The Boise Project

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The valleys of the Boise and Payette Rivers are blessed with a climate and soils that make them one of the best farming regions in the west. Driven by the needs of hungry miners in the 1860s, the fertile lands along the rivers were quickly developed, leaving only the higher lands open to further development. Before long, irrigation companies were formed that promised to water thousands of acres of new lands, but at a cost that few could bear. Grand plans to irrigate the higher bench lands soon faltered due to lack of money, and existing developments suffered from poor maintenance, and for many, failure loomed on the horizon. It would be the task of the United States Reclamation Service to save the Boise and Payette Valleys from returning to the desert.

Project Location

The Boise Project covers lands in the six south-western Idaho counties of Elmore, Ada, Boise, Canyon, Gem, and Payette, and a small portion of Malheur County in eastern Oregon. The geographic lay of the land naturally lends itself to the division of the project into two divisions: the Arrowrock Division and the Payette Division. The Arrowrock Division covers lands south of the Boise River while the Payette Division generally covers lands to the north. The primary features of the project are the Boise River Diversion Dam, Arrowrock Dam, Anderson Ranch Dam, and Lake Lowell in the Arrowrock Division, and Black Canyon Dam, Cascade Dam, and Deadwood Dam in the Payette Division. The Boise River Diversion Dam is located on the Boise River about 7 miles southeast of Boise. It diverts water into the New York Canal which carries water 40 miles from the river to Lake Lowell, an off-stream storage reservoir near Nampa, Idaho. Arrowrock Dam is on the Boise River about 22 miles upstream from Boise. Anderson Ranch Dam is located about 42 miles upstream from Arrowrock Dam on the south fork of the Boise River, about 22 miles northeast of Mountain Home, Idaho. Cascade Dam is located near Cascade, Idaho, on the north fork of the Payette River. Deadwood Dam is about 25 miles southeast of Cascade on the Deadwood River, a tributary of the south fork of the Payette River. Black Canyon Dam is located on the Payette River near Emmett, Idaho. In addition, there are powerplants at the Anderson Ranch, Black Canyon, and the Boise River Diversion Dams, several hundred miles of canals, and numerous pumping plants.[1]

Historic Setting

The discovery of gold in the Boise Valley in the early 1860s encouraged development of agriculture to feed the growing mining community. The first right to divert water from the Boise River for irrigation purposes was granted in 1864. The water was used for irrigation at the Boise townsite and to supply Fort Boise. By 1870, farming in the Boise Valley was well established, but most farming was limited to lands along the river and the development of new lands was hindered by lack of reliable irrigation facilities. In the early 1880s, A. D. Foote proposed construction of the New York Canal to irrigate thousands of acres on the south side of the Boise River. Foote began construction of his canal, but numerous problems persisted, and after 16 years of work, only a small trickle of water flowed through Foote's canal.

By 1900, about 148,000 acres of land in the vicinity of Boise was under irrigation with the potential of several hundred thousand additional acres if reliable irrigation facilities could be constructed. But the money required for such development was great, and few could raise the funds needed for construction. With the formation of the Reclamation Service in 1902, the people of the Boise Valley saw the answer to their problems. The money and expertise needed to bring water to undeveloped areas would be supplied by the Government and repaid by the

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1. Department of the Interior, Water and Power Resources Service, *Project Data*, (Denver: U.S. Government Printing Office, 1981), 45-6.

water users under a low-cost, long-term loan program.[2]

Project Authorization

Construction of features of the Boise Project were authorized under a number of different legislative acts. The initial authorization of the Payette-Boise Project (the name was changed to Boise Project in 1911) was made on March 27, 1905, under provisions of the Reclamation Act of 1902. Later authorizations under the Reclamation Act include Arrowrock Dam (January 6, 1911), and Black Canyon Dam (June 26,1922). Deadwood Dam and Reservoir and the Payette Division were both authorized by the President under provisions of the Act of June 25, 1910, which required approval of the President for new projects. Deadwood Dam was approved on October 9, 1928, and the distribution system of the Payette Division on December 19, 1935. Anderson Ranch Dam and Reservoir were determined to be feasible and authorized for construction by the Secretary of the Interior on August 12, 1940, under provisions of the Reclamation Project Act of 1939.[3]

Construction History

The first investigation undertaken for the Payette-Boise Project took place in the summer of 1902 with surveys of potential reservoir sites on the headwaters of the Boise River. Other investigations that year included surveys of the Deer Flat area and several potential canal routes. These investigations were conducted by the United States Geological Survey in cooperation with the State of Idaho. Survey work was supervised by the state engineer. Following passage of the Reclamation Act in June 1902, survey work was continued by the newly formed Reclamation Service. Surveys and investigations of reservoir sites on the upper reaches of the Boise River

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2. *Ibid.*, 46; Department of the Interior, Bureau of Reclamation, Historical Site, Boise Diversion Dam , (Washington: U.S. Government Printing Office, 1978).

3. *Project Data*, 47; Denver, National Archives and Records Administration, Rocky Mountain Region, Records of the Bureau of Reclamation, Records Group 115, “Project Histories: Boise Project” Vol. I: Through 1912 and Early History, introduction (hereafter cited as “Project History” with volume number, year, and page number).

were completed in early 1903. In 1904, the Reclamation Service conducted surveys to determine the nature of the facilities necessary for the project and the potential costs involved with construction. These surveys and cost estimates were considered by the Reclamation Services' board of engineers, who determined that the proposed project was feasible. In early 1905, the board of engineers recommended to the Secretary of the Interior that construction of the project should begin at once, and on March 27, 1905, the Secretary gave his approval and allocated $1,300,000 for construction. The approved plan called for the construction of a dam on the Boise River to divert water into a canal which would transport it to Indian Creek. The water would then travel down Indian Creek for a short distance where it would be diverted into a second canal and transported to a storage reservoir which would be constructed at Deer Flat. Water stored at Deer Flat would be distributed through a canal and lateral system to lands within the project boundary. The plan also contained provisions for construction of a storage reservoir on the headwaters of the Boise River.[4]

Two key factors helped gain approval for the project. The first was the formation of a formal water users organization that would help coordinate all of the existing canal and irrigation districts in the area. Since much of the lands within the project area were under private ownership or under control of the state, it was deemed essential to the success of the project to bring all interested parties together under one organization. Following completion of the initial surveys in early 1903, the Reclamation Service stopped further investigations until the issue of a water users organization could be resolved. In December 1903, community leaders in the Boise and Payette Valleys initiated efforts to form a formal water users organization. Meetings were held throughout the area to inform land owners of proposed project and to gather support for the

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4. Department of the Interior, United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910,* (Washington: Government Printing Office, 1911), 106-107 (hereafter cited with publishing agency, title, year, and year of publication).

formation of an irrigation district. In early March 1904, a communication was sent to the Secretary of the Interior with petitions signed by land owners representing 90,000 acres within the project area and backed by a resolution pledging cooperation by the state board of land commissioners representing an additional 60,000 acres within the project boundaries. The communication was referred to the director of the Reclamation Service, who recommended to the Secretary that investigations and surveys be continued pending formation of a formal water users organization. The Secretary agreed, and investigations resumed in April 1904. With the renewal of investigations, land owners in the Boise and Payette Valleys moved quickly to create a formal organization, and on August 10, 1904, the Payette-Boise Water Users Association was formally organized.[5]

The second factor that was key to the success of the project was the incorporation into the project all existing canals irrigating lands on the south side of the Boise River, particularly the New York Canal, which followed the best line from the river to Indian Creek. In early 1906, the Reclamation Service entered onto contracts with the New York Canal Company and the Idaho-Iowa Lateral and Reservoir Company, owners of another canal in the area, by which the Reclamation Service acquired the rights to control, operate and enlarge the canals of these companies which ran from the Boise River to Indian Creek. In return, the Reclamation Service promised to provide water to company stockholders in accordance with vested water rights and established priorities.[6]

Boise River Diversion Dam, Deer Flat Embankments, and Main Canal

Advertisements for bids for construction of the diversion dam, main canal, Deer Flat Embankments, and associated structures were published in December 1905. Bids were opened

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5. *Ibid.*, 107-108; United States Geological Survey, *Third Annual Report of the Reclamation Service, 1903-1904*, (1905), 238-9, 249.
6. United States Reclamation Service *Ninth Annual Report of the Reclamation Service, 1909-1910*; 107.

on February 1, 1906. The contract for construction of the Boise River Diversion Dam was awarded to the Utah Fireproofing Company of Salt Lake City. Their bid was $58,950. The contract for construction of the main canal from Indian Creek to Deer Flat was awarded to the joint venture of Conway & Whilhite of Star, Idaho, which submitted the low bid of $95,400. The low bid for construction of the Lower Deer Flat Embankment was submitted by the firm of Hubbard & Carlson of Boise. The amount of the bid was $256,550. The low bid for construction of the Upper Deer Flat Embankment was $382,150. After some consideration, the Reclamation Service rejected all proposals for construction of the Upper Deer Flat Embankment, electing to construct the feature using government forces.

The bids for enlargement of the New York Canal from the Boise River to Indian Creek were rejected and re-advertised under a different specification. Those bids were opened on April 16, 1906. The specifications for the work divided the project into four schedules, schedules Nos. 1, 2, and 3 for work on the canal, and schedule No. 4 for construction of bridges and structures. The contract for schedule No. 1, about 6.5 miles beginning at the Boise River, was awarded to W. H. Thompson. The contract for schedules Nos. 2 and 3, beginning from the end of schedule No. 1 and running to Indian Creek, was awarded to the contracting firm of Page & Brinton of Salt Lake City, who also received the contract for schedule No. 4. Other contracts awarded in association with construction of the diversion dam and main canal included a contract to supply canal head gates and mechanical equipment. This contract was awarded to the Chapman Valve Manufacturing Company of Indian Orchard, Maryland, which bid $12,928.[7]

The contract between the U.S. Government and the Utah Fireproofing Company for construction of the Boise River Diversion Dam was executed on February 21, 1906, with the

7. *Ibid.*, 110-1: United States Geological Survey, *Fifth Annual Report of the Reclamation Service, 1906*, (1907); 125: "Project History - Boise Project: Through 1912 and Early History," Vol. I: 3, 39-42, 47, 49.

contract specifying that construction be 20% complete by July 1, and setting the completion date as April 16, 1907. Construction began in March 1906, with work on tunnels to divert the river around the construction site. Prior to completion of the tunnels, a coffer dam was constructed on the east side of the river so that excavation for the eastern end of the dam could begin. Although weather conditions were favorable, construction proceeded slowly, with work only 17% complete by August 31. Work was further delayed by high water throughout late 1906, and in January 1907, when ice destroyed the coffer dam protecting the site.

