Water Conservation Review

BIG LOST RIVER IDAHO

February 1955

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

R. N. Irving, State Conservationist

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Purpose of the study is threefold:

1. To compile a summary of existing basic data relative to the problem of water supply.

2. To list, locate, and summarize the various proposals made in past years for development and conservation of water supplies.

3. To indicate the type of information still needed and how it might be obtained.

Compilation of material in attaining the first two objectives involved tabulation of data from many sources, including the U. S. Geological Survey, both Surface and Groundwater branches; U. S. Bureau of Reclamation; Idaho Department of Reclamation; and engineers and engineering boards whose services have been employed at various times by the Irrigation District. A list of these references appears below:

Sources of Basic Data

Water Distribution & Groundwater Investigations - 1921-22, Big Lost Water Commissioner.
U.S.G.S. Water Supply Papers, Part 13, Snake River Basin - 1953.
Annual Reports, Watermaster, Big Lost River Irrigation District - 1953.
Snake River Geology and Ground Water Resources, USGS, WSP 774 - 1938.
Well Records, USGS - WS Papers 775 - 1936.
Geologic Report, Big Lost River Valley - Idaho Bureau of Mines and Geology - 1931.
Geology of Mackay Dam Site, USBR - 1953.
Agricultural Census - 1949
Reservoir Site Surveys:
Wild Horse and Burnt Creek Sites, USGS - 1940.
Antelope Creek, Castle Creek, Garden Creek - Army Engr. Corps - 1948.
Salmon Watershed Reconnaissance - USBR - 1954.

Suggested Developments

Chilly Sinks By-Pass - Lynn Crandall - 1928.
Big Lost River Investigation - USBR - 1930.
Big Lost River Valley Reorganization Plan - W. G. Sloan - 1930.
Irrigation Situation Improvement - Board of Engineers - 1931.
Improvement for Irrigation Water Conservation - Thompson - 1933.
Possibilities for Irrigation Water Conservation - Idaho Conservation Board - 1937.
Thousand Springs Drainage Plan - U. S. Department of Agriculture - 1952.

DESCRIPTION OF THE WATERSHED

Distinctive Features

The Big Lost River Valley is a gravel-filled structure located in the mountainous region of south-central Idaho. Trending in a general northwest-southeast direction, the valley averages about 4 miles in width to extend some 60 miles where it fronts upon the Snake River Plain. Taking in parts of Custer and Butte Counties, the valley is delimited on the northeast by the Lost River Range and on the southwest by the White Knob Mountains. Elevations in the valley range from 5,300 feet at Arco to 6,300 feet at Chilly, in the upper end of the valley. Rather well-developed alluvial aprons having gentle slopes characterize both sides of the valley floor.

The watershed of the Big Lost River Valley is characterized by a marked contrast in relief with respect to the northeastern and southwestern halves.

Drainage

Draining the valley is the Big Lost River, a tributary of the Snake, which apparently derives its name from the so-called "sinks" along its course. The sinks represent segments of the main channel where the river loses heavily and at times actually disappears completely. Rising in the southwestern part of Custer County, the river enters the valley proper about 8 miles southwest of Chilly. It flows first in a northeasterly direction for approximately 8 miles to a point south of Chilly. It then turns to flow through the main valley in a general southeasterly direction to the Snake River Plain. Upon entering the Snake River Plain, it flows northeasterly for 40 miles to the Lost River Sinks where during years of excess runoff, the surplus water collects until lost by evaporation and percolation into the underlying lava rock (Stearns, et al., 1938, p. 243).

The Big Lost River and its tributaries drain an area embracing approximately 2,000 square miles. The most productive runoff, however, occurs on about 300 square miles in the upper headwaters of the Big Lost River (Crandall, 1920, p.1). The total runoff decreases as the watershed area increases due to heavy underground losses. Of the many tributary streams entering the main valley, only Thousand Springs Slough, Warm Springs Creek, and Antelope Creek reach the river channel(Crandall, 1920, p. 3).

Climate

The climate of the area is characterized by cold winters, hot summers and light precipitation. However, since it is in the area dominated by the prevailing westerly winds the climate is subject to the moderating influence of the Pacific ocean. Periods of extremely high or low temperatures are of relatively short duration and there is considerable variation in temperatures throughout any and all seasons of the year.

The valley area along Big Lost River has an average annual precipitation of less than ten inches. Although approximately one-half of the precipitation occurs during the months of May through September, it is not adequate to supply the crop needs. The average annual precipitation in the watershed varies from 7.4 inches at Barton Flat near Chilly to approximately 40 inches in the higher elevations. Approximately 40% of the precipitation occurs in the form of snow.

The yearly distribution of precipitation by months is shown in figure 1.

Temperature extremes in the watershed vary from approximately -40°F. to 100°F. Except for the lower valley from Mackay reservoir down to the plains, frost can be expected any month of the year. Frost-free season data are given below for Arco and Mackay.

*Percent Occurrence	Length of Frost-Free Season - Days			
	Average	67%	75%	90%
Arco	95	88	83	72
Mackay	105	102	98	88

*Percent occurrence means that a given size event will be equalled or exceeded that percentage of the time when considered over a long period of time. For example: at Arco 75 percent of the time the frost-free season will be 83 days or longer.

Average monthly temperatures for Arco, Mackay and Chilly are given in figure 1.

Topography

The first bottoms along the Lost River are generally gently sloping but in many places are broken by numerous old channels, gravel bars and slopes. Seepage from higher areas has produced extensive wet areas that produce wild meadow hay.

The second bottom is the area largely under cultivation. It is gently sloping and with moderate land leveling is well suited to irrigation agriculture.

Starting east of Leslie a gravelly foot slope extends northwest around the valley on the east and north sides of the valley. It lies well above the valley floor at most points. The slope of this area averages over 5% to the point of breaking into the valley below. The point of break-off is steep and has very little agricultural value.

Agriculture

Soils of the valley are generally shallow over coarse gravel with scattered areas of deep silt. The upper bench east of the river is a lime cemented gravel fan suitable for hay production if cheap water were available. A considerable area of silt lies on the bench south of Pass Creek that could become a productive site with the addition of water. Extending into the Snake River Plain south and west of Arco is probably the highest potentially productive area within reach of Big Lost River water.

Average crop yields in the valley are not high, possibly due to the effects of frost as well as low fertility. Long periods of high water application rates have leached the gravelly soils to the fertility level of the river bed. In the tabulation below are representative yields for seven crops grown in the valley.

Yields Per Acre

Alfalfa	2.5 Tons	Peas	22 bu.
Barley	40 bu.	Potatoes.....	200 bu.
Irr. Pasture..	5.5 A.U.M.	Wheat	45 bu.
Oats	50 bu.		

These yields, being averages, do not indicate the potential production of good land in the valley under good management. Neither do they indicate the extremely low production of lands that may have been or should be taken out of production.

Water Resources Below Mackay Reservoir

Streamflow records to 1952 along with calculations of runoff for ungaged areas of the watershed indicate a firm supply of 120,000 acre-feet at the Narrows. Only once in 30 years has less water been available at the head of the valley below Mackay Reservoir. This is supplemented by an inflow of approximately 60,000 acre-feet from the watershed between the reservoir and Arco. Most of this 60,000 acre-feet sinks into the ground before reaching the river, and ultimately passes out of the valley as discussed in the section of groundwater.

This means that with highly efficient irrigation and distribution, enough water normally enters the valley from the watershed below Mackay Dam to provide for water needs of the valley without a drop supplied from the Big Lost River.

In what was probably the lowest water year (1934) the surface flow at the Narrows was 61,980 acre-feet during the irrigation season extending from April 1 through September. Adding to that approximately 30,000 acre-feet from the watersheds of Alder, Antelope, Pass and Lower Cedar Creeks provided a total of 92,000 acre-feet. In addition, an unknown quantity flows steadily under the gage at the Narrows and possibly east of the rock ledge that forms the east side of the Narrows. This is enough to irrigate more than 40,000 acres with a full supply, indicating that the problem of the lower valley is not one of water shortage but one of water management.

SUMMARY OF IRRIGATION HISTORY IN BIG LOST RIVER

Irrigation began in the Big Lost River area about 1875 on ranches supplying forage to the many wagon teams plying the route from the Upper Snake River Valley to mines located on the upper reaches of the Salmon River. For about 30 years free usage of water existed with no unified regulation.

Formulation of the Moe-Harger Decree in 1903 marked the first adjudication of irrigation water of Big Lost River. The first attempt at water regulation was by a watermaster appointed by a water user's association organized after the decree was issued. The earliest water right decreed was for 512 second-feet on the Elkhorn Ranch at Chilly. The second right was dated September 30, 1879 on Antelope Creek. The earliest right issued on the main river below Mackay was at Arco, dated June 1, 1880.

Sometime in 1909, or earlier, the Big Lost River Irrigation Company was organized. This Company applied for the segregation under the Carey Act of 90,722.71 acres of land in Butte County to be irrigated from the flood waters of Big Lost River. Eighty thousand acres were actually segregated and sold by the State Land Board at Arco in 1909. This Company then began construction on the Mackay Dam, which was designed to be 120 feet high with a storage capacity of 170,000 acre-feet. As work on the dam progressed, investigating engineers found the construction plans and specifications unsound. Also, the costs of construction exceeded the cost estimates, with the result that the Big Lost River Irrigation Company went broke and the project passed into the hands of the Utah Construction Company, which had been interested in the contract of the Corey Brothers Construction Company. This Company held a claim of more than $500,000 against the original company.

The U.C.C. reevaluated the water resources and cut the amount of land segregated from the original 80,000 to 15,000 acres. Eventually no more than 7,000 acres were actually irrigated under the project. New dam construction plans were drawn and approved, construction was completed and the first water was stored in the spring of 1918.

The three year period 1918, 1919 and 1920 proved to be one of low runoff, and the water users of the valley felt that the dam, controlled by the U.C.C., was responsible for the failure of many decreed right flows being filled. After two years of turmoil and court action, the water users organized the Big Lost Irrigation District, in 1920, to look after their interests. This organization immediately levied assessments and employed engineers to make intensive studies of water and soil resources of the Big Lost River Valley and to determine the effect, if any, of water storage in the dam on these resources, especially on groundwater conditions. Lynn Crandall supervised these surveys.

As a result of much controversy between the U.C.C. and the water users, a new adjudication was made March 15, 1923, known as the Utah Construction Company adjudication. This settlement is still in effect.

Trouble over water rights and deliveries continued and reached its climax during the drought years of the early 1930's. In 1933, the U.C.C. gate at the Mackay Dam was dynamited, followed by similar action at the Leslie diversion gate in 1935.

In 1934, the Big Lost River Irrigation Company obtained an option to buy out the interests of the U.C.C. This option was renewed in 1935 and purchase was finally completed in 1936.

During the years of the Crandall survey (1921-1922) there were 45 canals diverting from the river below Mackay Dam, with an average loss of 58% of the diverted water to subterranean flow. In the ensuing years these have been cut to 19 under the assumption that losses would thereby be reduced. No comparable measurements have been made recently to determine canal losses, but the diversion per irrigated acre is still high.

GEOLOGIC & GROUND WATER SUMMARY

AND

PROPOSED WATER CONSERVATION MEASURES

A number of proposals have been made during the dry years since the Mackay Dam was constructed. Various reservoir sites have been surveyed, diversions studied and losses measured until a formidable array of data is available to cover almost any phase of the problem. These studies and proposals are listed on page two and will be summarized in the following pages. While the list is quite complete its very comprehensiveness indicates the possibility that some items may have been overlooked.

The proposals are reproduced in the following pages without comment. In a later section the proposals are listed and their development indicated.

The U. S. Geological Survey has developed rather extensive data on the geology and ground water of the Big Lost Basin. Because of the length and variety of the record it has been condensed for inclusion along with the proposals for water conservation.

GEOLOGIC CONDITIONS AND GROUNDWATER OCCURRENCE
IN THE BIG LOST RIVER VALLEY

Summarizing Studies by U. S. Geological Survey
Lynn Crandall, D. C. Livingston & O. E. Meinzer

Previous Work

An intensive study of water distribution and groundwater conditions in the Big Lost River Valley was first made by Lynn Crandall in 1920 (Crandall, 1920). From 1928-30 an investigation of the geology and groundwater resources of the Snake River Plain in southeastern Idaho was carried on by the United States Geological Survey in cooperation with the Idaho Bureau of Mines and Geology and the Idaho Department of Reclamation (Stearns et al., 1938). This study also included the Big Lost River Valley.

A general report on the geology of the Big Lost River Valley made by D. C. Livingston of the Idaho Bureau of Mines and Geology (Livingston, 1931), is included later in this report.

Geologic Conditions

The most distinctive feature in the Big Lost River Valley is the fault scarp extending the full length of the east side of the valley. The trend of the fault is shown by the characteristic steep triangular faceted ridge spurs forming the west face of the Lost River Range. It is thus inferred that the Lost River Range represents a tilted fault block and that the present valley has been down-faulted. In view of the structural origin, one would expect the valley to be filled to a considerable depth with gravel deposits. So far as known, bedrock has never been encountered in any of the borings in the main valley. The depth of these deposits has been estimated to be as much as 500 feet (Stearns et al., 1938, p. 245).

Exposed rocks in the watershed of the Big Lost River Valley include limestones and lavas as well as some local intrusive bodies of granitic composition. The oldest and most widespread of these are the Paleozoic limestones which are much folded and faulted.

In the southwestern half of the watershed the limestones are in large part overlain by younger lava rocks consisting mainly of flows of rhyolitic and andesitic composition. In two localities the flow material extends as a broad belt to the edge of the main valley on the southwest side (Stearns et al., pl.4). These same lavas are also extensively developed in the area drained by Pass Creek in the northeast part of the watershed.

Comparatively recent flows of basaltic lava have partly blocked the mouth of the valley west of Arco forcing the river to the east side of the valley and at the same time to aggrade its channel (Stearns et al., 1938, p. 245).

As a result of rapid alluviation, the Big Lost River has been unable to maintain a true course down the axis of the valley and in many places has been forced to the west side. This condition is well illustrated in the vicinity of the Mackay Dam, where rapid alluvial deposition has forced the river to the west side, causing it to cut a narrow gap through the limestone spur jutting out into the valley.

