Pick-Sloan Missouri Basin Program:

Angostura Unit

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Pick Sloan Missouri Basin Program:
The Angostura Unit

Silt–the four letter word that echoes like a curse along the valleys and bench lands of the Great Plains. Like an incurable disease, silt can shorten the life of a water project. It is a condition the South Dakota's Angostura Unit lives with. In the 1930s, federal engineers drew up plans for a reservoir in the shadow of the Black Hills along South Dakota's Cheyenne River. One of the Missouri River's many tributaries, the Cheyenne ranks fifth for the amount of silt it carries into the "Big Muddy." Engineers then would only guarantee fifty years of storage before silt would become a serious problem. Choosing to ignore what awaited them, a group of South Dakota farmers persuaded the Federal Government to build a water project. When the Government agreed to build, it opened up the possibilities of irrigated agriculture to a group of South Dakota dryland farmers victimized by the Dust Bowl. Angostura is the first started and completed unit of the Pick-Sloan Missouri Basin Program, providing irrigation, flood control, fish and water conservation, and recreation. In 1999, the Unit will have triumphed over pre-construction predictions to celebrate its fiftieth birthday. A countdown will begin that will be a turning point in the life of a water project and the people it serves.[1]

Project Location

One-time South Dakota State Engineer, Homer Derr, carried the word Angostura north from a Bolivian dam project. *Angostura* means "narrows" in Spanish, and is also a South American shrub used as an anti-malarial remedy. Three other dams in the Western Hemisphere share the name Angostura: one near Cochamba, Bolivia, one in northeastern Sonora in Mexico, and a diversion dam on Reclamation's Middle Rio Grande Project near Belem, New Mexico.[2]

On the southeast edge of the Black Hills, Angostura Dam and Reservoir straddle the Cheyenne River near the mouth of the Red Canyon. The reservoir extends 17 miles in length

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1. U.S., Department of Interior, Bureau of Reclamation, Report on Angostura Project, South Dakota, (October 1939), 64.
2. "Angostura Shows the Way," in The Reclamation Era, (December 1949), 232.

along the Cheyenne River and 7.6 miles up Horsehead Creek, a major tributary. Unit lands extend along the river from the damsite to a point 25 miles downstream, irrigating 12,154 acres in Fall River and Custer counties along the way. Smooth, gently slopping terraces rise 50 to 250 feet above the river, but are dissected into flats by deep, lateral stream valleys. About 78 percent of the irrigable lands lie south of the river in an area known locally as W.G. Flat. The remaining 22 percent are on the north side in the Harrison Flat. The nearest town, Hot Springs, is a few miles northwest of the dam.[3]

The climate is semiarid, with hot, summer days and cool nights. A growing season of 132 days pushes farmers to get their corn and alfalfa hay in early. Annual precipitation is 17.5 inches with 78 percent of that amount falling from April through September. The maximum temperature is 112 degrees F while the minimum is -41 degrees F. January is the coldest month of the year and July is the hottest.[4]

Historical Setting

The Black Hills country furnished physical nourishment and spiritual support to two native American tribes over the past 500 years. Sometime between 1550 and 1600, the Arikara, or Ree, Indians moved into the Missouri River Valley and present-day South Dakota. Drought forced their migration from the central plains of Nebraska and Kansas. The Arikara grew corn, squash, beans and tobacco, but other tribes knew them as the "corn-eaters." Attacking bands of Teton Lakota and small pox epidemics decimated the Arikara by the 1790s. By the 1820s, the remaining 500 Arikara moved into North Dakota joining the Mandan tribe.[5]

The departure of the Arikara ushered in the "Golden Era" of the Lakota along the Missouri Basin. Freed by the mobility of the horse and employing their talents as hunters and