By April 16, 1907, the date specified for completion of the dam, the project was only 41% complete. High water again delayed work in December 1907, February and March 1908, and from April through June 1908. In January 1908, the sixteenth superintendent of construction for the contractor took charge of the project, and by the time the dam was completed, at least nineteen different superintendents had supervised construction for the contractor. The dam and diversion works were completed on October 10, 1908. Delays and cost overruns amounted to a loss by the Utah Fireproofing Company of over $90,000.

The Boise River Diversion Dam is a rubble concrete and masonry weir structure with a height of 68 feet above the deepest point of the foundation. The crest is 500 feet long and has an overflow spillway with a capacity of 40,000 cubic feet per second (cfs). In addition, the dam has a log way for passage of logs over the dam, and a fish ladder. The headworks for the New York Canal consist of eight, 5- by 6- foot slide gates. The gates and lifting mechanisms were supplied by United Iron Works of Oakland, California. The diversion capacity of the dam is 2,815 cfs.[8]

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8. "Project History - Boise Project: Through 1912 and Early History," Vol. I: 3-4, 42-43; Department of the Interior, National Park Service, Historic American Engineering Record, "*Boise Project, Deer Flat Embankments*," HAER No. ID-17-B Vol. II: Historical and Descriptive Data, (1991), 38-39; United States Geological Survey, *Fifth Annual Report of the Reclamation Service, 1906*, (1907), 125; United States Reclamation Service, *Sixth Annual Report of the Reclamation Service, 1907-1908*, (1908), 87; United States Reclamation Service, *Eighth Annual Report of the Reclamation Service, 1908-1909*, (1910), 78; United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910*, (1911), 109-110; *Project Data*, 45, 51.

The plans for the main project canal called for enlargement of the New York Canal from the Boise River to Indian Creek, and construction of a similar canal from Indian Creek to Deer Flat. The construction firm of Conway & Wilhite began on the section of the main canal from Indian Creek to Deer Flat in February 1906. Work on the canal from the Boise River to Indian Creek was delayed because of the rejection of all initial bids. Work on this section began in June 1906. Work under the Conway & Wilhite contract involved construction of about eight miles of canal from Indian Creek to Deer Flat. This work began in late February 1906, and progressed without significant delay, with all work under the contract completed in February 1908.

Following rejection of the initial bids for enlargement of the New York Canal, the Reclamation Service re-issued the specifications as three schedules with a fourth schedule for construction of control structures and bridges. Work on schedule No. 1, beginning at the Boise River and running about 11 miles to schedule No. 2, began in May 1906. Work on this section involved widening the existing canal from a bottom width of 14-feet to 40-feet. Work had to be carried out in such a manner that irrigation deliveries would not be interrupted. To accomplish this, the contractor, W. H. Thompson, constructed a dike down the middle of the canal separating the completed portion of the canal from the section under construction. Work on schedule No. 1 went smoothly and without significant delay and was completed in April 1908. A small section of schedule No. 1 had been rehabilitated by government forces prior to commencement of work under the contract with W. H. Thompson.[9]

Page & Brinton also began work on schedules Nos. 2 and 3 in June 1906, but work on this section did not go as smoothly as that on the first section. Although the principals of the contracting firm were knowledgeable and skilled engineers, they had no experience as

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9. "Project History - Boise Project: Through 1912 and Early History," Vol. I: 3, 5, 41, 47-9; United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910*, (1911), 110-1.

construction supervisors, and soon began to fall behind schedule. Disputes between the contractor and Reclamation Service over the amounts and quality of the materials excavated further delayed work. By March 1, 1908, the date set for completion, the project was only 83% complete. Several extension were granted by the Reclamation Service, but the work was not completed. On November 4, 1908, the contract was suspended, and work was taken over by force account and completed in January 1909.[10]

The New York Canal from the Boise River to Deer Flat is 40 miles long. The original canal, constructed in the late 1800s, had a capacity of about 200 cfs, which was increased to 1,500 cfs by the Reclamation Service. The modified canal had a bottom width of 40 feet with water running at a depth of about 8 feet.[11]

Work on the Lower Deer Flat Embankment by the contractor, Hubbard & Carlson, began in March 1906. After rejection of all bids for construction of the Upper Deer Flat Embankment, Reclamation decided to go head with construction by force account. Construction by government forces began in October 1906. Construction of the lower embankment by Hubbard & Carlson was completed in January 1908 with work on the upper embankment completed in early September 1908. First water storage in the newly constructed reservoir occurred in early 1909.[12]

Deer Flat Reservoir, now known as Lake Lowell, is formed by three embankments and one dike. The Upper Deer Flat Embankment is 74 feet high, 4,165 feet long, and contains more than 1,245,000 cubic yards (cy) of material. The upper embankment contains two canal outlets, one on each end of the dam. Lower Deer Flat Embankment is 46 feet high, 7,270 feet long and

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10. "Project History - Boise Project: Through 1912 and Early History," Vol. I: 3, 7, 49-51; United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910*, (1911), 110-1.
11. Project Data, 51; United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910*, (1911), 111.
12. United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910*, (1911), 108-9; "Project History - Boise Project: Through 1912 and Early History," Vol. I: 3-4, 6, 8, 41.

contains about 2,400,000 cy of material. A single canal outlet was installed near the right abutment when the embankment was constructed. A second outlet was installed near the left abutment in 1959. In addition to the upper and lower embankments, there are two smaller embankments that were constructed in 1911. The Middle Embankment, also known as the Forest Embankment, is 16 feet high and 1,262 feet long. The East Dike was constructed on the eastern end of the reservoir to protect area farms from possible flooding. Since the lake is an off-stream storage reservoir and inflows are regulated by flows through the New York Canal, no spillway was constructed. However, the crest of the Middle Embankment is about 4 feet lower than the upper and lower embankment to serve as an emergency spillway.[13]

In addition to the modifications to the existing New York Canal, Reclamation constructed miles of new distribution canals and laterals and enlarged and modified many miles of existing canals and laterals. Work on the distribution and lateral system began in 1908 with most of the excavation being carried out by contract while Reclamation forces constructed control works and structures. Much of the excavation for laterals was done under a cooperative agreement between the Payette-Boise Water Users Association and Reclamation. The water users association contracted with the settlers to construct the lateral system under the supervision of Reclamation, with payment for the work being made with certificates that could be redeemed by Reclamation for payment of water charges. The majority of the system was completed by the end of 1910.[14]

Although the Reclamation Service had supplied water to project lands through the New

13. *Project Data,* 45,50; Memorandum: R. C. Rolin ,to Chief, Inspection Branch, Examination Report of Deer Flats Dams for SEED (Safety Evaluation of Existing Dams) Program - Boise Project, Idaho - Pacific Northwest Region. 30 June 1986; Memorandum: Bob Woodby, Operations and Structural Safety Group, and Victoria Hoffman, Facility Operations and Maintenance Group, to Manager, Operations and Structural Safety Group. Examination Report - Periodic Facility Review (PFR) - Deer Flat Dams - Safety Evaluation of Existing Dams (SEED) and Review of Operations and Maintenance (RO&M) Programs - Boise Project, Idaho - Pacific Northwest Region. 22 March 1996.

14. United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910,* (1911), 111.

York Canal for several seasons, early 1909 marked completion of the initial features of the Boise Project with the completion of the Boise River Diversion Dam. On February 22, 1909, as several thousand people looked on, the first water to be diverted by the newly completed dam flowed into the canal and onward to Deer Flat Reservoir.[15]

Arrowrock Dam

The first reconnaissance surveys for a storage reservoir on the headwaters of the Boise River were undertaken in 1902 and 1903. Cost estimates for storage works at a number of sites were drawn up, and in 1910, more intensive surveys were conducted at the most promising sites. Through a process of elimination, the Arrowrock site was chosen, and foundation explorations were carried out in late 1910 and early 1911. Fifty-nine drill holes and numerous test pits and tunnels were sunk in the foundation and spillway areas to determine the nature and depth of the bedrock. The results of the tests confirmed the favorable nature of the site.[16]

Before construction of the dam could begin, a significant amount of preparatory work had to be undertaken. The location of the dam, about twenty miles upriver from Boise, presented the Reclamation Service with a number of problems. The only access to the site was via an old wagon road which was not suited for the high volume of traffic and heavy loads that would need to travel to the site. To solve the problem, the Reclamation Service elected to improve the existing road and construct a railroad from Barber, the end of the rail spur from Boise, to the site of the dam, a distance of about seventeen miles. Even before the project had been approved, the Reclamation Service moved forward with construction of the railroad. In early 1910, the Reclamation Service tried to convince the Barberton Lumber Company, owners of the Intermountain Railway Company and holders of a right-of-way which passed within six miles of

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15. Department of the Interior, Bureau of Reclamation, *Boise Diversion Dam*, (U.S. Government Printing Office, 1978); "Project History - Boise Project: Through 1912 and Early History," Vol. I: 8
16. Department of the Interior, Bureau of Reclamation, *Dams and Control Works*, (Washington: U. S. Government Printing Office, 1929), 35.

the dam site, to construct the railroad. Faced with the loss of its right-of-way unless construction began before June 1910, but reluctant to undertake construction itself, officials of the Barberton Lumber Company came up with a unique solution: the Intermountain would grant an easement over their right-of-way to a common (public) carrier which would construct the railroad. In return, the Intermountain would lease track rights for as long as the common carrier owned the railroad. To accomplish this, the government would have to form a common carrier registered to do business as a public railroad, and on May 10, 1910, the Reclamation Service signed an agreement with the Intermountain Railroad, and the Boise & Arrowrock Railroad was born.[17]

The first days of the U. S. Government's first public railroad (the government operated two other railroads, one on the Panama Canal and one for the construction of Engle Dam in Texas, but neither were public carriers) were somewhat shaky. Technically, the railroad was part of the yet to be approved Arrowrock Dam, and amendments to the Reclamation Act that were passed in June 1910, changed the project approval process, requiring Presidential approval for all new projects. While the President might have approved a railroad for construction purposes, a public carrier was another matter. To help hide the existence of the railroad, space in the rail station in Boise was allocated as office space and charged to the existing project approval. The track from Boise to Barber, the terminus of the Boise & Arrowrock, was owned by the Boise City Railway & Terminal, and a gentlemen's agreement governed the Boise & Arrowrock's use of the spur. But through a series of previous lease agreements between the Boise City Railway & Terminal and the Oregon Shortline, the tracks and the station in Boise were acquired by the Shortline who refused to honor the agreement between the Boise & Arrowrock and the Boise City Railway & Terminal. As a result, the terminal for the Boise &

17. Chas. H. Paul, "The Arrowrock Dam, Boise Irrigation Project, U. S. Reclamation Service," *Engineering Record*, 6 June 1912, 1061; "The Arrowrock Dam, Boise Project, U. S. Reclamation Service; The Highest Dam in the World," *Engineering & Contracting*, 21 August 1912, 218; Jim Witherell, *The Log Trains of Southern Idaho*, (Denver: Sundance Publications, Ltd., 1989), 20-1, 25.