Stored in the great depth of gravel, sand, and silt deposits is the groundwater of the valley. These deposits are derived in part from the Big Lost River and in part from the alluvial materials collecting along the sides of the valley. The areas in the main valley where the river sustains heavy losses is an indication of the highly porous nature of much of the valley-fill. These areas are the so-called "sinks" of the Big Lost River. The uppermost sink is located in sec. 15, T. 8 N., R. 21 E., and consists of four small depressions aligned in a northeast direction. It has been suggested (Stearns et al., p. 246) that the southernmost depression may represent the collapse of a limestone cavern and that water entering here may give rise to Thompson Spring, five miles to the southeast. The next three sinks downstream, however, are not depressions but only areas where the river loses heavily in gravel and at times disappears.

The area of rising water just above the Mackay Dam appears to be a reflection of subsurface geologic conditions as are other areas of rising water in the valley. A narrowing of the valley occurs in the region of the dam. To the northwest the valley is also somewhat restricted by alluvial hills sloping westward. It is to be noted that minor faults exposed on the west abutment of the dam have trends transverse to the main valley. From these features it has been inferred that the hills are related to cross-faulting and thus "correspond to a restriction in flow of the groundwater", causing the area of rising water just above the Mackay reservoir (Stearns et al., 1938, p. 247). The rising water in this area as well as other places in the valley has also been attributed to impervious silt deposits derived from the damming of the river by alluvial materials (Livingston, 1931).

Whatever the nature of the geologic conditions giving rise to the area of shallow groundwater immediately above the reservoir, it is significant that streamflow records at Howell's ranch and at the "Narrows" below Mackay Dam indicate that water flowing into the upper valley eventually passes through the "Narrows" into the lower valley (Crandall, 1920, p. 22). Groundwater contours on the upper valley also tend to confirm this in that there is no indication of any side loss occurring (see pl.1). It may be concluded from flow records then that the upper part of the Big Lost River Valley is essentially a water-tight basin.

Groundwater Conditions

"A knowledge of the elevation and topography of the water table gives information in regard to the source, movement, and disposal of the underground water" (Meinzer and Hare, 1915, p. 103). The elevation and topography of the water table in the Big Lost River Valley is shown on Plate 1. The recent observation wells indicate no appreciable change in the present position of the water table. In using the map it should be kept in mind that groundwater movement tends to be always at right angles to the direction of the water table contours.

In the upper part of the Big Lost River Valley the water table contours show a uniform movement of ground water down the valley with no indication of any side loss (see pl. 1). In the southwestern part of T. 8 N., R. 22 E., there is a marked inflow from Warm Springs Creek that is clearly shown by the water table contours. This uniformity of underground flow continues down the valley between Mackay Dam and Leslie with the exception of a tendency for a drain to the west side of the valley as indicated by the water table contours about 1 1/2 miles southwest of Leslie (pl. 1). The water levels in local wells also show this;

however, as pointed out by Crandall (1920, p. 14), this does not necessarily mean a large flow of underground water. The wells as a whole in the area are quite uniform. Water levels show the water table to be the lowest in the spring before irrigation (Crandall, 1920, p. 16). With heavy irrigation and a rising river the water table fluctuates but the annual fluctuations amount to only a few feet. Groundwater contributions from Lower Cedar Creek are reflected by a late high-water peak in wells east of Mackay along the edge of the valley.

Under the Darlington sinks north of Darlington, there is a flattening of the water table (pl. 1). In the vicinity of Darlington, the irregularity of the water table contours (see pl. 1) seems to be due to large contributions from Antelope Creek. The large water losses occurring on the Darlington sinks are reflected by the wells in the area. Some wells show the effect of these losses to a much greater degree than others to indicate that the main underground flow is towards the west side of the valley. Furthermore, the fact that contributions to the water table in the valley above Darlington are much greater than the water rising above Moore indicates that there is a large loss of water underground somewhere between Darlington and Moore (Crandall, 1920, p. 15). Calculations based on streamflow records at the "Narrows" below Mackay Dam and at the Moore Dam for the period from 1921-29 show "that approximately 109,000 acre-feet annually moved underground past the Moore Dam" (Stearns et al., 1938, p. 248-249).

Water levels in the wells on both sides of the river immediately below Darlington show no indication of a large underground flow down the valley. Also, the water-table contours indicate (pl. 1) that the main source of rising water above Moore is seepage from irrigated lands north, east, and southeast of Leslie (Crandall, 1920, p. 15). It is evident from the foregoing then that any large underflow down the valley must take place on the west side. Moreover, a definite loss of underground water towards the west side of the valley is apparent from a point about three miles north of Moore to approximately three miles south of Moore (see pl. 1). It is clearly shown by the water table contours in this area that the main underground flow goes off to the southwest. In view of what is known of the geology of the area, it seems to be a reasonable conclusion that this underflow probably follows "an old buried channel from which the river was diverted by basalt flows" (Stearns et al., 1938, p. 249). The water table contours indicate (pl. 1) that much of this underflow leaves the valley west of Arco at considerable depth.

Water table contours indicate (pl. 1) that the rising water above Arco (mainly in James Creek) probably has its source in the groundwater along the east side of the valley about opposite Moore (Crandall, 1920, p. 16).

During the winter of 1929-30, four test wells were drilled just west of the Moore Dam to determine the feasibility of recovering the water known to be passing underground in the region of the dam (Stearns et al., 1938, p. 249). It was found that part of the underflow past the dam occurred from three-fourths of a mile to a mile west of the river channel, 50 feet beneath the alluvial cover of the Antelope fan. In view of the depth and economic conditions, it was concluded by Stearns et al., (1938) that recovery of the water would not be feasible. The location and significant information (Stearns et al., 1938,

p. 251-252) gained from the test wells is given below:

> Test Well 1 - NE 1/4 SW 1/4, sec. 4, T. 5 N., R. 26 E. - a 4-inch hole carried to total depth of 72 feet. Water first encountered at depth of 19 feet. Formations to depth tested found to be not favorable for large yields by pumping because free movement of water in lenticular gravel beds prevented by interfingering beds of impervious sandy clay.
>
> Test Well 2 - SW 1/4 SW 1/4, sec. 4, T. 5 N., R. 26 E. - a 4-inch hole carried to total depth of 80 feet. Water first encountered at depth of 61 feet. Abundant supply of water found in gravel below 72 feet.
>
> Test Well 3 - SW 1/4 SE 1/4, sec. 5, T. 5 N., R. 26 E. - a 4-inch hole carried to total depth of 85 feet. Water first encountered at depth of 61 feet. Free yield of water not lowered by bailing.
>
> Test Well 4 - NW 1/4 NE 1/4, sec. 9, T. 3 N., R. 26 E. - a 4-inch hole carried to total depth of 40 feet. Water first encountered at depth of 12 feet. At total depth, water level stood at 9.9 feet and could not be lowered by bailing.

Yields ranging from 0.16 to 0.30 second-foot per foot of drawdown have been reported for several units pumping 1 to 2 second-feet at different places in the valley in the past (Stearns et al., 1938, p. 253). The municipal well of Arco in 1922 showed a yield of 0.24 second-feet for each foot of drawdown. Stearns et al., (1938) concluded from a study of available well logs that similar yields can be obtained at other localities in the valley.

A map showing depths to the water table in the Big Lost River Valley has been included in this report (see pl. 2). Areas I and II are after Plate 31 in Water Supply Paper 774 (Stearns et al., 1938). The other areas which have been delineated are based on depths to the water table as shown by water levels recorded in Water Supply Paper 775 (Stearns et al., 1936). From this map it is possible to predict, within limits, how deep it will be necessary to sink a well to encounter water.

Three artesian wells have reportedly been developed on the west side of Chilly Valley. Further information on these wells is lacking at the present time; thus, whether or not a widespread aquifer has been penetrated is not known.

Interpretation of Groundwater Conditions

It has been shown that the valley above Mackay Dam is a relatively water-tight basin. Well records in the upper valley (Crandall, p. 24) also show that the water table in the upper valley is substantially higher at the end of the irrigation season than before the start of irrigation. This indicates that the upper valley acts as a natural underground storage reservoir. Water is stored during the flood-water season as a result of heavy diversions and river losses; however, as Crandall has pointed out (1920, p. 24), the difficulty lies in the fact "that no control exists by which the water so stored can be released when needed and actually most of the water so stored remains in storage at the end of the irrigation season and gradually drains into and under the Mackay reservoir during the winter months."

Since the valley above the Mackay Dam is a relatively water-tight basin and serves as a natural underground storage reservoir, it is evident that the use of the water in the upper valley will mainly affect the supply available for the lower valley "in the change that such use produces in the monthly distribution of runoff at Mackay Dam" (Crandall, 1920, p. 24). It follows from this that during any year when the flow entering the lower valley is not enough to fill decreed rights, the use of surplus water in the upper valley will deprive users in the lower valley of water they would be entitled to on the basis of priorities (Crandall, 1920, p. 24, 25). It also follows that the use of all water in the river above the Chilly sinks, during periods when water will not cross the sinks, has no effect on the users in the lower valley (Crandall, 1920, p. 26), however, it is apparent that from the lower end of the Chilly sinks to the Mackay reservoir where the stream formed by the confluence of Warm Spring Creek and the "Big Lost" flows into the reservoir continuously (if not all diverted), that the diversion of any of this water during the irrigation season will have a direct effect upon the supply passing the Mackay Dam (Crandall, 1920, p. 26).

The storage of water in the Mackay reservoir apparently has no significant effect on the water table in the valley above the Moore diversion dam when there is a continuous surface flow of water in the main stream channel between Mackay Dam and the Moore diversion dam (Crandall, 1920, p. 18). Below Moore, however, Crandall (p. 18) points out that the extent to which the water table is affected will depend on the distance seepage waters work down the river below the Moore Dam before the following irrigation season. At the same time, it does not seem that maintaining a winter flow in the channel below Moore will keep the water table high enough to effectively subirrigate any sizable acreages; hence, Crandall (p. 19) concludes that a high water table can be maintained only if substantial quantities of water are run down the channel during the irrigation season. It is probable that a high water table on the bottom lands below Moore will materially increase the amount of water rising near Arco, since at high levels the water table intercepts the bottoms of the various creeks which then act as surface drains (Crandall, 1920, p. 19).

Conclusions

Groundwater studies in the Big Lost River Valley have shown that a large volume of water is annually lost underground to the Snake River. It is also apparent that the upper part of the valley (above Mackay Dam) is a relatively water-tight basin which serves as a natural underground storage reservoir. The potentialities of this natural underground reservoir cannot at present be fully realized because no means now exists whereby the stored water can be released when needed. If the water so stored could be released when needed, it would then be possible to increase the capacity of the underground reservoir by use. This, in effect, means that more surface water would go into underground storage than would otherwise be the case. The net result then would be an increase in the supply of available water.

The water annually lost underground to the valley can be recovered in part by either (1) prevention of seepage losses in the river bed or, (2) by pumping from wells (Stearns et al., 1938, p. 255). It has been estimated (Stearns et al., 1938) that from 30,000 to 40,000 acre-feet annually could thus be saved.

Stearns et al. (1938) have concluded from their studies that "a large part of the underflow in the great depth of the valley fill must inevitably escape beneath the Snake River Plain."

REPORT ON WATER SAVINGS POSSIBLE BY THE CONSTRUCTION

OF A CANAL AROUND THE CHILLY "SINKS"

Lynn Crandall - October 1928

The question of whether the water that is lost on the Chilly "sinks" reappears again above the "Narrows" at the Mackay Dam can be further studied by comparing the runoff at Howell's ranch and at the 2-B gage below the Mackay Dam over a series of years. During the eight years from 1920 to 1927, inclusive, the total runoff at Howell's ranch amounted to 1,608,900 acre-feet, or an average annual runoff of 201,100 acre-feet. During the same period at the 2-B gaging station below the Mackay Dam, the total runoff was 1,700,100 acre-feet, or an average annual runoff at that point of 212,500 acre-feet.

The total average annual runoff entering the upper valley during the years 1920-27 may be estimated as follows:

Big Lost River at Howell's ranch	201,100 acre-feet
Warm Springs Creek at Barton	41,000 " "
Other minor tributaries	5,900 " "
Total supply	248,000 " "
Accounted for at 2-B gage	212,500 " "
Net loss in upper valley	35,500 acre-feet

This net loss of 35,500 acre-feet may be all accounted for as water consumed by the crops and lost by evaporation on the 15,000 acres of lands that are irrigated in the upper valley, amounting to about 2.3 acre-feet per acre.

The records of water supply thus corroborate the ground water measurements that were made during 1920-22 and indicate that the water contributed to the groundwater table in the upper valley from river and canal losses and seepage from irrigated lands all eventually finds its way back into the stream at the "Narrows" below the Mackay Dam.

Estimated Cost of Ditch

While it is impossible to get an accurate estimate of the cost of the ditch without more detailed surveys, the cost of a ditch to carry 200 second-feet may be roughly estimated as follows:

Seven miles of canal, 80,000 yards of excavation at 25 cents	$ 20,000
Diversion dam and headworks	5,000
Highway bridges and structures	1,000
Right-of-way	500
Engineering, surveys, etc.	500
Back channel improvement below mouth of proposed ditch	3,000
Total	$ 30,000

BIG LOST RIVER INVESTIGATIONS, IDAHO

E. B. Debler - August 1930

In years of high runoff the stream maintains a flow far into the desert, at times even forming temporary lakes northeast of Arco. With lessening flows the stream first retreats to its own valley and with low flows it becomes intermittent below Mackay. Irrigation is of long standing, but the principal crops are feeds required for the livestock industry. Much of the valley land has loose, shallow soils requiring excessive water applications for surface irrigation, but admirably adapted to subirrigation which is so extensively practiced. The area irrigated from Big Lost River and tributaries is about 10,000 acres above Mackay Dam, and 40,000 acres below that dam.

Mackay Dam, with a capacity of 45,000 acre-feet, was completed about 1914, for the irrigation of lands on the Snake River Plain. Shortly after the completion of this dam, a long period of low runoff conditions started and still prevails. The most severe conditions have occurred in the last few years. While at first only the late rights were short of water, in a few years very early rights have suffered and the flow is insufficient even to maintain the necessary water table for subirrigation in the lower valleys. Seepage streams that ordinarily run without let-up have recently been dry and the water table near Moore has dropped to a level 30 feet below ground level.