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3. U.S., Department of Interior, Bureau of Reclamation, Annual Project History, Angostura Unit, Vol. 2, 1947, 10.
4. U.S., Department of Interior, Bureau of Reclamation, Angostura Resource Appraisal Draft Study Report, (Denver: May 1996), 6.
5. Paul Little, River of People: A Multicultural History of the Cheyenne River Reservation Area, (Eagle Butte, S.D.: Eagle Butte Bilingual Program-Eagle Butte Public Schools, 1983), 10-14.

warriors, the Lakota ruled uncontested over their domain. The Black Hills, or *Paha Sapa* in Lakota, remains the sacred center of Lakota lands and lives. The Lakota fought incoming whites, before they were out-gunned and out-manned by the United States Army. The Angostura Reservoir is within lands ceded to the United States by the Sioux in the 1868 Treaty of Fort Laramie. The Cheyenne River forms the northeast corner of the Pine Ridge Indian Reservation and the southern boundary of the Cheyenne River Sioux Indian Reservation.[6]

The discovery of gold in the Black Hills in 1874 lured the first large influx of whites to the region. Several cattle companies drove their herds in from other states to feed on the open, unfenced range. A few companies established themselves while others sold out to incoming homesteaders. By the turn-of-the-century, homesteads dotted the land where cattle roamed two decades previous. A settler's shack could be found on almost any quarter-section, and each family kept a few cattle. Some grew discouraged, selling their holdings to neighbors, or turning the land over to the county to pay off their taxes. The successful and persistent gradually acquired more acreage. In their wake, the original homesteaders left a unfortunate legacy of soil erosion. Their teams broke acres of native sod, exposing the soil and leaving the ground and their crops vulnerable to wind erosion.[7]

The Federal Government completed the Angostura Unit, but Homer Derr is the unit's father. During the century's second decade, as other South Dakotans fought drought and dust, the former state engineer was in Bolivia helping to build an earthfill dam. Back in South Dakota in 1913, the state hired Derr to conduct a hydrographic survey of the Cheyenne. Once he reached a gorge known as Jackson narrows, he noticed a resemblance to a similar landmark back in Bolivia. In his report, Derr selected the Jackson Narrows as the best location for a dam, because of its proximity to the irrigable lands, and rechristened the area "Angostura."[8]

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6. U.S., Department of Interior, Bureau of Reclamation, Angostura Resource Appraisal Draft Study Report, 84; Little, River of People, 22.
7. U.S., Department of Interior, Bureau of Reclamation, Annual Project History, Angostura Unit, Vol. 4, 1949, 24-5.
8. "Angostura Shows the Way," 235.

Based on Derr's reconnaissance, in 1917 the South Dakota state legislature appropriated funds for one-half the cost of a survey under the direction of the United States Reclamation Service (USRS). In a subsequent report, Reclamation's C.T. Pease, estimated a Cheyenne River project could irrigate a maximum of 76,000 acres at a minimum of $150 to $160 per acre. The high price frightened off the Federal Government, and Reclamation declared Angostura unfeasible. Eleven years later in 1928, the U.S. Army Corps of Engineers investigated the entire Missouri River watershed. Their survey reduced the estimate of the number of potential irrigable area along the Cheyenne to between 51,000 and 61,000 acres and raised the estimated costs to between $173 and $181 an acre.[9]

From 1931 until decade's end, meager moisture produced only crop failures across South Dakota. The average 160-acre homestead was too small to offer a living to dryland farmers. A 1936 study found that of the existing 41 farmsteads on proposed project lands, owners occupied 20 lots, tenants rented 14 units, and seven had been abandoned. Farm homesteads came in sizes ranging from small shacks to six-room houses. As the number of farmers dwindled, the size of the farms increased. By the close of the 1930s, an average single family farm was a little more than 320 acres. The remaining farmers still kept the dream of a dam across the Cheyenne alive. A 1939 Reclamation study of the Cheyenne noted the persistent local interest in water development, while estimating 16,200 acres of nearby land were irrigable.[10]

By 1939, the government had purchased 75 percent of ravaged farm land under the Wheeler-Case Act. Named for South Dakota Republican Representative Francis Case and Democratic Senator Burton K. Wheeler of Montana, the Wheeler-Case Act authorized the Federal Government to develop irrigation and return land to private hands. The Rapid City Journal noted "some persons in the foothills" who saw Wheeler-Case as "a communistic trend in long-term government ownership on the land." Still, both the press and public realized Wheeler-

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9. U.S., Department of the Interior, Bureau of Reclamation, Angostura Project, South Dakota, (June 1938), 2.
10. Report on Angostura Project, South Dakota, (June 1938), 7.