Arrowrock became a field just outside Barber.

In September 1910, long after the agreement between the Reclamation Service and the Barberton Lumber Company had been signed, project officials sought approval from the Secretary of the Interior to study the feasibility of a railroad to the Arrowrock site. That approval came a few weeks later, and on August 22, 1910, the Boise & Arrowrock was registered as a public carrier in Ada County, Idaho. In December 1910, Reclamation officials submitted their plan to the President for approval, seeking $5,500,000 for construction of the dam, construction camp, and railroad. The submission failed to note that the railroad already existed and was fully recognized as a public carrier under Idaho law. The president approved the project in February 1911.[18]

With approval of the project in February 1911, construction activities moved forward at a breakneck speed. The wagon road to the construction site was improved to provide access until the railroad was completed. Communication was also improved when work on the first line of a two-line telephone system connecting the construction site with the project office in Boise was completed. When completed, the phone system included over 50 miles of wire servicing up to 54 telephones. To provide power for construction activities, the Reclamation Service constructed a 1,500 kilowatt (kW) powerplant at the Boise River Diversion Dam,[19] and connected the powerhouse with the construction site via two 23,000-volt transmission lines.

Construction of the railroad began in late May 1911, with grading of the first nine miles of the roadbed. The grading contract was awarded to the Manly Brothers of Salt Lake City, who reached the end of the first section, a bend in the Boise River known as the Gooseneck, on July 23. The Manly Brothers also received the contract for grading the remaining portion from the

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18. Witherell, *The Log Trains of Southern Idaho*, 25, 31.
19. For details about construction of the Boise River Dam Powerplant see "Post Construction History" on page 40.

Gooseneck to the construction site. Roadbed grading was completed on October 1. Track laying by government forces began in September, after being delayed by a shortage of ties. Track laying was again delayed at the Gooseneck by a shortage of timber for bridge construction. The river crossing at the Gooseneck was spanned by two 150-foot, prefabricated bridge sections. A second river crossing was spanned by four prefabricated bridge sections. The tracks finally reached Arrowrock in early November. The Boise & Arrowrock Railroad began service on November 9, 1911. For passengers, the trip was less than relaxing. The terminal was in a field west of Barber, and each car had to be individually winched across the partially completed Gooseneck Bridge while the passengers walked.[20]

For those who were hardy enough to make the trip, what they found was remarkable in itself. The construction "camp" at Arrowrock, built during the summer of 1911 and designed to accommodate 900 people, consisted of more than thirty buildings including a hospital, mess hall, hotel, a dance/amusement hall operated by the Y.M.C.A., a fully stocked store, an office building, bunkhouses, cottages for families, and a post office, which received is official designation on November 15, 1911. The camp was provided with a central heating plant that heated all of the buildings except the cottages, a water supply system, a sewage system, and a fire protection system. Lumber for the town was supplied by a mill that was constructed on Cottonwood Creek, fourteen miles above the dam site. The two-saw mill began operation in April 1911, and had a capacity of 15,000 to 20,000 board feet of lumber per-day. During its period of operation, from April 1911, to September 1913, the mill produced more than 6,740,000 feet of lumber. In addition to the government camp, many workers built private cottages nearby. At the peak of construction, about 1,400 people lived at Arrowrock, including 200 families. A

20. *Ibid*., 33.

school, staffed by two teachers served about 90 pupils.[21]

The first task undertaken as part of the construction of the dam itself was the diversion of the Boise River around the dam site. To bypass the river around the construction site, a 470 - foot long tunnel was driven through south abutment of the dam. Work on the tunnel began in early August 1911, with clearing and open cuts at both portals. Actual tunneling operation began on August 22, with headings being advanced from both ends. The initial tunneling plan called for workers to drive a single, 8-foot by 8-foot heading along the arch, or top of the tunnel. This was later changed, with excavations of the arch section advancing on three headings; left, right, and center. The left and right headings were advanced ahead of the center heading. Crews working from both ends of the tunnel met on November 4, 1911, and all excavation of the upper portion of the tunnel was completed on November 11. Excavation of the lower sections was carried out in two lifts, with crews working from both ends. All excavations were completed by December 23. Concrete placement for the tunnel lining began immediately after excavations were complete and progressed without delay until the final placement on January 27, 1912. The river was diverted through the completed tunnel on July 5, 1912. The completed tunnel was 487 feet long, including portal sections, 40 feet high and 30 feet wide. The bottom and side were lined with concrete and the roof was supported by timbers. The tunnel was designed to accommodate flows of up to 20,000 cfs. The upper and lower coffer dams were constructed to protect the construction site from flooding. They were timber cribs filled with rock, gravel and sand that was sluiced into place. Both dams were provided with a sheet piling cut-off. The upper dam was 200 feet long and 40 feet high, and the lower dam was 150 feet long and 25 feet

21. *Ibid.*, 33, *Dams and Control Works*, 38; Alfred B. Mayhew, "Construction Camp at Arrowrock Dam," *Engineering Record*, 2 August 1913, 116-8.

high. Both dams were designed to be overtopped during periods of peak floods.[22]

Excavations for the foundation began in late February 1912, before completion of the diversion works. Early excavation was concentrated in areas above the surface of the river. Investigations of the site indicated that bedrock was about 60 to 80 feet below the existing ground surface. All loose material had to be removed to provide a secure foundation on which the dam could rest. Investigations also revealed a lava bench between 20 and 50 feet thick running through the site on the south side of the river. Since lava was not considered a suitable foundation material, it had to be removed as well. Excavations in the river bed began in July, after the river had been turned through the diversion tunnel. The work was carried out using steam shovels and drag-line excavators.[23]

Excavations in the foundation area were covered by two, 12-ton, Lidgerwood cableways. The dragline excavator, working in the foundation area, loaded the cableway skips with excavated materials which were transported to the screening and crushing plant. Since the dam site lacked material for concrete manufacture, all suitable materials from the foundation and spillway excavations were stockpiled for later use. To ensure a secure bond between the dam and foundation, keyways were excavated along the heel, toe and center portions of the dam. Concrete placement in the first section of the dam began in November, 1912. The plan called for construction of the dam in three sections. The lower 100 feet would be constructed in two sections, an upstream section and a downstream section. The upstream section would be constructed first and would be a height and a width sufficient to hold back the maximum flow of the river. The completed upstream portion of the dam would then act as an enlarged coffer dam

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22. Department of the Interior, Bureau of Reclamation, *Dams and Control Works*, 2nd ed., (Washington: U. S. Government Printing Office, 1938), 53; Charles H. Paul, “Diversion Works for the Arrowrock Dam,” *Engineering Record*, 6 April 1912, 368; Charles H. Paul, “Excavation for the Arrowrock Dam, Idaho,” *Engineering News*, 17 July 1913, 98.

23. United States Geological Survey, *Fifteenth Annual Report of the Reclamation Service, 1915-1916*, (Washington: Government Printing Office, 1916), 140.

to protect the construction site. The first section was completed in mid-April, 1913, and was about 100 feet high contained about 67,500 cy of concrete.[24]

At the time Arrowrock Dam was constructed, engineers were just becoming aware of the rise in temperatures within massive concrete structures caused by the curing of the concrete. It was recognized that the richer the concrete mix, the greater the temperature increase. Experiments with natural materials, such as tufa, combined with cement showed a reduced temperature as well as a reduction in costs. For these reasons, Reclamation engineers elected to use a mixture of Portland cement and sand in construction of Arrowrock Dam. The mixture was a blend of 55% Portland cement and 45% crushed granite, which was taken from the spillway excavations. In preliminary tests, the strength of the sand-cement was shown to be only slightly less than that of pure cement after 6 months, and comparable in strength after 1 year.

The Reclamation Service pioneered dam instrumentation at Arrowrock Dam by installing ten thermometers within the dam to monitor the thermal behavior of the concrete during the curing process. In addition, construction techniques were modified to help control cooling of the mass concrete. Radial contraction joints were provided at distances that varied with the thickness of the dam. In the upper portion of the dam, the joints were spaced at 25-feet. In the mid section, the spacing was 50-feet, with a 150-foot spacing in the lower portion of the dam. The instrumentation within the dam showed the temperature to be significantly less that would be expected using straight Portland cement.[25]

Concrete placement in the second section of the dam began in mid-July 1913, and was completed by the end of December. Aggregate for the first two sections of the dam came from

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24. United States Reclamation Service, *Fifteenth Annual Report of the Reclamation Service, 1915-1916*, 140-141; *Engineering Record*, "Progress on Arrowrock Dam," 7 March 1914, 272; *Dams and Control Works*, 2nd ed., 53-4.