The most satisfactory solution of the difficulty would be an increase in the water supply for the valley adequate in amount to satisfy the full requirements of the underground stream which is lost in the Snake River Plains and leave a surface flow sufficient for irrigation. Topographic and hydrographic data indicate that the streamflow cannot be augmented at feasible cost by diversion from surrounding drainage areas, most of which need additional water much as the Big Lost River Valley. Reservoir sites suitable for hold-over storage at a reasonable cost are lacking and surplus water in the shape of out-flow from the valley, for a number of years, has been practically nil. The only remaining recourse is a saving of the water lost to the Snake River Plains, which loss amounts to an average of at least one-half the total runoff from the drainage area. In years of low runoff this loss is not appreciably diminished and takes nearly the entire flow of the stream.

A plan often suggested by residents of the valley is the "Chilly By-Pass." Chilly Valley lies immediately above Mackay reservoir and is deeply underlain with coarse gravels. The stream is ordinarily unable to cross the area on the surface; in times of flood the stream is heavily depleted in passing through the upper end of the valley. A study of in- and out-flows indicates no actual loss of water, but merely a detention of flood flow by ground storage. A by-pass channel would have no influence in years of high runoff as it would be impracticable to provide a channel of adequate capacity for the entire flow of the stream. In years when all waters could be detoured, the canal would cause heavier flows to reach Mackay in the early part of the season with correspondingly less later in the irrigation season and through the following winter. The junior irrigation rights would be benefited by an increased irrigation supply in the earlier part of the season; older rights would be injured in the latter part of the season, and the Mackay reservoir would receive less water in winter. As the plan effects no increase in usable waters but merely redistributes the available supply, in part detrimentally to existing rights with prospects of engendering litigation, its adoption cannot be recommended. Instead of minimizing ground storage in Chilly Valley, it should be encouraged, particularly at times when flood waters are passing out to the Snake River Plains.

From Mackay to Leslie, a distance of some 15 miles, Big Lost River never runs dry and the water table has relatively small fluctuation although there is a considerable ebb and flow of ground storage resulting principally from irrigation applications. While there is no material loss to the underflow in this section, there is no evidence of sink holes which might be stopped to conserve water. Neither does it appear feasible to reduce losses by a substitution of canals for the river channel. It is suggested, however, that diversions be encouraged whenever feasible, without injury to other rights, both in and out of the irrigation season to the end that ground storage will be augmented with increased outflow at needed times for irrigation purposes.

From Leslie to Moore's Dam, a distance of about 10 miles, the Big Lost River Valley has much of the characteristics of the Chilly Valley. Groundwater fluctuations are as much as 20 feet. The stream is often disconnected due to lack of sufficient flow to meet stream losses. After running disconnectedly for some time the water table in the dry portion falls to an extent productive of very heavy losses when an attempt is again made to carry waters through. This situation has led to the designation of the section of heavy losses as the "Darlington Sinks." While there is a very large unrecoverable loss in this section, to the underground flow, there is also a very beneficial ground storage effect of material proportions. In years of plenty the net loss is fully met by inflow from important tributaries, and any plan to divert waters around this section would have no value. The results in low years are intimately connected with the area below Moore's Dam.

At Moore's Dam, topographic and structural conditions result in a relatively high water table. Diversions are here made for nearly all of the lands down to Arco. This valley suffers from extreme variation in water table due to the more or less uniform loss to the underflow and the depletion of a variable streamflow by irrigation upstream. With ample streamflow water is everywhere at or near the surface, and a considerable area is subirrigated. When streamflow falls off, the small quantity passing upper irrigators is insufficient to meet the demands of the underground outflow, which then depletes ground storage. In places the water table fluctuates thirty to forty feet. There is, however, evidence that this condition has recurred from time to time as is to be expected. No tributaries here supply any part of the underground loss which is always drawn from the river.

Below Arco the situation is much the same as between Moore and Arco except that a part of the irrigated lands have a more dependable though extremely limited supply through ownership of Mackay storage rights and less fluctuation in ground water levels.

A proposal to store waters at Leslie for use in the valleys below may be dismissed with the statement that a practicable dam site appears unlikely and that the cost of such a reservoir would be out of proportion to the benefits obtainable.

The water commissioner, in distributing the small flows available in low years, has found it advisable to carry waters in as few ditches as possible and to eliminate diversions below Moore's Dam. It is believed this practice might profitably be extended. It is suggested that diversion for all lands below Leslie be made near Leslie, the exact point of diversion and the canals to be used to depend on further examination of river losses and consideration of the suitability of existing canals for this service. The Blaine canal has ample capacity to supply all lands below its heading. If used in the general scheme, between Moore and Leslie, it would have to be extended upstream some distance to eliminate heavy stream losses there existing, considerable reconstruction would be necessary on the canal itself to reduce losses, and one of the east side canals would have to be fitted to supply the considerable area there irrigated. The alternative plan is the abandonment of the Blaine canal in this section and the construction of a large new canal on the easterly side with all lands to be served therefrom. While possibly somewhat more expensive, this plan reduces the number of canals to a minimum with conservation of water and results in an attractive power opportunity at Moore where the canal would drop about 100 feet. Between Moore and Arco, three canals will be needed, one for each side and one through the "island." The choice of plans above Moore as well as the choice of the canal to carry water for the Arco lands from Moore to Arco must rest with a careful investigation of the relative costs and benefits of each plan. Whether the river channels should be used at Moore and Arco, even for short distances, or water carried across at these points in closed conduits, can only be decided upon trial. The object of the plan is to reduce the supply to the underground flows, and keep waters at the top of the ground for irrigation use. Its success will be measured by the extent to which the water table will be further lowered, as such lowering reduces the loss to outside regions. Improvements should be effected in the water holding ability of the canals through a maintained improvement program such as concrete lining and clay puddling, incidental to ordinary operations. The plan is not free of difficulties as lands that have been largely irrigated by subbing may be injured to some extent. Examination of these areas indicates that surface irrigation can, with some readjustment such as land leveling and crop changes, be practiced almost universally. What has been said applies to low runoff conditions when irrigation canals are largely capable of diverting all streamflow. In years of high runoff, nothing is to be gained by such a change in diversions.

Upon completion of the program of canal rearrangement heretofore outlined, consideration should be given to pumping as an auxiliary supply, particularly for the better class of lands below Leslie. From present indications the most favorable places for such pumping will be at Leslie, Moore and near Arco, but this situation may change very materially with operation of the revised canal system. The comparatively low crop values will not justify high charges for pumping. Cheap power will be necessary, and may be obtainable at the drop at Moore on the suggested east side canal.

Matters to be given future consideration are the tightening of Mackay reservoir and increase in storage capacity. These measures are sure to be costly and unlikely to be of value until the supply available for storage has been augmented through a saving in waters now lost to the Snake River Plains.

The possibilities of improvement herein outlined are not of a character such that complete and final plans with assured and definite results can be prepared. They are rather a series of progressive measures, each of moderate outlay, and each step depending on results being obtained from previous work. They are, therefore, not well adapted to execution by the Bureau of Reclamation. Their execution will, however, require concerted action by an organization of ample authority and some financial resources. An irrigation district comprising all lands irrigated from Big Lost River below the Mackay Dam is believed the proper organization for this work. The existing district comprising as it does only a part of these lands should be revived and enlarged to include all of the lands. Aside from its legal powers to distribute costs in proportion to benefits, and its ability to direct expansion of the irrigated area to the best lands when improved water supply so permits, the district can effect a distribution of water in accordance with actual requirement rather than legal right, and with benefits to all. Among other things, it would permit more effective use of Mackay reservoir, even though individual rights are not fully merged or pooled.

SUMMARY OF

BIG LOST RIVER VALLEY REORGANIZATION PLAN

W. G. Sloan - 1930

Construction of a by-pass from the Blaine diversion dam to a connection with the old Pass Creek channel above Moore Dam with a capacity of 600 second-feet, and the carrying of all decreed and storage water through this by-pass during the entire year except when the volumes are greater than the capacity of the by-pass canal, also an improvement of three-quarters of a mile of the river channel between Blaine canal heading and three-quarters of a mile below Leslie.

Revision and enlargement of the Moore canal from the Moore dam to the Blaine canal with a capacity of 350 second-feet for the purpose of carrying all stored and decreed water for the Era Flat and the territory served by the Moore, Harger, Sullivan, and West Side canals, and at times to serve some of the territory in the vicinity of Arco.

Enlargement and extension of the Island Ditch to a capacity of 175 second-feet from the head to a point about halfway between the Henna and James Lanes, for the purpose of carrying some of the decreed and storage water to the Arco heading in dry years, and in the early portions of each season.

The purchase of all rights of the Utah Construction Company in the Mackay reservoir and the extension of the boundaries of the irrigation district to include about 8,000 acres of the Utah Construction project lands.

The construction of Thousand Springs reservoir to a capacity of between 30,000 and 35,000 acre-feet, completion of the feeder canal from the river to the reservoir and the construction of a canal to carry the reservoir water back to the river channel above the Mackay reservoir.

The purchase of all water rights or their equivalent in the Nielson, Davidson, Neef, Chilly, Ingram, and Ivey ditches, for use in conjunction with the new reservoir, and the Mackay reservoir.

	UNIT	ESTIMATED YIELD	ESTIMATED COST	COST/ACRE-FOOT
(1)	Leslie By-Pass	9,000 ac.-ft.	$ 64,800.00	$ 7.20
(2)	Moore Canal Enlargement	3,000 " "	37,500.00	5.50
(3)	Island Ditch Enlargement ...	4,000 " "	24,000.00	6.00
(4)	Mackay Reservoir	25,000 " "	156,250.00	6.25
(5)	Thousand Springs Reservoir .	34,000 " "	172,500.00	3.32
(6)	Purchase of Water Rights ...	18,000 " "	110,300.00	6.13
	TOTALS	93,000 ac.-ft.	$565,350.00	$34.40

Required Bond Issue - $409,100 - Called $410,000.

BOARD OF ENGINEER'S REPORT

BIG LOST RIVER

May 1931

E. B. Debler - K. Q. Volk - J. B. Lippincott
Lynn Crandall - Roy W. Thompson - George N. Carter

Thousand Springs Reservoir

Diversion of waters for storage at this site would be reflected in an equal reduction in inflow to the Mackay reservoir. In years when the Mackay reservoir would not fill, the Thousand Springs reservoir would merely redistribute annual inflow to Mackay reservoir with an estimated net increase of 6,000 to 10,000 acre-feet in water available for use below the Mackay Dam in the irrigation season. In the winter, leakage from the Mackay Dam would be equally decreased with some lowering of the water table in the valley below Leslie. In years of high runoff, Thousand Springs catchment would result in a direct increase in available water, but in such years the water would be of little value except as a holdover for the following year. The value of the increased water supply is not commensurate with the probable cost of this feature. Such amounts as might have to be paid for the right-of-way in the reservoir site would probably fall far short of reflecting the injury to the cattle industry in the upper Big Lost River Valley through loss of a large part of its winter grazing area which would react adversely on the proper use of the balance of the area. It is concluded that construction of this reservoir is not warranted.

Purchase of Water Rights in Chilly Valley

Due to inadequate water supply and adverse economic conditions, a considerable area of land in the Chilly Valley has fallen into county ownership through tax sales, and additional areas will no doubt follow the same course in the near future. To the extent that water rights now appurtenant to such lands can be acquired at small cost and transferred to irrigated lands of greater value in the valley below Mackay, such transfers are desirable. The value of such water rights is dependent on their priority and should be carefully determined before acquisition. Water rights so purchased will result in an annual gain to the lower valley estimated to be equal to a depth of one to one and a half feet on the area to which the water has heretofore been applied, any diversions already being made in excess thereof, returning to the stream unconsumed. To obtain the full benefit of rights so acquired, it would also be necessary to provide a means of by-passing such water around the Chilly Sinks of Big Lost River during periods when that stream is broken.

The acquisition and transfer to other lands of fully used and valuable water rights in the Chilly section is not recommended.

Chilly By-Pass Canal

The Board has concluded that all, or nearly so, of the waters lost by Big Lost River in the Chilly Sinks is returned to the stream above Mackay, and largely so above the Mackay reservoir. A canal, in itself, would then effect no annual saving in water. The purpose of such a canal would be (1) to increase the supply to natural flow rights below Mackay Dam prior to the time the river becomes connected through the Chilly Sinks and while river flow above the sinks exceeds local requirements, (2) to pass water around the Chilly Sinks near the close of the irrigation season when Chilly canals have reduced their diversions and (3) to by-pass waters accruing to such water rights as may be purchased at nominal cost in the Chilly Valley. The object in each case is to hasten delivery to lands below Mackay Dam of waters which would otherwise arrive at less opportune times or become stored in the Mackay reservoir. For these purposes a canal of 200 second-foot capacity is deemed adequate. A suggested location is one paralleling the Davidson ditch and highway. The cost for a canal of shallow, wide section, to cope with the prevailing gradient of 25 feet to the mile would have an estimated cost of $30,000.00, the diversion dam contemplated being a timber crib affair. This feature would appear to be desirable, particularly if the Mackay reservoir is acquired so as to preclude objections on account of changed inflow conditions.

Leslie By-Pass Canal

The carriage of Big Lost River waters around the Darlington Sink below Leslie has frequently been proposed with the idea that prevention of the loss would result in a clear gain of water approximating such losses in amount. This conclusion rests on the theory that the losses represent waters entering underground channels which do not return such waters to the valley. There is, however, much reason to believe that the waters lost in the Darlington Sinks merely pass through the Antelope Creek delta and return in part to the river in the vicinity of the Moore Dam. If this be true, then a by-pass canal in this section will conserve water only by lowering the water table at the Moore Dam and thereby reduce the underground valley outflow to the Snake River Plains. The most certain benefit appears to be the ability to deliver sizable irrigation heads to canals below the Blaine Dam while the river is, under present conditions, establishing a surface stream across the Darlington Sinks. The Board has concluded that the uncertainties connected with this feature make it inadvisable to incur heavy expenditures and suggest a channel of 200 second-foot capacity, diverting at the easterly end of the Blaine Dam, thence by way of the Back Slough and enlargement of the Gray or lower Burnett ditches to the center of Section 19, T. 6 N., R. 26 E., where a short new ditch would carry waters to the Pass Creek channel. The cost of such a channel exclusive of rights-of-way and waiver of damages along Pass Creek is estimated at $20,000.00. Provided the channel proved to be free of heavy losses of water, it would be expected to be used in conveyance of all Big Lost River waters from Blaine Dam to Moore Dam so long as streamflow is less than canal capacity. If the operation of this channel, when built, proved more beneficial than anticipated, consideration should be given to enlargement thereof to a capacity of possibly 600 second-feet and attention should also be then given to reduction of existing losses in the river channel immediately above the Blaine Dam.