Case was agriculture's only chance in the area. Congressman Francis Case captured the yearning of his constituents in a letter to Reclamation Commissioner John Page in 1940: "I was hardly prepared for the pathetic, desperate hopes that are being pinned on the present work, from all classes of people."[11]

Project Authorization

Citizens in Case's Second Congressional District besieged the federal government into including a Black Hills water project in the Water Conservation and Utilization (WCU) Act of August 11, 1939. The Farm Security Administration and the Department of Agriculture also showed interest in rehabilitating lands and resettling distressed farmers into that region. Behind the scenes, from 1939 to 1942, Case cajoled and begged Reclamation Commissioner John C. Page to build water projects in his state. Once, he went as far as sending Commissioner Page a state highway map indicating potential damsites in blue crayon.[12]

A condition in the WCU Act, as amended October 14, 1940, limited funds to $1,000,000 per project. This, and the lack of a suitable power market in the immediate area, held up the project until it could no longer come under the provisions of the WCU Act. The Works Progress Administration (WPA) stepped in and funded surveys and foundation explorations to complete a construction estimate. Reclamation calculated the cost of construction at $3.9 million, of which, the WPA and Civilian Conservation Corps (CCC) would pay $2 million with the balance picked up by Reclamation. Congress approved on March 6, 1941, following a joint recommendation from Secretary of Interior Harold L. Ickes and Secretary of Agriculture Claude R. Wickard. Ickes called Angostura a "work relief" irrigation project that would solve the problems of local unemployment, interstate movement of farmers, and stabilize the agricultural economy. By

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11. Rapid City Journal, 14 August 1941, no page number; U.S., Department of Interior, Bureau of Reclamation, Project Correspondence File, 1930-1945, letter from Francis Case to John Page, December 8, 1940, entry 7, box 11; Annual Project History, Angostura Unit, Vol. 4, 1949, 25.

12. U.S. Department of Interior, Bureau of Reclamation, Personnel Correspondence File, 1930-45, Department of Interior press release, March 8, 1941; Personnel Correspondence File, 1930-45, letter from Rep. Francis Case to Commissioner John Page, May 24, 1939, both entry 7, box 11.

1942, basic design and construction data was in place. Case expressed his appreciation to Page: "I doubt if anything will ever happen to me which will ever seem as important or as good as the final approval on the Angostura Project."[13]

Case's gratitude was premature, as Angostura was one of many reclamation projects marking time during World War II. The unlikely partnership between Reclamation and the Corps of Engineers, known as the Pick-Sloan Missouri Basin Project, provided the legislation that led the way to the first day of construction. The outline of the Angostura Project is included in the Missouri River Basin plans as set forth in Senate Document 191, 78th Congress, 2nd Session. These plans were re-authorized by Congress in section 9 of the Flood Control Act of 1944 (58 Stat. 891).[14]

Construction History

The Utah Construction Company successfully bid to complete the dam and reservoir on May 28, 1946. Utah Construction's bid of $4.2 million was below Reclamation's estimate of $4.9 million. Construction began September 11, 1946, with the contractor stripping material for placement in the earth embankment. Excavation of the embankment core trench and stripping operations carried on simultaneously into December. Approximately 30,000 cubic yards of excavated gravel and rock from the core trench formed the embankment.[15]

Reclamation's leadership realized that despite Angostura's small size it carried a great weight as the first of the Bureau's Pick-Sloan assignments. At ground breaking ceremonies on August 23, 1946, Assistant Commissioner William E. Warne heaped praise on the work ahead. He declared it held "the number one place today in the roster of reclamation projects" because of the scope and significance of the Missouri River Basin plan. He explained, "Although the Angostura will not be a giant like Grand Coulee nor a behemoth like Boulder (now Hoover

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13. "Angostura Shows the Way," 235, 252; letter from Francis Case to John Page, March 8, 1941, General Personnel File, 1930-1945, entry 7, Box 11.

