53	.52	2.89	2.73	1.99	1.51	1.55	2.85
Cosnino	5500	1.24	1.14	1.20	1.10	.55	.37	2.65	2.48	1.97	1.32	1.05	1.73
Flagstaff	6907	2.49	2.06	2.36	1.30	1.00	.45	3.12	2.69	1.63	1.37	1.40	2.05
Ft. Defiance	6950	1.03	1.07	.90	.79	.75	.76	2.05	2.34	1.62	.60	1.03	.74
Ft. Valley	7300	2.29	2.15	2.21	1.37	.89	.55	3.55	3.01	2.01	1.69	1.28	1.95
Ganado	6365	.29	.99	.25	.90	.43	.72	1.61	1.25	.93	.74	.90	.59
Heber	6484	1.77	1.48	1.23	1.17	.59	.65	3.63	2.91	1.84	1.17	1.12	1.38
Holbrook	5069	.62	.61	.60	.54	.27	.40	1.85	1.42	.94	.69	.72	.59
Jeddito	6700	1.19	.92	.80	.68	.42	.26	2.17	1.93	.69	1.20	.66	1.02
Keams	6600	1.31	.95	.90	.66	.39	.27	2.41	1.81	.70	1.25	.70	1.08
Leupp	4700	.63	.42	.29	.70	.19	.24	1.28	1.14	.79	.57	.35	.57
Pinedale	6500	1.49	1.57	1.52	1.21	.55	.78	3.64	2.68	1.64	1.59	1.48	1.84
Pinto	5660	.91	.94	.77	.70	.29	.51	2.11	1.78	.91	1.09	.83	.99
St. Michaels	6950	.96	.97	.95	.51	.38	.43	2.44	2.39	1.32	1.11	.68	1.01
St. Johns	565	.67	.57	.78	.53	.42	.45	2.27	2.23	1.30	.66	.56	.75
Show Low	6300	1.78	1.38	1.81	.79	.49	.46	2.47	2.38	1.73	1.23	1.41	1.71
Snowflake	5644	.69	.84	.85	.68	.45	.62	2.39	2.57	1.35	.89	.61	.68
Springerville	6862	.50	.53	.49	.46	.46	.57	3.23	2.84	1.33	.78	.62	.66
Winslow	4848	.56	.40	.47	.46	.26	.36	1.62	1.72	.78	.52	.52	.93
STATIONS IN NEW MEXICO													
Blackrock	6455	.79	.73	.92	.73	.61	.40	2.59	1.99	1.33	.89	.55	.80
Ft. Wingate	6997	.96	1.42	1.02	.98	.58	.69	2.34	2.31	1.37	1.05	.76	.97
Gamerco	6785	.51	.59	.81	.78	.57	.40	2.03	2.18	1.35	1.01	.72	.69
McGaffey	8000	1.28	1.47	1.69	1.07	.73	.80	2.96	2.27	1.82	1.28	.73	1.16
Manuelito	6252	1.09	1.52	.93	1.14	.49	.21	1.78	3.10	1.12	.80	1.32	.90
Ramah	7200	.48	1.12	1.02	.72	.67	.45	2.35	2.25	1.98	.82	.73	.78

AVERAGE MONTHLY PRECIPITATION FOR STATIONS IN LITTLE COLORADO BASIN

Table 1

WHR 56

NN001875

THE SUPER-FLOOD OF 1888.

There can be no doubt that a super-flood which occurred in the early months of 1888 was by far the largest which has taken place since the American flag snapped in the breezes of the great Southwest. We have discovered no estimate of its volume, but the story of that flood was written in ridges of driftwood which still remain, and it was deeply carved in the memories of those who were witnesses.

"Only the tops of the cottonwoods remained above water," is a phrase to which our ears have become accustomed. Again we hear the old settlers say, "The whole country seemed to be under water", or, "There was water everywhere".

In Clear Creek, a tributary near Winslow, the water rose more than 70 feet according to Burr Williams, a young cowboy in those days -- a human landmark in the Winslow of today. He is of the opinion that before this flood most of the water which now enters the Little Colorado through Corn Creek joined the river at Slough Bend, some eight or ten miles above Leupp. Mr. Billy Williams, also of Winslow, does not agree on this point. He is of the opinion that Corn Creek water entered the river near Slough Bend during this flood, but that this was not usual. Both agree that not until more than twenty-five years had passed did Corn Creek become topographically conspicuous.

Two miles south of Leupp, near the point where the road to Canyon Diablo joins the Leupp-Winslow highway, great quantities of driftwood were deposited at an elevation of more than 4720 feet -- indicating that much of the site of Leupp was under practically twenty feet of water! For years afterward, according to Burr Williams, this was a favorite camping place because of the abundance of fuel. Little, if any, of it remains today.

Such is not the case a few miles farther down the river near Tolchaco. There one can still feel something of the magnitude of that flood when he finds great logs and gnarled tree trunks stranded more than three miles from the normal channel of the river, or traces the margin of the flood for long distances by distinct lines of flood debris which are still clearly defined after half a century. At the crest of the flood the river in this area may have been nearly four miles wide, with a maximum depth of about twenty feet.

In this connection we feel it is important to call attention again to the anticline which the river bisects two miles below Tolchaco. The channel here is relatively narrow, and a major flood may become bottled - up at this point. We believe it is highly probable that this gorge caused considerable back-pressure and the

CV-6417-201 NN001876

impounding of huge quantities of water above it during the flood of 1888. It is largely due to this that twenty years afterward deposits of driftwood in the Tolchaco area could still be measured in hundreds of acres according to the statements of Mr. David Ward and Mr. Philip Johnston who lived there in 1908.

In all probability the only living eye-witness of the flood in the Tolchaco area is Mr. Bill Williams of Winslow, already referred to above. He came to Arizona in 1878 as a boy of some ten years. At the time of the flood he and his father were on the north side of the Little Colorado, Winslow-bound from Blue Canyon. It was their intention to ford the river at Wolf Crossing which is situated at the point where the river enters its gorge in the anticline below Tolchaco. Owing to water which inundated the country it was not possible for them to come within several miles of this point. Mr. Williams concurs with our opinion that the waterway in the gorge was entirely too small to carry so great a flood, and consequently backed it out over many thousand acres of the surrounding territory. Eventually a considerable portion of this water found a new passage around the northeastern end of the anticline, flowing toward the northwest into the Dinnebito, and entering the canyon of the Little Colorado four miles below Grand Falls. Plate 9.

The flood, Mr. Williams says, was the result of a quick spring thaw accompanied by three days and nights of warm rains throughout the entire Little Colorado Basin, after a winter in which much snow had fallen with no previous opportunity to melt. Similar snow conditions may be expected about once in five years. How frequently heavy snows may be expected to combine with rapid thaws and warm, prolonged rains of general distribution we can not say.

About twelve miles below Grand Falls, in the Black Falls area, considerable quantities of driftwood may still be found. Trunks with diameters of as much as four feet are stranded at unbelievable elevations. From such evidence we are hopeful that reasonably accurate estimates of the size of the 1888 flood may be made. If a volume of at least 300,000 cfs is indicated we shall not be greatly surprised.*

How often do such huge floods occur? No man knows. Of one thing we may feel certain. They are very rare. In the day when such a flood does come again, Holbrook, Joseph City and Winslow may suffer quite as much as Leupp. The present dike system at Leupp will be of no more benefit than a single sack of dirt. To anticipate such a flood and attempt to protect the settlement against it would cost much more than the rebuilding of the entire plant in a more wisely chosen location.

* "We only need a good profile of the valley before [illegible]" [illegible]

CV-6417-201 NN001877

Whether the next great flood is a week or a century or even a millennium away we can not tell. There is evidence at hand which leads us to believe that they have been exceedingly rare during the past twelve centuries. Almost within the limits of Leupp may be found pottery sherds which show the site was occupied during the Eighth and Ninth Centuries by Pueblo Indians. Elsewhere in the immediate vicinity sherds are abundant. It is reasonable to believe that frequent floods would either have burried or swept away these evidences of earlier occupations. On the contrary surface evidence of former occupations are conspicuously present throughout the entire valley, and where they have been burried it is wind rather than water which has done the work.

Of this we may be certain. The super-flood of the late '80s is half a century behind us, and the next one is fifty years nearer.

THE FLOOD OF NOVEMBER 1905.

We are indebted to Mr. David Ward, of Winslow, Arizona, for first calling our attention to the flood of November 1905. It is also mentioned by Gregory. (19b)

For many reasons this flood is of particular interest, and not the least among them is the fact that Leupp was being laid out when it occurred, but was either not badly enough flooded to make it obvious that a different site should be chosen or else the founding party ignored the facts. In addition it was the only November flood of which we have record and may have been the largest since the one of 1888.

Each of the seven stations reporting set its all time high for November precipitation in that month. Flagstaff reported 7.10", with 26.7" of snow. The other stations were as follows: Ft. Defiance 3.58; Holbrook 3.82; Pinto 3.85; Show Low 5.68; Ft. Wingate 2.70; and Manuelito 4.14. The average for the seven stations was 4.41"; their November normal only 1.07". The actual precipitation was 416% of the normal -- a greater departure than any other month has shown this century. Only July 1911, January 1916, July 1919, July and August 1921, and July 1929 have been wetter, and these only slightly so since the wettest of them had only 4.94", and two were almost identically the same as November 1905. Our charts show that we have had more than four inches of precipitation only once for each 63 months considered, and that more often than not it came in July. During the first 22 years of this century there were six such months, three of which came in a period of 25 months, or one in each 8 2/3. Since this period of greatest frequency there has been only one month -- one in 176 -- with precipitation above four inches. There was no such month in the final 92.

The severity of the flood of November 1905 was greatly increased by the manner in which the precipitation came, and the accompanying temperatures. Mr. Ward recalls that there came first a prolonged period of very gentle rain which thoroughly soaked the ground without causing any run-off. With the ground in this condition very cold weather suddenly arrived and the soil was frozen deeply. Then there came a heavy snow (over 26" at Flagstaff) which blanketed the entire basin. Again there was a sudden change in temperature, and a driving snowstorm became a warm rain. The rapidly melting snow ran off the frozen earth as if from pavement.

Another factor which contributed to the violence of this flood might easily be overlooked, largely because of its bigness. In 1880 a drought began which inflicted the entire Southwest. Texas, Utah and California found ranges overgrazed and conditions becoming desperate. The completion of the railroad across northern Arizona in '83 had made accessible those wonderful grasslands Beale reported. But it was in '86, when west Texas was particularly hard hit, that the first big shipments began to arrive, as the Hashknife outfit unloaded 29,000 longhorns at Holbrook and Winslow. Before the '80's ended at least 70,000 had been shipped to those two points. The drought burned on through the '90's. In 1893 there were 800,000 cattle and over a million sheep in the state, as we have previously pointed out, and thousands of horses. For another dozen years adequate rains were withheld and beneath the restless hooves of the ever-increasing hordes of starving creatures the paradise of northern Arizona became, with tragic swiftness, a paradise lost.

So it was that the opening years of the present century found the grassy paradise of 1880 changed to a land of desolation, the abode of choking dust-storms, creeping dunes, and hot winds armed with flying sand that burned and stung the struggling vegetation which drought and over-grazing had not already destroyed. The morning's green leaves were often crisp and black at sunset. A stockman's heaven had become a land accursed.

With this rather broad and hastily sketched picture of conditions in mind it is not difficult to understand why 1905, with heavier precipitation than any other year in recent times, should have had serious floods, and should mark the beginning of severe arroyo cutting which still continues.* It was in 1905 that the Wepo Valley, site of many Hopi farms, had its agricultural value largely destroyed by an arroyo which ate through it with surprising rapidity. It seems probable, also, that the severe silting of Tolani Lakes began at this same time, for the Wepo drains into the Polacca which at that time emptied into Tolani Lakes.

destruction protected

*"Yes – here is protection [illegible] and has been for thousands of years, [illegible] and it is probably of the intermittent type, not continuous as [illegible] condition, which alone is underlying [illegible] is [illegible] though [illegible] minimum. Of course, a very [illegible] and serious drought might well have [illegible] so denuded as to cause similar destruction – as it seems to have done at some (one) prehistoric time, which is not adequately dated." Reiche.

CV-6417-201 NN001879

The discharge of the Little Colorado River at Holbrook reached a momentary peak of 20, 180 cfs on November 27. (51a) It is to be remembered that a large number of important tributary streams enter the Little Colorado below Holbrook. Leroux, Manilla, Chevalon, Clear Creek, Cottonwood, Corn Creek (Oraibi, Polacca and Jeddito), Coyote and Canyon Diablo are the best known among them. Momentary discharge from Clear Creek alone has been known to reach 39,000 cfs during recent years (April 4, 1929), and Chevalon has contributed over 10,000 cfs within the past decade. It is improbable that either of these recent maxima approach the contributions made by these streams in the flood of 1888. The flood which passed the site of Leupp in November 1905 was augmented by flows from all the tributaries mentioned, except Canyon Diablo, and may well have exceeded 75,000 cfs.

So far as we can discover the flood took only one human life. Mr. David Ward, referred to above, was Indian trader at Oraibi at the time. He had sent an Indian teamster to Winslow for supplies. Returning along the west side of the Little Colorado to a point not quite midway between Leupp and Winslow, the Indian attempted to ford the river at the ordinarily safe Old Hopi Crossing. Horses, wagon, supplies and driver were swept away, and no trace of them was ever found. A week or two later Mr. Ward stopped at the little cluster of tents which were pitched on the site of Leupp, but could learn nothing about the whereabouts of his vanished outfit. Late in the afternoon he turned his horse about to return to Oraibi and crossed the Little Colorado two miles below Leupp. The land on the north side of the river had become a veritable quagmire, and nearly 30 hours were consumed in traveling the next six miles. Mr. Ward is not now certain just what had caused this unusual condition, but it seems highly probable that the area was not inundated by overflow from the river. Since 1929 this area has occasionally been dotted with numerous small ponds, and it seems likely that similar but exaggerated conditions existed early in the winter of 1905.

We may consider 1905 of particular interest because it marks the end of a quarter of a century of drought with the wettest year since records have been kept in the Little Colorado Valley, because it saw the beginning of arroyo cutting, and rapid silting of Tolani Lakes, and because Leupp was founded that year actually during one of the largest floods of this century.

FLOOD OF DECEMBER 1908

In December 1908 another flood swept down the river with surprising swiftness. Sudden rises are the rule, but certainly this seems to have been an extraordinarily rapid one. Guy Yazzie, a Navajo Indian of Leupp, recalls that he had been hunting rabbits

with his grandfather across the river from his hogan. After killing one a few hundred yards from the normal channel, they recrossed on dry ground to their home and skinned their kill almost immediately. Probably not more than thirty minutes had passed after the killing of the rabbit until Guy and his grandfather looked out across the dry channel toward the spot of their recent triumph. To their amazement water had covered the site, and within an hour the river was nearly a mile wide.

Almost 20 miles farther down the river Mr. David Ward, at that time at Tolchaco, to which place he had moved from Oraibi in 1907, spent the night with other men of the little settlement building dikes to save his home and other buildings which were threatened by the rising water. By daylight the water had subsided, and there was no further immediate danger. Unlike many other builders in the Little Colorado Valley, Mr. Ward took the river's warning seriously, and built his trading post, which had been planned for a site near his residence, nearly a mile away on a rocky bench where it would never be menaced by the river.

The flood was brief, as we have seen, and apparently of no particular importance. It is of interest, nevertheless, for several reasons. It is the only December flood of which we find record, and the only winter flood in which melting snow seems to have played no appreciable part. Although it was one of the wettest Decembers ever recorded in the Arizona section of the Little Colorado Valley, precipitation in the New Mexican drainage was below normal (31.8%), and the storm was distinctly an Arizona affair. Average precipitation for the 7 Arizona stations was 3.14" (2.64% of normal) and even at Flagstaff only 20% was accounted for by snow. None remained from the previous month.

Nine stations reported their monthly precipitation as follows:

Flagstaff	5.74	Pinto	1.72	Winslow	4.38
Holbrook	1.51	St.Michaels	1.80	Blackrock	.46
Keams	3.76	Show Low	3.05	Ft. Wingate	.10

The unusually heavy precipitation at Winslow and Keams Canyon probably explains the sudden rise in the river.

FLOOD OF JULY 1911

Gregory writes that destructive floods occurred in the major tributaries of the Little Colorado in 1911, but mentions no month. (19b) A study of precipitation records makes it almost certain that July was the time. Eight stations reported average rainfall of

CV-6417-201 NN001881

4.70", which was 183% of their normal. Although the station average for July 1919 was 4.94", this was only 184% of normal for the 17 reporting stations; the station average for July 1929 was also 4.70", but in this case it was only 175% of normal for the 14 reporting stations. Therefore July 1911 was probably more nearly like July 1919, the wettest on our chart, than it was like July 1929, in spite of station averages which are identical.

George Greeley, a Navajo Indian who has lived at Leupp for more than 20 years, recalls the period, but in no great detail. He says that he was in northern New Mexico at the time, that heavy rains came on several consecutive days and that all streams were very badly flooded.

On March 7, 1916, Mr. H. F. Robinson, Superintendent of Irrigation, wrote the Commissioner of Indian Affairs, "Twice within seven years the river has been high enough to allow water to leave the stream bed and run across the land following the old channel to the west. (The channel referred to is the one which became the main channel of the Little Colorado in 1933.)