Irrigation Operations Below Moore Dam

There is no doubt that the use of the river channel below Moore Dam should be avoided if possible except in years of plentiful water supply. To this end it is recommended that the Island ditch be enlarged and extended to serve all lands on the eastern side of the valley down to Arco Dam excepting that the Darnley ditch would be retained. On the West side there are too many ditches and laterals. A single main ditch such as might be provided by enlarging the Moore canal with a series of short section line laterals leading east therefrom would adequately serve this area with a minimum of water loss. For river flow of more than 200 second-feet at the Blaine Dam, waters intended for the enlarged Moore canal could optionally be carried either in the Blaine canal to a convenient point for delivery to the Moore canal or permitted to flow down the present river channel to the Moore Dam, depending on the probable relative losses. In years of low runoff, water for lands below Arco should be carried through the Arco canal and not in the river, such waters to be delivered to the Arco canal either by further enlargement of the Island ditch to a point on James Creek 1 and 1/2 miles above the Arco Dam or through the Blaine canal, the lower Blaine canal and an extension of the same easterly to James Creek. The Munsey ditch would be extended upstream to the Arco Dam. The cost of the improvements for this section cannot be closely estimated from available data, but is expected to be not over $40,000.00.

Antelope Creek Channel

Considerable quantities of water are now lost, particularly during flood stages, in the several channels of Antelope Creek between the Richardson ranch and Big Lost River, due to the water spreading in various channels. The improvement and enlargement to a capacity of 150 second-feet of the south channel of Antelope Creek for a distance of about 6 miles as it flows over the Antelope fan would effect a substantial saving in the existing losses. This improvement could be made for about $10,000.00.

Purchase of Mackay Reservoir

The various improvements heretofore outlined cannot be expected to greatly increase deliverable waters nor has any such plan come to mind. The most attractive plan to improve conditions is the purchase of the properties of the Utah Construction Company, including the Mackay Dam. It is understood that the Company is delivering water to 1,700 acres of valid Carey Act water rights and to some 5,000 acres of lands held by the Company and individuals associated therewith, lack of water precluding a larger irrigated area. If the property were purchased the valid rights of about 1,700 acres should be concentrated on a compact area, preferably near Arco or transferred to valley lands above Arco, to minimize transit losses, and the remaining storage water utilized on valley lands. Waters so utilized above Leslie would do double duty in that return flow resulting therefrom would be rediverted to lower lands. It is believed that the resulting increase in delivered waters on lands within the valley would be fully twice the amounts now delivered to lands of the Utah Construction Company. The proper price to pay for these properties is not of easy determination, and would have to be finally determined as the result of negotiation with the officials of the Utah Construction Company. In considering the matter, due allowance should be made for the fact that a substantial sum of money, roughly estimated at from $175,000 to $200,000, will be required for improvements and repairs at the Mackay Dam if that structure is to be placed in condition for safe and dependable operation.

Repairs and Improvements to Mackay Dam

The continuation of heavy leakage through the dam and the south abutment cannot be viewed with complacency. The former is so heavy that there is some danger at high reservoir stages of fill materials being removed, while leakage through the south abutment may eventually develop solution channels in the porous limestone with heavy increase in leakage. Leakage through the dam is believed largely to be water passing through and under the earth blanket placed by the

Utah Construction Company thence upward through the gravel fill of the central portion of the dam and over the core wall to the lower toe. In the main, this leakage is concentrated in that portion of the dam where the upper part of the core wall was removed when the outlet tower was built. This leakage might be reduced and scattered by replacing the removed section of core wall and possibly raising the entire core wall, but the increased danger of piping under the dam resulting therefrom makes the plan inadvisable. Blanketing of the upper toe of the dam and of the reservoir floor immediately above the same is considered preferable. Tightening of the south abutment appears most practicable by means of drilling and grouting, but this work may be deferred for some years.

The spillway is neither safe nor adequate. Large flood discharges would erode the present spillway and drain the reservoir rapidly with extensive property damage, if not loss of life. Adequate spillway capacity is not obtainable through the present outlet tunnel and the additionally needed capacity can probably be most economically obtained by an adequate concrete lined spillway and concrete chute to the river along the line of the present spillway or a tunnel spillway through the right abutment is likely to be only slightly more expensive.

The cost of these various repairs and improvements needed at the Mackay Dam is estimated at $175,000 to $200,000.00.

Pumping for Additional Water Supply

While the feasibility of securing additional water over the surface supply by means of pumping from wells has been given consideration heretofore, yet sufficient assurance of the success of this feature is not apparent at the present time and the electric power situation is far from favorable. After the benefits of the other improvements herein recommended have been realized and opportunity offered to determine their effect upon the groundwater of the valley, the location and desirability of pumped wells will be susceptible of more accurate forecast. It is therefore suggested that the matter of pumping be left for future consideration.

Financial Arrangements

A district organization including all lands irrigated from Big Lost River below Mackay Dam is considered essential in any improvement program to provide the financial backing and to handle numberless matters of common interest that will continually arise. In view of the unpopularity of irrigation district bonds with resultant heavy discounts and high interest rates, funds obtained by that method should be held to a minimum.

Provided the activities of the district should be limited to minor improvements in canal systems to save water, no doubt the expense thereof could be met by ordinary annual assessments. In case the reservoir and lands of the Utah Construction Company be purchased and the necessary repairs and improvements made on the dam, it may still be possible to finance the purchase thereof, without resort to bonds, although the sale of bonds to the extent of $200,000.00 may be necessary to provide the cash for work on the dam. With a probable district irrigated area in the neighborhood of 30,000 acres, such a bond issue should not prove burdensome. To finance the purchase of the dam as it stands it is suggested that the district annually lease such storage water as may be available, at the best obtainable price, and that income so obtainable be applied (1) on the interest and principal on the purchase price of the reservoir and (2) on interest and principal of outstanding bonds. Under this plan no one within the district, excepting only outstanding Carey Act rights of about 1,700 acres would have any claim to storage, and the usual problem of fixing varied reservoir benefits to fit variable natural flow priorities would be avoided. While income from storage rentals will in most years probably meet requirements for interest and amortization of the cost of reservoir purchase, requirements for interest and amortization of bonds sold to provide funds for reservoir repairs and improvements will very likely have to be met by assessments. The small general assessment which would in most years be necessary to meet charges not carried by storage rental income would be justified by the indirect benefits accruing to all valley landowners through improved water supply and resulting greater prosperity. As a further source of district income, it is suggested that the district acquire junior water rights whenever obtainable at nominal prices as well as the lands now controlled by the Utah Construction Company with a view of making annual leases thereof to the extent warranted by outlook for water. It should be understood that the plan of financing herein described is a suggestion only.

Conclusions and Recommendations

The valley water supply can not be greatly improved except through purchase of the Mackay reservoir and the use on valley lands of storage waters now used on lands belonging to the Utah Construction Company, its officers and associates. The purchase of the reservoir and above properties is recommended if it can be made at a reasonable price.

The present Big Lost River Irrigation District should be reorganized on an operating basis and the district should make such minor canal additions and extensions as appear to have merit for improving the valley water supply. The most promising of these is the enlargement and extension of the Island canal and the supply of all lands below Arco through the Arco canal which should in turn be supplied from either the Island or Blaine canals without permitting water to pass through river channels below Moore Dam, except in years of plentiful water supply.

By-pass canals for the Chilly and Darlington sinks and improvement of Antelope Creek channel appear desirable and would no doubt improve irrigation efficiency but large savings in water are not to be expected from their operation.

Needed Repairs to Mackay Dam

1. Blanket toe of dam and adjacent reservoir floor with material now on top of dam westerly from the spillway.

2. Cover above blanket with silt material taken from bottom of reservoir at about the north shore line of reservoir at low water stage, moving same either by dragline - flume and pumps, or by scow and kicker motor.

3. Drill and grout south abutment from present roadway.

4. Excavate spillway to grade and section and then coat with gunite.

GEOLOGICAL REPORT ON BIG LOST RIVER VALLEY

D. C. Livingston - 1931

Introduction

Big Lost River Valley is one of the structural valleys of southeastern Idaho which lie between the mountainous central portion of the state and the Snake River Plains. The general trend of the valley is northwesterly and it is somewhat over 50 miles from the Snake River Plains to the foot of the mountains to the north that separate its waters from those of the Salmon River. In this 50 miles the valley rises about 1,000 feet, as it is a little over 5,300 feet at Arco and over 6,300 feet at Dickey near the valley head.

The main drainage area of the valley lies to the west and Lost River flows into this structural depression, from the west, a short distance below the head of the main valley. The drainage area of Lost River contains some of the highest peaks in Idaho. Among them is Mt. Borah, 12,600 feet; Mt. Hyndman, 12,060 feet; Mt. McCaleb, nearly 12,000 feet; and several between 10,000 and 12,000 feet in altitude.

In spite of its high drainage basin, the snowfall is light and has been steadily decreasing during the last 27 years, which is the length of time over which records of runoff and precipitation have been kept. During this 27 years there has been a decrease in runoff of over 22 percent in the last nine years compared to the first nine years. That the present dry spell is more likely the average condition to be expected is presumed from the evidence of old settlers in the valley, who state that in the eighties and nineties the valley was just as dry as it is today. In other words, the period from 1904, to 1912 inclusive, and up to 1918, was apparently one of excessive snowfall, as compared with what is probably the average climatic condition on the watershed. The development of the extensive irrigation projects was initiated during this period of maximum snowfall, runoff, and resultant high water table. Accordingly the present economic distress in the valley would seem to be due to over-development of irrigated lands based upon insufficient data of the climatic conditions.

It is interesting to note that whereas the runoff of the watershed decreased 22 percent in the last nine-year period of records, the precipitation at Mackay, which is about nine inches annually, shows a drop of only two percent in the same period. As the runoff is a factor of the snowfall in the mountains, it is evident that there is little relationship between the precipitation in the valley and the snowfall in the high ranges.

The evidence obtained from glaciation indicates that this has apparently been a region of light snowfall, both during and since the last glacial period. Whereas, in the Raft River and Albion ranges of Utah and Idaho to the south, and in Long Valley to the northwest, glaciers extended down to 4,500 feet. In the Big Lost River region, they show no evidence of extending below 7,000 feet. This can only be explained on a basis of difference in snowfall due to the track of storms which apparently pass north and south of this region, except in unusual years.

It may be that the high peaks in this region owe their altitude to lack of erosive material in the form of snow rather than to a greater difference in elevation, compared to the surrounding country.

Physiography of Main Valley

The east or northeast side of the main Big Lost River Valley is bounded by fault scarps.

From Arco to a little south of Pass Creek the scarp that bounds the east side of the valley trends a little west of north. From Pass Creek north another scarp trends north 45 degrees to 50 degrees west. The junction of these two scarps forms an embayment on the east side of the valley a little to the south of Pass Creek. Accordingly, the lower part of the valley trends almost north and south, the upper part northwest, forming an elbow in the valley a little to the south of Pass Creek.

The face of the scarp along the Big Lost River Range shows square-shouldered truncated ridges, between which the streams emerge upon the valley through narrow V-shaped canyons with nearly perpendicular walls. This indicates comparatively rapid uplift of the block through which they have cut their way. Pass Creek and both Upper and Lower Cedar Creeks are excellent examples of this condition.

On the west side of the valley the topography is entirely different. Here, long ridges with slopes of from six degrees to 10 degrees extend from the mountains to disappear below the gravels of the valley floor. The streams from this side, represented by Big Lost River and Antelope Creek, flow in wide aggraded valleys that slope gently to the main valley. Here they have formed flat, but extensive, gravel fans.

From the rising fault block to the east of Mackay the streams brought quantities of limestone cobbles and gravel, forming extensive fans--the "Fanglomerate" of Stearns. These old fans have a slope of from two degrees to three degrees, or from seven percent to ten percent grade, towards the mountains. They are the oldest visible gravel accumulations in the valley and have been tentatively correlated by Stearns with the Salt Lake formation to the south. They were evidently formed when the block of the Big Lost River Range, northeast of the valley, was rising and the streams were at the height of their activity. They have since been eroded by the tributary streams, and new, shallow valleys have been cut in these "fanglomerates" during the present geological cycle. Upper Cedar Creek, for instance, has cut a shallow valley across the old fan, from the mountains to the northeast, to the Mackay Dam. During occasional periods of flood, water flows down this channel to the dam and might be an actual menace to its safety, under exceptional conditions.

On the west side of the main valley are two points, or rocky headlands, that extend a short distance across the valley. One of these is Leslie Butte, and the other lies a short distance below the Mackay Dam.

Leslie Butte is separated from the range to the west by a low saddle which is crossed by a road. It undoubtedly represents a small subsidiary fault parallel to the general direction of the main valley.

The point, or island, east of the canyon below the Mackay Dam consists of hard, cherty limestone in which the beds are almost vertical and have a strike parallel to the valley. This evidently represents a hard portion of a ridge from the west. Big Lost River was forced behind this ridge by the encroaching fans from the rising fault block to the northeast. This caused the stream to cut through the ridge, probably in a saddle, thus forming the narrow and recently cut canyon below the Mackay Dam.

General Geology

The outcrops of rock on both sides of the valley consist chiefly of limestone beds, largely of Mississippian age.

As the gravel fans from the Big Lost River Range to the east filled the valley from that direction, the river in general flows nearer the west side of the valley in consequence. In some places it actually flows against the limestone for short distances, as at the Mackay Dam and north of the Leslie buttes. The limestone is badly shattered and full of solution cavities and undoubtedly provides a reason for considerable leakage of water along that side of the valley.