14. "Angostura Shows the Way," 252.

15. Annual Project History, Angostura Unit, Vol. 1, 1946, 24.

Dam), but it will have an important role in the regeneration of your valley." To make sure this first cog in Pick-Sloan ran smoothly, Reclamation selected H.V. Hubbell as project engineer. Hubbell served as construction engineer for the Fresno Dam on the Milk River Project a decade earlier.[16]

Accommodations for the contractor's employees were luxurious considering the location and the economic constraints just after World War II. The camp consisted of 25 one and two bedroom houses, seven barracks to house 300 single men, a mess hall, offices, machine shop, and a warehouse. All facilities were in place by mid-December 1946. During peak operations in the summer and fall of 1947, Utah Construction employed 400 men, before eventually cutting back to a hundred for the winter. A high turnover in men during the first two years handicapped the dam's progress. Besides completing the dam contract, Utah Construction built access roads branching from the main highway to the dam site and from the dam to the rock quarry. They also completed two bridges, one upstream and one downstream, to connect the camp to the outside world.[17]

The Angostura Dam is a 187-foot-high combination concrete gravity and earthfill embankment. Angostura reservoir holds a total capacity of 130,000 acre feet with an active capacity of 82,400 acre-feet and dead storage of 48,300 acre-feet. The dam's crest length is 2,030 feet with the concrete section measuring 970 feet in length and the earth embankment 1,060 feet long. The concrete portion features a gated spillway section located in the river channel and two non-overflow sections, one extending to the left abutment and one abutting the earth embankment extending to the right abutment. The maximum width of the concrete dam is 220 feet including the spillway apron. A 25-foot-wide roadway runs across both sections. The contractor's placed the first bucket of concrete on July 28, 1947. Building from that bucket, the dam soon held a total of 274,191 cubic yards of concrete. River water circulating through

16. "Angostura Shows the Way," in The Reclamation Era, (December 1949), 252.
17. Annual Project History, Angostura Unit, Vol. 1, 1946, 24; "Winter Stops Work at Angostura Dam," in Engineering News-Review, (December 18, 1947), 6; Annual Project History, Angostura Unit, Vol. 2, 1947, 25.

embedded pipe coils cooled the concrete after placement. A cableway system transported buckets of concrete for placement in the dam. Reclamation believed the cableway was "the most vital equipment" at Angostura. Despite "some defects" soon after installation, the cableway ran without any trouble for the next two years.[18]

The dam's concrete overflow spillway is in line with the river channel. Five 50-foot-wide by 30-foot-high radial gates control the spillway. Any overflow is dissipated by a specially designed slotted-type, large-radius spillway bucket set within the retaining walls at the toe of the dam. The bucket proved to be more economical than conventional spillway aprons. The spillway's peak discharge capacity is 217,000 cfs with the reservoir water surface at elevation 3198.1. The river outlet works consist of a 4.5-foot-diameter steel conduit through the concrete dam section. A four-foot-square high pressure gate in the valve house in the downstream end controls the outlet. Discharge capacity is 590 cfs.[19]

The earthfill embankment begins at the right end of the concrete section and extends 1,063 feet into the right abutment. The embankment is a zoned, rolled, earthfill structure with an impervious core of clay, sand, and gravel. Rock riprap protects the upstream and downstream faces of the embankment. A cutoff trench under the embankment section intercepts layers of sand and gravel, providing a positive cutoff to bedrock. Zone 1 embankment material is a shovel-cut mixture of stratified layers of clay, silt, sand and gravel taken from a pit 4,000 feet from the dam. Most of the Zone 2 sand and gravel came from the cutoff trench excavation. A borrow area 2,500 feet upstream from the dam provided the rest of the material. A 16-inch layer of rock fines prevented Zone 2 material from washing through the riprap. The riprap came from a location 1,400 feet upstream from the dam.[20]

