Control of Natural Chlorides—Arkansas River Basin

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In July 1957, the U. S. Public Health Service began a study of stream pollution in the Arkansas-Red River Basins under the Federal Water Pollution Control Act. By resolution of the U. S. Senate, Public Works Committee in December 1959, the Corps of Engineers was authorized, in cooperation with the U. S. Public Health Service, to determine the various factors which cause natural mineral degradation of the waters in the two river systems and to suggest methods or measures which could be used to improve the overall water quality.

The initial phase of the project consisted of collecting, reviewing and analyzing existing information on the mineral quality of the Arkansas and Red Rivers and their tributaries. This analysis shows that two mineral constituents — chlorides and sulfates — are the principal pollutants. Detailed investigations located five major natural salt sources in the Arkansas River Basin and ten in the Red River Basin (Figure 1). Nine additional natural brine sources of secondary importance were also located, three in the Arkansas Basin and six in the Red River Basin. To illustrate the magnitude of the problem, the Arkansas River carries an average daily chloride load of 12,300 tons as measured at Van Buren, Arkansas.

In the Red River at Fulton, Arkansas, the average daily load is 3,800 tons. These totals include both natural and man-made brines.

In addition to chlorides, large volumes of surface and ground waters of these basins are polluted by sulfates originating in widespread gypsum deposits. The total sulfate load in the basins approaches 9,600 tons per day, with approximately 500 tons measurable in the 15 major salt-source areas. Control of the chloride-emission areas would also remove some of the sulfate load. In general, the sulfate concentrations at points of potential water usage are lower than chlorides and place no serious limitation on water use. The PHS reports that the methods suggested for control of chlorides could not be effective for control of sulfates and that the sulfate pollution problem should be the subject of further research outside the scope of this study.

The remainder of this paper will be limited to a discussion of the natural chloride pollution problem in the Arkansas Basin and in particular to the three larger source areas, Areas I, II-III. It will cover a discussion of the brine emission phenomena in the areas, plans considered for control of the brine and the effects of potential control measures.

Slightly over 20 percent of the natural chlorides polluting the Arkansas River comes from the Great Salt Plains. Water flowing in the Salt Fork of the Arkansas River above the plains is generally of good quality. However, ground water flowing from the higher terrain around the plains circulates down to the salt bearing strata, and becomes brine which is drawn upward to the surface by capillary action and evaporates leaving the salt crust on the surface. The average daily chloride load from the plains is approximately 1440 tons.

In the studies of methods to control or contain the natural chlorides of the Great Salt Plains, we have considered such possibilities as diverting the fresh water around the salt plains area, lowering the brine level within the salt plains by pumping, and intercepting the brine flows by underground drainage galleries. Schemes considered for disposal of brine included injection into deep subsurface strata or transportation of brine to evaporation ponds.

The plan which appears to offer the best solution is shown on Figure 2. It is essentially the same plan that was explained at a public hearing at Enid on 18 February 1964. Variations to this plan are being studied at this time. The relatively good waters from Salt Fork and Medicine Lodge Rivers and Driftwood Creek would be diverted around the Great Salt