Rhyolites and andesites occur in certain places alongside the valley on the west side, and near Pass Creek on the east side. These seem to be in the form of irregular flows and dikes. The large springs at the head of Warm Spring Creek emerge from these rocks, which at those points are probably very close to the underlying limestone.

Below Arco the mouth of the valley has been blocked by the Snake River lavas, which flowed from a number of orifices and reach their maximum development in the northwesterly trending lava cones of the Craters of the Moon.

The gravels of the valley can be divided into two main types: (1) the "fanglomerates" formed by the streams from the rising fault block of the Big Lost River Range, and (2) the alluvial fans from Big Lost River, Antelope Creek, etc., which flow from the more gently sloping surface of the down-dropped block on the west side of the valley.

These gravels are distinctly different in character. The "fanglomerates" are composed almost entirely of limestone cobbles which are largely subangular. They may be partly of glacial origin derived from the summit of the range, but they have travelled a comparatively short distance.

The latter stream fans consist of a well rounded, water-worn boulders and pebbles composed of a great variety of rocks which are largely of igneous origin with porphyries predominating. These have come long distances and are younger than the "fanglomerates."

The upper part of the "fanglomerates" consists of a typical cemented hardpan of variable thickness, with a possible maximum of 100 feet. The cementing material is calcareous and this interesting formation was undoubtedly formed under an arid climate. Below this hardpan the gravels are unconsolidated and certain small irregular inclusions of fine silt. The hardpan, near the surface, is full of erosion cavities forming peculiar small arched caverns.

Below the cemented hardpan capping, this formation is very open and permeable to water. As all the streams have cut well below this capping, water losses in ditches conducted across these "fanglomerates" would be, and undoubtedly are, very high.

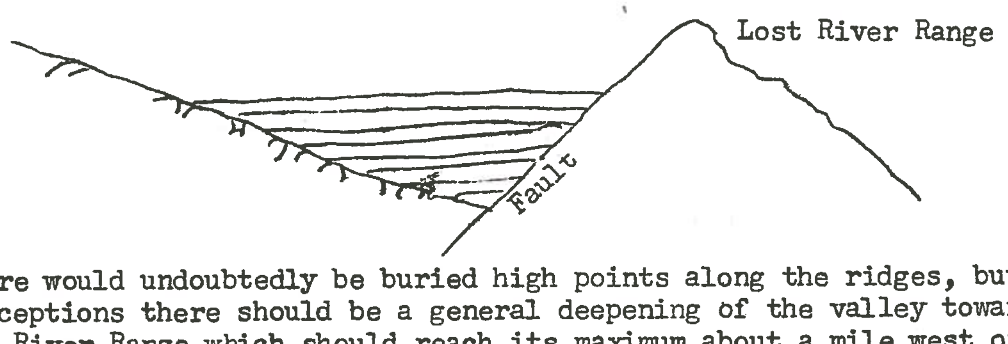
Certain parts of the valley, as for instance immediately above the Mackay Dam, consist almost entirely of the "fanglomerates" formation and are of little value for anything but grazing. Other parts consist of the more recent gravel fans from the streams west of the valley. Some of the farms on these fans are rather gravelly, but the soil is productive though decidedly porous. The best farming land is, of course, on the recent flood plains of the river that lie between the coalescing fans. Here the water table is comparatively close to the surface and some of these low places are actually swampy in wet years. Certain crops, such as alfalfa, in some cases can be raised on these flood plains without irrigation.

The reason for the height of the water table at these places is due to the fact that whereas the ground water table has a fairly uniform slope, as shown by the contours, the surface contours of the valley do not. On the fans the surface contours parallel the water table contours approximately. On the flood plains the surface contours flatten out while the water table contours maintain their normal slope. Consequently, the two come fairly close together on the flood plains and in wet seasons they actually meet in certain places.

Summary of Geological History

The late geological history of the valley might be summed up about as follows: The old mountain area, or erosion surface of central Idaho, was uplifted and broken by faults during the late Tertiary period. One of these faults occurred along the east side of what is now Big Lost River Valley. On this side of the valley a large block of the earth, the Big Lost River Range, uprose, while the west side remained comparatively stationary. The evidence of this lies in the different types of topography displayed on the two sides of the valley. There are only three known processes or forces that produce the square-shouldered, or truncated, ridges like those on the west front of the Big Lost River Range. These are glaciation, block faulting, or rapid erosion by waves. If the first of these had formed this topography, both sides of the valley would be alike. The latter process can be safely eliminated, leaving only the hypothesis of faulting as explanatory of the topography.

This is important because it has been suggested that the valley is crossed by fault blocks which cause the underground water to rise above the blocks. There is no evidence of this in the topography.. The conditions existing below the valley floor are more likely to be a continuation of those exposed on the surface, i.e., a steep descending scarp along the face of the Big Lost River Range and gently sloping ridges extending to meet this scarp from the west.



There would undoubtedly be buried high points along the ridges, but with these exceptions there should be a general deepening of the valley towards the Big Lost River Range which should reach its maximum about a mile west of the range. The few limestone points that occur along the front of the Big Lost River Range appear to be landslide blocks from the fault scarp.

Following the uplift of the block, quantities of boulders and gravels were washed from the rising surface to the valley by the small gulches and tributary streams. The gravel deposits along the front of the Big Lost River Range have filled the valley to a depth of several thousand feet.

This "fanglomerate" blocked the streams from the west, causing them to aggrade or build up their extensive, gently sloping, fans. Along the sluggish reaches of the river, caused by the coalescing fans from the two sides of the valley, wide flood plains formed that were covered with silt and now form excellent soil. The lava flow below Arco accentuated this condition and was doubtless the main contributing factor in the formation of the wide areas of the fine silt land in that vicinity.

Underground Water

As previously pointed out by other geologists and engineers, Big Lost River Valley is a gravel-filled and porous structural depression, forming a great underground reservoir of water.

As no surface contour map of the valley exists, the relation between the water table surface and the slope of the valley cannot be defined with an exactitude. During the last dry cycle, which started about 1919, the river is intermittent in its flow over considerable detached lengths of its course through the valley.

After leaving its northeasterly channel, and entering the main valley opposite Chilly, the river disappears during periods of low water in what is known as the Chilly Sinks. This is apparently due to two main factors, the greater width and underground volume of the main valley, and the porous nature of the great fan that has been formed in this vicinity.

It reappears again in considerably diminished volume above the Mackay Dam after receiving a considerable addition from Warm Spring Creek to the west.

This return of the water to the surface above the Mackay Dam has been ascribed by Stearns to a narrowing of the bedrock walls of the valley in the vicinity of the Mackay Dam. The writer does not agree with this conclusion. As previously stated, the writer is of the opinion that below the Mackay Dam the river has cut through a ridge.

A careful examination of the geology discloses the fact that the cherty limestone bedrock slopes downward to the northeast beneath the "fanglomerates." The inference from this is clear. There is to the northeast of the high rocky point that causes the canyon, as great a depth of "fanglomerates" as there is in other parts of the valley, and no narrow neck between the bedrock walls exists at this place.

The rise of the water table at this point can be more easily explained by the fact that the "fanglomerate" fan from Cedar Creek piled up against this ridge impounding the water above. This resulted in the filling of that part of the valley lying between the "fanglomerate" and the ridges to the southwest with silt. In this flat portion of the valley the water table contours cut the surface contours.

The other sinks and places of rising water table are undoubtedly due to similar factors and not to any fault blocks crossing the valley.

A good topographic map of the valley in combination with water table contours would undoubtedly show the same relationship for other places where the water table rises.

Thousand Springs is another excellent example of a rising water table at the head of a flat silt-covered basin formed by the junction of the Big Lost River fan with the fans from the high mountains to the east.

IRRIGATION WATER CONSERVATION

James Spofford - Fred A. Tolman - Walter Jensen

October 1937

Brief field inspections have been made of the Big Lost River Valley and a careful study taken of water measurements on the river and the watermaster water delivery records for a long period of years, with the idea of conserving water for irrigation purposes.

The Big Lost River Valley lies between the mountainous central portion of the state and the Snake River Plains. The general slope of the valley is toward the southeast. From the foot of the mountains that separate its waters from the Salmon River watershed, near Dickey, with an elevation of 6,300 feet, the valley falls 1,000 feet to Arco, a distance of 40 miles. Although the drainage area of the river contains some of the highest peaks in Idaho, yet the snowfall is light and has decreased for the last 33 years, which is the period over which runoff and precipitation records have been kept.

The "Chilly Sinks", so called, lie a short distance below the head of the main valley and the river, rising from the main drainage area to the west, flows east in this structural depression which is located about 10 miles above the back-waters of the Mackay Reservoir.

Some consideration has been given to a river by-pass around the "Chilly Sinks" with the purpose of increasing the water supply below Mackay Dam in the early summer before water rises and flows from the "Sinks" and also during the summer when the rights under the Chilly canals have been reduced. This canal would also serve as a carrier for additional water that might be purchased and transferred from lands in the Chilly Valley.

Based on United States Geological Survey records for many years, it is generally agreed that a canal with a carrying capacity of 200 second-feet would produce the greatest benefits. There has been a great difference of opinion relative to the type of canal to be used. Some investigations have favored a wide canal with shallow depths as the initial cost would be less than any other type of construction, but due to the fact that the valley has a nearly uniform fall of 25 to 26 feet per mile and passing over a gravelly and porous soil, the seepage losses would be high and the erosion of the canal banks would cause a very unsatisfactory condition with a high maintenance cost.

A small ditch, lined with hand-placed boulders, grouted with cement, is recommended. This canal, to be most effective, should be diverted from the river in section 1, Township 8 North, Range 21 East, Boise Meridian, near the diversion of the Davidson Ditch and will parallel this ditch for several miles and at about 7 miles from its diversion will enter the back channel of the river in section 24, Township 8 North, Range 22 East, Boise Meridian, which is a short distance below the old highway steel bridge.

This completed canal will have a bottom width of 4 feet, with side slopes of 2:1 and a carrying depth of 2 1/2 feet of water.

Estimated Cost of Canal Construction

Seven Miles Excavation -- 50,000 cubic yards at 10 cents	$ 5,000.00
Hauling and Hand-Placing Cement Grouted Limestone Boulders for Canal Lining -- 71,600 square yards at 80 cents	57,280.00
Diversion Dam and Headworks	5,000.00
Highway Bridges	500.00
Back Channel River Improvement	3,000.00
TOTAL	$70,780.00

If the river water were diverted as heretofore outlined, the flow in the river below the by-pass canal diversion would be decreased and naturally affect water deliveries on the several thousand acres of agricultural and grazing land lying between the diversion and a point about 3 miles above the reservoir. Any change in the point of diversion of the river above Chilly Valley will therefore involve expenditure of money in the purchase of water rights thereby affected.

The real benefit that is derived from the construction of this by-pass canal is to speed up the time of delivery of irrigation water to Mackay Reservoir as the stream measurement records taken at Howell gaging station above the Chilly Valley, Warm Springs Creek at Barton, Upper Cedar Creek and other sources above the reservoir, (Crandall report, October 4, 1928) and the "B" station below the reservoir, only show a loss that can be accounted for.

The total average annual runoff entering the Upper Valley during the years 1921 to 1936, inclusive, may be estimated as follows:

Big Lost River at Howell Gaging Station	*170,271 acre-feet
Warm Springs at Barton	41,000 " "
Other Sources	5,900 " "
Total Supply	217,171 " "
Accounted for at "B" Line Station	208,323 " "
Net Loss in Upper Valley	8,848 acre-feet

*Records at Howell's Gage are incomplete for the years 1921, 1922, and 1923.

This net loss may be accounted for as water consumed by crops and loss by evaporation on the large acreage that is irrigated in the Upper Valley. Mr. Lynn Crandall points out in his report of 1928 that "the records of water supply thus corroborate the groundwater measurements that were made during 1920-1922 and indicate that the water contributed to the groundwater table in the Upper Valley from the river channel losses and seepage from irrigated lands all eventually finds its way back into the stream at the "Narrows" below the Mackay Dam."

It is of interest in this connection to note the storage effect of the "Chilly Sink", so called, as the supply at the Howell gage fluctuates from year to year and shown by the following tabulation of water records for the sixteen-year period.

Year	Flow Past Howell Gage (acre-feet)	Flow Past "B" Line Gage (acre-feet	Gain or Loss at "B" Line (Gain)	(Loss)
1921	256,420*	278,090	21,670	
1922	238,240*	264,798	26,558	
1923	208,820*	254,365	45,545	
1924	101,750	142,508	40,758	
1925	244,040*	233,078		10,962
1926	107,200	146,249	39,049	
1927	230,100*	212,129		17,971
1928	178,510*	199,698	21,188	
1929	118,370	140,677	22,307	
1930	179,354*	171,514		7,840
1931	98,084	120,526	22,472	
1932	209,740*	194,031		15,709
1933	138,675	154,967	16,292	
1934	80,968	97,986	17,018	
1935	185,670*	175,758		9,912
1936	148,420	146,797		1,623
TOTAL	2,724,361	2,933,171		
AVERAGE	170,272	183,323	27,285	10,678

*Above average.

It is noted by the foregoing table that in years of less than average flow at Howell's, which are preceded by years of excess flow, the "B" Line record shows a gain over the amount available at the upper end of the valley while in years of excess flow, which follow a year of shortage, the "B" Line records show an apparent valley loss.

This would indicate that the gravels above the reservoir act as a storage reservoir in high water years and yield a somewhat corresponding dividend in the following year of low supply, and in such case must be of great benefit as a stabilizer of flow and supply for the Lower Valley.

The main river channel from a point about 1 mile above the old highway steel bridge crossing the river, above the reservoir, to the steel bridge river crossing near the Chilly store is badly eroded and the water spreads in several channels, thereby slowing down the velocity of the water, increasing surface evaporations and deep percolation into the gravels, thus retarding the flow of water into the reservoir.

It is advised that river channel improvement be made from this lower location up the main water course, straightening the alignment and confining the river to one channel insofar as possible without interfering with the water deliveries to adjacent ranches.

If this betterment is made with modern earth moving equipment, the cost would not be expensive. It is possible that some government relief agency might complete this work at no material cost to the district.