Water from the reservoir travels through a 30-mile-long main canal extending from the

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18. Annual Project Report, Angostura Unit, Vol. 2, 1947, 25, 28.
19. U.S., Department of Interior, Bureau of Reclamation, SEED Report on Angostura Dam, (Denver: Oct. 1981), 1, 9; U.S., Department of Interior, Bureau of Reclamation, Angostura Dam: Final Design Report, (Denver: August 1951), 15.
20. SEED Report on Angostura Dam, 11.

dam along the south edge of the unit. The canal crosses under the Cheyenne River through a 9,800-foot-long inverted siphon to the river's north bank. First delivery came in 1953. Irrigation came to the entire unit three years later. The canal's cross section averages a bottom width of 14 feet with 2:1 side slopes and a normal water depth of 5.2 to 5.5 feet. Average annual releases to unit lands is 40,000 acre-feet. This provides an average on-site farm delivery of 2.5 acre-feet of water per acre. Thirty-nine miles of laterals and 21 miles of open and closed drains serve individual farms. Peter Kiewit Sons of Rapid City constructed all canals, laterals and drains from 1951 to 1953.[21]

On March 16, 1948, at 9:30 a.m. six months of uncertainty and tragedy for the project began. At that moment, floodwaters tore through the contractor's interlocking sheet pile cofferdam. The gush of water carried away three of the contractor's men while inundating blocks 12 and 13 in the concrete section and the downstream area. Divers brought out from San Francisco searched for the men over the next four days. Murky silt resulted in poor underwater visibility, forcing the contractor to call off the search. Utah Construction pumped out the flooded area, removing the silt carefully to avoid mutilation of the missing men. The weather fought rescue efforts between March and August, as floods washed out the area six times. On August 10 and 11, workers discovered the remains of the three men buried in the foundation section.[22]

On September 28, 1949, the night before the official dedication, Reclamation Commissioner Michael W. Straus spoke to the South Dakota Reclamation Association. Straus thanked the farmers and citizens of Hot Springs who first asked the Federal Government's help, "without your cooperation, the Bureau of Reclamation could never have gone ahead as rapidly as it has." Total cost of the completed unit came to $15,383,863.[23]

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21. Angostura Resource Appraisal Draft Study Report, 15; U.S., Department of Interior, Bureau of Reclamation, Annual Project History, Angostura Unit, Vol. 6, 1951, 9-10.
22. Annual Project History, Angostura Unit, Vol. 3, 1948, 9; Annual Project History, Angostura Unit, Vol. 4, 1949, 7.
23. "Angostura Shows the Way," 252; U.S., Department of Interior, Bureau of Reclamation, Repayment of Reclamation Projects, (Government Printing Office: Denver, 1972), 274.

Post-Construction History

Representatives of the Bureau of Reclamation, the National Park Service, the U.S. Fish and Wildlife Service, and U.S. Forest Service met at Hot Springs in 1949 to map out the recreational future of Angostura. The gathering authorized the Forest Service to construct, operate, and maintain the reservoir's recreational areas. Reclamation arranged for eight wildlife habitat development areas and basic park facilities. A January 1959 Memorandum of Understanding between Reclamation and the South Dakota Department of Game, Fish and Parks turned over administration and development of the reservoir to the state.[24]

For a few years after completion of the dam, a 1200-kilowatt hydroelectric plant furnished energy for irrigation pumping and commercial use. Completed by Barnes-Mattison of Minneapolis in December 1951, the plant sat on the right side of the river, 500 feet downstream from the dam. Officials of the Black Hills Power & Light Co. signed a contract with Reclamation in September 1950, for sale of approximately 12 million kilowatt-hours to the company. The Angostura plant would help Black Hills Power provide 50 communities and industry with more service during peak demand. Delays in equipment and materials pushed the scheduled completion date on the hydroelectric plant from June to December 1951.[25]

On April 20, 1955, Angostura Reservoir filled for the first time and its waters churned against the spillway gates. A year later, water became available for the first time to all district lands through the completed carriage, distribution and drainage system. It was an unusually moist in a dry decade.