25. Eric B. Kollgaard and Wallace L. Chadwick, eds., *Development of Dam Engineering in the United States*, (New York: Pergamon Press, 1988), 17-18.

the foundation and spillway excavations. When that supply dried up, aggregate was transported by rail from a pit on the Boise River 13 miles away. The sand-cement mixture was manufactured at a plant located on the north abutment of the dam. At the plant, crushed granite was combined with Portland cement and the mixture was pulverized to achieve the desired consistency. The sand-cement mixture was then transferred about 1,500 feet to the mixing plant on the opposite side of the river by compressed air through a four-inch pipe. After mixing, concrete was transported for placement by a cableway and hopper system constructed especially for that purpose.[26]

Excavations for the spillway channel began in June 1911. The channel is located in a rock cut along the north side of the river just downstream from the dam. Because the spillway channel runs along a steep slope, the depth of the cut varies from 80-foot to almost 250-feet. Initial excavations concentrated on creating a level work area on the steep slope. A 70-ton Atlantic stream shovel and two 18-ton "dinkey" steam engines with 4-yard dump cars were moved to the spillway excavations in October 1912. Rough excavations were completed in December 1912, after almost fourteen months of continuous work. Concrete operations in the spillway began in September 1914. Concrete for the spillway was transported by one of the main cableways to a holding hopper. From there it was discharged into a dump car or a small cableway hopper and transported to the area of placement. All of the concrete placed in the spillway is reinforced and is anchored to the rock by anchor bolts attached to the reinforcement steel. Concrete placement in the spillway was completed in October 1915.[27]

With completion of the second section of the dam in December 1913, efforts were concentrated on completing the dam to its final height of almost 350-feet. Concrete placement

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26. "Construction of Arrowrock Dam," *Engineering Record*, 6 September 1913, 266-267.
27. United States Reclamation Service, *Fifteenth Annual Report of the Reclamation Service, 1915-1916*, 141-142.

moved forward at a rapid pace, and the contractor broke several records for mixing and placing concrete using one cubic-yard (cy) mixers during 1913. In April, 45,700 cy of concrete was placed, establishing what was believed to be a world's record. That record was surpassed in May, when workmen placed 51,490 cy. A third record was established in June, when 56,520 cy was placed. Concrete operations on the dam were completed in November 1915, with the total volume of concrete placed in the dam exceeding 585,160 cy.[28]

When completed, Arrowrock Dam was the tallest dam in the world at just over 348 feet above the deepest point of the foundation, with crest length of 1,100 feet. It is 225 feet thick at its base and 15 ½ feet thick at the crest. There are 25 outlets running through the dam at different levels. At the level of the river bed, about 248 feet below the crest, there are five, 60-inch, sluice gates, each controlled by a 60-inch by 60-inch sliding gate. Approximately 197 feet below the crest, there is a set of 10 outlet conduits. Three are 72-inches in diameter are reinforced for use as penstocks in future power developments.[29] The other seven outlets are 52-inches in diameter and are used to release water for irrigation. These outlets were controlled by specially designed balanced needle valves attached to the upstream face of the dam and protected by steel trashracks. One hundred and ten feet below the crest is a second set of ten, 52-inch, outlet conduits. These were also controlled by balanced needle valves. The controls for all of the outlet valves are located in galleries which run through the interior of the dam.

The spillway is located on the north end of the dam. It has an overflow weir crest discharging into a concrete lined channel excavated in granite. The channel discharges spills into Deer Creek which flows into the Boise River about 800 feet below the dam. The spillway crest is over 400 feet long and is controlled by six, 62 foot long, automatic drum gates. The

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28. *Ibid.*, 142; "World's Concreting Record at Arrowrock Dam, Idaho ," *Reclamation Record*, June 1914, 223; "Another Concreting Record at Arrowrock Dam," *Reclamation Record*, July-August 1914, 271; "Concreting at Arrowrock Dam," *Reclamation Record*, September 1914, 321.
29. The power potential of Arrowrock Dam was never developed.

spillway is designed to handle flows of up to 40,000 cfs.[30]

Arrowrock Dam was dedicated on October 4, 1915, a day that also marked the end of daily service to Arrowrock by the Boise & Arrowrock Railroad. From mid-October to December 31, 1915, only Saturday service was available. During the first half of 1916, Reclamation used the railroad to transport equipment and salvaged material from Arrowrock. By June 1916, the once bustling and active town consisted of a hotel, three houses, and the headquarters building. The railroad was formally abandoned on June 30, 1916, and sold at auction. During its period of operation, from November 1911 to June 1916, the Boise & Arrowrock Railroad carried over 89,500 passengers, 14,000,000 ton/miles of freight, and traveled more than 110,000 miles on the 17 mile long line. The Boise & Arrowrock Railroad was officially decommissioned by Act of Congress on August 11, 1916.[31]

The Payette Division

Completion of Arrowrock Dam marked the close of the first phase of development of the Arrowrock Division. Although construction of the distribution and drainage system would continue for several years, it would be almost a decade before additional major development took place on the project. While development of the Arrowrock Division went forward with few apparent problems, development of the Payette Division went nowhere. The original project plan called for development of lands in both the Boise and Payette Valleys, hence the name Payette-Boise Project. But lack of funds and the generally unsettled nature of the Payette Valley convinced the Reclamation Service to develop the Arrowrock Division first. The promise of a government sponsored irrigation project brought many settlers to the Payette Valley, and soon most of the lands had been taken up. Lack of funding continued to delay development of the

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30. *Dams and Control Works*, (1929), 35-37.
31. *The Log Trains of Southern Idaho*, 42, 52."Construction, Use, and Disposal of Arrowrock Railroad," *Reclamation Record*, April 1918, 186-186.

Payette Division, and the entrymen soon became impatient, petitioning the Government to remove Payette Division lands from the project and allow private development of the valley. The government accepted the settlers request and abandoned plans to develop Payette Division lands.

Private development of the valley proved to be a failure. While settlers built homes and leveled lands in anticipation of development, bonds to finance construction of an irrigation system could not be sold, and many where forced to abandon their homesteads. Many turned their lands back to the State in hopes of development under the Carey Act. But this too failed, and those who remained were forced to turn to the Reclamation Service for relief. In 1915 and 1916, surveys were conducted and plans drawn up to provide water to about 7,000 acres of Payette lands from Arrowrock Division drains. The recovered water would be siphoned under the Boise River and used to irrigate lands north of Notus. Construction of the Notus Canal began in February 1919, and the first deliveries of water to the Notus Unit took place in late April 1921. Even though a "first unit" had been completed, development of the newly revived Payette Division failed to gain momentum. A major step toward full development of the Payette Division came with the construction of Black Canyon Dam on the Payette River. Although built to supply water to existing developments in the Emmett Irrigation District, Reclamation designers anticipated the eventual development of Payette Division lands and designed the dam to supply those lands as well.[32]

Black Canyon Dam

In the early 1920s, the Emmett Irrigation District consisted of about 22,000 acres of land in the Payette River Valley near Emmett, Idaho. Water for the lands was obtained from the

32. "Thousand Persons Celebrate Delivery of First Water to Payette Division," *Reclamation Era*, June 1939, 144; "Project History, Boise Project, 1919-1921," Vol. V, 1919, 14-15; 1921, 6.

Payette River and transported by canal to district lands. About 16 miles of the canal ran through the canyon of the Payette River and was prone to frequent failures. Because maintenance and reconstruction charges were reaching beyond the District's ability pay for them, district officials began looking for alternative sources of water. The district entered into negotiation with the Reclamation Service whereby a diversion dam would be constructed on the Payette River to supply water to district canals, thereby allowing abandonment of the canyon section of the canal. On November 8, 1921, the Reclamation Service and the Emmett Irrigation District entered into an agreement for construction of Black Canyon Dam as a unit of the Boise Project. Under the terms of the contract, the irrigation district agreed to repay the entire cost of the dam unless the dam was used to divert water for lands in the yet to be approved Payette Division, in which case the district's liability would be reduced by half. Construction of Black Canyon Dam was authorized by the Secretary of the Interior on June 26, 1922.[33]

Work on Black Canyon Dam began in July 1922 with construction of the camp, wagon roads and power lines. A branch of the Oregon Shortline Railroad ran along the south side of the site making handling of freight to and from the site a simple matter. A 10-ton electric cableway was constructed at the site to transport materials and supplies. A movable head tower with a 225-foot range of travel assured that no part of the construction site was out of reach. Concrete aggregate was obtained from a site about 1½ miles upstream from the construction site.[34]

The dam was constructed at a point were the Payette River exits the canyon and flows into a wide valley. At the site, the valley is over 1,000 feet wide with the river flowing through a channel about 150 feet wide. The dam was designed as a concrete gravity dam with the spillway

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33. United States Reclamation Service, *Twenty-First Annual Report of the Reclamation Service, 1921-1922,* (1922), 121; *Project Data*, 47; Walter Ward, "Building Black Canyon Dam in Western Idaho," *Engineering News-Record*, 20 November 1924, 818.

34. *Twenty-Second Annual Report of the Reclamation Service, 1922-1923,* (1923), 125-126; Ward, "Building Black Canyon Irrigation Dam in Western Idaho."

located in the river channel. Although primarily a gravity dam, the spillway section was located slightly upstream from the ends of the abutments, thereby giving the dam some arch action. Because work started late in the construction season, project engineers elected to concentrate initial efforts on the abutments so that construction forces could have a full season of low water to construct the spillway section.

Preconstruction investigations revealed that the foundation consisted of high quality basalt which proved to be very solid. In addition, the surface of the foundation was very rough and irregular with many natural keyways which served to help anchor the dam in place. Excavations for the dam abutments were carried out using high-pressure streams of water to strip loose materials from the foundation and clean the irregular surface. Excavations ranged in depth from 1 to 40 feet. Excavated materials were loaded into 4 cy dump cars and hauled away. Concrete placement in the abutment sections was handled by the cableway using 3- and 4-cy buckets and skips. Reusable concrete forms were used throughout the project. When an upper form was filled, the lower forms were removed and placed above the most recently filled form. This process continued until the top of the dam was reached. During construction of the south abutment, two 10 -by 14 -foot concrete culverts were constructed through the abutment to be used to pass the river during construction of the spillway section. Temporary channels were constructed upstream and downstream of the culverts and gravel dikes were used to divert the river into the channel.

When the abutment sections were completed, the river was diverted through the by-pass conduits and efforts were concentrated on the spillway section. The spillway section was excavated using three drag-line excavators and two 10-ton derricks. The deepest part of the excavation was about 92-feet below the normal surface of the river. Concrete in the spillway section was placed using a 6-cy hopper and chute system. Concrete was transported to the hopper in small carts and fed into the chute system from the hopper. Contraction joints were provided at 73-foot intervals in the spillway section and 50-foot intervals in the abutments. These joints were later sealed with grout during winter months when the concrete had fully contracted.

The spillway section is divided into three sections, each with a single automatically controlled drum gate located in recesses in the top of the spillway. The gates are controlled by a system of floats that act to keep the level of the water behind the dam at a constant. As river flows increase or decrease, the gates rise and fall to maintain a fixed water surface.[35] Each gate is 14½ feet high and 64 feet long, and weighs about 108 tons. In addition to the spillway gates, two low level sluice gates were installed.