It is believed that the greatest factor to be given consideration at this time is the betterment of the distribution system below the Mackay Dam. For the benefit of a clear analysis of the situation, it is thought advisable to divide the irrigated lands into three segregations, namely; Section "A", covering diversions from the "B" Line station below Mackay Dam to the Blaine Heading; and Section "B", covering diversions from the Blaine Heading to Savaria Lane.

Based on measurements taken from the watermaster's reports on Big Lost River, from 1928 to 1937, inclusive, a period of 10 years, it is found that the annual 6-month period (May 1 to October 31, inclusive) loss in Section "A" is 18,105 acre-feet; and Section "B" 11,681 acre-feet.

The section of the lower valley where the greatest loss occurs is in the Darlington Sinks and extends from a point in the river near Leslie to the Moore Dam, a distance of approximately 7 miles.

Due to the fact that gaging stations are established only at "B" Line, Blaine Heading, Savaria Lane and Arco Dam, it has been difficult to determine the loss across this sink. The watermaster's records on the river, however, for the years 1920 to 1922, inclusive, show that water measurements were kept also at the Leslie gaging station and at the Blaine gage. The record of flow past the "B" line station for the year 1920 totals 168,150 acre-feet and is therefore a good average for the past 10-year period. Based on the complete records for 6 months of this year, May 1 to October 31, inclusive, it is found that the average total loss, for this 6-month period, from the "B" Line gaging station to the Moore gage is 16,784 acre-feet, of which 3,084 acre-feet, or 18.4%, was lost between the "B" Line station and the Leslie gage; 8,701 acre-feet, or 51.8%, was lost between the Leslie gage and the Blaine heading; and 4,999 acre-feet, or 29.8%, was lost between the Blaine heading and the Moore gage.

Based on these relative percentage losses, it is therefore determined that the average loss for the 6-month period (May 1 to October 31, inclusive) during the years 1928 to 1937, inclusive, will be as follows: "B" Line gaging station to heading of the proposed canal near Leslie gage, 5,481 acre-feet; Leslie gage to Blaine Heading, 15,429 acre-feet; and Blaine Heading to Moore Dam, 8,876 acre-feet. The loss, therefore, from Leslie gage to Moore Dam aggregates 24,305 acre-feet, which practically covers the Darlington Sink section of the river.

The foregoing conclusions are very closely corroborated by the watermaster's measurement records, in second-feet, taken on September 19 and 28, and October 7, 1937, which are as follows:

Date	River at "B" Line	Diverted Above Moore	River at Moore	Total Available For Use	Loss to Moore	Deduct Loss to Leslie	Recoverable Loss
9/18/37	139	39.0	30	69	70.0	18	52
9/28/37	139	40.7	30	70.7	68.3	18	52.7
10/7/37	139	39.7	30	69.7	69.3	18	51.3

Mean recoverable losses under present conditions — 52 second-feet.

To this recoverable loss of 52 second-feet, may be added an estimated saving of 8 second-feet, resulting from river channel improvements above the proposed new canal heading. This saving of 60 second-feet will, during an irrigation period, (184 days) from May 1 to October 31, inclusive, aggregate 22,080 acre-feet.

If we capitalize on this recovery of 22,080 acre-feet at $10.00 for an acre-foot, an expenditure of $220,800 would appear justifiable. However, it is believed that this saving may be accomplished by a maximum expenditure of $150,000.00 as hereinafter shown.

Governed by careful meter measurements, it has been determined that the new by-pass should take its heading from the river a few hundred feet above the wooden bridge river crossing about 3/8 of a mile south of Leslie and extend on a nearly uniform grade to the Moore Dam, a distance of approximately 7 miles.

The location of the heading is a favorable one, and a low cutoff wall will be built of reinforced concrete about 40 feet long and with a spillway crest of 30 feet. A reinforced concrete head wall will be constructed for the by-pass intake, and the flow of water into this canal will be controlled by two steel gates.

The canal itself will have a 6-foot bottom, 2:1 slopes, and may carry a 3-foot depth of water with a freeboard of 1/2 foot. The fall per mile is about 20 feet and the velocity of flow will, therefore, exceed 11.5 feet per second and will deliver more than 400 second-feet of water at the Moore Dam. The time of transit over this 7-mile distance will be about 1 hour.

<u>Estimated Cost of Constructing 7 Miles of Canal</u>

Excavating and Grading 56,100 Cubic Yards at 10 cents	$ 6,510.00
Concrete Lining, 4" Thick (1:2:4 mix) 10,150 Cubic Yards at $12.	121,800.00
Reinforced Concrete Diversion Dam and Canal Heading 35 Cubic Yards at $16.	560.00
2-4' x 4', Outlet Gates with Hoists	500.00
Reinforced Concrete Culvert Under Highway, 16' x 40', 60 Cubic Yards at $16	960.00
Reinforced Concrete Culvert under Railroad Track	1,000.00
Eight Timber Bridges for Road Crossings at $120.	960.00
Incidentals and Overhead Expense	3,630.00
Estimated Total Cost	$135,920.00

The proposed construction of the Darlington Sink by-pass would of necessity wait upon the modifications of the Federal Court Decree, which designates the river channel as the water carrier.

This estimate of cost is only preliminary for the reason that actual surveys and measurements must be made on the ground before more exact estimates can be made. The ground alignment, however, for the canal location is very uniform and located on gravelly land having good subdrainage and for this reason a minimum of reinforcement will be needed in the concrete lining.

The river channel from the point of diversion of the proposed new canal heading up the river for 6 miles is badly eroded and the alignment of the channel very crooked. The straightening of this channel and the leveling and riprapping of the water will decrease the evaporation losses. This betterment may be made by a governmental relief agency with little cost to the project.

ADDITIONAL WATER SUPPLY FOR BIG LOST RIVER VALLEY

Chief, Hydrology Branch, USBR, Region 1

May 4, 1954

To meet the needs of the Regional Director in complying with the request of March 1 from Mr. Albert B. Pearson, Secretary, Big Lost River Irrigation District, for information on this subject, the data in this office have been reviewed and analyzed. Previous work by the Bureau, by the Geological Survey, and by the Corps of Engineers has been reviewed to find data pertinent to the suggestion made by Mr. Pearson regarding diversion from East Fork of Salmon River and other means of securing additional water for Big Lost River Valley.

On the Bayhorse Quadrangle, Geological Survey topographic map, all headwater drainage areas in the East Fork Salmon River Basin within reasonable distance of upstream tributaries of Big Lost River were outlined. The drainage area, potential yield, and approximate length of diversion tunnel required for each of these areas were determined. The results are summarized as follows:

Tributary of East Fork Salmon River	Contrib. Area in Sq. Mi.	Est. Ann.* Runoff Acre-Feet	Diversion Tunnel		Yield (Acre-Feet/Mile Tunnel Required)
			To Big Lost Trib.	Length-Miles	
Lake Creek	9.85	7,100	Twin Bridges Cr.	6.0	1,180
East Fork Herd Cr.	4.71	3,400	No. Fork Big Lost	4.4	770
West Fork Herd Cr.	12.42	8,900	" " " "	3.2	2,790
East Pass Creek	17.85	12,800	" " " "	7.4	1,730
West Pass Creek	13.91	10,000	" " " "	4.9	2,040
Comb. East Fork & West Fork Herd Cr.	17.13	12,300	" " " "	6.3	1,950

*Based upon average annual runoff of 718 acre-feet per square mile which is equivalent to unit runoff of Salmon River above Clayton. Unit runoff from East Fork Salmon River near Clayton is 289 acre-feet per square mile. Diversion areas are at high altitudes on North Slope and hence should have greater than average runoff.

It appears quite doubtful if any of these small diversion plans would be economically justified. To secure any sizable annual flow would mean diverting well down the East Fork drainage, where elevations are below 6,000 feet. Corresponding elevations on Big Lost River are downstream from Mackay Dam. A tunnel length in excess of 37 miles would be required in such a plan. Regulatory storage on the East Fork of Salmon River, above the tunnel, would also be required to limit the size of tunnel required. Such a plan might yield about 100,000 acre-feet annually, but would undoubtedly be more costly than the potential benefits would justify.

BIG LOST RIVER

U. S. Corps of Engineers - Columbia Basin Review Report

October 1948

The initial water rights on Antelope Creek were held by owners of lands southwest of Arco. When Mackay Reservoir did not prove as successful as anticipated, the Big Lost River Irrigation District bought the Antelope Creek water rights and transferred the water use to lands between the mouth of Antelope Creek and Arco. The original lands were abandoned. Antelope Creek drainage, lying at a lower elevation than the Big Lost River tributaries, has an earlier spring runoff than the rest of the river. This condition is taken advantage of by use of Antelope Creek water for early season irrigation and use of storage in Mackay Reservoir for the later part of the season. There appears to be much wasteful use of the water, and most of the spring flood runoff escapes without use.

PROBLEMS AND SOLUTIONS CONSIDERED

The principal problem is that of conserving and using all the available water supply on the best lands available, and avoiding excessive groundwater losses. Flooding problems and bank erosion problems also exist as a result of uncontrolled spring flood flows.

Storage reservoirs in Big Lost River Basin would have to be located outside areas where excessive seepage occurs, and especially outside the sink areas near Chilly and the mouth of Antelope Creek. Stored water should be conveyed to the point of use in lined canals or closed conduits to avoid seepage losses. There are several possible sites for reservoirs above the sink areas, but none below.

Lands along Big Lost River west of Arco could use additional water supply for irrigation. Storage on headwater tributaries of Big Lost River would not be adequate for irrigation of all these lands. The best solution would be to provide storage capacity to conserve the runoff of Big Lost River and Antelope Creek for beneficial use on these lands.

The following paragraphs describe possible future storage and local flood-control projects considered.

Garden Creek Project

This site offers the first possibility for storage on Big Lost River above the sink area near Chilly. It is about 10.6 river miles upstream from Chilly and about 0.4 river miles above the mouth of Garden Creek. The river valley, which is wide all the way above the Mackay Reservoir, is constricted somewhat at this point by a towering mountain on the south and a high ridge on the north. The valley at the site is still quite wide, but it is the best site below the junction of the North and East Forks and is adaptable for construction of an earth-fill dam to provide a reservoir adequate to store all of the runoff at that point.

Measurements at the Howell Ranch gaging station, 3 miles below the damsite, indicate that the average flow is 250 second-feet and the average annual runoff from the 420 square miles of drainage area is 181,000 acre-feet. A usable storage of 180,000 acre-feet could be obtained by construction of a dam to raise the water surface elevation about 216 feet to elevation 6,912. This pool would reach into only the lower ends of the North and East Fork Valleys.

The flow line from this site to the point of use would be quite long. The base of the dam would be at about elevation 6,700 and a canal could carry the water by gravity and remain high enough for all purposes. A shorter and probably more trouble-free line could be obtained by constructing a 7- or 8-mile tunnel, from about a mile below the damsite, through the north end of the White Knob Mountains into the valley of Warm Springs Creek. A canal could then carry the water to the hill forming the right abutment of Mackay Dam, where another tunnel 2 or 3 miles long would place the water at the head of the irrigated lands and well above them. This latter line would be about 22 miles long from the damsite to Mackay. The canal line would be much longer, as it would require several miles of canal to get around the north end of the mountains and back into Warm Springs Creek Valley.

Castle Project

Castle site on the East Fork is the best in Big Lost River Basin. It is located immediately downstream from the mouth of Castle Creek, about 7 miles above the junction of the North Fork and East Fork roads. Drainage area above the site is about 200 square miles and the average annual runoff past the site is estimated to be more than 90,000 acre-feet.

The damsite is about 200 feet wide in the bottom and shows good rock throughout. The rock is believed to be continuous under the river and not deeply buried. The site is suitable for construction of a concrete gravity dam, or for part earthfill and part concrete. The right abutment is cut very steeply on its upstream face by the canyon of castle Creek which comes in from the east, and is not believed to be suitable for earth-fill construction. Materials for either type structure are available in the vicinity.

A dam raising the water surface elevation 242 feet to elevation 7,392 would create usable storage capacity of about 100,000 acre-feet and provide some holdover storage. The site is about 700 feet wide between abutments at an elevation 100 feet above the river. The reservoir area is very satisfactory from a storage standpoint. The valley widens just above the damsite to form a flat-bottomed valley 2,000 or 3,000 feet wide in which the river runs in a shallow channel. This valley continues up to Copper Basin, where it widens into a very large basin. The pool behind this dam would reach only to the lower end of this basin. The narrow, low-grade road through the reservoir would present the only flowage problem.

This site has several distinct advantages over the other sites available. Foundations obviously are good and a definite cutoff would be assured. Although the site is high in the tributary area, at elevation 7,200, its 200-square mile drainage area contributes a large volume of runoff. The flow line from the dam to the point of use could be made comparatively short. A 5.5-mile tunnel leading to the east would place the water high above the Warm Springs Creek Valley, from which point it could be dropped to the vicinity of Mackay by any one of several routes. The reservoir capacity would be considerably less than at the Garden Creek site. Castle Reservoir alone could not control adequately the runoff of Big Lost River Basin, but it would have considerable advantage, in that water could be made available, at a comparatively low conveyance cost, to high lands in Warm Springs Creek Valley as well as the area around Mackay.

Antelope Creek Project

The site is in the box canyon about 3 1/2 miles downstream from Grouse Flat. Here the canyon walls narrow until the flat-bottomed valley is only about 600 feet wide and the rock canyon walls rise quite steeply on either side. The crest length of a dam 150 feet high would be about 1,800 feet. Both abutments show massive rock formations of banded rocks, probably gneissic, in which the strike is almost perpendicular to the stream, and which dip very steeply upstream. Rock does not show in the valley floor, but there is not believed to be much overburden.

The reservoir for this site would be entirely contained in the box canyon. A dam raising the water surface 135 feet to elevation 6,015 would create a pool extending upstream about 3 miles, with a usable capacity of about 70,000 acre-feet. It would not encroach upon the hay meadows in Grouse Valley, but it would inundate two or three smaller ranches with smaller hay tracts in the canyon bottom. Here also, the ranches and the road would constitute the only flowage problem.

Big Lost River Flood-Control Project

The principal flood problem results from the fact that channel velocities are high during floods and much channel deterioration occurs annually. Local interests have attempted to solve the problem, and at the same time build up groundwater storage, by diverting flood flows into the sink area near Chilly. Also, they have rectified certain reaches of channel and constructed numerous concrete drop structures in the vicinity of Chilly and near the mouth of Antelope Creek.