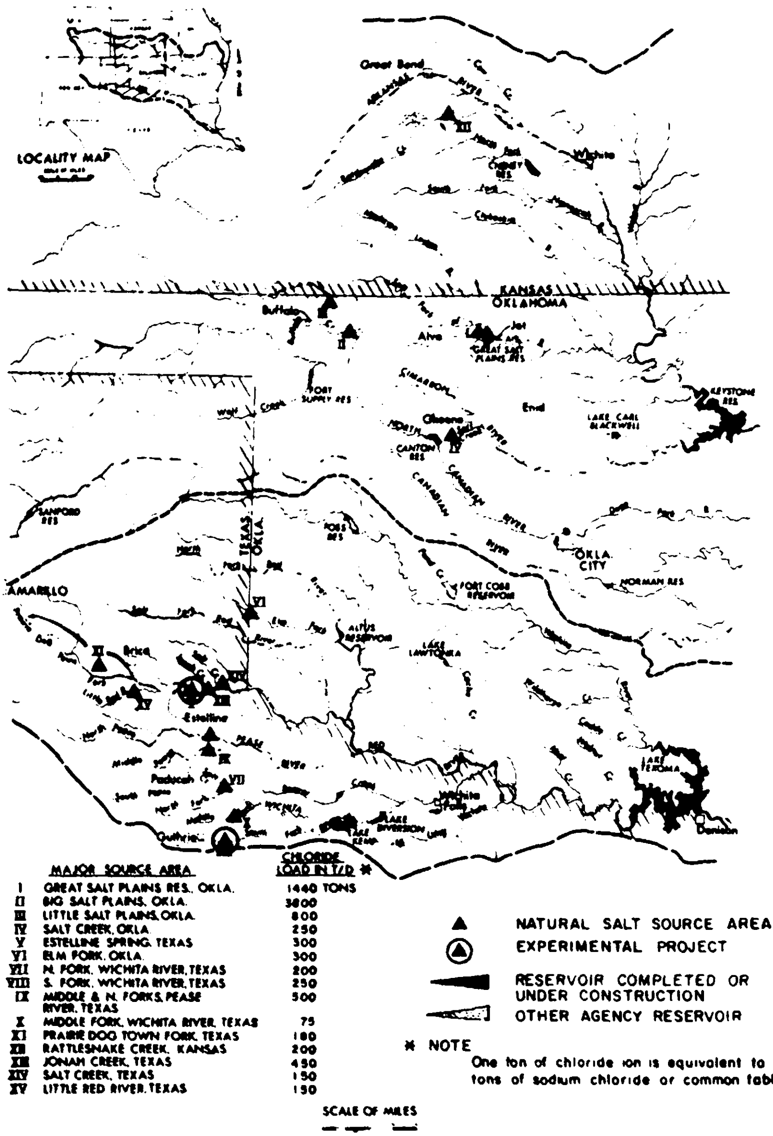

FIGURE 1

MAJOR SALT SOURCE AREAS

Plains into the river below the Great Salt Plains dam. The existing reservoir would be used primarily to store brine flows and flood waters from the area draining into the reservoir through Cottonwood Canyon, Clay Creek and the other streams west and south of Cherokee.

A diversion dike about 12 miles long would be located to the north of the salt plains as near the perimeter as possible. It would start just north of Cherokee and around the plains to high ground on the east side of the

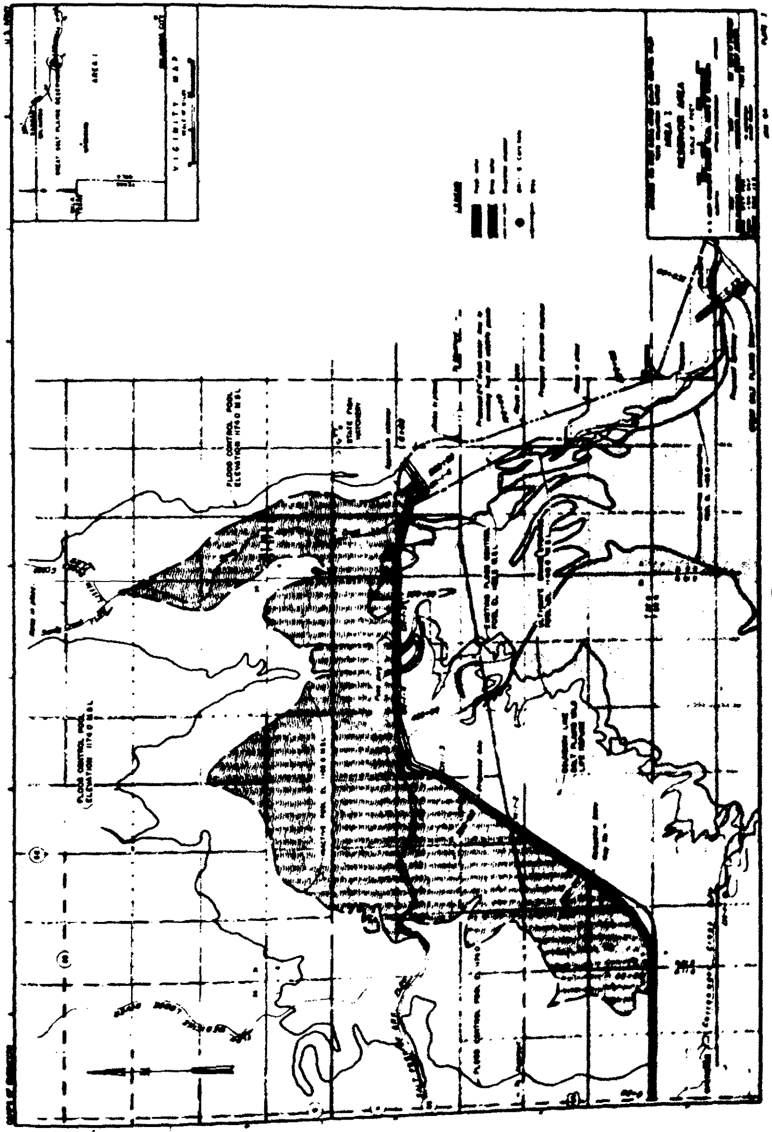

Figure 2

valley. At this point, the diversion channel about seven miles long would be dug along the northeast side of the present reservoir. Flows into the channel would be over a weir similar to the spillway at the Great Salt Plains dam.