"The first time the school grounds were flooded. Subsequently a couple of dykes were constructed (as shown on the map), and this year the water failed to reach the school grounds only because of these dykes and the fact that the water was not quite as high as in the former flood." (45a) See Plate 6.

In 19[illegible] a report, also the Commissioner of Indian Affairs, states that the dikes mentioned were constructed in 1909, but the source of this information is not indicated. Our own conversations with early residents had lead us to believe that construction had taken place in 1911. It is, of course, a matter of no great importance. If, however, the dikes were built in 1909, the flood which invaded the campus at Leupp must have been the one of December 1908. If 1911 is the correct date, then the flood about which Mr. Robinson wrote may have been the one under consideration.

The damage mentioned by Gregory must have been in the nature of arroyo cutting, for the most part, although no definite statement to that effect was made. At the time of the flood approximately 2,000,000 head of livestock were grazing on 14,983,667 acres of the Navajo and Hopi Reservations. There were more than 1,600,000 sheep and goats, but less than 35,000 cattle. Horses, mules and burros numbered about 333,000. (19b) The previous year had been dry, with only 10.82" of precipitation. The probable improvement in range conditions which accompanied the relatively heavy precipitation from 1905 - 1909 could easily have been erased by the single dry year of 1910. "A sharp desert year", says

Isaiah Bowman, "may have more effect on crops, tree seedlings, and soil erosion than half a dozen normally moist years." (5a) Nearly a billion restless hooves trampled the sparse and struggling vegetation during a dry May and a burning June, setting the stage for the torrential rains of July. It would be surprising if those showers had not destroyed as well as blessed the countryside.

Preston, Dean and Post, in their report to the Commissioner of Indian Affairs, under date of June 2, 1931, state that a flood of magnitude took place in 1916. Precipitation data (Table 2) indicate strongly that there may have been two or possibly three periods of high water in that year. (For Table 2, turn page).

December and January precipitation in the winter of 1915-16 was unusually heavy, indicating that floods might easily have occurred in either or both months, providing temperatures were favorable. No December ever recorded at the Flagstaff weather station has had more snow than December 1915, and only two months (Jan. 1895 and Aug. 1904) have surpassed the 8.16 inches of precipitation recorded in January 1916. In those two consecutive months 10.7 feet of snow fell at Flagstaff! (In January 1895 the all time record was set -- 120 inches. In the preceding December there were 38 inches -- a total of 13 feet 8 inches in two months.)

As might be expected, unusual falls of snow occurred during those same months over most of the Little Colorado Basin in New Mexico as well as Arizona. December and January temperatures were below normal at Flagstaff, and may be assumed, with reasonable safety, to have been so rather generally. Flagstaff's February temperatures were slightly above normal, with an average maximum of 45.3°, and a highest temperature of 58°.

We know that on February 8 the Commissioner of Indian Affairs wrote Mr. H. F. Robinson, Supt. of Irrigation, regarding flood protection work at Leupp. (45a) It seems probable, although we have no proof to offer, that the Commissioner was writing in response to either a telegram or a letter telling him of flood conditions. Even in recent years correspondence regarding the situation at Leupp has lagged except during or immediately after periods of emergency. In replying to the Commissioner's letter Mr. Robinson stated that additional dikes would be needed, and recommended the construction of jetties and the cutting of a small pilot channel. Minimum cost, $6,500.00.

Precipitation, temperatures and correspondence, then, all point toward a possible flood in February 1916. Furthermore floods of importance have occurred in the early part of February in both 1932 and 1937, making such a flood seem all the more likely. Our personal experience during many years of residence in the Little Colorado Basin has taught us to expect severely cold weather during

STATIONS	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANN'L
Flagstaff	1.82	5.03	8.16	0.77	1.77	0.06	0.37	0.00	2.46	3.29	1.78	3.61	0.00	1.11	23.38
Fort Valley	1.35	4.45	8.57	0.82	2.69	0.30	0.35	0.00	3.54	3.87	2.01	3.82	0.00	1.15	27.12
Holbrook	0.75	1.37	2.04	0.21	0.64	0.67	0.11	0.00	1.36	3.26	2.91	2.46	0.00	0.50	14.16
Heber	1.40	3.87	6.91	0.41	2.01	0.93	0.08	0.00	3.42	4.18	0.96	3.03	0.0T	2.54	24.47
Keams Canyon	N.R.	1.27	5.10	0.01	0.80	0.60	0.15	0.00	1.86	1.13	0.81	2.86	0.00	0.55	13.69
Leupp	0.40	1.50	0.93	0.02	0.20	T	0.02	0.00	1.90	0.07	0.47	0.03	0.00	0.45	4.09
Pinedale	1.94	4.15	6.32	0.62	1.89	0.82	0.15	0.00	5.27	4.29	1.29	3.74	T	0.87	25.26
Pinto	0.82	1.14	2.88	0.26	0.84	0.64	0.02	0.00	1.42	2.95	1.96	1.98	0.00	0.85	13.80
St. Johns	0.63	1.03	3.51	T	1.17	1.20	0.31	0.00	2.14	0.97	0.45	2.21	0.00	0.58	12.54
St. Michaels	1.04	1.04	3.61	T	0.34	T	0.23	0.00	3.18	2.91	1.31	2.14	T	0.40	14.12
Show Low	1.66	1.96	5.39	0.41	1.74	0.58	0.21	0.00	2.72	2.74	1.27	2.76	0.00	1.16	18.98
Snowflake	0.84	1.71	2.59	0.07	1.85	0.56	T	0.00	1.41	2.43	0.95	2.17	0.00	0.50	12.53
Springerville	0.61	1.06	1.64	T	0.54	T	T	0.00	3.65	2.28	0.32	2.02	0.01	0.10	10.56
Winslow	0.60	1.34	1.50	0.24	0.66	0.31	0.24	0.00	0.98	2.54	0.93	1.65	0.00	1.20	10.25
Blackrock	0.78	1.18	3.40	0.33	1.60	0.33	0.42	0.02	3.38	2.12	1.71	3.91	T	0.30	17.52
McGaffey	N.R.	N.R.	2.86	0.14	1.24	0.50	0.35	T	5.20	0.65	1.35	3.45	0.15	0.66	16.55
Station Average	1.04	2.14	4.09	0.27	1.25	0.47	0.19	0.00	2.74	2.48	1.28	2.61	0.01	0.80	16.19

Station average for the year was 2.10 inches above normal. Average for the entire basin was 1.75 inches above normal.

PRECIPITATION DATA FOR THE LITTLE COLORADO BASIN
November 1915 to December 1916

Table 2

WR# 65
CV-6417-201
NN001884

the first three weeks of January, but delightfully moderate weather thereafter.

It is altogether possible that high water or even serious floods also occurred in July and August, and perhaps again in October. In the latter month the precipitation average of 2.61 inches was 249% of the normal. It must be remembered, however, that October rains are seldom of the torrential character of the storms of July and August, and that therefore run-off is relatively much less.

Although we have pointed out that floods were possible in July and August we are inclined to believe there were none. In the summers of 1932 and 1933 comparable precipitation is recorded for the months of July and August, but in neither period was there run-off sufficient to have created even a moderately serious flood in 1916. The rainy season in 1916 was spread out rather evenly over a period of four months, July to October, and interestingly enough was preceded and followed by two of the driest months ever recorded. Prior to 1923 we have no definite records of floods occurring in summer months with less than four inches of precipitation. We are, consequently, not justified in supposing that floods took place in the summer of 1916, and are encouraged in the belief that early February is the most probable time, with late January a possibility.

It is our belief that the period of considerable flow continued at least until the middle or latter part of April. Stored snow in the higher areas was unusually great, as we have seen, and this must have melted readily under the temperatures which prevailed in March and April. At Flagstaff both months show the highest average maximum temperatures in periods of twenty years or longer. On March 7 Mr. Robinson wrote that banks of the river were being rapidly eroded in the Leupp area, with the water at mid-stage. (45a)

THE FLOOD OF 1919

Post, Preston and Dean, in their report of June 2, 1931, call attention to a flood of magnitude which occurred in 1919, but do not mention the month. Ordinarily it is difficult to determine accurately from the available precipitation reports the month in which such a flood may have occurred. In the present instance there seems to be little doubt that the time was July or very early August, since this particular July was the wettest ever recorded in the Little Colorado Basin. June, ordinarily dry, had been dryer than usual. Consequently July's torrential rains fell upon parched earth, and the Little Colorado River went on the rampage. We present, in Table 3, the available precipitation records for the basin.

CV-6417-201 NN001885

CV-6417-201

STATIONS	ELEV	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bly	6800	1.50	2.40	1.02	T	.70	.34	6.91	3.65	2.03	1.07	3.21	.76
Cosnino	5500	1.00	2.16	2.80	.09	2.16	.00	3.69	2.31	1.80	3.42	2.60	.60
Flagstaff	6907	.94	2.17	1.38	.37	1.78	T	7.58	2.87	1.54	3.42	5.50	.73
Fort Valley	7300	T	2.75	1.68	.68	3.54	T	8.39	2.32	3.22	3.91	4.56	.98
Heber	6484	.65	2.52	1.40	.35	.78	.67	4.31	3.58	3.04	1.20	4.89	1.56
Holbrook	5069	.25	.94	1.01	1.04	N.R.	N.R.	N.R.	2.08	1.49	.24	1.92	.31
Keams Canyon	6600	T	1.15	1.80	.55	.45	.00	3.60	.60	N.R.	N.R.	N.R.	N.R.
Leupp	4700	.10	.58	.78	.20	.60	.10	.82	T	1.73	.95	.80	T
Pinedale	6500	.29	2.81	1.85	.46	.87	1.05	7.78	2.27	2.57	1.74	4.92	2.93
Pinto	5660	.17	1.14	1.34	.70	1.04	T	4.70	1.01	1.67	.85	1.03	1.00
St. Michaels	6950	.11	.96	2.24	.36	1.08	.50	5.29	3.64	2.57	1.51	.90	1.69
Show Low	6300	N.R.	.25	N.R.	N.R.	N.R.	.65	5.22	1.32	2.09	1.38	3.91	2.38
Snowflake	5644	.43	.95	1.27	.48	.85	.40	4.16	2.37	3.40	.35	2.93	.76
Springerville	6862	.23	1.20	.27	.30	.20	.01	4.58	3.60	1.68	.20	.75	.60
Winslow	4848	.33	.78	.63	.19	.61	T	1.84	.68	.65	.48	1.85	.36
Blackrock	6455	.05	.85	1.38	.67	.79	T	5.39	.92	3.57	.41	1.17	1.74
Gamerco	6785	.06	.76	1.48	.91	1.75	.10	4.26	.75	1.35	1.01	.85	1.33
McGaffey	8000	T	1.73	3.40	.74	1.32	.03	5.47	1.81	1.80	.51	1.24	1.70
Average	6293	.39	1.45	1.51	.48	1.16	.26	4.94	1.09	2.13	1.33	2.53	1.14

Annual Average for 15 stations 19.66 inches.

PRECIPITATION DATA FOR THE LITTLE COLORADO BASIN

1919

Table 3

WR 67

NN001886

Regardless of the exact date of this flood, it was of great importance in the history of silting and the flood hazard at Leupp for two reasons:

1. Tolani Lakes were so disasterously silted up by a great flood entering them from the Oraibi that their value as a settling basin for Oraibi and rarely for Polacca flood waters was largely destroyed. Huge quantities of silt which would have been effectively trapped in earlier times, rushed through the lakes and into Corn Creek to be deposited at the junction of this stream with the Little Colorado.

2. This silt load was of sufficient quantity to force the Little Colorado to abandon the channel it had occupied for many years, and seek a new one near the tiny cluster of buildings which then comprised Leupp. That was the first step in the long march which has carried the river from the north side of Leupp to the south side of it, a march which has already cost more than $150,000.00.

Reid Jensen, a Navajo Indian who has lived at Leupp for many years, says that he believes that this was one of several occasions when the silt deposits laid down by Corn Creek were so great that a dam was thrown completely across the channel of the Little Colorado, thus creating a temporary reservoir.

THE FLOOD OF SEPTEMBER 1923

Before we consider the important flood of 1923 it will be worth our while to review the records for the summer of 1921. Although Preston, Dean and Post do not mention this period in their report to the Commissioner of Indian Affairs in 1931, there can be little doubt that it was even more important in Leupp's history than their reported flood of 1919. It is possible, too, that only human intervention made the flood of September 1923 more conspicuous than the one which must have occurred in 1921.

We present, in Table 4, on the following page, the available precipitation data.

The combined average precipitation for July and August 1921 falls only .85" below the average for July, August and September 1923. It will be noticed that both June and September 1921 are fairly dry months, indicating a possible concentration of rainfall in much less than the 62 days provided by July and August. Obviously the almost equal precipitation of the summer of 1923 might have been distributed over a much longer period. This may not have been the case, however, since the flood reached Leupp on September 14, a fact which indicates that the vast majority of the September precipitation fell between the 8th and 13th.

YEAR	1921				1923			
MONTH	JUNE	JULY	AUG.	SEPT.	JULY	AUG.	SEPT.	OCT.
STATIONS								
Bly Ranger					3.62	6.93	3.94	1.30
Cosnino	.30	3.51	5.42	T	4.87	2.30	7.47	T
Flagstaff	1.03	5.78	4.74	.83	1.08	1.86	3.37	1.32
Fort Valley	.83	4.93	4.67	.19	4.03	2.70	4.49	.32
Heber	.47	6.26	6.50	.23		No Record		
Holbrook	.82	4.10	2.21	.35	2.13	2.39	3.51	.72
Keams Canyon	.65	4.57	7.13	.00		No Record		
Leupp	.50	1.05	4.51°	.02		No Record		
Pinedale	.64	4.27	9.00	.42	2.71	5.38	5.04	1.75
Pinto	1.46	3.93	2.68	.19		No Record		
St. Johns	1.18	7.11	3.58	.80	2.93	3.87	1.59	.70
St. Michaels	.68	2.13	5.51	T	2.91	4.24	3.01	1.57
Show Low	N.R.	5.80	4.10	.97	2.13	4.98	4.38	2.17
Snowflake	.86	6.59	5.38	.05	3.43	3.05	3.77	1.86
Springerville	.60	7.89	6.69	.19	3.76	5.67	3.07	.73
Winslow	.57	2.29	3.21	.13	4.81	2.49	3.10	.44
Blackrock	1.04	5.84	2.55	.28	1.71	3.19	3.41	.63
McGaffey R. S.	3.70	6.10	5.47	T	1.53	4.14	3.42	1.58
Gamerco	1.13	2.36	5.25	.02	1.78	2.76	2.66	1.57
Average		4.42	4.92		2.89	3.72	3.58	
Normal		2.57	2.25		2.65	2.54	1.52	
Percentage of Normal		161	207		109	147	236	

°Interpolated

PRECIPITATION DATA FOR THE LITTLE COLORADO BASIN

June-September 1921 and August-October 1923

Table 4

WH 69

CV-6417-201

NN001888

Be that as it may, the floods of 1921 passed unheralded and unsung -- left Leupp untouched, while the flood of September 14, 1923, achieved lasting fame.

Why?

Some of the reasons are not difficult to find. Look first at the 1921 records from Keams Canyon. Only one July was wetter, and only one August was half as wet from 1894 until now (1937) so far as records exist for this station. Yet these two months were side by side with their 4.57" and almost unbelievable 7.13" of precipitation -- a total of 11.7" in two months at a station where annual normal is only 12.43". The entire year of 1894 had less than 7" !

Keams Canyon empties into the Polacca which, in turn, adds its water to that of Corn Creek. The Oraibi, Polacca and Jeddito Washes -- principal tributaries of Corn Creek -- have drainage basins subequal in area. Gregory gives the following estimates, probably conservative: Oraibi 652 square miles; Polacca 672 square miles; Jeddito 623 square miles. (19b) Geographically the Polacca is the central one of these three which spread narrowly, like the fingers of a hand, across northeastern Arizona. These washes, with their companion which is called Dinnebito, are often referred to as the Washes of Tusayan. The Spanish called the Hopi Country of today "The Province of Tusayan", and it is drained by the washes so named.

It is unbelievable that the Keams area, situated as it is near the center of the Oraibi-Polacca-Jeddito drainage basin, could be so thoroughly drenched and not share its fortune with neighboring territory. Owing to disasterous silting in 1919 and earlier, Tolani Lakes were no longer able to swallow at a single gulp the bulk of the Oraibi's flow. Enormous quantities of silt, formerly checked by them were thrust into the Little Colorado River at the mouth of Corn Creek. "Mud-balls", so characteristic of this drainage, were rolled onto the flood-plain of the larger stream in thousands, rapidly building up an effective dam. The Little Colorado found its course blocked, took its second step toward the southwest and Leupp. A small irrigation project of the Indian Service, located at the mouth of Corn Creek, became a hopelessly silted mess. Beyond that there was little apparent damage, and probably less anxiety about the future in the minds of the handfull of people who lived at Leupp.

There followed the unusually dry year of 1922. Only one year since 1910 had been dryer. If floods occurred, and we doubt it, they were mediocre affairs which went unrecorded.

Down the edge of the Little Colorado's broad valley to Leupp

"The silting up of Tolani Lakes makes us more than ever wonder how Tolani depression originated. We should look it over!" Reid.