The location of the tracks of the Oregon Shortline Railroad along the south bank of the river prevented Reclamation from constructing a dam higher than about 90 feet above the river bed without flooding the tracks. As a result, the main canal of the Emmett Irrigation District is about 25 feet higher than the water surface behind the dam. To get water to the canal, a pumping plant was constructed. The plant consists of two screw-type pumps connected to hydraulic turbines. The turbines are powered by water from the reservoir. The pumps discharge water into a common conduit that runs along the crest of the north abutment and discharges into the canal. Because the dam was constructed with the intention of providing for future development of Payette Division lands, a canal headworks consisting of two 10 -by 14 -foot radial gates with a capacity of 1,000 cfs was constructed at the south end of the dam.

Black Canyon Dam and Pumping Plant were essentially complete by late April 1924, and the diversion conduits were closed and sealed with concrete on April 28. The water surface

35. The automatic control system is no longer in service. The gates are controlled remotely from a control center.

reached maximum on May 5, and the pumps began operation on May 7. The start of the pumps couldn't have come at a better time, coming four days after failure of the canyon section of the irrigation district's canal. Black Canyon Dam is a concrete gravity structure 1,134 feet long and 184 feet high. The spillway is a concrete overflow type 218 feet long that is divided into three, 64-foot wide bays each controlled by an automatic drum gate. The maximum capacity of the spillway is 40,000 cfs. The pumping plant consists of two units with a combined capacity of 300 cfs and is located at the downstream toe of the dam.

The design of Black Canyon Dam anticipated future power developments by incorporating two, 7-foot diameter power penstocks in the design and providing for future expansion of the pumphouse to accommodate two generating units. Work on construction of the power facilities began in late 1924 following an agreement between the Reclamation Service and the Gem Irrigation District whereby the irrigation district would purchase power generated at Black Canyon Dam to power pumping units on district lands. The two power units each consist of a vertical shaft turbine supplied by the S. Morgan Smith Company of York, Pennsylvania, and a 4,000 kilowatt (kW) generating unit supplied by the Allis-Chalmers Manufacturing Company of Milwaukee. Power generation began in late December 1925. The power house is located adjacent to the pumphouse downstream from the dam.[36]

Development of Payette Division lands got a major boost in July 1927, when the Black Canyon Irrigation District entered into a contract with the Reclamation Service for construction of canals and a distribution system for the Payette Division. The agreement called for

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36. Ward, "Building Black Canyon Irrigation Dam in Western Idaho."; "Project History: Boise Project, 1922-1925," Vol. VI, 1925 61, 65; L. N. McClelland, "Black Canyon Power and Pumping Plant, Boise Project, Idaho," *New Reclamation Era*, February 1928, 30-31; Julian Hinds, "Automatic Spillway Gates of Black Canyon Dam," *Engineering News-Record*, 25 June 1925, 1046-1050; Ivan E. Houk, "Black Canyon Diversion Dam, Boise Project Idaho," *New Reclamation Era*, August 1928, 125.

construction of a canal system to be supplied by diversions at Black Canyon Dam, construction of a storage reservoir on the Payette River or its tributaries to augment the natural flows of the river thereby assuring a reliable water supply, and a share of the power generated at Black Canyon to be used for pumping on division lands. At the time of the agreement, the available flows of the Payette River were too small to provide a reliable supply throughout the irrigation season, and shortages often occurred resulting in reductions of the power output at Black Canyon. Because of the shortage of water, the Reclamation Service elected to construct a storage reservoir before construction of the distribution system.[37]

Deadwood Dam

Construction of Deadwood Dam was approved by President Coolidge on October 19, 1928, as an intermediate step in the development of the Payette Division. Bids for construction of the dam and clearing the reservoir area were opened on July 16, 1929. The contract for construction of the dam, appurtenant works, and access road was awarded to the Utah Construction Company of Ogden, Utah, which submitted the low bid of $673,485. The bid did not include the cost of cement, steel, outlet gates, or other materials to be supplied by the government. All bids for clearing of the reservoir area were rejected and the contract readvertised. Revised bids were opened in late August, and the contract was awarded to Holmberg and Norman, of Port Orchard, Washington. Both contracts called for completion in time for storage of spring runoff in 1931.[38]

Each time a new dam is constructed, designers and contractors are faced with a unique set of circumstances that must be accommodated. Those circumstances can range from the type

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37. "Contract with the Black Canyon Irrigation District for Construction of the Payette Division of the Boise Project," *New Reclamation Era*, September 1927, 140-1.

38. R. J. Newell, "Deadwood Dam, Boise Project, Idaho," *New Reclamation Era*, August 1931, 175-179;"Deadwood Dam, Boise Project, Idaho," *New Reclamation Era*, September 1929, 138-139; "Deadwood Dam Construction Approved by President Coolidge," *New Reclamation Era*, December 1928, 181.

and quality of foundation materials to the variability of climactic conditions to the availability of suitable construction materials near the construction site. At Deadwood Dam it was the distance from the nearest railhead to the site that was the most difficult factor to overcome. Deadwood Dam is located on the Deadwood River about 25 miles southeast of Cascade, Idaho, the location of the nearest rail station. But to get there, one must traverse 67 miles of steep mountain roads which are closed by snow from November to June each year. Because of this situation, road construction and improvement was a major portion of the construction contract. Just over 58 miles of the road was a Forest Service road which had to be widened and improved. These improvements were carried out through a cooperative agreement between Reclamation and the Forest Service and were completed during the 1928 and 1929 construction seasons. The remaining portion, about 8½ miles, had to be constructed by the primary contractor and was the first item of construction undertaken following award of the contract.[39]

Construction activities began in early August 1929, with construction of the last 8½ miles of road. Following completion of the road, the contractor erected the construction camp, plant, and sawmill, built a temporary diversion flume for the river, and began excavation of the foundation area before work was shut down for the winter in December. Several men remained at the camp during the winter to care for equipment as did the reservoir clearing crew, which continued to work as much as possible during the winter. Work on Dam construction resumed in mid-March 1930, with the initial force of workers reaching the camp by means of snowshoes or dog sleds. Clearing snow from the road between Cascade and the construction camp took two and a half months and cost more than $8,000.[40]

Because Utah Construction had to have the dam sufficiently complete by the 1931 spring

39. Newell, "Deadwood Dam, Boise Project, Idaho,"; *Dams and Control Works*, 2nd ed., 92.
40. Newell, "Deadwood Dam, Boise Project, Idaho,"; R. J. Newell, "Deadwood Dam Construction Work Controlled by 60-Mile Truck Haul," *Engineering News-Record*, 23 July 1931, 144.

runoff season, it was necessary to complete the majority of the work in only one construction season. To accomplish this, a constant supply of cement needed to be maintained throughout the construction period and there could be no delays in supplying needed materials. Utah Construction sublet the contract for hauling supplies and equipment from the railhead at Cascade to the construction site to Knowles Brothers of Colorado. Knowles Brothers used four specially designed truck/trailer rigs which they had built just for the Deadwood hauling contract. Each truck was equipped with a 200-horsepower motor and four wheel drive, and both the truck and trailer were equipped with air brakes. Each rig could carry 250 sacks of cement, 150 on the truck and 100 on the trailer. Beginning on June 1, 1930, the four trucks made two round trips each day on a schedule that was so tight that backhaul was refused because the extra loading and unloading time would defeat the schedule. To save time, a special system was devised to off-load the sacks of cement. The truck/trailer rigs were tipped by driving the wheels on one side onto an inclined ramp 24 -inches high, and the cement was pushed off the smooth metal decks of the truck/trailer rig. In this manner, a driver could off-load 250 sacks of cement in just five minutes. So tight was the schedule that during the period of peak concrete placement in the dam, the last sack of cement at the dam would be used just as a new load was arriving.[41]

Concrete placement began in early June 1930. Sand and gravel for concrete were obtained from pits along the river channel upstream from the dam. Processed aggregates were transferred from the processing plant directly to the mixing plant by a conveyor belt system. Concrete was mixed in a 2-cy mixer, and the finished product was transported for placement by a 5-ton cableway. The concrete was deposited into a suspended hopper which fed chutes that discharged the concrete into forms. The dam was constructed in 25-foot wide blocks which ran the full thickness of the dam with contraction joints placed between each block. A pipe system

41. Newell, "Deadwood Dam, Boise Project, Idaho."

was installed so that the joints could be sealed after the dam was completely cooled. Reusable wooden forms with sheet metal facing were used. Each form was 26 -feet wide and 8 -feet high, so two, 4 -foot lifts could be placed without having to re-set the form. Concrete placement in the main body of the dam was completed on November 7, and work under the primary contract was completed on November 16, 1930. Grouting of the contraction joints was carried out by government forces in March 1931, and the dam was placed into service for the spring run-off of 1931.[42]

Deadwood Dam is a concrete arch structure with a gravity section tangent to the right abutment. A thrust block is located at the junction between the arch and gravity section to carry the load transmitted by the arch section. The top of the dam is 165 feet above the deepest point of the foundation. The gravity section has a maximum height of 30 feet and is 235 feet long, including the thrust block. The total length of the dam is about 750 feet. The top of the dam is 9 feet wide and the maximum thickness is 62 feet. The dam contains 56,400 cy of concrete. The spillway is a 100-foot wide overflow section located near the center of the dam with a crest 6 feet below the top of the dam. The spillway capacity is 11,300 cfs. The outlet works consist of two, 66 -inch diameter conduits through the base of the dam. Discharges are controlled by two, 54-inch needle valves, each protected by a 4-foot by 6-foot slide gate.[43] The maximum capacity of the outlets works is about 2,000 cfs. Deadwood Reservoir has a maximum capacity of 162,000 af and a surface area of 3,000 acres when full. The primary use of water stored in Deadwood Reservoir is regulation of flows for the Black Canyon Powerplant and irrigation of Payette Division lands.[44]

Completion of Deadwood Dam assured a reliable and consistent supply of water for

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42. *Ibid.*
43. The needle valves were replaced by two jet flow valves in the early 1990s.
44. *Ibid.*; *Project Data*, 45, 50.

power production and irrigation at the Black Canyon Dam. With a reliable supply of water assured, the next step in development of the Payette Division was construction of the gravity distribution system. Funds for construction of the Black Canyon Canal were allocated in December 1935. Construction began in early 1936 and took just over two years to complete. The Black Canyon Canal was dedicated on April 30, 1939, and deliveries of water began soon after. Black Canyon Canal is 29 miles long and has a capacity of 1,300 cfs. Along its route, it passes through nine tunnels and across numerous reaches of bench flume. At the end of the Black Canyon Canal, two smaller canals branch from the main canal. The A Line Canal is 33 miles long and has a capacity of 226 cfs, and the D Line Canal is 39 miles long and has a capacity of 254 cfs. Construction of the A and D Line Canals was completed in 1940.[45]