A permanent fresh water pool of about 11,00 acres, or about equal in size to the permanent pool in the existing reservoir, would be formed above

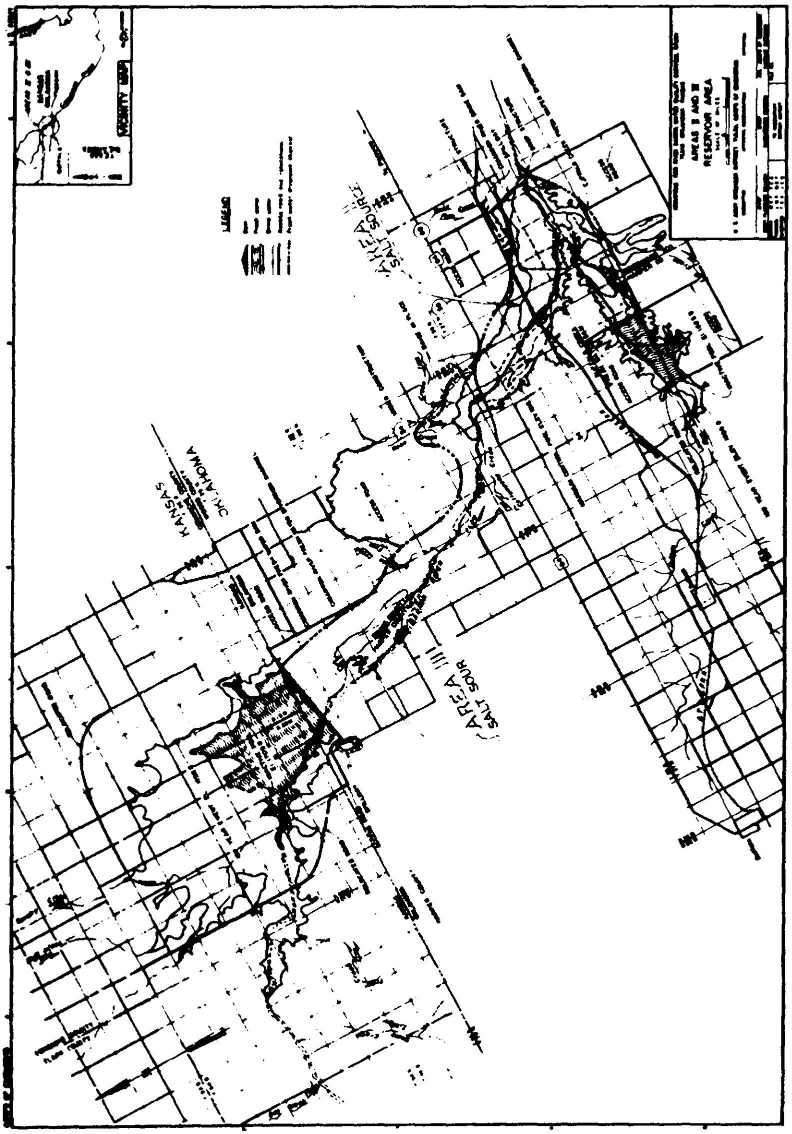

Figure 3

the diversion dike. The outlet works into the channel would be sized to provide the same degree of flood control as does the present reservoir. At full flood control pool this would cover about 26,400 acres.

Because of their proximity, Areas II and III, the Big and Little Salt Plains of the Cimarron River were studied as one area. These plains were formed in much the same way as the Great Salt Plains. Precipitation falling in the uplands surrounding the plains area recharges the ground water that circulates through the salt zones and discharges into the valley of the Cimarron River. These two salt plains contribute over 70 percent of the natural chloride pollution in the Arkansas River, or 4600 tons of chlor-