WR 70

wandered the main highway from Winslow and the East to Flagstaff and the West. Just beyond Leupp the road crossed Canyon Diablo without human help and headed for Flagstaff. To the right a fork, also on its own initiative, crossed the treacherous Little Colorado on a limestone ledge and straggled off into the Hopi Country to the northeast.

In horse and buggy days travelers camped near these crossings and rested when streams were too dangerously swollen. If the tales of pioneers are true it took a lot of swelling for those hardy folk to diagnose it as too dangerous.

In 1921 automobiles were far from unknown in the Navajo Reservation, but foolish, indeed, was the man who started off without shovel, axe, water, food and bedding. Bridges were practically non-existent even though swollen streams were apt to be abundant for several months each year. Cars, equipment, even lives were lost while those pioneers of motordom were discovering that horses, lacking ignition systems, carburetors, gas tanks and excess weight, had fording advantages no car possessed. As motorists sat by for hours or even days after teams and wagons had crossed safely and with ease, there grew a conviction that "something should be done about it".

Before anything was done, however, Mary Roberts Rinehart arrived at Leupp searching for colour for an article, which we are told, was to be entitled "Roughing It in the Painted Desert". If traditions are to be trusted, the noted author was roughing it in three Pierce Arrows, one of which contained complete dining equipment and a negro chef! Be that as it may, the Rinehart cavalcade bogged down as it tried to negotiate the crossing in the Little Colorado below Leupp, and had to be rescued by local talent.

In fairness to Mrs. Rinehart we hasten to add that "Roughing It in the Painted Desert" was never written, but "Desert Caravaners" was. Mrs. Rinehart not only frankly admits that there was a dining car and a chef, but states that there were two other huge trucks and eight passenger cars as well. (43a) Because that famous writer gave a most excellent description of conditions at the crossing below Leupp at that time we take the liberty to quote briefly from "Desert Caravaners", condensing as we go, and regretting that we must do so. We find her on one side of the river wishing she was on the other, with Flagstaff a few hours behind her, and the Hopi Snake Dance a day or so ahead.

"Now my idea of crossing a river has generally been a bridge, I have done it on a horse and in a boat. But in a machine I prefer bridges. Indeed, my liking for bridges when I am in a car amounts to an obsession. It seemed, however, that there was no bridge over the Little Colorado at Leupp.

CV-6417-201 NN001890

"The trucks were at Leupp. So was the river. So were we. And all of us gave every indication of remaining at Leupp.

"Over a breadth of bed of some six hundred feet of fissured mud and sand, the river sent small trickles of water which wandered here and there, as if seeking the mother stream. But if they did not know where the mother stream was, we did. It was hiding under the far bank, which was twenty feet high and extremely steep. Not that the mother stream was much, really. It was some thirty feet across and waist-deep in the center, but, with the usual instinct of rivers, she had dug her channel abruptly. That is, one stepped off from the shallow into trouble at once. I know. I did it.

"So on Jordan's stormy bank we stood, and cast a wistful eye * * *

"But the school superintendent was both kindly and resourceful. He sent to the school for a team, Indians, and ropes, while our drivers took off their shoes and socks and rolled up their trousers. * * *

"The Ford had caught up with us, and was, as is the custom with Fords, selected for the first victim. Escorted by running men it shot out on the mud, stuck, was dug out, stuck again, again was rescued, and now made a flying leap at the stream. Suddenly we gave a loud wail. The Ford went forward smartly, dipped, fell forward, buried its nose in the hole in the river bottom, and there remained, slowly drowning. There is nothing sadder than a drowning Ford.

"We camped that night on the other side, in a sandy desert plain, for the men were exhausted."

Not long after this event steel bridges, only a few hundred feet apart, were constructed with Federal funds across both streams. They were completed in that fortunately dry year of 1922.

It was those bridges, coupled with the relocation of the river channel in 1919 and probably again in 1921, which forced the flood water of September 14, 1923, into Leupp until it stood more than a foot deep in some of the buildings. It drowned hogs in the government pens and sheep in a corral behind the Leupp Trading Post.

Above Leupp it was possible for the river to attain a width of over two miles, and it did. At the new bridge it was expected to squeeze through an opening just 300 feet wide, and could not. To complicate the situation the greatest flood since the arrival of the White Man came roaring down Canyon Diablo. Up in the canyon the water was actually 60 feet deep. (45b) As it issued from the hills it could spread broadly southwest of Leupp, but it was expected to compress itself sufficiently to pass beneath the new 150 feet bridge which had so recently been constructed at its mouth. It refused.

CV-6417-201 NN001891

To make a very bad matter worse, both bridges had been set high above the stream-beds to protect them from floods. Long, high, earthen approaches made access to them possible. But those same approaches very effectively dammed back the flood waters of the rampaging streams -- that is, they held the water back long enough to thoroughly frighten the inhabitants of Leupp. Then, when water was beginning to splash the stringers of the bridges, nearly 20 feet above the normal stream-bed, the approaches - all four of them failed. Water subsided rapidly at Leupp.

Below the bridges a mile or two lived an obstinate Navajo. He had lived there for many years and the river had never reached his home. No amount of argument could convince him that he should take his flock of nearly 1,000 sheep and goats to higher ground, or move his family to safety. When his sheep were struggling to keep their nostrils above water, he and his family were rescued from the top of his hogan with a team and wagon. His sheep were lost. Several miles down the river a fellow tribesman was found several days later on the roof of his hogan -- dead from exposure. At least one other band of sheep was lost, and part of a third flock.

Interesting, to say the least, are the available figures for the volume of that flood. Santa Fe engineers at Winslow, long accustomed to estimating the Little Colorado's floods placed the crest at 50,000 cfs as it raced past their bridge in Winslow. Eighteen miles below Leupp, at Grand Falls, the U. S. Geological Survey gaging station reported a flood maximum of 120,000 cfs. (51a) That is an increase of 240% in less than 60 miles! Beyond any reasonable doubt it reflects the impounding of the water by the new bridges near Leupp. No considerable tributary enters the Little Colorado between Canyon Diablo and Grand Falls. For that reason the Grand Falls record of 120,000 cfs is often misquoted as the approximate crest which Leupp withstood, although it was almost wholly without dikes. It is our opinion that the combined crests of Canyon Diablo and the Little Colorado in the Leupp area did not exceed 100,000 cfs and that 80,000 cfs might be a rather close approximation of the truth.

In 1922 it had been decided to enlarge considerably the school and agency facilities at Leupp. This work had scarcely been undertaken at the time of the September flood. Tradition tells us, but we have not verified the statement, that one Hugh Russell, foreman in charge of construction at Leupp, wired the Bureau of Indian Affairs advising that work be abandoned. According to the story as now told he received a reply saying, "It is your duty to build not to advise."

Whether that is true or not, approximately half a million dollars has been expended in improving plant and equipment at Leupp since the flood menace became painfully obvious. Even approximate figures are not available for the cost of flood protection since 1929. Lowest estimates place the sum at a little more than $125,000.00, while the highest ones are just about double that amount.

But returning to 1923, the flood and the inadequate bridges, we find Mr. H. F. Robinson, Supervising Engineer in the U.S.I.S., writing the Commissioner of Indian Affairs on October 9, making a report in response to the Commissioner's telegraphed request of September 21. It was a carefully prepared report, stating what had happened, why it had happened, and what should be done. We quote briefly from it:

"The water did not reach the bridge structure, but the underside shows traces of muddy water that had been splashed against the surface. * * * had not the approaches given away to allow the additional waterway, * * * the bridge itself would have been destroyed.

"From the Cañon Diablo bridge, on the west it is 180' to the high water mark. On the east side is a wide flat and water backed up over that for a long distance with no perceptible current. From the Little Colorado bridge it is 400' to the south to the high water mark and 1005' to the north. * * *

"The only portion of the four approaches that is left is a little pile of dirt at the east end of the Canon Diablo bridge * * *, and a piece of the approach on the north side of the Little Colorado bridge about 125' long * * *."

The Little Colorado Bridge was left between 18 and 20 feet above the ground at either end, according to Mr. Robinson's report. He made suggestions for temporary repairs which would make it available for use until permanent repairs could be made. The report continues:

"It is suggested and recommended that the only safe method of permanent repairs would be to build an additional span or spans to this bridge at the south end. As the rock is so near the surface, it will not be very expensive or difficult to make a solid foundation at a reasonable expense, and it is believed that there should be constructed two spans of 100 feet each in this direction."

The following suggestions were made regarding the Canyon Diablo bridge:

"For permanent repairs, the east approach should be constructed of earth or shale and on the west approach another span

should be constructed not less than 100' long. Inasmuch as for that distance there is no bed rock within a reasonable depth, it might be more practicable and it certainly would be cheaper to put in a pile approach, in which case, owing to the obstruction caused by the piles, the length should be at least 150'".

As this is being written more than 13 years have passed since Robinson's report reached Washington. Aside from temporary repairs, made and made again, absolutely nothing has been done. On February 8, 1937, (just eight days ago) the approaches again held back a flood until the campus in Leupp was partially inundated, and once more the water overshot the south approach to the Little Colorado Bridge, but for so short a time that little damage was done.

Such was not the case in April, 1929, when the south approach was again carried away. More than two years later, on June 2, 1931, a letter was addressed to the Commissioner by William S. Post, Director of Irrigation; John Paul Dean, 1st Lieut. Corps of Engineers; and Porter J. Preston, Engineer, Bureau of Reclamation. We quote:

"In considering the flood problem at Leupp School the related flood problem at Ashurst Bridge, two miles below, which serves the Leupp Indian Reservation, also came to our attention. This bridge across the Little Colorado River immediately below Canyon Diablo is useless at high water because its approaches wash out. It is now 300 feet long and should be extended to twice this length for proper waterway.

"Such widening would tend to relieve the backwater situation at the school above."

Time and again tens of thousands of dollars have been made available for the construction of dikes -- dikes which were the more urgently needed because not one cent had been made available for the proper altering of the bridges. Thousands of feet of those dikes are in ruins today. It is apparent now that these ruined sections should never have been constructed. It is easy for us to say that now because "hindsight" is so much keener than foresight. On the other hand, when hindsight has for thirteen years insisted that the bridges below Leupp are inadequate, and nothing is done to remedy the grave situation, it seems to indicate a complete lack of anything which even faintly resembles foresight. Perhaps it is just another case of the very famous leaky roof which couldn't be fixed while it was raining, and didn't need fixing when it wasn't.

FROM 1923 TO 1929

The period from September 1923 until April 1929 was one without notable floods, but not one which was free from inconspicuous changes of importance.

Only two years, according to our calculations, have been wetter than 1923 during the present century -- only four have been drier than 1924. Although 1925 was wetter it was still more than an inch below normal, while 1926 was wet by nearly half an inch.

Then came 1927 with a surplus of almost two inches. The rainy season arrived late in June. On the 28th the gage at Grand Falls recorded a flood crest of 28,800 second-feet. The sun had risen that day on a dry river bed! That flood left Leupp untouched. Two years later a nearly identical flood actually entered the town and did some serious property damage.

There are no official precipitation records from the area drained by the Tusayan Washes (tributaries of Corn Creek) that year. At that time, however, the writer was leading a photographic expedition into the "Province of Tusayan" for a great eastern newspaper, and many are the records which were written indelibly in his mind. Arroyos gouged to new and terrifying depths, vanished bridges, adobe traps lying in wait for an overloaded Model T, roads transformed to arroyos overnight, detours which lasted for days -- such things are not soon forgotten.

Late in August and far into September Corn Creek ran full again and again, pouring its turbulent waters, fairly groaning with a burden of silt, into the Little Colorado, hurrying madly along to rush beneath the new bridge, leaving countless thousands of tons of its burden on the flood-plain or in the channel of the river. For the third (possibly the fourth) time the Little Colorado was force to make a new channel closer to Leupp. In June water had come uncomfortably close to the barn and the hog pens, but there was nothing exciting about that with the flood of 1923 so handy for comparison. The September floods were smaller, but considerably prolonged.

The year 1928 was dry -- drier even than 1925 when cattle died from thirst or starvation, and wealthy stockmen found themselves suddenly bankrupt. It was, in fact, the driest year in a dozen. Over much of the Little Colorado Valley the summer rains failed to arrive. Elsewhere they were half-hearted except at Winslow where 4.44" fell in August to make it the wettest one in history. Most of this rain came in a single cloudburst on August 2nd, flooding basements and making a shables of the lower floor

CV-6417-201 NN001895

of the old Harvey House.

Eventually the rainy season did come, but it was very late. At many stations October and November were the wet months. December was cold with moderate to light snows. January's temperature was about normal, though a bit on the cold side, with moderate snows again. February was bitter with light snows to add to all that had fallen in the two previous months. Although March was warmer it was below normal and the light snows continued. Then came an April which was cold, but not cold enough to prevent rains from pelting down upon the accumulated snows of four cold months.

The trader at Leupp awoke on April 5th to find his store almost surrounded by the Little Colorado. Death came to the hogs and the rabbits in government pens, while floors of the lowest buildings were covered with a few inches of muddy water. For the first time in its history Leupp was being inundated in a dry year.

Before many hours the southern approach to the Ashurst (Little Colorado) Bridge was carried away. "Everything", we have been told by many who were there, "was running -- Corn Creek, the Little Colorado and Canyon Diablo. Until the approach let go even the water from Diablo backed up almost to Leupp. Afterward the water went down pretty quick."

It seems probable that at the crest of the flood between 45,000 and 50,000 cfs were attempting to get through the "bottle neck" beneath the Ashurst Bridge. The flood was definitely smaller than the one of 1923, although nearly the same water level was reached in Leupp. The gage at Grand Falls recorded a maximum flow of 50,500 cfs, against 120,000 in 1923. The changed course of the river directed the stream much more squarely at the town than had been the case in 1923. Furthermore it seems almost certain that for years the bridge had been inducing rapid silting for several thousand feet upstream. Then, too, the unusually dry years of 1924 and 1928 had merely served to aggravate an already serious overgrazing situation in the Navajo and Hopi Reservations, making for accelerated run-off and capacity silt loads.

It is surprising that despite the fact that an approach had been washed out for a second time, thus demonstrating how important a factor it was in forcing flood water into Leupp, it was not only replaced but an attempt was made to make it "flood proof" with faces of wire-bound rock. It appeals to us as a plain [illegible] of putting a gentleman of color on the safety-valve. [illegible] this new approach has been over-topped on at least four [illegible] and as recently as February 8, 1937, it has held

against all onslaughts. A flood of the magnitude of the one of September 1923 has yet to come. Perhaps the approaches will withstand it, but it is to be hoped, for the safety of Leupp, that they will not. But we are getting ahead of our story, and must return to other events of 1929.

Shortly after the newly constructed approach was completed it was put to the test. June 1929, was one of the driest months ever recorded in the Little Colorado Basin -- which is simply another way of saying it was practically bone dry. May, ordinarily dry, was drier than usual. So it was that the first weeks of July found the ground parched and baked to bricky hardness. More than half the month burned past without relief. Then, as one resident put it, "They just pulled out all the corks". At the close of the month 14 stations reported an average of 4.70", and that nicely concentrated.

The writer has cause to remember that summer. He arrived in Leupp barely in time to greet and help fight that flood -- a struggle which was frequently renewed in both August and September. The flood reached Leupp on July 27th and its crest arrived on the 29th. Once more rabbits drowned in the government pens, and for weeks the campus was a cluster of islands surrounded by inches of water. A small torrent raged past the trading post, cutting it off from the remainder of town until a small bridge was thrown across it. A few hundred dollars worth of damage was done to some "green" concrete, and the four recently completed wells, which constituted the source of the domestic water supply, were filled with muddy water.

With adequate equipment it would have been easy to combat that flood. But there was no machinery, not even any teams. Weary men fought that flood with shovels -- and won! It seemed an endless fight with the water always rising so rapidly that quitting time, meal time, time for a deep breath could never come. Once a kind citizen went down the line of volunteer workmen with a welcome bottle of pop for every man. All stopped a few seconds to drink -- while the water came over the top in three places! There followed hours of frantic labor, but again the flood was stopped.

It was really a case of nip and tuck much of the time. On another occasion four workmen stopped for a meal. Before they could be served they were recalled because the dike could not be held without them. Hungry and tired beyond all reason they toiled on until the gap was filled.

There is a limit to the endurance of even willing workmen with much at stake to spur them on. Eventually that point was reached during the afternoon of July 29. The little cluster of

CV-6417-201 NN001897

workers, worn out by ceaseless labor, hungry, sleepless for what seemed ages, drearily admitted that the river was too much for them. Exhausted, they sat down with their backs to the water which had risen incessantly for days and nights on end. One inch more and the dike would fail -- one little breeze to ripple the surface!

The croaking of thousands of desert toads filled the air. No doubt it had filled the air for hours, but it had remained unheard. Now there was a chance to listen. A Navajo youth smiled a haggard smile and remarked, "All this water makes some people happy". Those about him were amused by his philosophical remark. But not a man among them cared to see the water, which brought happiness to "dusty" toads, start over the top of the dike, as they knew it surely would. Perhaps that explains why not one of them looked back at the flood as all waited for the inevitable rise to destroy the labor of many days and nights. For half an hour they talked of many things as they waited. Then one could stand the strain no longer. He turned slowly, dreading what he might see.

The water had fallen three inches!

The writer knows. He it was who looked.