Anderson Ranch Dam

In the late 1930s, Reclamation engineers began investigating ways to furnish additional water to lands within the Arrowrock Division which often suffered from a lack of water during dry years. In 1938, Reclamation proposed to construct a dam and powerplant on the middle fork of the Boise River to provide additional water to the Arrowrock Division. Before construction could begin, the U.S. Army Corps of Engineers and the U. S. Department of Agriculture, which were making flood and siltation control surveys in the region, determined that the Anderson Ranch site on the South Fork of the Boise River was more desirable from a flood control standpoint. Additional studies were conducted and it was determined that by constructing a dam at the Anderson Ranch site and altering operations at Arrowrock Reservoir, the goal of providing additional water for irrigation while protecting the Boise Valley from floods could be achieved. The studies further revealed that the dam would significantly reduce damage due to siltation. The conclusion of the feasibility studies showed that the annual benefits derived from irrigation,

45. "Thousand Persons Celebrate Delivery of First Water to Payette Division."

flood control, power generation and reductions in siltation damage exceeded the annual costs. Under Section 9 of the Reclamation Project Act of 1939, the project was deemed feasible and submitted for approval. Construction of the dam was approved by the Secretary of the Interior on August 25, 1940.[46]

Appropriations to begin construction were approved by Congress in June 1941. Bids for the primary contract which covered construction of the dam, spillway and outlet works, and the first stage of the powerplant, were opened on July 7, 1941. The contract was awarded to the lowest bidder, a joint venture made up of the Morrison-Knudson Company, Inc., the J. F. Shea Company, Inc., the Ford J. Twaits Company, and the Winston Brothers Company. The low bid was $9,986,203.[47]

Work under the primary contract began in early August 1941. Among the first tasks to be undertaken was diversion of the Boise River around the construction site. This was accomplished by driving a 1,500 foot long, 24 foot diameter tunnel through the left abutment. Following completion of the dam, the tunnel was to be used as part of the outlet system. Excavation of the tunnel began from the outlet end in early November, and took only 80 days. The excavation was carried out in such a manner as to allow concrete lining operations to follow closely behind excavations. Concrete work in the tunnel began in late January 1942, and was completed by mid-May. Immediately following completion of the tunnel, the contractor began construction of a coffer dam to divert the river through the tunnel. The river was successfully diverted through the tunnel on May 18, 1942.[48]

Construction of Anderson Ranch Dam, the highest embankment dam in the world at the time, presented Reclamation engineers and designers with numerous challenges to overcome. In

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46. United States Department of the Interior, Bureau of Reclamation, *Technical Record of Design and Construction, Anderson Ranch Dam and Powerplant*, (Denver: U.S. Government Printing Office, 1956),6-8.
47. *Ibid.*, 145-146.
48. *Ibid.*, 149, 179, 197.

addition to the challenges of constructing an embankment to such unprecedented height, over 450 feet above the deepest point of the foundation, the site conditions also presented numerous challenges. Preliminary investigations of the site revealed a very complicated geology consisting mainly of granite but with numerous areas of intrusive igneous materials. In addition, investigations revealed that much of the rock was extremely broken and deeply weathered. Test drilling in the foundation area revealed granitic bedrock with overburden, materials deposited on the bedrock over time that would have to be removed prior to construction, ranging in thickness from a few feet to more than 140 feet. Tests conducted along the left side of the canyon showed the rock to be severely broken and deeply weathered, a condition not fully appreciated until after construction was well under way. These conditions would force designers to make significant changes in the design and layout of the outlets works.[49]

Stripping of the overburden and excavations for the cutoff trench began in September 1941. Bulldozers working high up on the left abutment pushed dirt and rock downward to the level of the river were it was removed. Work on the right abutment began in November and was carried out in the same manner. Excavations for the cutoff trench in the river channel began in mid-May 1942, immediately following diversion of the river through the diversion tunnel. The cutoff trench was required to be excavated more than 140 feet down to bedrock. The floor of the cutoff trench is 200 feet wide and extends the full width of the valley floor. Excavations progressed at a steady pace and without significant difficulty. Less water than expected was encountered during excavation, and although an elaborate system to keep the area clear of water failed to operate as designed, water in the excavations was not a significant problem. Excavations were completed in September 1942. About 630,000 cy of material was removed

49. *Ibid.*, 9, 13, 17, 43, 59-60, 155, 158.

from the cutoff trench.[50]

When the floor of the cutoff trench had been cleared, work began on the two cutoff walls located in the bottom of the trench. While the cutoff trench provides a keyway to help anchor the dam in place, the cutoff walls provide a seal between the embankment and foundation and help prevent seepage under the dam. The two concrete cutoff walls have a maximum height of 16 feet and have footings that extend 3 or more feet into foundation bedrock and extend across the canyon and up both abutments. To further seal and stabilize the foundation, grout curtains were placed under pressure along both walls. The curtains extend as much as 150 feet into the foundation rock. In addition, the area between the two cutoff walls was thoroughly sealed by blanket grouting up to 30 feet deep.[51]

When the foundation grouting and cutoff walls had been completed, the contractor began backfilling the cutoff trench. The embankment was designed as a zoned embankment with an impervious core zone protected on the upstream and downstream sides by zones of semi-pervious and pervious materials. The area within the cutoff trench was classified as zone 1, requiring backfilling with impervious materials. One of the problems faced by the designers and contractor was locating sufficient embankment materials near the construction site. Most of the material for the impervious core section came from a pit located on a plateau about 2 miles from the site and more than 1,200 feet above the valley floor. Because of the high cost of building haul roads to the pit, the contractor elected to build a conveyor system to move materials from the pit to the construction site. The 2 mile-long belt system moved material at a rate of 550 feet per minute and had a capacity of 900 cy per hour. Materials in the impervious zone were placed in 8-inch layers and compacted by 12 passes of a 20 ton tamping roller. Areas along the cutoff

50. *Ibid.*, 160-161; *Dams and Control Works*, 3rd ed., 106.
51. *Dams and Control Works*, 3rd ed., 104, 106-7.

walls and the abutments were compacted by hand held pneumatic tampers.[52]

Other factors not associated with the design or location of the dam caused significant delays in construction. Following America's entry into World War II in December 1941, material and manpower shortages began to plague the project, and in some cases forced design changes to accommodate the lack of materials. To help alleviate the manpower shortage, Japanese "evacuees" from the detention camp at Hunt, Idaho, were brought to Anderson Ranch. Work progressed until December 26, 1942, when the War Production Board suspended the primary contract and halted all construction except minor work on the outlet works intake, backfilling the cutoff trench, and any work necessary to protect already completed work. At the time work was stopped, the contractor had been progressing steadily on excavations for the spillway, spillway inlet channel, and the powerhouse, as well as constructing the cutoff walls and backfilling the cutoff trench. On October 6, 1943, the War Production Board authorized resumption of construction, without power facilities and spillway gates, as part of the War Food Program to provide additional water for irrigating lands in the Boise Valley. The original contractor signed a new contract on November 14, 1943, which covered completion of the dam and reservoir as authorized by the War Production Board, on a cost-plus-fixed-fee basis.[53]

As work at Anderson Ranch continued, so too did the problems. The original specifications for the outlet works had called for the use of the entire length of the diversion tunnel for the outlet works. But rock conditions near the inlet portal forced Reclamation designers to modify their plan, moving the intake portal upward to a point above the original portal, and constructing an inclined tunnel from the new portal to the diversion tunnel. Excavations for the inclined tunnel had been completed by the contractor prior to suspension of

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52. *Ibid.*, 107.
53. *Technical Record of Design and Construction,* 145,0156, 222; "Project History, Boise Project, 1943-44, Vol 12, 18.

the original contract, but because of several rock slides, particularly one that occurred in May 1943, which dumped 20,000 cy of rock into the inclined tunnel, Reclamation designers once again elected to modify the design for the outlet works. The revised design moved the intake portal to a rock outcropping about 300 feet to the right and slightly upstream from the original location. Excavations of the inclined tunnel to connect the new intake portal with the diversion tunnel began in mid-July 1941, and were completed in October. The original inclined tunnel was sealed by a concrete plug and filled in.[54]

The intake portal was not the only area plagued by slides. Numerous slides occurred in the area of the spillway channel, causing general concern. While most slides create additional work and increase costs and danger, one slide in the spillway area was actually beneficial. In July 1945, blasting in the area of the outlet works caused the hillside above the spillway to begin to move. The effected area extended up the hill for about 500 feet and was between 175 and 195 feet wide. Investigations of the slide area revealed that the material would make excellent embankment material for the semi-pervious and pervious sections of the dam, eliminating the need to obtain materials from other sources farther away from the construction site. A berm was constructed to protect the spillway area from further movement, and the slide material was excavated and placed in the dam embankment, eliminating the threat of further slides.[55]

On October 15, 1945, the War Production Board lifted all restrictions on construction at Anderson Ranch. Reclamation entered into negotiations with the primary contractor on a cost-plus-fixed-fee agreement to complete the dam including the powerplant, penstocks and outlet pipes, spillway gates, and other work previously prohibited by the War Production Board. Due to a general reduction of public works projects and Congress' failure to appropriate sufficient

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54. *Technical Record of Design and Construction,* 179, 183.
55. *Ibid.*, 157-8.

funds for 1947, an a agreement could not be reached, and all work was terminated in early 1948. Specifications for completion of the dam and powerplant were issued in late 1947, with bid opening scheduled for early 1948. The low bid for the completion contract was submitted by J. A. Terteling and Sons, Inc., of Boise, which bid $2,499,364. The notice to proceed was delivered to the contractor on April 1, 1948, and work began immediately.[56]

Work to be competed under the Terteling contract included completion of the crest of the dam, placement of riprap, completion of the spillway and outlet works including excavations and concrete placement, placement of the penstock and outlet pipes, and construction of the powerplant. Excavations for the powerhouse and outlet structures were completed during the 1948 construction season, with excavations for the spillway stilling basin finished in 1949. The major portion of the work on the powerhouse was completed in early 1950, and the first generating unit was installed during the mid-1950. Delays in delivery of the second unit prevented its installation and testing until 1951. All work under the Terteling contract was completed by mid-October 1950, leaving only minor work to be completed. Delayed by material and manpower shortages, unforeseen site conditions, severe weather, and the effects of World War II, Anderson Ranch Dam and Powerplant became fully operational in mid-1951, ten years after construction began.[57]