The best solution to the problem appears to be an extension of these works to stabilize the channel and confine floods to the channel and any desired groundwater recharge areas. Such extensions would serve in the interim prior to construction of storage reservoirs and ultimately would stabilize the channel against damage from flood flows originating downstream from the damsites and sink areas. This work, however, does not appear to be justifiable at this time.

Conclusion

In spite of the extremely porous nature of Big Lost River channel and the adjoining lands downstream from Chilly, it would be possible to construct storage reservoirs to conserve runoff for application to the land during the irrigation season. Such reservoirs could be operated on a forecast basis to create substantial flood-control benefits. Certain local channel improvements would be desirable for flood control and groundwater recharge prior to development of storage, and would serve to stabilize the channel and confine floods originating below the damsite after storage was developed.

Storage capacity adequate for control of the available runoff from North and East Forks probably could be obtained at the Garden Creek site, but the upstream Castle site still would be desirable from the standpoint of foundation conditions, location with respect to runoff producing area, location with respect to irrigable lands, and seepage conditions. An ultimate development probably would include both Garden Creek and Castle sites.

Storage on Antelope Creek could be used to provide water for lands west of Arco. A 4-mile tunnel would carry water from either of the sites to the upper edge of the irrigable area, from which point it could be distributed by canals or, preferably, by closed conduit for sprinkler application.

The problem of flood control and irrigation in Big Lost River Basin should be given further study by the Corps of Engineers and Bureau of Reclamation.

SUMMARY AND STATUS OF PROPOSALS

Proposed Developments	Probable Effect	Estimated Cost	Present Status
Chilly By-Pass Canal	Speeds water to lower valley	$ 30,000	Not constructed.
Leslie Reservoir	Storage for lower lands		Not constructed.
Divert all water through Blaine or East Side Canal	Avoid loss in river & develop power at Moore		Not constructed.
Canal lining	Prevent seepage loss		Not constructed.
Use 3 canals Moore to Arco	Reduce seepage loss		Partially const.
Pump w/power from Moore Drop	Additional supply		Not accomplished.
Tighten dam	Prevent winter loss	180,000	Not accomplished.
Enlarge irrigation district	Improve water distribution		Completed 1929.
By-Pass Leslie to Pass Creek	Avoid river loss	64,800	Partially const.
Improve 3/4 mi. river at Leslie	Reduce loss to gr. water		Not accomplished.
Combine Moore, Harger, Sullivan & West Side Canals, 350 cfs	Reduce seepage loss	37,500	Partially const.
Enlarge Island Ditch, 175 cfs	Reduce seepage loss	24,000	Not constructed.
Purchase U.C.C. Rights	Control storage water	156,250	Purchased 1936.
Thousand Springs Reservoir	Flood water storage	172,500	Not constructed.
Purchase rights of Nielson, Davidson, Neef, Chilly, Ingram & Ivey Ditches	For use below Mackay Reservoir	110,300	Not accomplished.
Leslie By-Pass to Pass Creek, 200 cfs	Avoid river loss	20,000	East Side Canal built 1936.
Enlarge Island Ditch to Arco Canal. All West Side canals into one.	Carry all East Side water	40,000	Not constructed.
Enlarge So. Channel Antelope Creek, 150 cfs	Consolidate flow	10,000	Not constructed.
Pump When Cheap Power Avail.	Addit. supply 18,000 a.f.		Some pumping.
Chilly By-Pass Canal, 200 cfs	Speed time of delivery below reservoir	70,780	Not constructed.
Realign river above highway bridge	Speed water into reservoir		
Leslie By-Pass to Moore Dam, 400 cfs	Avoid river loss	135,920	Partially constr.
Tunnels from Salmon River Watershed			
Lake Creek	Add 7,100 acre-feet		Not constructed.
Herd Creek	Add 12,300 acre-feet		Not constructed.
East Pass Creek	Add 12,800 acre-feet		Not constructed.
West Pass Creek	Add 10,000 acre-feet		Not constructed.
Thousand Springs Drain	Enlarge grazing harvest & water yield at Mackay Reservoir		Not constructed.
Garden Creek Reservoir	Storage 180,000 acre-ft.		Not constructed.
Castle Creek Reservoir	Storage 100,000 acre-ft.		Not constructed.
Antelope Creek Reservoir	Storage 100,000 acre-ft.		Not constructed.

LOSSES TO GROUND WATER

BIG LOST RIVER IRRIGATION DISTRICT

April to October 1920, 1922, 1934, 1950

	1920*	1922*	1934**	1950**
	(Losses in Acre-Feet)			
Flow below Mackay Reservoir	126,220	230,308	70,676	185,100
River Losses (Mackay Dam to Arco)	24,580	25,221	24,000	25,000
From Tributary Streams	24,960	56,490	15,000	40,000
Seepage from Canals & Irrigated Land	71,203	129,994	30,000	173,700
Total Loss	120,843	213,627	69,000	238,700
Recovery from Rising Ground Water	12,055	60,574	6,000	20,000
Net Loss to Ground Water	108,788	153,053	63,000	218,700
Percent Lost	51%	39%	53%	69%

* Data taken from Lynn Crandall report.
** Estimated.

CONCLUSIONS

In spite of the proposals for improvement in water distribution, there still remains an annual loss to underground outflow of over half the total watershed run-off. This is true even with the recovery generally possible along lower reaches of the river.

At no time since records of flow have been kept on the Big Lost River has the supply of water fallen below that needed for the irrigation of 50,000 acres of land. Extremely poor utilization of the water from that part of the watershed below the Mackay Dam is evident with only a small proportion of the water that enters the subsurface flow becoming available for use in the valley. Well development offers a means of retrieving some of the loss, but at best wells would enable recovery of only a small portion of the water now allowed to enter the underground flow. The result would be like rounding up wild cattle with a lame horse.

None of the proposals for water conservation mention better use of water after it leaves the ditch. It is possible to water two acres of well prepared land with the water used on one acre of rough land. Considerable benefit could also result from a transfer of water from gravelly coarse soil to a soil more adaptable to irrigation and at the same time more productive. There are probably 40,000 acres of such soil lying south and west of Arco and a soil survey of the valley would undoubtedly locate other areas well adapted to irrigation farming.

A topographic map of the entire valley would be of great help in planning any improvements in the water distribution system. The U. S. Geological Survey could possibly be interested in making such a map. It seems obvious that the water collection and distribution system remains the weak link in economic development of the valley, but firm recommendations cannot be made on the basis of available information. In the meantime, the use of large quantities of water on poor land should be discouraged so long as good land is available without any greater loss of water.

Considerable evidence points to the futility of attempting to solve the valley's water problems by increasing the capacity of Mackay Reservoir. There are too many years when it does not fill at its present capacity to make holdover quantities of much value. In addition there is a flow of from 20 to 30 thousand acre-feet that goes by the reservoir unmeasured by the storage record or the stream gages above. In extreme low years this underflow equals or exceeds the quantity of water stored behind the dam.

Regulation of river flow might be more economical by the use of spreading areas instead of raising the Mackay Dam. This effect is obtained to a limited extent by the use of flood flows in the upper valley. The net result of such use is probably beneficial to the valley below the reservoir. Using Copper Basin and the gravel fill above the Wild Horse gage as flood spreading areas could provide as much as a year's delay, thus equalizing the flow even more than a surface reservoir. Use of snow survey forecasts to plan the season's operations would undoubtedly be a stabilizing influence if the surveys can be made reliable forecasting tools.

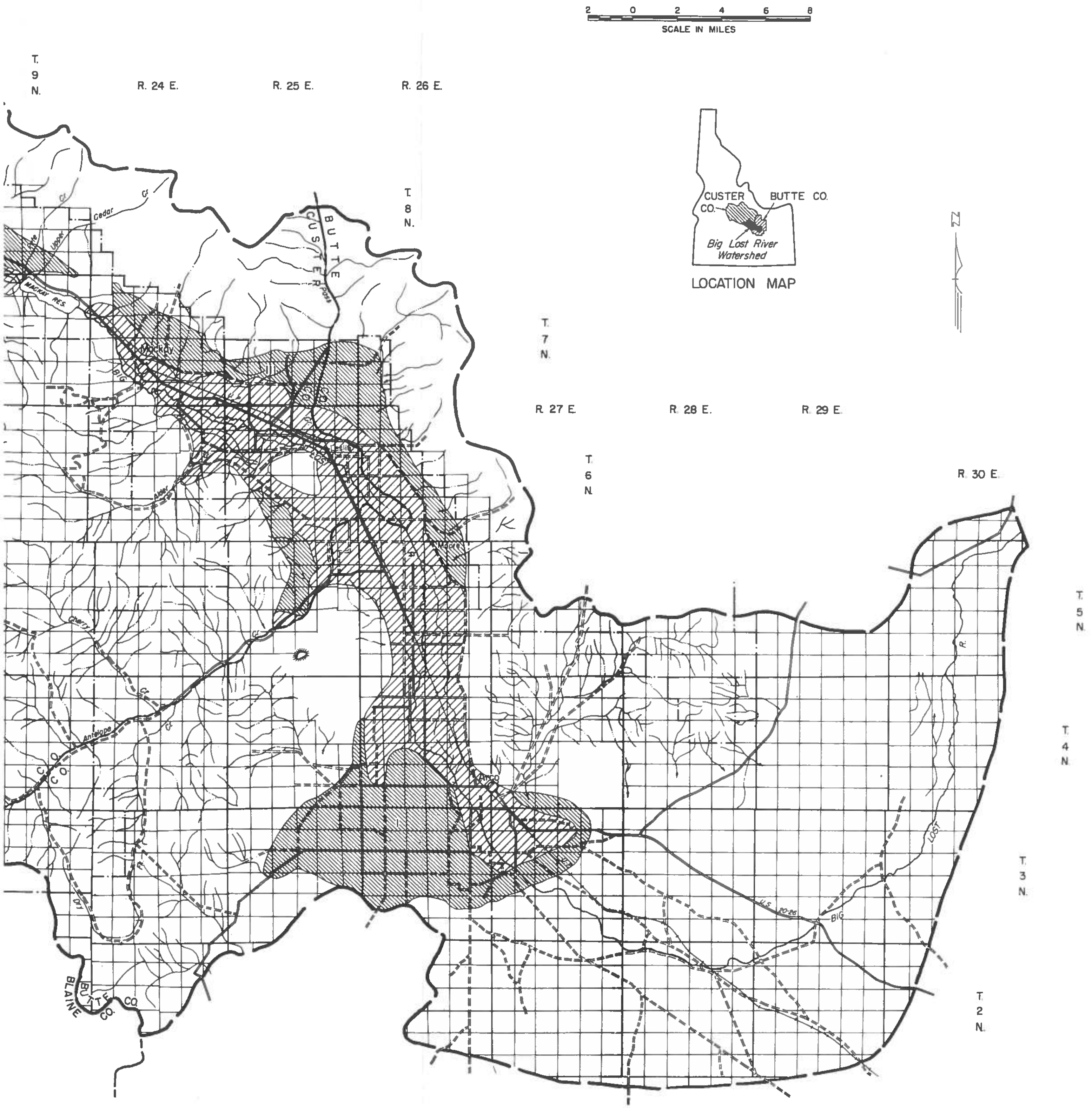
Present knowledge is not sufficient to say definitely what are the best measures to take in the interests of more efficient water distribution. Study along the lines indicated above should provide a physical solution. Any solution for such a situation is likely to be expensive and will need the unanimous support of the water users involved.

IRRIGATED & IRRIGABLE LANDS

BIG LOST RIVER WATERSHED

CUSTER & BUTTE COUNTIES, IDAHO

NOVEMBER 1954



R. 23 E.

PAST PROPOSALS & PRESENT CANAL SYSTEMS
BIG LOST RIVER WATERSHED
CUSTER & BUTTE COUNTIES, IDAHO

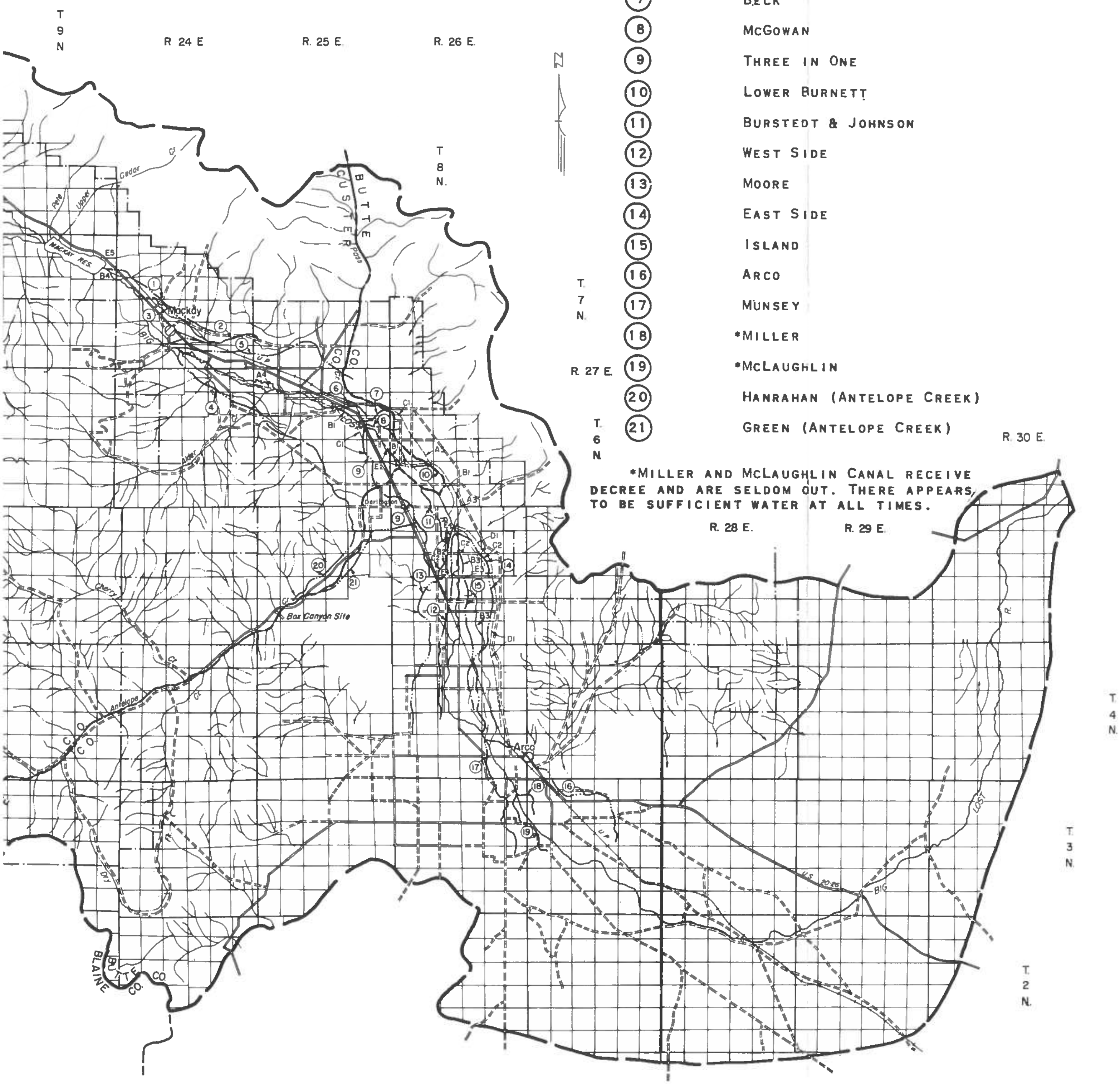
NOVEMBER 1954

2 0 2 4 6 8
SCALE IN MILES

T 10 N

No. on Map	Name of Canal
1	Sharp
2	Swauger
3	Streeter
4	Darlington
5	Upper Burnett and Harris Vought Diversions combined.
6	Angelo
7	Beck
8	McGowan
9	Three in One
10	Lower Burnett
11	Burstedt & Johnson
12	West Side
13	Moore
14	East Side
15	Island
16	Arco
17	Munsey
18	*Miller
19	*McLaughlin
20	Hanrahan (Antelope Creek)
21	Green (Antelope Creek)