For a few days the waters retreated, as if resting for a renewed attack. An informal council of defense was held in Leupp. Most of the men present favored building a dike to force the river to stay in its old channel, thus preventing it from flowing south of the town and cutting it off from Winslow. It was pointed out that the river was coming through a few small breaks in its former banks -- breaks which could be readily filled with sandbags. One of the councilors suggested that eventually the river would establish a new channel south of the town, and that the thing to do was to encourage it to go that way. "That would put us on the north side of the river", the others objected, "and we'd have to build a bridge over which to get to Winslow. We don't want that".

"Regardless of what you want", replied the lone councilor, "that is exactly what you are going to get". Two years later, after a fortune had been spent trying to force the river to go where it could not, that bridge was built. Three years saw the length of the bridge doubled. The sixth year saw $20,000 spent to encourage the water to go under that bridge, to persuade the river to use the course it wanted to use in the summer of 1929. Now, in the last half of the eighth year since that suggestion was made, the Little Colorado River is firmly entrenched on the south side of town, and Leupp finds itself entering its fourth year on the north bank, with life going on as usual.

Back in August 1929 the breaks in the river bank were filled with bags of sand, and the bags were promptly ignored by the flood which arrived August 12, soon after the little dams had been completed. Again the river went south of town and covered the road to Winslow for a full half mile. "What we need", was the concensus of opinion, "is a dike out there on the edge of the channel which will hold the river where it belongs". "What we need", maintained one to the merriment of all others, "is a bridge and a 'canal' to tell the river to go under it".

From 1929 to 1937.

This period, as we have previously stated, has been marked by repeated floods at Leupp, and by the construction of an elaborate system of dikes, jotties and pilot channels. The first comprehensive survey of the area immediately surrounding Leupp was made in August 1929 by a young engineer named Stover whose work was made difficult by much high water. A copy of his map upon which have been drawn the protective structures which were first suggested with a view to giving Leupp adequate protection, is presented herewith as Plate 7.

This first plan had three major features. 1. A system of dikes, 33,150 feet in length, which would completely surround the town and extend upstream for a distance of more than 2 miles, terminating at a point near the junction of Corn Creek with the Little Coloredo. 2. A series of retards (numbered 1 to 8 on Plate 7.) on the southwest side of the river which would induce silting, and force the river to reoccupy approximately its former position, labeled "Ultimate Channel", while protecting the dikes. 3. A pilot channel above the mouth of Corn Creek which would force its waters to enter the main stream at a more favorable angle.

Fortunately conditions had changed so completely before this plan could be carried out that it was never attempted. It is obvious that its authors did not appreciate the magnitude of the silt burden carried by the waters of Corn Creek, and the impossibility of forcing the river to return to its earlier channels by the means suggested. In view of what has happened, it seems exceedingly doubtful that the channel which was to have been excavated above the mouth of Corn Creek ever would have functioned properly. The plan does show, however, that the real nature of the problem was recognized, despite the fact that the solution suggested was just a bit naive in the light of subsequent events. We, of course, have the distinct advantage which "hindsight" affords.

CV-6417-201 NN001899

Another early plan, which also recognized that Corn Creek was the villain in the case, called for a series of dams and cuts which would have taken that stream from its normal channel near Tolani Lakes and lead it through an entirely different one to a point about 3 miles below Leupp. A survey was actually carried out, and it was shown that there was sufficient fall to allow this to be done. There was no assurance that the 12 or 14 miles of this new channel would keep itself clean. The cost of construction would have been more than $300,000.00, as against a possible valuation of $400,000.00 for Leupp. Even if the channel had worked there is a strong possibility that a new delta might have been built below Leupp in such a way that flood dangers would have been increased.

Still a third plan was considered, attacking the problem from an entirely different angle. Its author recognized the importance of Grand Falls as the final control point for downcutting in the Leupp sector of the river, and suggested that a channel be blasted through the lava to a depth of twenty feet or more. This, he pointed out, would allow the river to entrench itself deeply, to reoccupy its old canyon, and thereby prevent all future floods from doing any serious damage. If the river had actually followed its former canyon, and we see no particular reason why it should have done so immediately, the Canyon Diablo Bridge and a number of the buildings in Leupp would have been undermined and destroyed. No thought seems to have been given as to where this new entrenchment might stop, to what damage might be done to valley lands by the lowering of the water-table, to the impetus this change in bed level might give to the cutting of arroyos in the main valley or in those of tributary streams, or to other possibilities for serious trouble. The idea was abandoned for none of these reasons, but because the estimated first cost was about $750,000.00.

A fourth plan called for the lowering of the channel through the anticline below Tolchaco. Its author believed that the control point for bed levels was this anticline, and also that the anticline was still in the process of formation at a rate which was so much more rapid than that at which the river was entrenching that the stream was now "hung up" at that point, causing the floods at Leupp. This plan seems never to have had really serious consideration.

As we have said, not one of these plans was ever carried out. During August and September 1930 a modification of the one shown in Plate 7 was constructed, however, under circumstances which were made difficult by several minor floods. Plate 8 shows the dike which was built, and the Kellner jetties which were installed. Some of these jetties were obviously placed to protect

the embankment which, because it had been built with a dragline, and not compacted, fairly melted wherever a current of water reached it. The long line of jetties which curves away from the levee was expected to force the river northeastward into earlier channels, by inducing silting along the streamward side. Actually the river got behind this line, caused extensive silting on the wrong side, and forced the river through the dike not far from its junction with the one constructed in 1909 - Dike D, Plate 7.

All this work was carried out in feverish haste following a flood which had lasted from July 12 to 23, and reached a crest of nearly 14,000 cfs on the 19th. During this flood several small dikes which had been constructed with Indian teams, or by hand, were destroyed, and the road to Winslow was inundated as part of the water swept south of the town.

On April 6, 1931, Supt. J. E. Balmer wrote the Commissioner of Indian Affairs, "Since the dikes were constructed we have kept a very careful watch over them and from time to time have repaired weak points, but it is believed that it would be economy to move the entire school plant immediately. Approximately $55,000 have been expended during the past two years in trying to save the present plant, but at this time we have less protection than we had a year ago."

Preston, Dean and Post, on June 2, 1931, summed up the situation at that time in the following paragraphs which we quote in full. "The present protection system consists of a frontal levee about three feet higher than the crest of recent floods. (The highest daily average shown at the Grand Falls station from October 1930 to June 1931 was only 1920 cfs. We do not have crest figures for the period, but crests are rarely more than double the highest daily average. The floods referred to were therefore far more apparent than real, and serve to show how really bad the situation had become. Flows of less than 5,000 cfs looked quite as serious as flows of 50,000 cfs had a few years before.) These levees have been gradually built up by teams and draglines until the top is in general seven feet above the general surface of the bottom land. The first low levees thrown up have been overtopped within the last two years but as they now exist some seven feet in height they have been adequate to meet such flood conditions as have existed so far as elevations are concerned. These levees have been thrown up in the face of immediate or anticipated dangers. Neither their location nor their dimensions are suitable to cope with the situation that now confronts them. Behind the frontal levee the School area is partially surrounded by a secondary levee tying into a low ridge immediately north of the School. This has served in the past to

CV-6417-201 NN001901

keep most of the water away from the buildings when the frontal levee has failed. However, during this situation the Leupp School became an island. To reach the mainland on the south required the use of a road which was submerged with a foot or more of water.

"Riverward of the frontal levee, Kellner steel jetties have been placed. They serve as a measure of protection to the levee itself. They undoubtedly assist in deflecting the current away from the levees. Light barbed wire fences have also proved effective for deflecting the current and inducing deposit. Approximately $60,000 has been expended in maintenance and construction of the levees and jetties to date." (12a)

It was recommended that the existing dikes be strengthened and others added, one of which would form a causeway and contain a bridge, thus allowing water to escape if the frontal levee failed, and also affording a safe roadway to high ground. The town was also to be protected by a substantial dike on the south and west sides so that backwater could not enter. This last provision was never carried out, according to specifications. After the flood of February 8, 1937, a much less expensive dike was constructed, and its approximate location is indicated on Plate 8. This dike, smaller and shorter than the one recommended, is a real contribution to Leupp's future safety.

Just two months after the report of Preston, Dean and Post was written a flood with a crest of 6,800 cfs did considerable damage to the frontal levee, and brought speedy action on the construction of the causeway and bridge which had been recommended. The frontal levee was repaired and extended on its southern end until it reached high ground, thus filling in an emergency spillway which had been considered advisable. This and the construction of a bridge only 300 feet long were soon shown to be serious mistakes.

The Flood of February 11, 1932.

During the exceedingly severe winter of 1931-32 snowfall in the Little Colorado Basin had been unusually heavy. When temperatures finally moderated the change was sudden and was accompanied by several days of light, warm rain. The river began to rise on February 8, a serious flood was rapidly destroying the outer or frontal levee on the 10th. On the afternoon of the 11th the dike failed in several places as the flood reached a crest of approximately 30,000 cfs. Every one of the nearly 400 school children was immediately moved to high ground. Army tents were rushed to the scene and set up on a hill south of town. Because

the waterway beneath the new bridge was not adequate the flood was impounded in the dike-surrounded area southeast of the town and rose to within 18 inches of the top of the newly constructed causeway. The approaches to the new bridge were saved only after great labor. Leupp was abandoned for the remainder of the school year, the pupils being cared for at great expense in temporary quarters at Winslow, or distributed to other government schools in Arizona and New Mexico.

Hysteria -- always a greater menace than high water during floods at Leupp -- reached its all time high at the time of this flood. Of this we have abundant proof in the form of telegrams, letters, official reports and vivid recollections. Owing to the fact that the new causeway had been constructed with teams it had never been threatened, and there never was any actual danger to life at any time during this flood. The flood passed almost as fast as it had come, but considerable flows were almost continuous until April 19.

Agitation for the removal of the entire plant reached fever heat. On February 14, Roy Nash, Field Representative for the Commissioner of Indian Affairs wired his superior, "At Leupp main dike is breached in such position that another flood like last will impinge directly upon agency buildings stop Two hundred thousand dollars will not ensure safety stop Two hundred fifty dollars a day now being spent on dikes is money down the rat hole stop To return children to school and patients to hospital is courting disaster stop Airmail follows."

In that letter Nash said, "I wish to put myself on record as follows:

1. Whoever located the agency at Leupp originally lacked judgment.
2. Those who poured money into the plant after the flood menace had been demonstrated were criminally stupid.
3. He who assumes responsibility of ordering school children and hospital patients back into those buildings after what happened last week is very likely to become a party to a ghastly murder of innocents.

"As I have just telegraphed, the main dike is breached not only a mile and a half above the plant, but directly opposite the plant. Neither team nor steam shovel can be put into that muck to repair the dike for 30 days.

"If, -- and there is every likelihood -- melting snows or spring rains bring another flood before the dike can be repaired, the main current will shoot directly at the plant. Then God help them!

"With all the earnestness I possess, I advise abandonment of that plant now. Stop sinking $50,000 every few years in what

must be perpetual repairs."

The opinion of Mr. Nash was very widely shared at that time, and has been little changed up to the present time, despite the very great changes which have taken place in the channel of the river, and marked improvement in the protective works.

The net result of all the uproar -- and there was lots of it -- in 1932 was that the height of the causeway was increased, the length of the bridge was doubled, Dike D was raised nearly 4 feet, and two frame buildings sufficiently large to house all the school children, were constructed on the hill where the army tents had been pitched during February. Slightly more than a year was required to carry out this program. The frontal levee was not rebuilt, but a new levee, marked "1933 Levee" on Plate 8, was constructed from Dike D around the northeastern quarter of town. This dike will do much to protect property in the event that Dike D and the lower section of the frontal levee fail.

During 1934 the river began eating into the causeway about 1000 feet north of the bridge, and threatened to pierce it at that point. Fortunately the only high water that summer was from August 29 to September 2. This caused much anxiety for the safety of the dike where the river meandered against it and precautionary measures were carried out during the flood which reached the astonishingly low crest of 3,060 cfs on the 30th.

On November 14, 1934 a committee composed of Charles F. Bentley, Guy Hamilton and F. W. Slattery recommended the construction of a series of pilot channels to remedy this situation, and to encourage the river to cut a new course which would make it approach the causeway bridge directly. This recommendation resulted in the construction of the 7 pilot channels which are shown in Plate 8. Work was begun in April 1935 and completed in June. The estimated cost had been $11,000 but the actual cost was nearly double that sum.

In order to encourage the river to use these new channels a diversion dam was built across the bed of the Little Colorado immediately north of Pilot Channel 1. Floods approximating 3,000 cfs arrived in August and destroyed this dam, although all the channels were forced to function for a short period. Channel 2, which was originally dug deeper than the others, continued to carry a portion of the flow after the destruction of the dam. Channel 7 was, we believe, cut afterward and a second dam was built to divert the water through it. This structure failed almost immediately.

During March 1936 the river adopted Channel 2 as its normal low water bed, and abandoned its former meandering course until the arrival of rather high water during April when, for a time the old channel was reoccupied. During this period of high water Channel 2 was greatly widened and considerably deepened. When flow stopped in May the stream was apparently so deeply entrenched that it could be expected to continue there indefinitely. The upper ends of all other channels were more than six feet above the dry stream bed as it entered Channel 2.

In August there came a big flood down Corn Creek and another down the Little Colorado. Water began to run across the flats south of the pilot channels in considerable volume, and the lower portion of Channel 4 began to receive several tributaries from the south, particularly in the area below the frontal levee. On Labor Day we discovered the surprising fact that Corn Creek had driven the Little Colorado from Channel 2, and taken possession. For two miles the Little Colorado was a river without a channel. It seemed to wander almost aimlessly over several sections of flat land, and was controlled only by the breaks in the frontal levee through which it had to pass.

During September it was rapidly entrenching itself in the area immediately southeast of the bridge. This we show rather roughly in Plate 8. By the end of this late August and early September flood Corn Creek had very seriously silted Channel 2. In fact its bed was considerably higher than it had been at any time since it was constructed. The 1933 - 36 Channel was also very heavily silted, and gave every appearance of being permanently abandoned. During the fall there was no further run-off in Corn Creek. Flow in the Little Colorado was consistently low, and confined entirely to the lower section of Channel 4 and the flat area to the south of it.

December found unusually heavy snows falling in Arizona and New Mexico. January was one of the coldest months ever recorded in the Little Colorado Basin. Early in February came a quick thaw, accompanied by light rains and scattered showers. At noon on the 8th the flow at Leupp was not over 200 cfs. Before 6 P.M. the crest of a flood which may have surpassed the one of February 11, 1932, had swept past Leupp. All the pilot channels ran full, then overflowed their banks. The 1933 - 36 Channel was reoccupied. Channel 2 was cleaned out and continued to carry large quantities of water for several days. The newly entrenched channel which the river was cutting southeast of the bridge moved steadily northward toward the lower end of the pilot channels, and gave every indication that it would cut into them about 1000 feet east of the bridge.

This is not the place to go into the details of the behavior of the river or the pilot channels. Such information must be reserved for a later report -- a report of a very different nature. Suffice it to say here, that our rather careful study during 1936 of the changes made in the Leupp area leads us to conclude that, for a time at least, the greatest of Leupp's flood difficulties have passed. In 1932 the river was trying to shoot directly at the town. Today, thanks to the increased size of the delta of Corn Creek, the course of the river has been so greatly altered that this is no longer the case. The channel beneath the bridge in the causeway has been considerably enlarged and deepened by the cleaning out of deposits both old and new.

Exact figures are not yet available as to the size of the floods of August '36 and February '37, but when they are published we believe they will show fairly equal crest volumes. The August flood created a mere flurry of excitement, whereas the February flood very nearly precipitated a panic, particularly after a portion of the town was inundated with a few inches of backwater. In our opinion each of these floods will be found to approximate in size the one of February 11, 1932, which had a crest volume of slightly more than 31,000 cfs.

Both of the February floods followed exceedingly severe Januaries. In each case January temperatures at Leupp fell more than 20 degrees below zero! Not only was January 1937 the coldest month ever recorded in northern Arizona, but Leupp had the lowest mean temperature of any weather station in the entire state! Deeply frozen ground prevented deepening and widening of channels to take place at normally rapid rates which usually accompany severe floods. Deposits of silt which were extensive under the causeway bridge and under the Ashurst Bridge -- two miles farther downstream -- could not be readily swept away. This fact resulted in water being forced to abnormally high levels both above and below the dikes, and backwater was forced onto the campus. Exactly similar conditions prevailed during the flood of February '32.

We feel that this factor must be given consideration in all predictions of what future floods may do to Leupp. A flood which may pass in perfect safety through unfrozen channels might prove disasterous over deeply frozen ground.

In spite of all the flood exitement at Leupp during the past eight years, the Little Colorado River has staged only three floods worthy of the name since 1929. Those are the three we have just discussed -- February '32, August '36, and February '37. In proof of this statement we present the momentary flood peaks for each year since the gaging station was installed at Grand Falls,

CV-6417-201 NN001906

and our own estimates for the recent two floods, records of which have not yet been published.

Year	cfs.	Year	cfs.	Year	cfs.	Year	cfs.
1926	27,800	1929	50,500	1932	31,300	1935	30,000
1927	28,800	1930	13,700	1933	7,500		
1928	2,140	1931	6,800	1934	30,009		

Floods of 1926 and 1927 caused no excitement at Leupp. Neither did the one of August 1936. That is at least interesting.