The dry 1950s claimed the Angostura powerplant by decade's end. The discharge required to run the plant under a full load was 173 cfs. That amount seldom flowed down the Cheyenne during the 1950s. In 1959, Reclamation suspended operations until further notice. On April 15, 1966, the federal government ordered the permanent shutdown of the plant.

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24. "Recreation at Angostura," in The Reclamation Era, (May 1972), 11.
25. "Angostura Dam Power Contract," in The Reclamation Era, (December 1950), 228; U.S., Department of Interior, Bureau of Reclamation, Annual Project History, Angostura Unit, Vol. 6, 1951, 6.

Reclamation put the plant's equipment up for salvage in May 1971, sealing the vents and external openings shut.[26]

A 1981 Safety of Dams report identified that a probable maximum flood would overtop the dam causing a failure. The 1992 implementation of an Early Warning System assigned the damtender with the responsibility of reporting when the reservoir exceeded certain levels, and if the rate of inflow threatened the structure.[27]

From the mid-1980s to the mid-1990s, the Angostura Irrigation District and the Soil Conservation Service planed to install buried pipelines, replacing open laterals. In 1993, the Irrigation District drew up a schedule for modifying the dam's outlet works.[28]

Settlement of Project Lands

Other Reclamation projects turned returning soldiers into homesteaders. Angostura offered a second chance to veterans of the Dust Bowl. Through Wheeler-Case, the Federal Government owned 78 percent of unit lands by the close of the 1940s. A Settlement Committee screened all applicants and selected homesteaders. Each applicant had to be a citizen of the United States, in good health, have $3,000 cash or credit, and a background in agriculture. They also had to prove their willingness to stick with farming and not look at the Federal Government's offer as a potential real estate deal.[29]

In August 1950, the Soil Conservation Service (now the Natural Resource Conservation Service) tackled the job of subdividing the district into farm units. The Service prepared the land for irrigation, by leveling and constructing drainage and distribution systems. The first units were ready for occupancy by the fall of 1952. Each unit contained about 320 acres of irrigable land. Each fall from 1952 to 1954, the farm units developed during the year went up for sale. Farmers who owned or rented land during the dryland era held first preference. After that group,

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26. U.S., Department of Interior, Bureau of Reclamation, Annual Project History, Angostura Unit, Vol. 26, 1971, 2.
27. Angostura Unit Project Review Report, 2.
28. Angostura Unit Project Review Report, 6.
29. "Angostura Shows the Way," 235; U.S., Department of Interior, Bureau of Reclamation, Angostura Unit, Project Review Report, (November 1993), 1.

veteran farmers from other areas were next in line. Typical of the dryland farmers reborn as irrigation believers was Michael O'Day. O'Day grew wheat and corn on a 1,400-acre plot before drought forced him off his land. In 1953, he planted 11 acres of sugar beets out of 121 irrigable acres on his new property. Eventhough, he never previously grew beets, O'Day's fields yielded a respectable 15 tons an acre.[30]

In 1950, commissioners of Fall River and Custer Counties approved the creation of the Angostura Irrigation District. The Irrigation District and the United States agreed to a service and repayment contract in May 1951. Since 1951, the District and Reclamation have amended the repayment contract five times. Under the agreement, the United States reimburses the District for 27.6 percent of the cost of operating and maintaining the supply works. That percentage reflect the portion applicable to benefits other than Angostura unit irrigation. The Irrigation District has operated and maintained the dam, reservoir, and associated project irrigation facilities since January 1, 1968. Repayment toward construction of the distribution system totals $718,000, while annual water service charges amount to $3,650 over a 30-year period beginning in 1968. The annual payments are the result of a formula reflecting the farm parity ratio and the total irrigated crop value for the project each year. Besides providing water to irrigable lands, the district holds temporary water service agreements with the Hot Springs Airport and two private landowners. The Irrigation District’s headquarters are in the town of Oral.[31]