Anderson Ranch Dam is a zoned earth and rockfilled dam that towers 330 feet above the stream bed and 456 feet above the deepest point of excavation. At the time of its completion, it was the tallest earthfill dam in the world. The crest is 1,400 feet long and 40 feet wide, and the base is 3,000 feet wide from upstream toe to downstream toe. The embankment contains 9,200,000 cy of material. The spillway is an open channel located along the left abutment. It is

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56. *Ibid.*, 145-6.
57. *Ibid.*, 146-147, 183-184, 203-209, 222; D. L. Goodman, "Anderson Ranch Dam and Power Plant," *Water Power*, November 1953, 411-421.

controlled by two, 25- by 22- foot radial gates and has a capacity of 20,000 cfs. The outlet works consist of an intake structure with a 15 foot, 3-inch by 30 foot fixed wheel gate, 420 feet of concrete-lined tunnel leading to just over 900 feet of 15 foot diameter steel pipe. At the downstream end, the pipe branches into three, 90-inch penstocks, and five, 72-inch outlet pipes. The outlets works are controlled by five, 72-inch hollow jets valves each protected by a ring-follower gate which can be closed to allow maintenance or repair of the valve. The outlet works and spillway share a common discharge and stilling basin. The capacity of the outlets works is 10,000 cfs. The powerplant contains two, 13,500 kW generators and was designed and constructed to house a third unit. Water to the turbines is supplied by three, 90-inch penstocks which branch from the outlet pipe. The flow to the turbine units is controlled by 100-inch butterfly valves. When full, Anderson Ranch Reservoir is 13 miles long with a surface area greater than 4,700 acres, and holds just under 500,000 af.[58]

Cascade Dam

Specifications for the construction of Cascade Dam were first issued in 1941, but due to America's entry into World War II, they were withdrawn and plans for construction were placed on hold. A contract for relocation of the Oregon Shortline Railroad around the reservoir site was let, but due to wartime shortages, Reclamation paid the contractor for the completed portion of the contract, about 50%, and canceled the remainder. Following the war, specifications were re-issued, and bids were opened on April 18, 1946. The low bid of $1,396,889 was submitted by the Morrison-Knudsen Company, which received the contract. The contract for construction of Cascade Dam also included the remaining portions of the railroad relocation.[59]

Morrison-Knudsen began work in early June 1946. Excavations for the diversion tunnel

58. *Technical Record of Design and Construction,* frontispiece.
59. "Project History: Boise Project," Vol. 14, 1946, 60.

began in mid-July, and the tunnel was holed through in late August. Concrete lining of the tunnel began September 18 and took one month to complete. The design of the dam called for the tunnel to be used for the outlet works following completion of the dam. Work during the 1946 construction season concentrated on the diversion tunnel, and excavations for the spillway and dam foundation. In addition, some concrete was placed in the trashrack structure and portions of the outlet works. In 1947, work continued in the foundation area and on the cutoff wall. Changes in the design of the spillway necessitated additional excavations and placement of additional backfill behind the spillway walls. By the end of 1947, the embankment was complete, and only minor concrete work and the installation of mechanical equipment remained. Concrete placement was completed in mid-January 1948, the Morrison-Knudsen contract was completed on July 10, 1948.[60]

Cascade Dam is a zoned earthfill dam 107 feet high and 785 feet long. The embankment extends 630 feet from the upstream toe to the downstream toe and contains 395,000 cy of material. The outlet works consist of a concrete lined tunnel through the right abutment which is controlled by two 5-foot by 5-foot high pressure gates. The total capacity of the outlet works is about 2,500 cfs. The spillway is a concrete lined chute at the right abutment that is controlled by two 21-foot by 22-foot radial gates and has a capacity of 12,000 cfs. When full, Cascade Reservoir holds over 703,000 af and has a surface area of more than 26,000 acres. Cascade Reservoir is the largest the five Boise Project reservoirs.[61]

Completion of Cascade Dam assured a reliable supply of water for the Payette Division, but one final piece would be needed to bring the division to its full potential. Between 1946 and 1948, Reclamation constructed the C Line canal system of the Payette Division. The system is

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60. "Project History: Boise Project," Vol. 14, 1946, 60, 62-66; Vol. 15, 1947, 64; Vol. 16, 1948, 36; Vol. 17, 1949, 52.
61. *Project Data*, 51.

fed by the C Line Pumping Plant and supplies water to more than 25,000 acres. The system consists of the C Line Pumping Plant which has five units with a total capacity of 600 cfs. The pumping plant lifts water more than 90 feet into the 21 mile long C Line Canal East. About a mile from the pumping plant, the 24 mile long C Line Canal West branches from the east canal. The east canal as a capacity of 469 cfs and the west canal has a capacity of 60 cfs. The C Line Pumping Plant is located on the Black Canyon Canal about twenty miles below Black Canyon Dam.[62]

Post Construction History

Construction of the Boise Project spanned almost five decades, beginning with the Boise River Diversion Dam, Deer Flat Embankments and main canals in 1906, and ending with the completion of Anderson Ranch Dam in 1950. As a result of this long construction period, many features of the project were transferred from the construction stage to the operation and maintenance stage before work on other features began. The Reclamation Service began operation of the project in 1907, with deliveries through the main canal. Since the diversion dam was not completed at that time, the Service used the old headworks of the New York Canal Company, upstream from the diversion Dam. The Boise River Diversion Dam was placed into service in 1909, with the official opening of the main canal. During the 1909 log run on the Boise River, the boom that directed logs through the logway at the diversion Dam was removed by the director of the log run, allowing logs to go over the main spillway, causing severe damage to the downstream apron of the Dam. Repairs to the apron and modifications to prevent similar incidents in the future took three years and cost over $73,000.[63]

Soon after completion of the Deer Flat Embankments, seepage water began to appear

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62. *Ibid.*, 43, 45-6, 52.
63. "Boise Project, Deer Flat Embankments," HAER No. ID-17-B Vol. II: Historical and Descriptive Data, 38-39; "Project History - Boise Project: Through 1912 and Early History," Vol. I, 43-4.

below the upper embankment. Concerned about the potential loss of structural integrity, Reclamation took measures to alleviate the problem. A well drained gravel blanket 200-feet wide and 1,000-feet long was placed over the area of seepage and a line of sheet piling was driven along the lower edge of the blanket. Drains were provided to remove accumulated seepage. About 78,000 cy of gravel was placed and over 9,000 feet of drains installed. In addition to the work to correct the seepage problem, additional rip-rap and gravel protection was placed on the upstream face of both embankments to prevent erosion from wave action. Modifications were completed in 1911.[64]

Even before the main canal was completed, the Reclamation Service was drawing up plans to increase the capacity of the main canal from 1,500 cfs to more than 2,700 cfs. The plan called for widening the canal from 40 feet to 70 feet to accommodate the increased flow without the danger of erosion of the earthen canal. Work on enlarging the canal began in 1909 and was carried out by a combination of force account and contract. The project was completed in early 1912. The enlarged canal has a capacity of 2,800 cfs and a bottom width of 70 feet. In sections where the canal runs through rock cuts or along steep slopes, it could not be widened, but was instead lined with concrete to eliminate erosion. In all, about 30,000 feet of canal, about 14%, was lined with concrete.[65]

When Reclamation engineers began planning for construction of Arrowrock Dam on the headwaters of the Boise River, they investigated a number of possible solutions to the need for electricity to power construction activities at Arrowrock. After some consideration, they determined that the best course of action was to construct a powerplant at the Boise River Diversion Dam with a two line transmission system from the powerplant to the Arrowrock

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64. Memorandum: Woodby and Hoffman, 22 March 1996; United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910*, (1911), 113.
65. "Project History - Boise Project: Through 1912 and Early History," Vol. I, 75-76; United States Reclamation Service, *Ninth Annual Report of the Reclamation Service, 1909-1910*, (1911), 111.

construction site. While this plan seemed simple enough, it involved several difficulties that needed to be overcome.

When the diversion dam was constructed, there were no provisions made for future power development, and there was only a small area between the canal and logway that could be used for the powerplant. Construction of the powerplant began in June 1911. The area where the powerhouse would be built was directly over two tunnels that had been used to divert the river past the dam during its construction. Reclamation engineers decided to use those tunnels, each about 160 feet long, as discharge tunnels for two generators and to construct a third tunnel for an additional generator. Excavation of the third tunnel was particularly difficult as much of the work was under water and in material that, if allowed to slip or subside, would cause damage to the canal or dam.

The three turbines and other electrical equipment were supplied by General Electric Company and the Allis-Chalmers Company. Because of the limited space available for the facility, designers settled on a vertical shaft design for the turbines. In addition, three large openings to the turbine pits had to be cut through the structure of the dam, significantly reducing the strength and stability of the dam. To make up for the loss of structural integrity, the powerhouse was designed to carry the load usually carried by the dam, and special gates for the turbine pits were designed that, when closed, transferred the load to the walls of the powerhouse and away from the Dam.

Construction of the powerplant was completed in early 1912 and began operation on May 3, 1912. The powerhouse at the Boise River Diversion Dam contains three, 500 kW generators, each driven by a vertical shaft turbine rated at 725 horse-power at 180 revolutions per minute.

The total capacity of the powerplant is 1,500 kW.[66]

The crest of the thirty-foot wide logway at the Boise River Diversion Dam is four-feet lower than the crest of the spillway. Reclamation designers wished to construct a type of gate that would close the logway, providing greater head for both the powerhouse and canal, but could be opened when necessary to pass logs or large floods. After considerable time had been spent attempting to design a gate that could be installed at a reasonable cost, Reclamation designers began to investigate the use of a roller crest. The design, patented by the Maschinen-Fabrik Augsburg-Nurnberg, A. G. Of Germany, consists of a large, hollow cylinder, that, when lowered onto the crest of the dam, raises the water behind the dam an amount equal to the diameter of the cylinder. Each end of the cylinder has a sprocket which engages an inclined track attached to each abutment. The gate is raised and lowered by a cable which attaches to, and partially encircles the cylinder. This design was well suited to the Boise River Diversion Dam because the gate allows the water surface behind the dam to be raised, providing better flows to the powerhouse and canal, but when opened, it allows clear passage for logs and debris, even when the river is running high.