We have already stated that we believe there will come at some future date a flood of such huge proportions that present flood protection will be of no use whatsoever. By this we do not mean to say that we feel Leupp should be immediately abandoned. Quite the reverse is true.

Leupp is now connected by telephone with the most important points in the Little Colorado Basin above it. By cooperation with the Forest Service, and the use of various units of the Indian Service it should be possible to know of the coming of any flood of disasterous proportions at least three days in advance of its arrival. It takes a flood crest from 15 to 18 hours to travel from Winslow to Leupp, and any flood which will greatly damage Leupp under present conditions will first damage Winslow, in all probability. The entire population of Leupp can walk to safety in thirty minutes. There is, therefore, no excuse for the loss of a single life. Fifteen hours, with present available facilities for transportation, would allow the most valuable parts of the equipment to be removed in advance of the arrival of any serious flood. There would doubtless be some damage to buildings and heavy equipment.

Of course we have no way of knowing when such a flood may strike. It may not come for a decade, or a century or longer. True, the maintenance of dikes can not be done without some expense from time to time. But neither can Leupp be moved or abandoned without great expense.

To us it seems that Leupp represents an investment of, let us say, half a million dollars. It never was a gilt-edge investment. Recognizing this fact, nearly a quarter of million dollars was spent to make it better. Now that this has been done, is it not strange to abandon the whole place? If a man invested $500,000 in bonds which he found someday become worthless due to forces beyond his control, then built a $250,000 strong box to protect those bonds, we might think he was foolish, but if he suddenly decided to burn those bonds while they were

still paying dividends simply because they would ultimately be worthless -- Well, we would know he was crazy.

Stone buildings can not be profitably dismantled and rebuilt. Sewers can not be salvaged at a profit, sidewalks are a total loss, and steam and water lines are not much better. If Leupp is either abandoned or simply moved to a safer site close at hand, the present buildings represent almost a total loss, as does every cent which has been put into dikes and channels, and most of the investment in the bridge. If Leupp is destroyed by a flood, at some future date, the loss will not be much greater. Property, not human life, is at stake.

Recent changes in the river have contributed to the safety of the town, not to its peril. If future changes reverse this situation, and the cost of maintaining flood protection becomes prohibitive, Leupp can still be abandoned, and it should be. We do not feel that the "bonds" are worthless today, or that the time has come to burn them.

SUMMARY OF CONCLUSIONS

1. We concur in the conclusion of Herbert E. Gregory that the anticline below Tolchaco is responsible for the form of the Little Colorado River Valley from Tolchaco to Winslow.

2. We conclude that Grand Falls has been the control point for bed levels in the Leupp area for several thousand years.

3. We conclude that for many centuries the Little Colorado Basin has been subjected to periods of accelerated erosion during which arroyos were present.

4. We contend that although the present period of accelerated erosion, which began in 1905, followed the overdevelopment of the grazing industry in northern Arizona, it also followed a drought of 24 years' duration which ended in 1905. Therefore, since archaeological evidence indicates that a similar period of arroyo cutting followed the great drought of 1275 - 1300, we conclude that prolonged dry periods are a major cause of accelerated erosion.

5. We concur in the conclusion of other students that the delta of Corn Creek was the underlying cause of the floods which afflicted Leupp in 1929 and afterward, and that the Ashurst Bridge also contributed to the seriousness of major floods. We conclude, further, that the continued growth of this delta has alleviated rather than increased the flood hazard by forcing the river far to the south of Leupp where it is rapidly entrenching.

6. We conclude, for reasons appended, that the abandonment of Leupp at the present time is neither necessary nor advisable: A. Because present channel conditions tend to alleviate rather than aggravate flood hazards. B. Because protection afforded by dikes has been recently increased. C. Because a more thorough understanding of the factors involved, and improved facilities for communication allow predictions to be made as to the probable time of arrival and the approximate volume of floods far enough in advance to permit necessary emergency measures to be taken.

It is [illegible] "natural degradation" [illegible]
I still insist that [illegible] and have given [illegible]
evidence in the note on page 6. Bill
"I see" Richie
4 years! The archaeological evidence here goes back [illegible]
not 1 [illegible]? Come, think! Richie. "Come, I agree" Bill.
"OK OK" Richie.

WR 90

BRIEF BIBLIOGRAPHY

1. Bancroft, Hubert Howe
   (a) History of Arizona and New Mexico. 1530 - 1888.

2. Beale, Edward Fitzgerald
   (a) Report to the Secretary of War Concerning the Wagon Road from Ft. Defiance to the Colorado River. April 26, 1858.

3. Bentley, Charles F. In collaboration with Guy Hamilton and F. W. Slattery.
   (a) Recommendations for the Construction of Pilot Channels Near Leupp, Arizona.

4. Bolton, Herbert Eugene
   (a) Spanish Exploration in the Southwest, 1542 - 1706.

5. Bowman, Isaiah
   (a) Our Expanding and Contracting "Desert". Geographical Review - Volume 25. 1935.

6. Brady, L. F.
   (a) Geological Activities of the Museum of Northern Arizona, 1931.
       Being Vol. 4, No. 9 of Museum Notes, Museum of Northern Arizona.

7. Castañeda, Pedro
   (a) Relation du Voyage de Cíbola. Winship's translation.

8. Colton, Harold S.
   (a) A Brief Survey of Early Expeditions into Northern Arizona.
       Vol. 2, No. 9. Museum Notes Mus. of N. Arizona
   (b) A Survey of Prehistoric Sites in the Region of Flagstaff, Arizona.
       Bureau of American Ethnology Bul. 104.
   (c) Sunset Crater. Geographical Review, Vol
   (d) The Rise and Fall of the Prehistoric Population of Northern Arizona.
       Science, October 16, 1936.

9. Coronado, Francisco Vasquez de
   (a) Letter to Mendoza, August 3, 1540. Winship's Translation.

10. Coues, Elliott
   (a) On the Trail of a Spanish Pioneer.
       Being an annotated translation of Padre Francisco Garcés'.
       Diario y Derrotero 1776.

CV-6417-201 NN001910

11. Cozzens, Samuel W.
(a) Three Years in Arizona and New Mexico.

12. Dean, John Paul in collaboration with Post, William S., and Preston, Porter J.
(a) Report on the Flood Conditions at Leupp, Arizona. Submitted to the U. S. Commissioner of Indian Affairs, June 2, 1931.

13. Dellenbaugh, Frederick Samuel
(a) Naming the Grand Canon.
(b) The Romance of the Colorado River.

14. Delong, Sidney R.
(a) The History of Arizona. (Poor.)

15. Englehardt, Father Zephyrin
(a) The Franciscans in Arizona.

16. Espejo, Antonio de
(a) Account of the Journey to the Provinces and Settlements of New Mexico, 1583. Bolton's Translation.

17. Farfan (de los Godos), Marcos.
(a) Account of the Discovery of the Mines, 1599. A sworn statement prepared for Juan de Oñate. Bolton's Translation.

18. Garcés, Padre Francisco
(a) Diario y Derrotero que siguio ... a los pueblos del Moqui de N. Mexico, 1776. Coues' Translation.

19. Gregory, Herbert E.
(a) Geology of the Navajo Country. Being U.S.G.S. Prof. Paper 93.
(b) The Navajo Country. Being U.S.G.S. Water-Supply Paper 380.

Hamilton, Guy. See Bentley, Charles F.

20. Haskett, Bert.
(a) Sheep Industry in Arizona. Arizona Historical Review. Vol. VII, No. 3 July 1936.

21. Hammond, George Peter in collaboration with Rey, Agapito
(a) Luxán's Narrative. A translation of the diary of Diego Perez de Luxán. 1583.

CV-6417-201 NN001911

22. Hewett, E. L.
(a) Ancient Life in the American Southwest.

23. Hinton, Richard J.
(a) The Hand-book to Arizona, 1877.

24. Hodge, Frederick Webb
(a) Handbook of American Indians.
Bureau of American Ethnology Bulletin 30.
(b) Introduction to "Coronado", Grabhorn Press Edition.
(c) Footnotes for above.

25. Hrdlička, Aleš
(a) The Coming of Man from Asia in the Light of Recent Discoveries.
Annual Report, Smithsonian Institution. 1935.

26. Huntington, Ellsworth
(a) Civilization and Climate.

27. Ives, Hoseph C.
(a) Report Upon the Colorado River of the West.
36th Congress, 1st Session Senate Executive Document 90. 1861.

28. James, George Wharton
(a) In and Around the Grand Canyon.

29. Jaramillo, Juan
(a) Relacion que dio el Capitan Juan Jaramillo.
Winship's Translation.

30. Johnston, Phillip
(a) The Story of Tolchaco
Museum Notes, Vol. 9, No. 2. Museum of N. Arizona

31. Kidder, A. V.
(a) An Introduction to Southwestern Archaeology.

32. Kincer, J. B.
(a) Precipitation Trends.
Bulletin of the American Meteorological Society Volume 15. 1934.

33. La Rue, E. C.
(a) The Colorado River and Its Utilization

. Leslie, Lewis Burt. See Stacey, May Humphreys

34. Lockwood, Frank C.
(a) Pioneer Days in Arizona.

35. Luxán, Diego Perez de
(a) Entrada qui hizo en el Nuevo Mexico Anton de Espejo en el ano de 82.
Hammond and Rey Translation. Published by Quivira Society. 1929.

36. McClintock, James H.
(a) Arizona
(b) Mormon Settlement in Arizona

37. McGregor, John C.
(a) Culture of Sites which were Occupied Shortly Before the Eruption of Sunset Crater.
Bulletin 9, Museum of Northern Arizona. Oct. 1936.
(b) Letter to the author. March 1937.

38. Nelson, N. C.
(a) The Antiquity of Man in America in the Light of Archaeology.
Smithsonian Institution Annual Report, 1935.

39. Neuffer, H. C.
(a) Report on the Flood Situation at Leupp, Arizona. October 2, 1930.
A report to the Commissioner of Indian Affairs. MS

40. Newberry, J. S.
(a) Geological Report for the Ives Expedition. Washington 1861.
Post, William S. See Dean, John Paul.
Preston, Porter J. See Dean, John Paul.

41. Reiche, Parry
(a) Quarternary Deformation in the Cameron District of the Plateau Province, Arizona. MS
(b) Letter to the author. March 1937.
Rey, Agapito. See Hammond, George Peter

42. Richardson, Rupert Norval in collaboration with Rister, Carl Coke
(a) The Greater Southwest

43. Rinehart, Mary Roberts
(a) The Out Trail. Chapter entitled "Desert Caravaners"
Rister, Carl Coke See Richardson, Rupert Norval.

44. Roberts, Frank H.H. Jr.
(a) A Survey of Southwestern Archaeology.
Smithsonian Institution Annual Report, 1935.
(b) The Ruins at Kiatuthlanna, Eastern Arizona.
Bureau of American Ethnology Bulletin 100.

CV-6417-201 NN001913

45. Robinson, H. F.
(a) Report on Flood Conditions at Leupp, Arizona. March 7, 1916 Map. MS
(b) Report on Flood Damage at Leupp, Arizona. October 9, 1923. MS

46. Simpson, James H.
(a) Coronado's March
Smithsonian Institution Annual Report 1869.

47. Sitgreaves, L.
(a) Report on an Expedition Down the Zuñi and Colorado Rivers. Washington 1853.
Slattery, F. W. See Bentley, Charles F.

48. Spinden, H. J.
(a) The Population of Ancient America.
Smithsonian Institution Annual Report 1929.

49. Stacey, May Humphreys
(a) Uncle Sam's Camels
Being the Journal of Stacey who accompanied Beale in '57. Ed. by Lesley, Lewis Burt.

50. Twitchell, Ralph Emerson
(a) Leading Facts of New Mexican History.

51. United States Geological Survey.
(a) Surface Water Supply of the Colorado River Basin.
Numerous Water-Supply Papers.

52. United States Weather Bureau.
(a) Climatic Summary of the U. S. Sec. 25. Northern Arizona.
(b) Climatic Summary of the U. S. Sec. 27. Northwestern N.M.
(c) Climatological Data. Arizona Sec. Vol. XXXV No. 1 to XL No. 12, inclusive.
(d) Climatological Data. N. Mexico Sec. Vol. XXXV No. 1 to XL No. 12, inclusive.

53. Unknown Author (Possibly Cárdenas, Garcia Lopez de)
(a) Relacion del Suceso de la Jornada que Francisco Vasquez de Coronado hizo en el Descubrimiento de Cíbola.

54. Whipple, A. W.
(a) Journal of an Expedition from San Diego, California, to Rio Colorado.
Washington 1851.

CV-6417-201 NN001914

54. Continued.
(b) Report of Explorations for a Railway Route Near the 35th Parallel North Latitude.
Vol. 3, Pacific Railroad Reports, 33rd Congress, 2nd Session. Senate Executive Document 78.

55. Winship, George Parker
(a) The Coronado Expedition.
14th Annual Report of the Bureau of Ethnology.

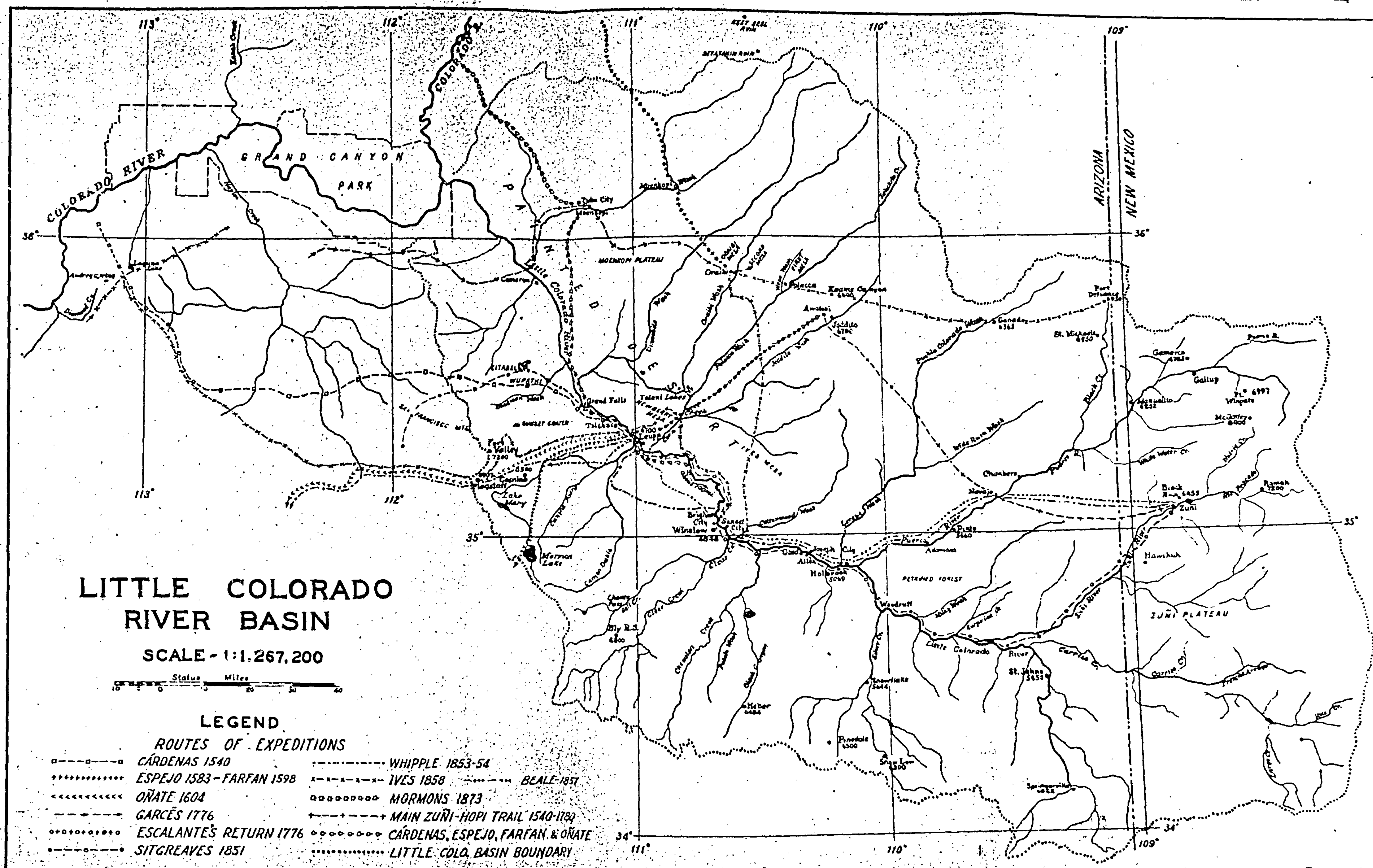
56. Woodhouse, S. W.
(a) Report on the Natural History, Sitgreaves Expedition.

57. Zárate-Salmerón, Padre Geronimo
(a) Relaciones de todas las Casas que en el Nuevo Mexico etc.
Bolton's Translation. Paragraph 46 in this document is of interest to this paper.