*Miller and McLaughlin Canal receive decree and are seldom out. There appears to be sufficient water at all times.

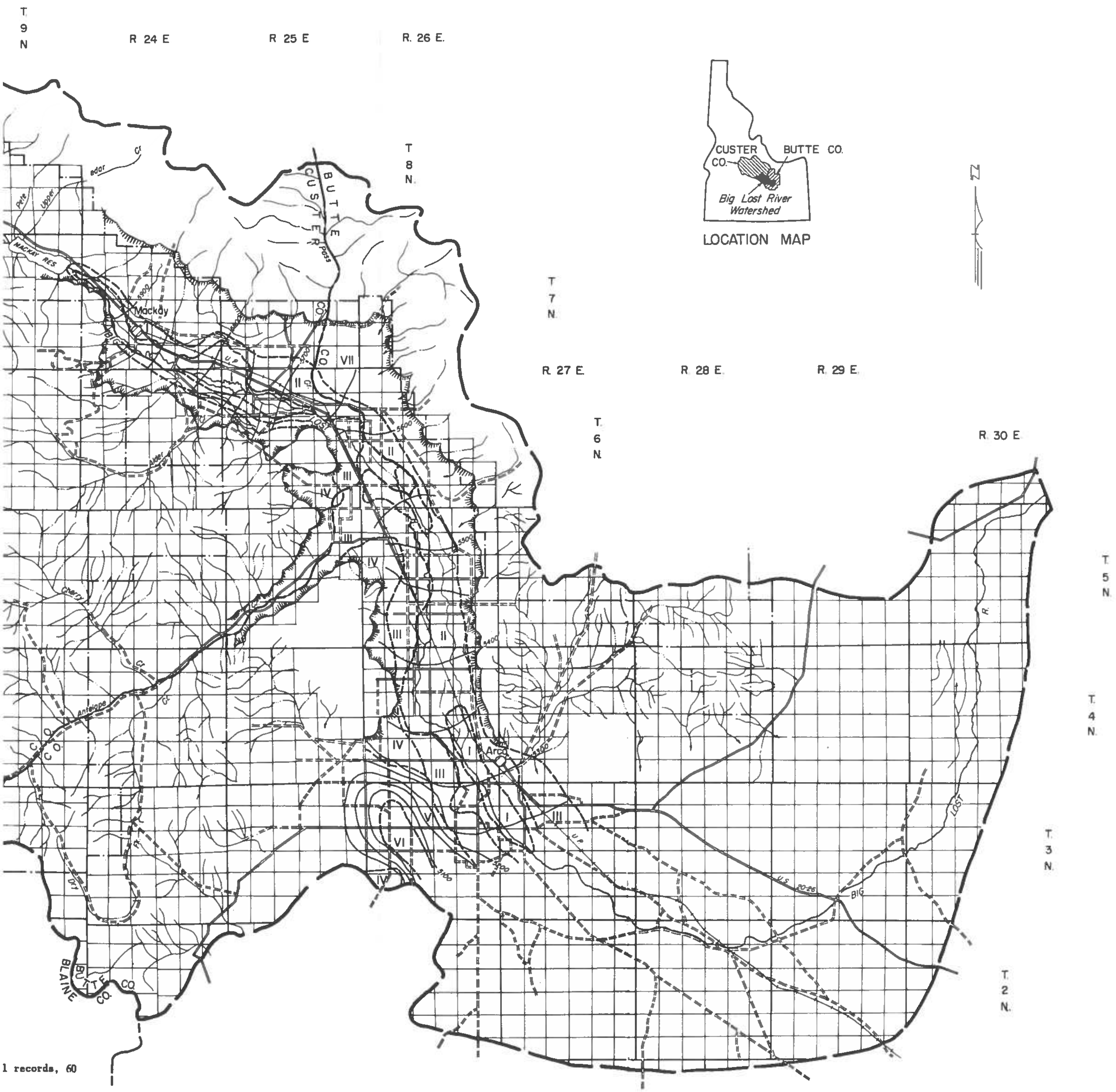


23 E.

GROUND WATER AVAILABILITY
BIG LOST RIVER WATERSHED
CUSTER & BUTTE COUNTIES, IDAHO

NOVEMBER 1954

2 0 2 4 6 8
SCALE IN MILES



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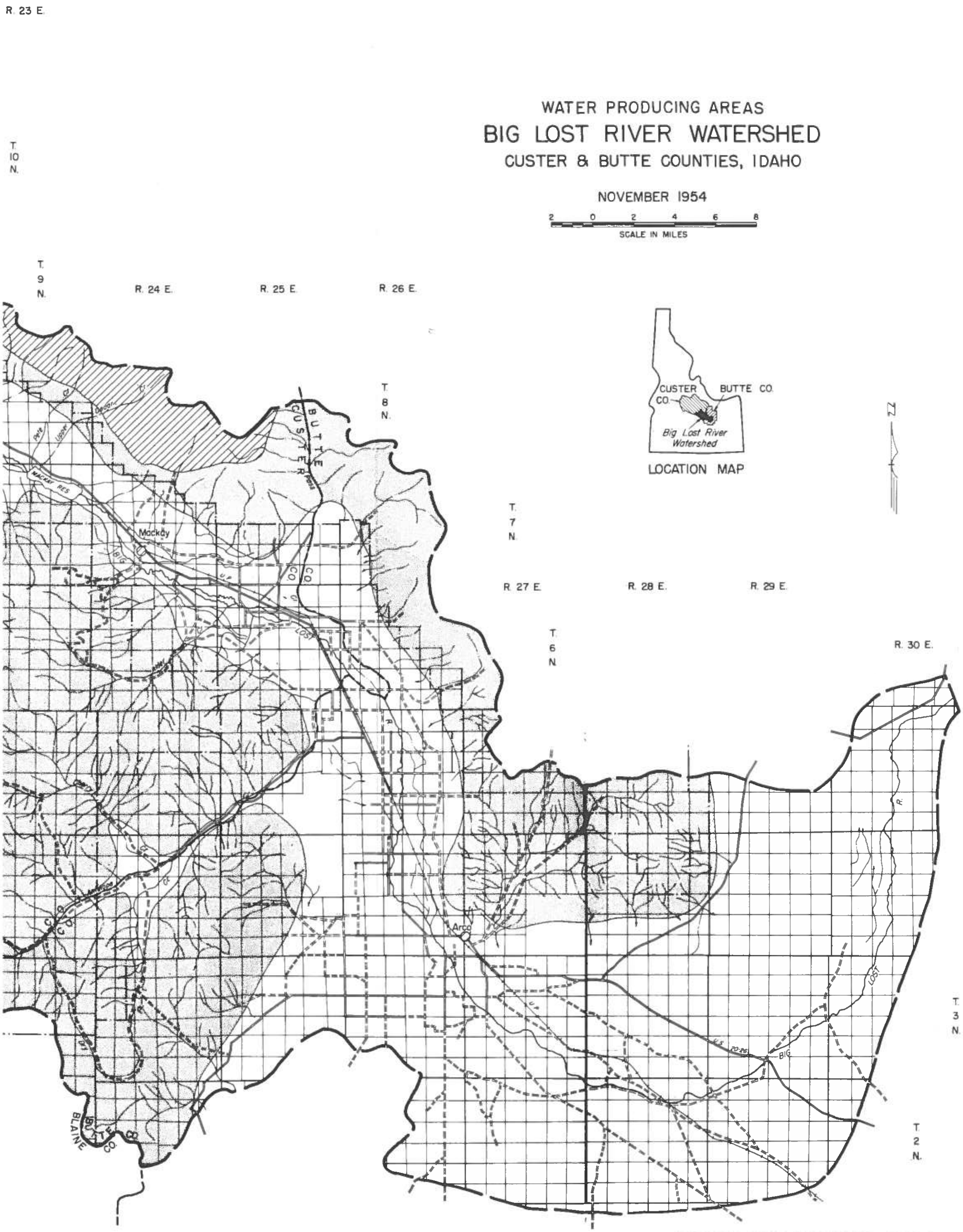
WATER PRODUCING AREAS

BIG LOST RIVER WATERSHED

CUSTER & BUTTE COUNTIES, IDAHO

NOVEMBER 1954

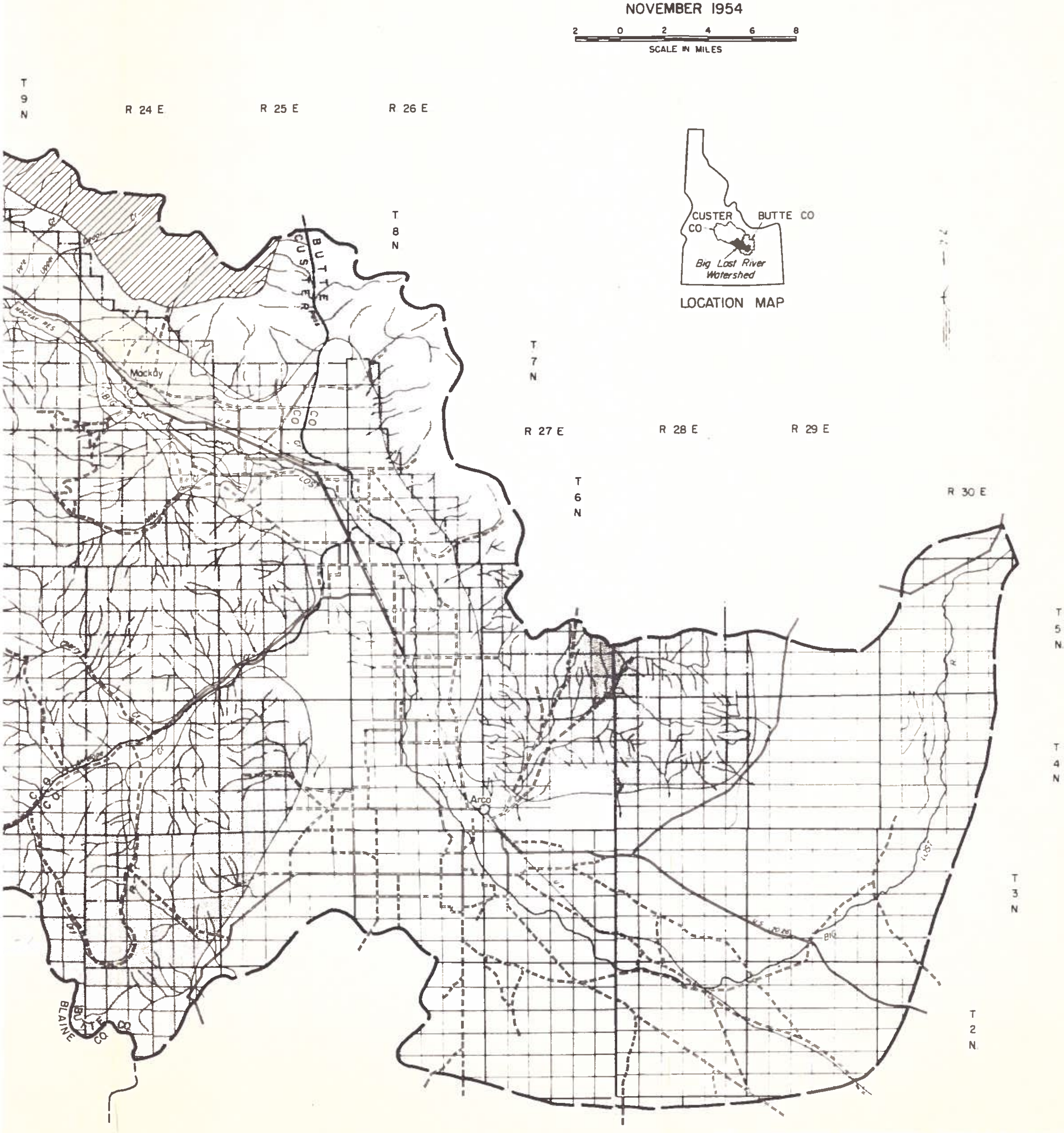


WATER PRODUCING AREAS

BIG LOST RIVER WATERSHED

CUSTER & BUTTE COUNTIES, IDAHO

NOVEMBER 1954



BIG LOST RIVER WATERSHED, IDAHO 7-R-14953-N
SHEET 2 OF 3 SHEETS