Uses of Project Water

In 1995, Reclamation began negotiations began with the Irrigation District over a new water supply contract. Traditional questions of silt, recreation, and irrigation were joined by Native American water rights, interstate water development, conservation, water rights, and water supply contracting. Water development on the Angostura Unit enters the new century

30. "Modern Pioneers," in The Reclamation Era, (November 1954), 83-4.
31. Angostura Resource Appraisal Draft Study Report, 33; Repayment of Reclamation Projects, 274.

facing questions more difficult than those its builders answered.[32]

On August 13, 1948, representatives from Wyoming and South Dakota signed the Cheyenne River Compact. The Compact negotiated both states' use of the river. However, the U.S. Congress vetoed the agreement. The state of South Dakota approved a revised compact in 1951, but this time, Wyoming rejected the contract. As of 1996, there is no legal agreement allocating flows in the river between Nebraska, Wyoming, and South Dakota. The water supply of the basin is increasingly over-appropriated, but South Dakota and Wyoming work informally to coordinate development of existing flows.[33]

A 1953 United States Geological Survey (USGS) examination indicated declining inflows to the reservoir. The report blamed stock dams upstream for depletion of flows to Angostura. Stock dams reduce the overgrazing of a single pasture and allow livestock to graze over a wide area. Unfortunately, these dams reduce reservoir yields and deplete river's flow. Losses chargeable to stock dams measure from 20 percent in wet years to 50 percent in dry seasons. In South Dakota, anyone can build stock dam smaller than 25 acre-feet without having to file a location notice with their county until after construction. A 1993 Reclamation study noted annual net inflow to the reservoir averaged 80,800 acre feet from 1952 to 1992.[34]

On the fine particles of sand and clay, smaller than 1/16 of millimeter, rests the prospects of the Angostura Unit. Based on an estimated sedimentation rate of 1,700 acre feet a year, a 1931 U.S. Army Corps of Engineers report predicted that Angostura had fifty years of useful life before active storage capacity silted in. The Corps conducted their study 150 miles below the proposed Angostura dam site. The Corps found the silt "particles are smaller than cement and were so light . . . owing to the viscosity of the water, their rate of settlement was extremely slow even in quiet water." A 1957 Reclamation investigation of the Upper Cheyenne River watershed estimated that in less than fifty years, the reservoir's capacity would no longer provide adequate

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32. Angostura Unit Project Review Report, 3.
33. Angostura Resource Appraisal Draft Study Report, 10, 33.
34. Angostura Resource Appraisal Draft Study Report, 33.

irrigation storage for Unit lands. Reclamation returned to conduct two further silt studies in 1965 and 1979.[35]

According to the 1979 sedimentation survey, the reservoir has an active capacity of 82,400 acre feet with 48,300 acre feet of inactive storage. The reservoir contains a surcharge capacity of 56,400 acre feet, with an average sedimentation rate of 985 acre feet per year since 1949. That figure is almost half of the Corps' 1931 estimate. From 1949 to 1979, 29,151 acre feet of sediment accumulated in the reservoir, representing a 18 percent loss in storage capacity. In 1996, a projection of total volume of sediment accumulation in the reservoir since 1949 to the year 2030 totaled 79,785 acre-feet (81 years multiplied by 985 acre-feet per year), culminating in a loss of about 98 percent. These predictions state the reservoir's total capacity in 2030 would be 80,134 acre-feet at elevation 3187.2 (top of active conservation) with an active capacity of about 67,000 acre-feet. Analysis of the remaining useful life of the reservoir will continue before the renegotiation of the water service contract with the Angostura Irrigation District.[36]