58. Lubbock, Sir John
(a) Prehistoric Times.

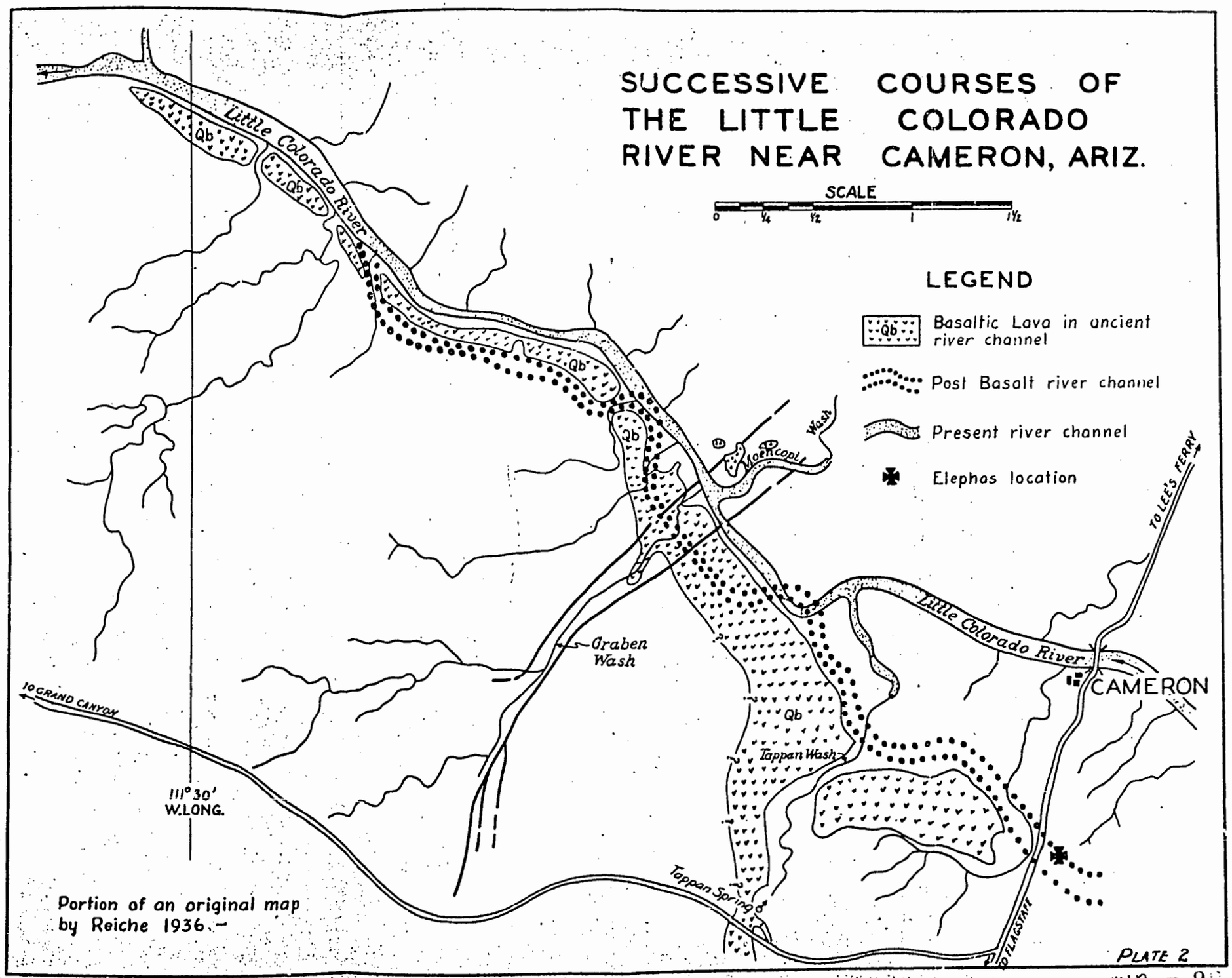
CV-6417-201

NN001915



CV-6417-201
NN001916

CV-6417-201



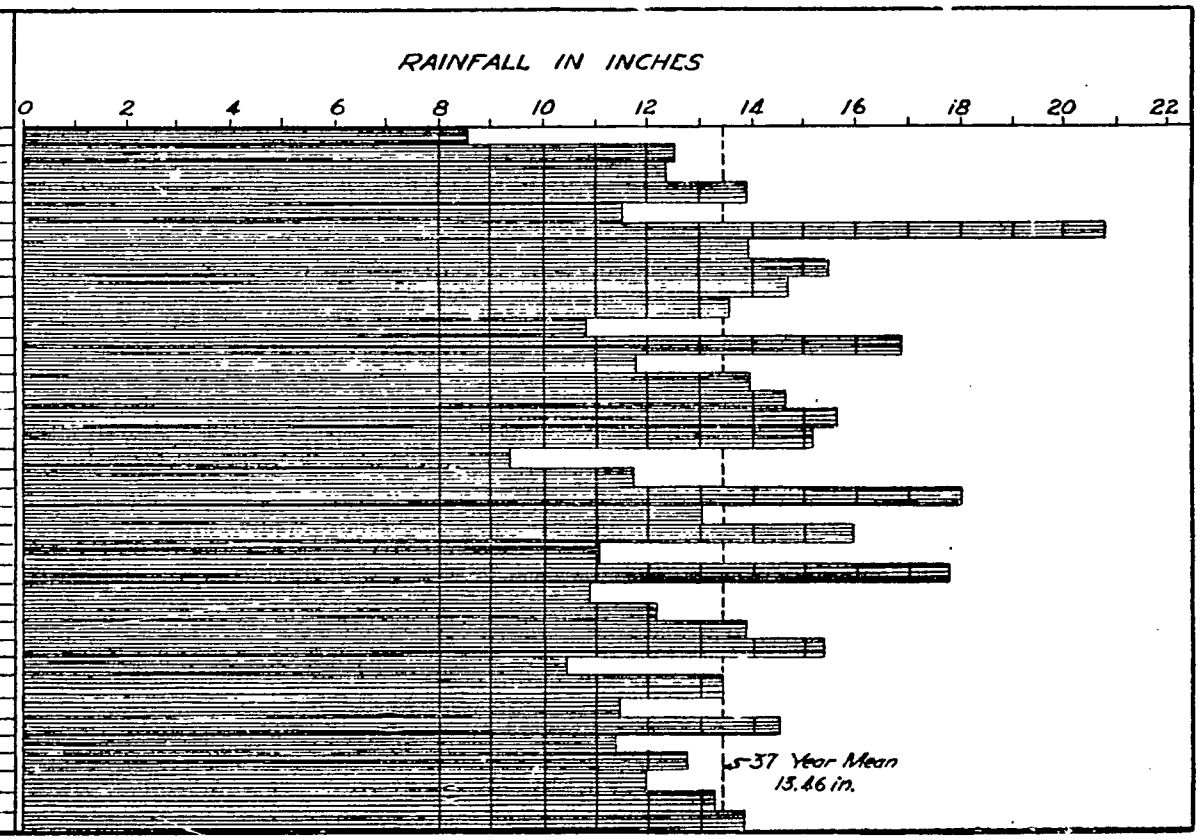
Portion of an original map by Reiche 1936.–

PLATE 2

WR – 96

NN0019177

YEAR	AVERAGE PRECIP.	NO. OF STATIONS	AV. PRECIP. PER STA.
1900	8.55	4	9.58
1901	12.54	4	13.08
1902	12.37	4	14.74
1903	13.92	4	15.90
1904	11.50	5	11.94
1905	20.79	5	22.16
1906	13.95	6	15.14
1907	13.51	7	13.94
1908	14.71	8	14.76
1909	13.55	9	14.84
1910	10.82	9	10.94
1911	16.87	8	18.76
1912	11.77	9	12.33
1913	13.97	11	13.99
1914	14.63	10	15.58
1915	15.66	12	16.63
1916	15.21	16	16.19
1917	9.35	16	11.09
1918	11.72	17	13.16
1919	18.00	15	19.66
1920	13.03	18	14.66
1921	15.96	17	16.33
1922	11.06	14	13.30
1923	17.79	15	19.80
1924	10.89	14	11.44
1925	12.18	13	13.51
1926	13.87	12	15.33
1927	15.38	13	17.03
1928	10.41	13	11.55
1929	13.44	12	15.14
1930	11.42	14	13.16
1931	14.51	13	15.50
1932	11.35	14	12.74
1933	12.78	15	14.09
1934	11.99	14	11.32
1935	13.28	13	13.94
1936	13.84	16	14.75



ANNUAL PRECIPITATION IN THE LITTLE COLORADO BASIN
ABOVE GRAND FALLS - DRAINAGE AREA - 22,100 SQ. MI.