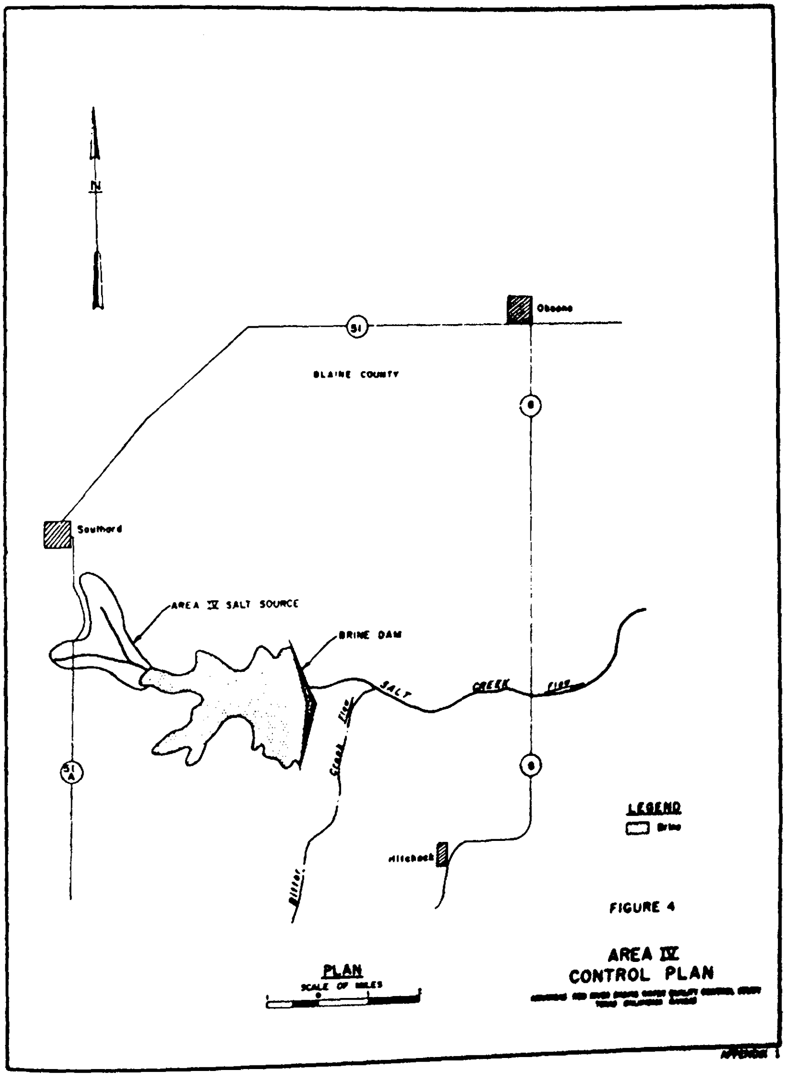

FIGURE 4

AREA IV
CONTROL PLAN

ide per day. The physical size of Areas II and III limited the number of plans that could be considered for effective control. The plan that appears to offer the best solution is to divert the fresh water around the areas of chloride contamination by the use of a 3-reservoir system with two diversion channels. The reservoir located on the upper part of Figure 3, just below the Kansas-Oklahoma State line, is for holding flood flows until they can be bypassed around the area of contamination. The brine dams shown on the lower right of the map would be designed to catch all the water that enters the river below the upper fresh water reservoir. The reservoir shown on Buffalo Creek will hold flood flows until they can be discharged to the river below the brine storage dam. This plan should control 90 percent of the natural chloride pollution from the area.

One of the smaller sources of natural salt pollution, and probably known only by people in the immediate area, is located on the Salt Creek of the Cimarron River in north-central Blaine County, Oklahoma. Although the average daily chloride contribution from this area is only 250 tons a day, studies indicate that control of this amount of chlorides is required during critical drought periods to improve the water quality of the Arkansas River. The apparent best solution for control of this area is to construct a dam that would capture and contain all flows and serve as a large evaporation reservoir (Figure 4).

The other natural salt source area on the Arkansas River is Area XII, Rattlesnake Creek in Kansas. Studies of this area have not progressed as far as on the other Arkansas River source areas, and various solutions are being studied for controlling the 200 ton- per-day load from this area.

Appraisal of the physical effects of remedial solutions for water quality improvement at the source areas just discussed were made at key downstream check points in the Arkansas River Basin. Since Keystone Reservoir is the first station below the confluence of the Cimarron and Arkansas salt source areas, this station was chosen as the first key check point (Table I).