While silt menaces the reservoir, weeds threaten to choke Angostura's canals out of existence. Moss and waterweeds in the main canal, and kochia, sunflowers, sweet clover, willow, cattails, and cottonwood trees along the banks of the canals, laterals and drain banks often interfered with the unit's delivery system. In the 1950s, Reclamation fought back by placing chemicals in the water and spraying along the canal banks. The District and Reclamation also dewatered the main canal for a few days each June, killing the moss and waterweeds through exposure to the sun. A dragline with a weed check attachment cleared weed jams in the main canal after the initial release of irrigation water. Pulling weeds by hand took ten days, but after the introduction of the dragline, it took only four days to clear weeds.[37]

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35. U.S., Department of Interior, Bureau of Reclamation, Annual Project History, Angostura Unit, Vol. 12, 1957, 13; Report on Angostura Project, South Dakota, 40; U.S., Department of Interior, Bureau of Reclamation, Angostura Unit South Dakota: Extracts from Appendixes to Cheyenne River Basin Survey Report Covering the Angostura Unit, (October 1943), D-12.
36. Angostura Unit, Project Review Report, 1; Report on Angostura Project, South Dakota, 2; Angostura Resource Appraisal Draft Study Report, 13-14, 105.
37. U.S, Department of the Interior, Bureau of Reclamation, Annual Project History, Angostura Unit, Vol. 13, 1958, 26; U.S, Department of the Interior, Bureau of Reclamation,

Corn and alfalfa hay accounts for over 90 percent of total planted acreage. Gated pipe or concrete lined ditches and siphon tubes flood irrigate both crops. Corn is sold by harvest, or stored for later sale. Irrigation also sustains beef cow herds, as the livestock feeds on alfalfa hay from January to May, and pastures from May through October. In 1996, Reclamation calculated the average annual return to a unit farm family is $28,750.[38]

The reservoir is growing in prominence as a recreation spot for Black Hills residents and for visitors as far away as Minnesota and Colorado. Angostura is the largest warm-water recreation lake within a hundred-mile radius. The 1959 agreement between Reclamation and the South Dakota Department of Game, Fish, and Parks (GF&P), authorized the GF&P to administer all activities at the reservoir. Recreation at the lake include fishing, campgrounds, boat ramps, marinas, swimming beaches, and cabins for lease during the spring and summer. Shortly after the first impoundment of water in 1949, the GF&P eradicated trash fish like carp and suckers. Since restocking, anglers can catch walleye, pike, bass, black crappie, perch and bullheads. Visits have increased steadily since the 1970s, except a time during the late '80s when the reservoir's lower water levels reduced use. People returned in 1991 after the reservoir filled to normal. Reclamation estimates the reservoir's popularity will increase as more people move to the Black Hills and out-of-state visits multiply.[39]

Despite all the potential flash points over use and developments, the efficiency of the existing irrigation district delivery system is 70 to 78 percent, well above average for a 50-year-old gravity distribution system. Effective seepage reduction features built into the delivery system and excellent management by District employees both contribute to this high mark.[40]

Conclusion

Annual Project History, Angostura Unit, Vol. 15, 1960, 29.

38. Angostura Resource Appraisal Draft Study Report, 15; U.S., Department of Interior, Bureau of Reclamation, "Angostura Irrigation District Payment Capacity Study, Appendix J" in Angostura Resource Appraisal Draft Study Report - Appendices, (Denver: May 1996), 2, 5, 14.

39. Annual Project History, Angostura Unit, Vol. 14, 1959, 43: Angostura Unit, Project Review Report, 4; "Recreation at Angostura," 11.

40. Angostura Unit Project Review Report, 3.

The Angostura Unit will pass a major milepost on its fiftieth birthday in 1999. Looking back over its first five decades, the dam initiated a variety of recreational activities and laid the foundation for irrigated farming. However, low flows were the undoing of plans to provide added hydroelectricity. The first phase of the Angostura story is closed. The length of the next chapter depends on the ingenuity of science and the calculation of nature.

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