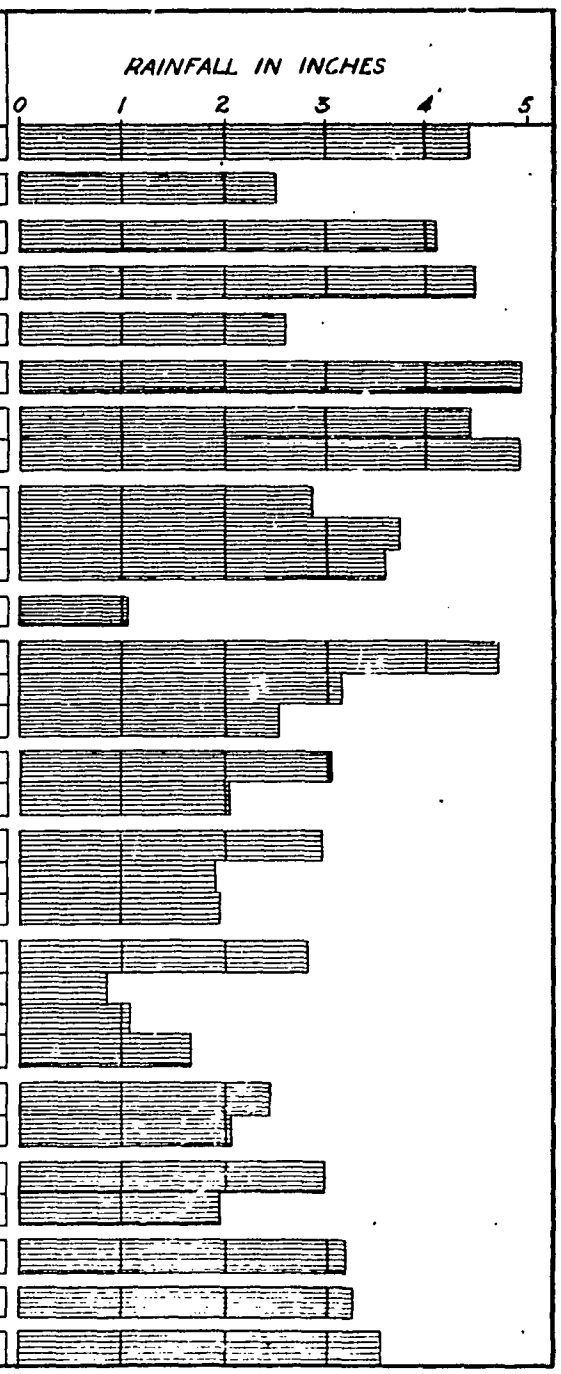
PLATE A

WR 109

PLATE 4

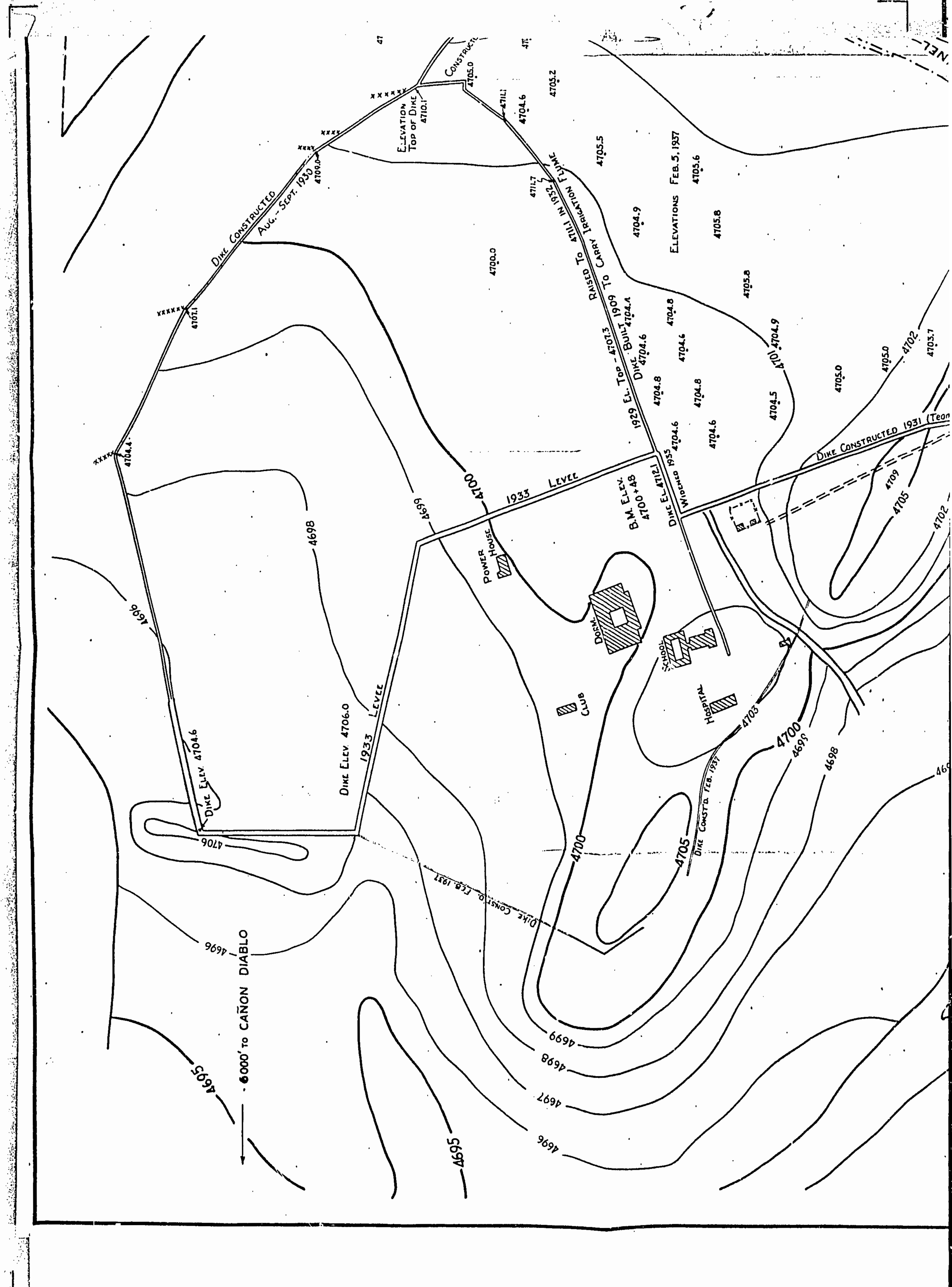
CV-6417-201
NN001918

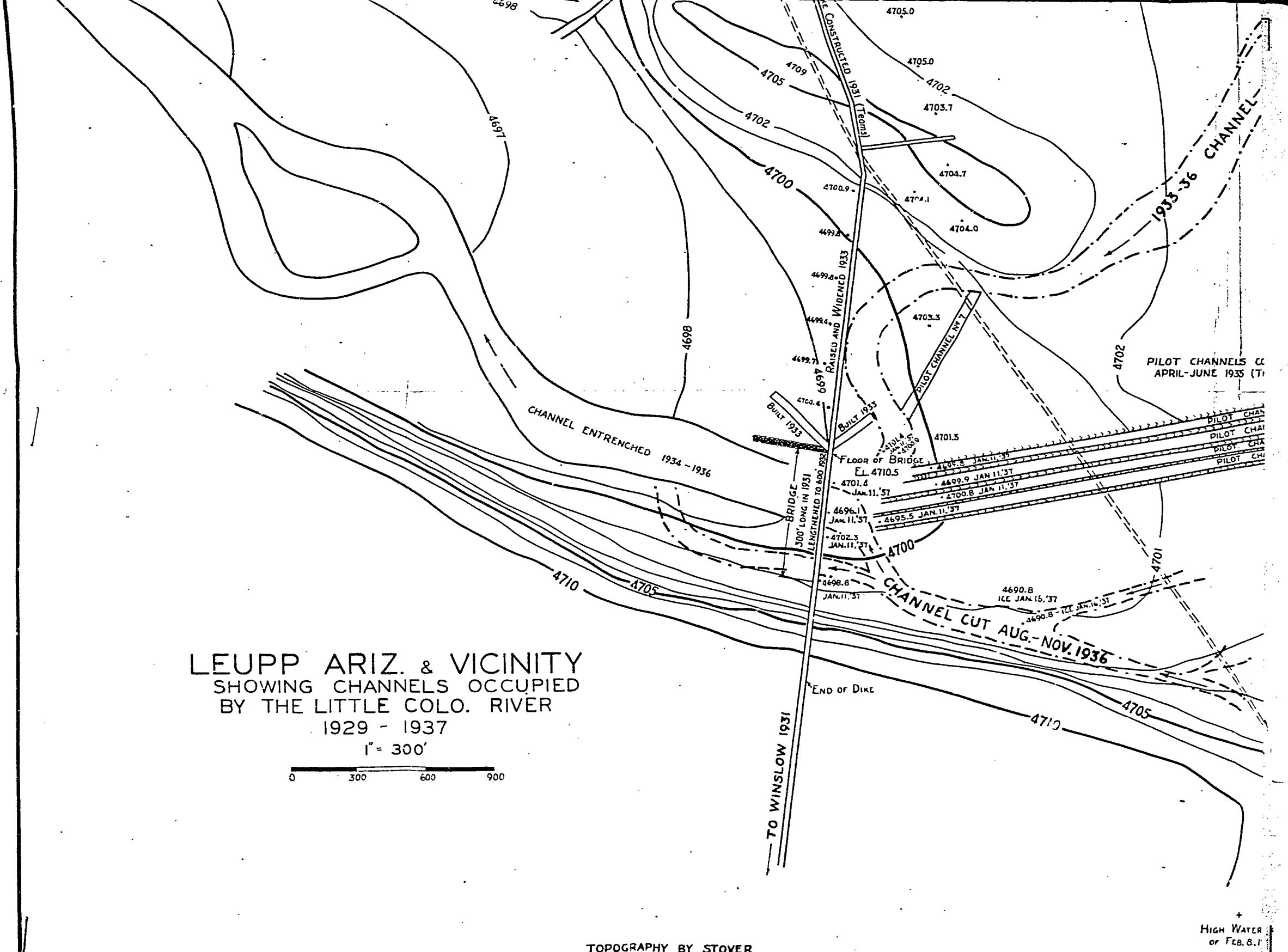
MONTH	YEAR	AV. PRECIP. PER STA.	NORMAL OF STA.	PER CENT OF NORMAL	NO. OF STATIONS
NOV.	1905	4.41	1.07	416	7
DEC.	1908	2.50	1.12	223	9
JULY	1911	4.10	2.56	183	8
JAN.	1916	4.44	1.23	360	17
OCT.	1916	2.61	1.05	249	16
JULY	1919	4.94	2.69	184	17
JULY	1921	4.42	2.57	161	18
AUG.	1921	4.92	2.25	207	18
JULY	1923	2.89	2.65	109	16
AUG.	1923	3.72	2.33	147	16
SEPT.	1923	3.58	1.49	2.36	16
APR.	1929	1.05	0.91	115	15
JULY	1929	4.70	2.69	175	14
AUG.	1929	3.14	2.37	132	14
SEPT.	1929	2.56	1.49	171	14
JULY	1930	3.06	2.66	115	15
AUG.	1930	2.07	2.33	89	15
JULY	1931	2.98	2.44	122	13
AUG.	1931	1.92	2.19	88	13
SEPT.	1931	1.95	1.34	145	12
NOV.	1931	2.81	0.81	347	13
DEC.	1931	0.84	0.96	87	12
JAN.	1932	1.08	1.03	105	14
FEB.	1932	1.69	1.04	163	14
JULY	1932	2.47	2.51	98	14
AUG.	1932	2.08	2.22	94	14
JULY	1933	2.99	2.50	119	15
AUG.	1933	1.96	2.22	87	15
AUG.	1934	3.18	2.22	143	14
AUG.	1935	3.24	2.30	141	13
AUG.	1936	3.54	2.15	165	16



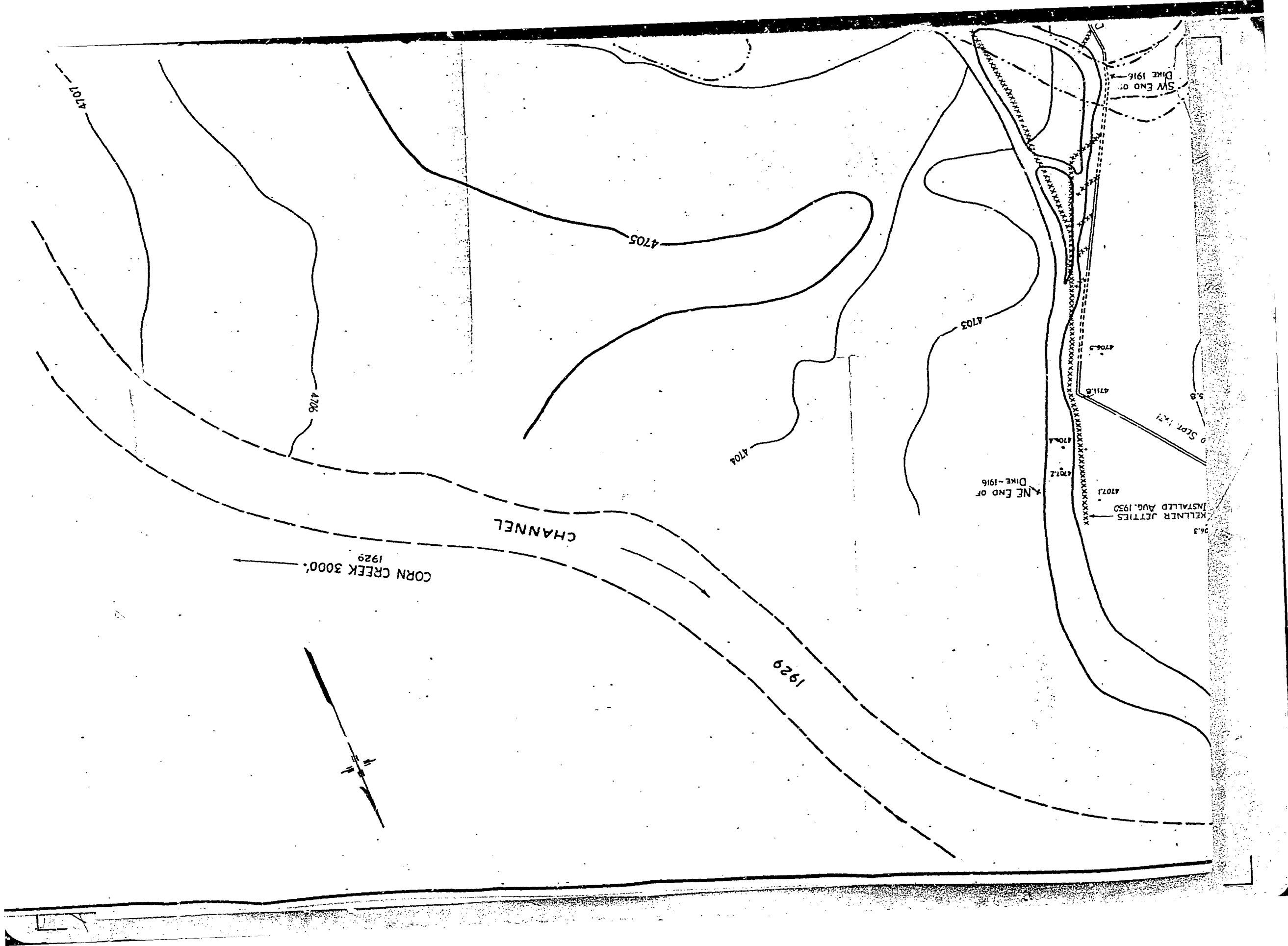
PRECIPITATION ACCOMPANYING OR PRECEDING
RECORDED FLOODS SINCE 1900

WR 101 PLATE 5


DIKE CONSTRUCTED AUG.-SEPT. 1930
ELEVATION TOP OF DIKE 4710.1
CONSTRUCTED
1929 EL. TOP - 4707.3
RAISED TO 4711.1 IN 1932 TO CARRY IRRIGATION FLUME
DIKE BUILT 1909
ELEVATIONS FEB. 5, 1937
1933 LEVEE
B.M. ELEV. 4700+48
DIKE EL. 4712.1
WIDENED 1935
POWER HOUSE
DORM.
SCHOOL
CLUB
HOSPITAL
DIKE ELEV. 4706.0
1933 LEVEE
DIKE ELEV. 4704.6
DIKE CONST'D. FEB. 1937
DIKE CONSTRUCTED 1931
6000' TO CAÑON DIABLO
4700
4699
4698
4697
4696
4695
4705