TABLE I. PROJECT EFFECTS ON CHLORIDE CONCENTRATION IN KEYSTONE RESERVOIR

Extent of Control of Chloride Loads (Natural & Man-made)	Concentrations in mg/l Chlorides Keystone Reservoir		
	Percent of Time Average Daily Concentrations are Equal to or less Than		
	50%	90%	98%
Existing conditions	615	905	1200
Anticipated control of *natural* sources at proposed projects	210	295	325
Anticipated control of *man-made* sources only	460	635	680
Anticipated control of *natural* and *man-made* sources	105	145	180

Under existing conditions, the median chloride concentration in Keystone Reservoir is approximately 615 mg/l. With the anticipated control of the five natural salt source areas, the median chloride concentration in Keystone can be reduced to 210 mg/l. It was assumed that 75 percent of the man-made pollution sources in the Arkansas Basin could be controlled through enforcement efforts of State agencies. With the anticipated 90 percent control of natural and 75 percent control of man-made

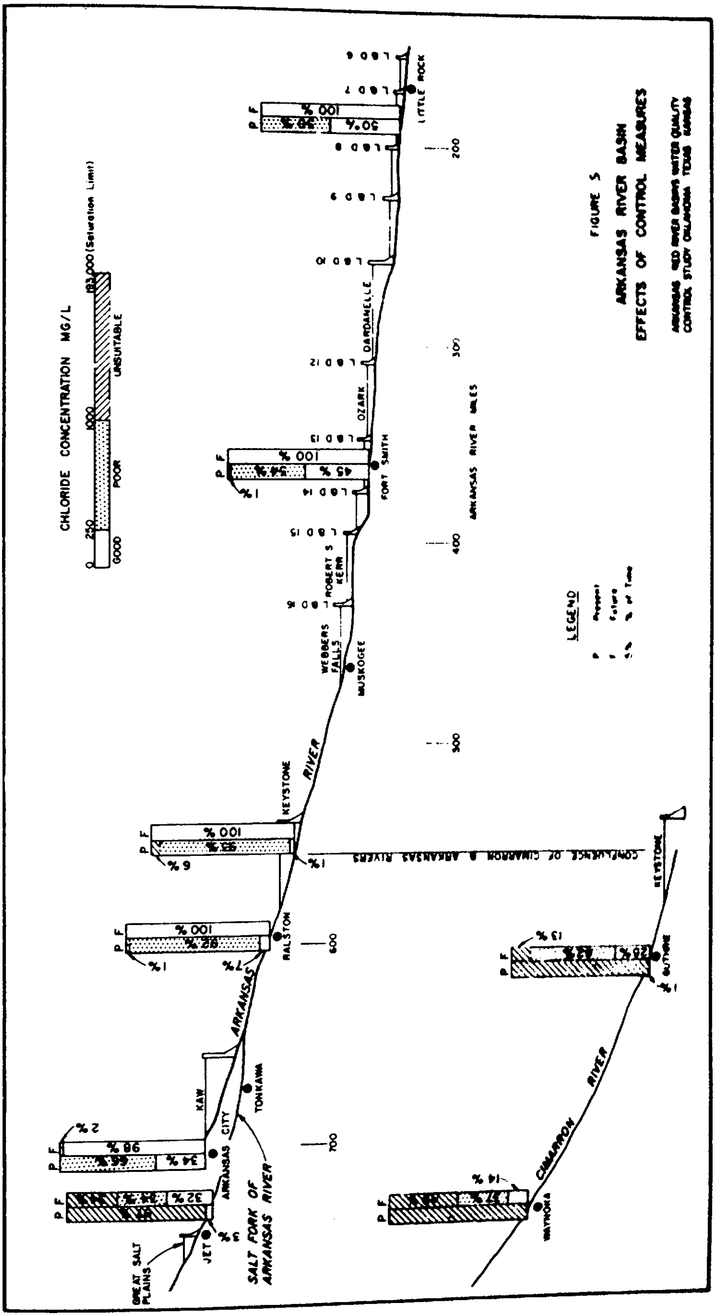

FIGURE 5
ARKANSAS RIVER BASIN
EFFECTS OF CONTROL MEASURES

chlorides, chloride concentrations in Keystone Reservoir and the Arkansas River downstream will be less than 180 mg/l 98 percent of the time.

Figure 5 indicates that under present conditions the waters in the Arkansas River Basin from Great Bend, Kansas, to Ft. Smith, Arkansas, are unfit for most municipal and industrial uses. With control of chlorides, these waters would be suitable for municipal and industrial uses at major demand centers from the mouth of the Arkansas River to Arkansas City, Kansas.

The national water situation has reached the stage where all available water resources are being examined for maximum utilization. In general, there is no impending water shortage in the United States. The water itself is usually available. When cities do run out of water the difficulty has not been so much a shortage of water but a shortage of vision.