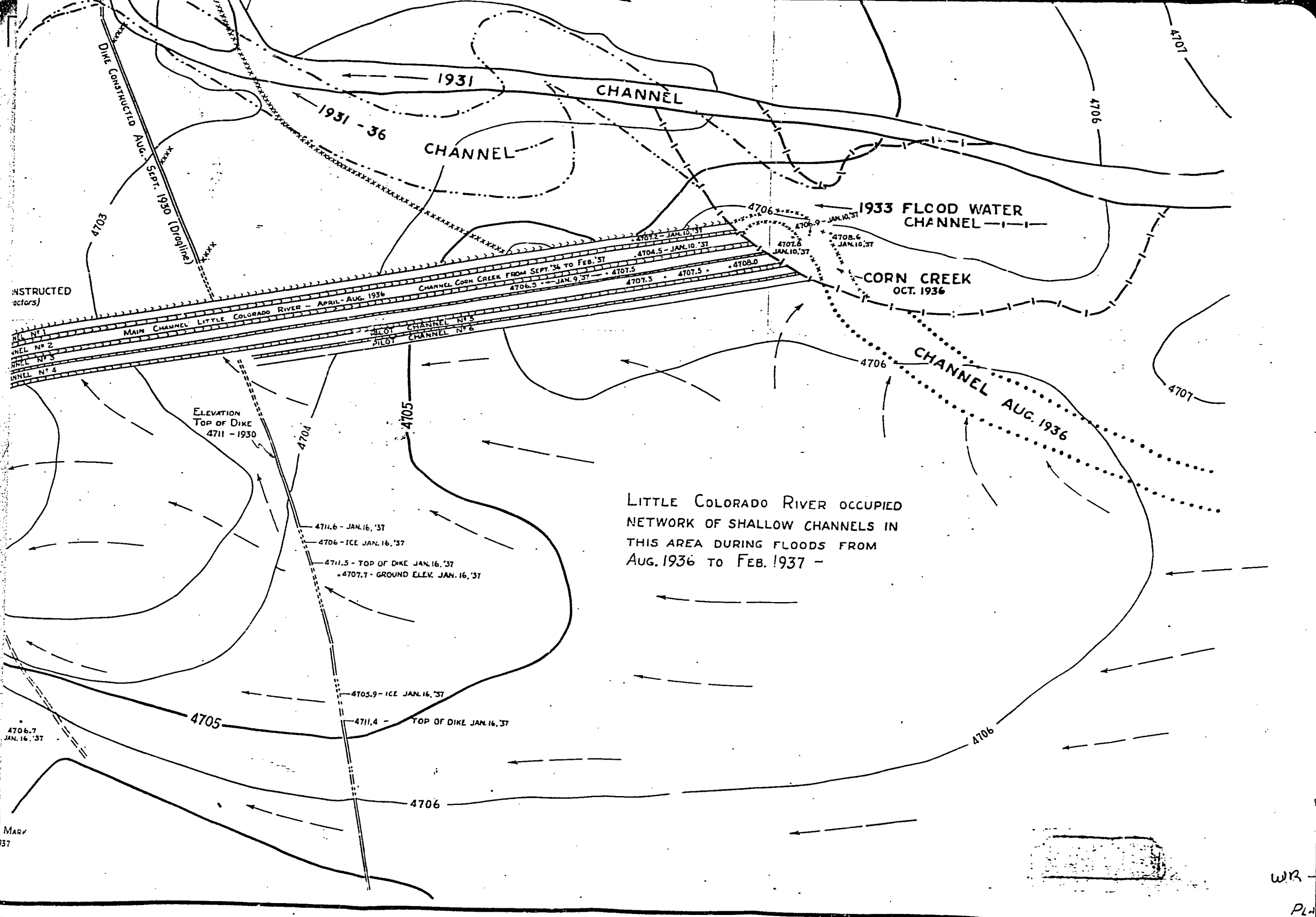


CV-6417-201
NN001921



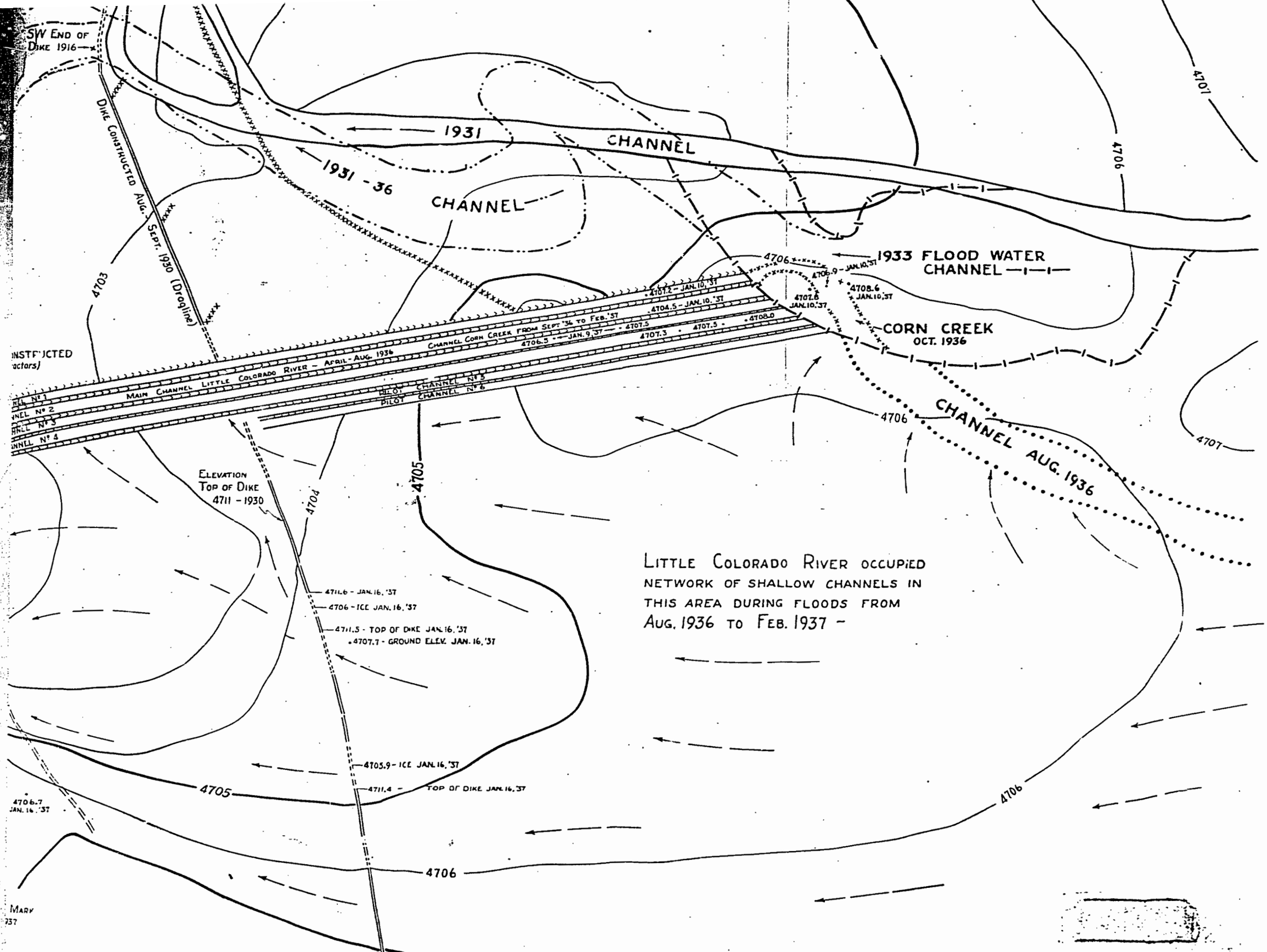
NN001922

CV-6417-201



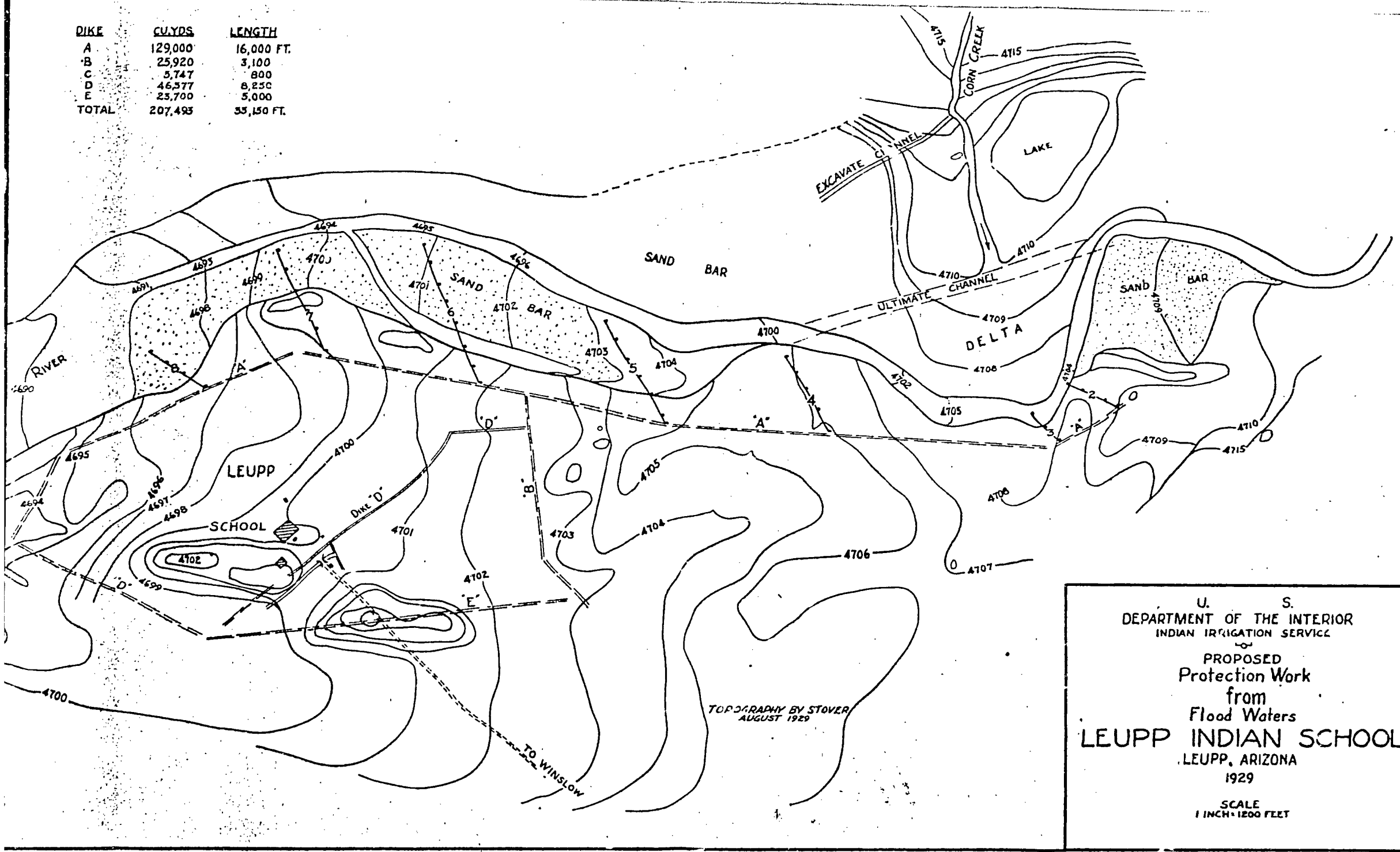
CV-6417-201

NN001923


S/W End of Dike 1916
Dike Constructed Aug.-Sept. 1930 (Dragline)
1931 CHANNEL
1931-36 CHANNEL
1933 FLOOD WATER CHANNEL
CORN CREEK OCT. 1936
CHANNEL AUG. 1936
Main Channel Little Colorado River - April-Aug. 1936
Channel Corn Creek from Sept. '36 to Feb. '37
Pilot Channel No. 5
Pilot Channel No. 6
Channel No. 1
Channel No. 2
Channel No. 3
Channel No. 4
4707.2 - JAN. 10, '37
4704.5 - JAN. 10, '37
4706.9 - JAN. 10, '37
4708.6 JAN. 10, '37
4707.8 JAN. 10, '37
4706.5 - JAN. 9, '37
4707.5
4707.3
4707.5
4708.0
Elevation Top of Dike 4711 - 1930
4711.6 - JAN. 16, '37
4706 - ICE JAN. 16, '37
4711.5 - TOP OF DIKE JAN. 16, '37
4707.7 - GROUND ELEV. JAN. 16, '37
4705.9 - ICE JAN. 16, '37
4711.4 - TOP OF DIKE JAN. 16, '37
4706.7 JAN. 16, '37
4707
4706
4705
4704
4703
Little Colorado River occupied network of shallow channels in this area during floods from Aug. 1936 to Feb. 1937 -

CV-6417-201

DIKE	CU.YDS.	LENGTH
A	129,000	16,000 FT.
B	25,920	3,100
C	5,747	800
D	46,377	8,250
E	23,700	5,000
TOTAL	207,493	33,150 FT.



U. S.
DEPARTMENT OF THE INTERIOR
INDIAN IRRIGATION SERVICE

PROPOSED
Protection Work
from
Flood Waters
LEUPP INDIAN SCHOOL
LEUPP, ARIZONA
1929

SCALE
1 INCH = 1200 FEET

WR-103

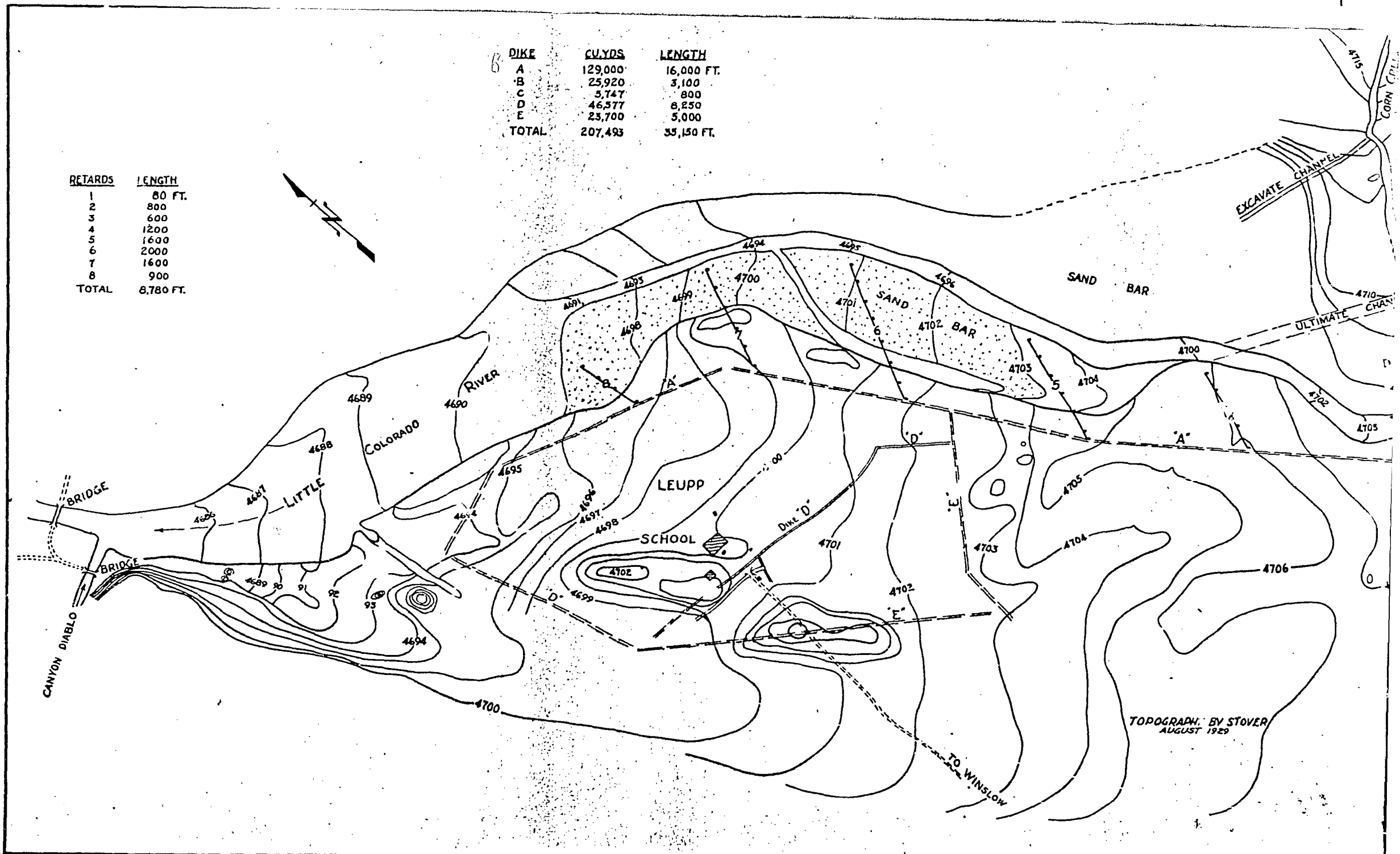
PLATE 7

NN001925

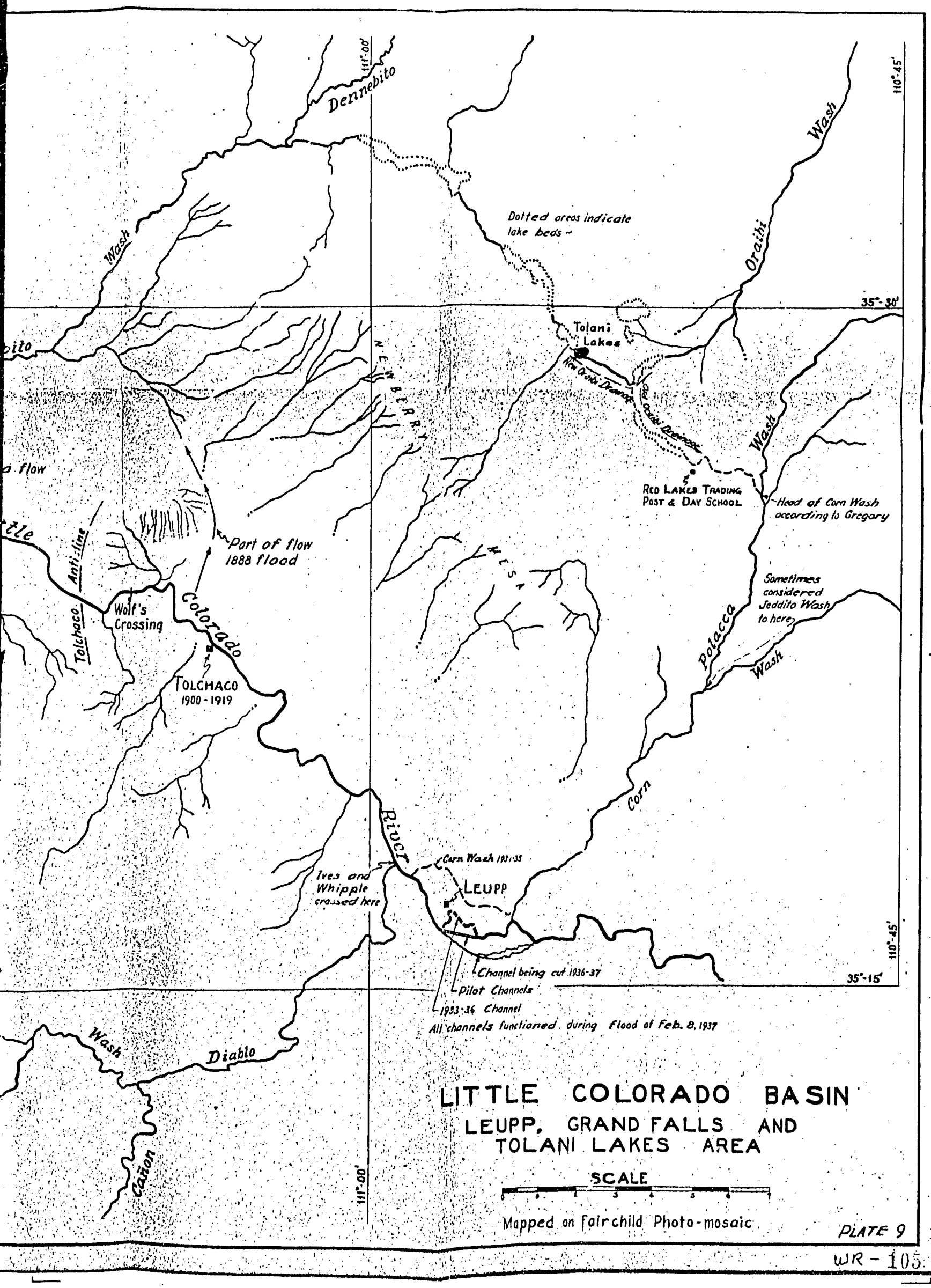
CV-6417-201

DIKE	CU.YDS.	LENGTH
A	129,000	16,000 FT.
B	25,920	3,100
C	5,747	800
D	46,577	8,250
E	23,700	5,000
TOTAL	207,493	33,150 FT.

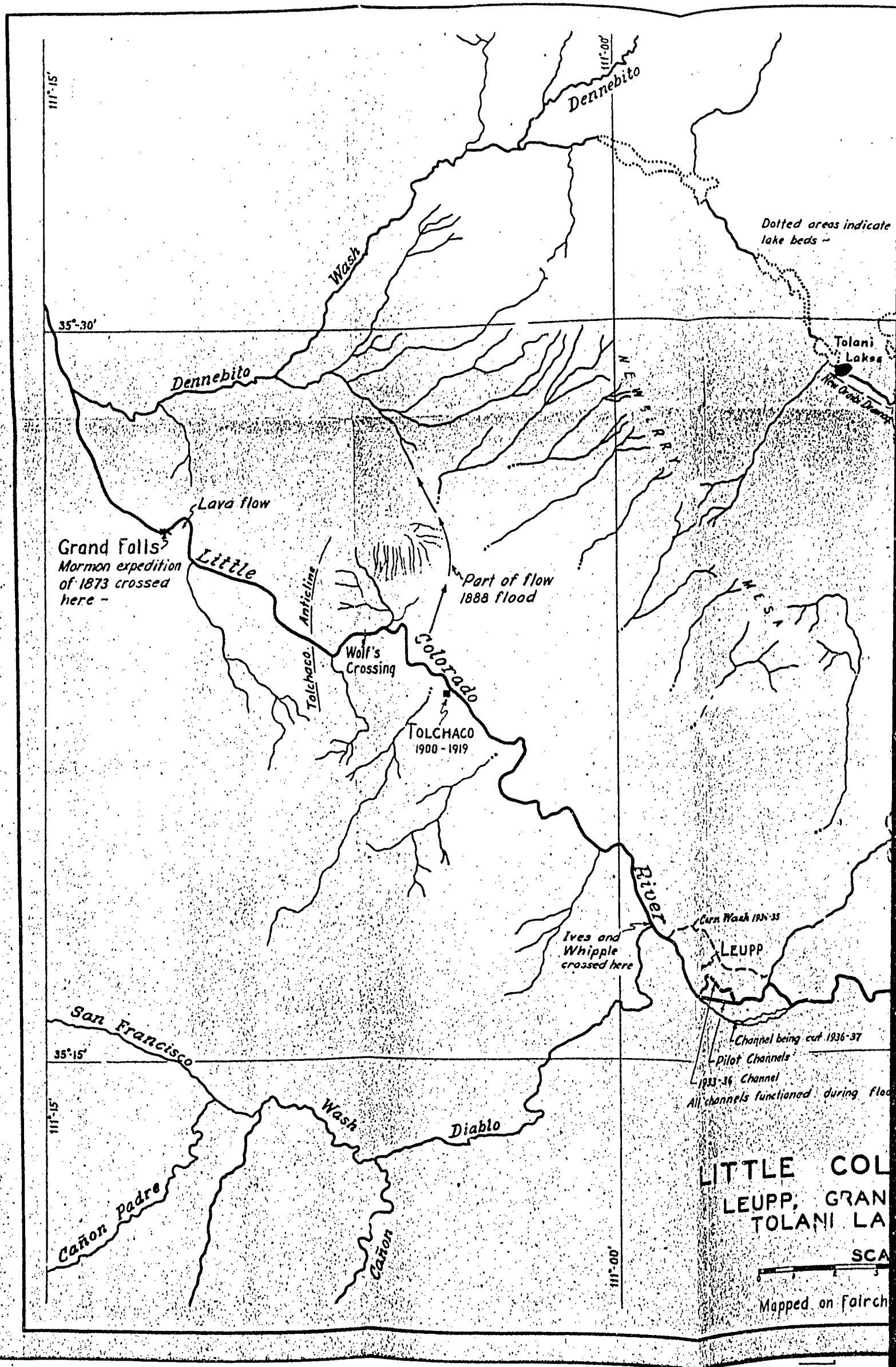
RETARDS	LENGTH
1	80 FT.
2	800
3	600
4	1200
5	1600
6	2000
7	1600
8	900
TOTAL	8,780 FT.



NN001926


Dennebito
Wash
Dotted areas indicate lake beds ~
Oraibi
Wash
110°-45'
35°-30'
Tolani Lakes
New Oraibi Drainage
Old Oraibi Drainage
Wash
Red Lakes Trading Post & Day School
~Head of Corn Wash according to Gregory
Sometimes considered Jeddito Wash to here
Potacca
Wash
Corn
Part of flow 1888 flood
Anti-line
Tolchaco
Wolf's Crossing
Colorado
Tolchaco 1900-1919
River
Corn Wash 1931-35
Ives and Whipple crossed here
Leupp
Channel being cut 1936-37
Pilot Channels
1933-36 Channel
All channels functioned during flood of Feb. 8, 1937
35°-15'
110°-45'
Wash
Diablo
Cañon
111°-00'
LITTLE COLORADO BASIN
LEUPP, GRAND FALLS AND TOLANI LAKES AREA
SCALE
Mapped on Fairchild Photo-mosaic
PLATE 9

WR - 105


111°-15'
111°-00'
Dennebito
Wash
Dotted areas indicate lake beds ~
35°-30'
Dennebito
Tolani Lakes
New Oraibi Dam
Lava flow
Grand Falls
Mormon expedition of 1873 crossed here ~
Little
Anticline
Part of flow 1888 flood
Tolchaco
Wolf's Crossing
Colorado
TOLCHACO
1900 - 1919
River
Corn Wash 1934-35
LEUPP
Ives and Whipple crossed here
San Francisco
Channel being cut 1936-37
Pilot Channels
1933-34 Channel
All channels functioned during flo
35°-15'
111°-15'
Wash
Diablo
Cañon Padre
Cañon
111°-00'
LITTLE COL
LEUPP, GRAN
TOLANI LA
SCA
Mapped on Fairch