The Reclamation Service began negotiations with the German patent holder in late 1911. Two options were investigated. The patent holder offered to provide all drawing and specifications necessary for the Reclamation Service to advertise for manufacture and installation of the gate by local manufacturers. In return, the patent holder would receive a royalty, which would be included in the cost of the design drawings. The second option called for the patent holder to manufacture and supply all materials necessary for installation of the gate. Estimates indicated that either option would cost about the same, and because of

66. United States Reclamation Service, *Tenth Annual Report of the Reclamation Service, 1910-1911*, (1912), 97; United States Reclamation Service, *Eleventh Annual Report of the Reclamation Service, 1911-1912,* (1913), 4, 73; O. H. Ensign, "A Hydroelectric Plant for Construction Work," *Engineering Record*, 24 August 1912, 209.

Maschinen-Fabrik's experience with the manufacture and installation of roller gates, the Reclamation Service elected to go with the second option.

The Reclamation Service entered into a contract with Maschinen-Fabrik on June 12, 1912, and preparation for installation of the gate began in August. To accommodate the gate, it was necessary to modify the piers on either side of the logway to allow installation of the inclined track on which the gate would ride. It was also necessary to raise both piers. Materials and equipment for the roller crest were delivered to the dam on January 3, 1913, and the assembly and installation of the gate was completed on February 8, 1913.[67]

For ten years following its completion, Arrowrock Dam stood as the tallest dam in the world. That title was taken over in 1925 by the Schraeh Dam outside Zurich, Switzerland, with a height of 362 feet. The construction of Schraeh Dam marked the beginning of an era of dam building worldwide that pushed the heights of dams further and further, culminating with the construction of Hoover Dam in 1936, at a height of 725 feet.[68]

Soon after the completion of Arrowrock Dam, it became apparent that the use of sand-cement, although effective in reducing temperatures and material costs, had significant drawbacks. The material proved to be highly absorbent, resulting in significant deterioration due to freezing and thawing. In 1927, Reclamation engineers realized that measures would have to be taken to protect the dam from further deterioration. In 1935, $600,000 was appropriated for repairs on the dam and spillway. The contract for the repair work was awarded to T. E. Connelly, Inc., of San Francisco.

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67. Charles H. Paul, "Rolling Dam of the Boise Project," *Engineering Record*, 2 August 1913, 125; Denver, National Archives and Records Administration, Rocky Mountain Region, Records of the Bureau of Reclamation, Records Group 115, Reclamation Headquarters Group, Entry 10, "Boise Project - Storage Unit; Annual Report for 1913," 2; United States Reclamation Service, *Thirteenth Annual Report of the Reclamation Service, 1913-1914*, (1915), 107.

68. "Arrowrock Dam Topped by 362-foot Swiss Dam," *New Reclamation Era*, November, 1928, 176; *Project Data*, 86.

Repairs consisted of the placement of an 18-inch thick concrete slab on the downstream face of the dam from about 20-feet below the crest down to the lowest point of the dam. To gain access to the downstream toe of the dam, a coffer dam was constructed just upstream from the outlet portal of the original diversion tunnel, and the area between the coffer dam and main dam was then pumped clear of water. During repairs, releases for irrigation were made through three of the lower outlet conduits, which were connected to the lower portion of the original diversion tunnel by a second tunnel that had been constructed just for this purpose. In addition to placement of the concrete slab, the upper twenty feet of the dam was covered with gunite. The concrete in the spillway channel had suffered damage as well, and the floor of the channel was covered with a reinforced concrete slab, and the sides of the channel received a layer of gunite reinforced with steel mesh. At the same time the repairs were being made, the crest of the dam and spillway was raised 5 feet to provide greater storage.[69]

In 1955, the U.S. Army Corps of Engineers completed construction of Lucky Peak Dam, about a mile upstream from the Boise Diversion Dam. Lucky Peak Reservoir, with a capacity of 278,000 af, extends upriver to Arrowrock Dam, and when full, partially submerges the downstream face of Arrowrock Dam. Lucky Peak is operated primarily for flood control purposes and irrigation releases from Arrowrock Reservoir are allowed to pass through Lucky Peak. Lucky Peak, Arrowrock , and Anderson Ranch Reservoirs on the Boise River system are operated jointly to provide maximum benefits for irrigation, hydropower production and flood control.[70]

Settlement of Project Lands

Initially, most of the lands under the Boise Project were in private ownership or held by

69. Department of the Interior, Bureau of Reclamation, *Dams and Control Works*, 3rd ed., (Washington: U. S. Government Printing Office, 1954), 66.

70. *Project Data*, 43; Department of the Interior, Bureau of Reclamation, *Statistical Compilation of Engineering Features on Bureau of Reclamation Projects*, (Denver: U.S. Government Printing Office, 1992), 20.

the state of Idaho. The first withdrawals of lands under the Reclamation Act took place in March 1903 when all unentered public lands in the project area were temporarily withdrawn pending surveys. By 1908, most of the lands withdrawn in 1903 had been entered even though it would be several years before water would be available. In July 1908, all unentered lands within the project area were withdrawn from any form of entry, but only about 90 farm units remained unentered at that time. By 1910, 85,820 acres had been entered under the Reclamation Act, and in 1912, there were 2,700 farms on the project with a population of more than 9,000 people. In 1915, the remaining 90 unentered farm units were opened for entry and immediately taken up. In addition, 9,000 acres of state held lands were sold at action and entered by settlers.

Settlement of the Boise Project continued at a steady pace. As new project lands were opened they were immediately entered and placed under cultivation. In 1915, more than 12,500 people lived on project farms. By 1923, that number had grown to 14,700 people living on 4,900 farms, with 36,170 people living in nearby towns. At that time, more than 67,000 acres of public lands had been entered for settlement. In 1930, the number of farms had decreased to slightly less than 4,200, but the farm population had risen to 15,400. By 1940, the number of farms had fallen further, totaling 4,050 units with a population of about 16,000 people. Completion of the distribution system of the Payette Division provided stimulus for further settlement as new lands were made available for entry. Forty-six new farm units were opened in the early 1940s with another 50 units opened in 1950. In 1950, the number of farms had risen to 4,693 with a population of 12,700 people. The number of project farms continued to grow throughout the 1950s. In 1960, there were 7,951 farms with more than 26,000 people which received all or part of their water supply from Reclamation. In addition, water supplied for residential, commercial and industrial uses provided benefits to more than 60,000 additional people in the region.[71]

Today, the Boise Project supplies water to more than 8,900 farm units with a population of just over 28,200 people. In addition, more than 110,000 non-farm water users benefit from Boise Project deliveries.[72]

Project Benefits and Uses of Project Water

The Boise Project is a multi-purpose water resource development project that provides a wide range of benefits to the citizens of southwestern Idaho. The primary benefit realized from the operation of the Boise Project is irrigation. In 1992, project lands comprised more than 397,000 acres, of which, just over 334,800 acres received project-supplied water. Many different varieties of crops are grown on project lands including more than 69,000 acres of cereal crops, 131,000 acres of forage crops, 20,000 acres of vegetables, 29,000 acres of seed crops, and more than 12,000 acres dedicated to fruit production. In 1992, the total value of crops grown on project lands exceeded $182,739,000 with a value per-acre of slightly more than $561.00.[73]

Hydroelectric power is another benefit of the Boise Project. Since the first unit at the Boise River Diversion Dam went into service in 1912, the project's hydropower units have generated more than 10,217,000,000 kilowatt-hours (kWh) of electricity for the people of the northwest. At present, the generating units of the Boise River Diversion Dam are maintained at operational readiness, but are only used for emergency backup. Plans are currently underway to rebuild the plant, increasing its capacity from 1,500 kW to 2,100 kW. Plans to install a third unit at Anderson Ranch have been placed on hold. Electricity generated by Boise Project units provides energy for pumping water on the Boise Project as well as the Minidoka Project and

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71. Information of project settlement taken from Annual Reports for years 1903-04, 1907-08, 1909-10, 1912-13, 1914-15, 1915-16, 1930, 1940, and 1950. Additional information taken from *Reclamation Crop Reports and Related Data* for years 1950 and 1960.
72. Department of the Interior, Bureau of Reclamation, *1992 Summary Statistics, Water, Land, and Related Data*. (Denver: U.S. Government Printing Office, 1995), 60, 63.
73. *Ibid.*, 149.

Owyhee Project. Surplus power is marketed by the Bonneville Power Administration.[74]

The six reservoirs that comprise the storage and regulating features of the Boise Project provide extensive recreational opportunities for the residents of southwestern Idaho. More than 21,000 acres of lands and 48,000 acres of water surface are open to recreational activities which range from fishing and hunting to camping, boating and sightseeing. In addition to recreational benefits, the benefits to fish and wildlife are numerous. About 1,100 acres of land upstream from Black Canyon Reservoir in the Montour Valley has been acquired and is managed as a wildlife and recreation area and is visited annually by millions of waterfowl. The area around Lake Lowell is home to the Deer Flat National Wildlife Refuge, and about one-third of the land surrounding Anderson Ranch Reservoir has been set aside as a game management area. Recreational and wildlife management activities at Anderson Ranch, Arrowrock, and Deadwood Reservoirs are administered by the U. S. Forest Service. The Bureau of Reclamation manages activities at Black Canyon Reservoir, Boise River Diversion Dam, and the Montour Wildlife Recreation Management Area. Reclamation and the Forest Service share management of Cascade Reservoir. Lake Lowell and the Deer Flat National Wildlife Refuge is managed by the U. S. Fish and Wildlife Service.[75]

In addition to the many other project benefits, units of the Boise Project also provide a degree of flood protection along stretches of the Boise and Payette Rivers. Arrowrock and Anderson Ranch Dams are operated in coordination with the U. S. Army Corps of Engineers' Lucky Peak Reservoir under a formal agreement to maintain the Boise River at a safe level during times of high run-off or peak flows. Cascade and Deadwood Dams are operated under an informal agreement and help to keep flows of the Payette River at safe levels. Since 1950,

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74. Ibid, 131; Project Data, 48; Department of the Interior, Bureau of Reclamation, *Generations, A New Era of Power, Performance, and Progress*, (Denver: U.S. Government Printing Office, 1997), PN-C2.

75. *1992 Summary Statistics*, 107; *Project Data*, 48.

Anderson Ranch and Arrowrock Dams, working in conjunction with Lucky Peak Reservoir, have prevented $249,286,000 in flood damages along the Boise River and in the City of Boise. During that same period, Cascade and Deadwood Dams have prevented damages valued at more than $33,400,000 along the Payette River.[76]

Conclusion

The development of the Boise Project spanned more than four decades and included the construction of two of the then-highest dams in the world. Today the project covers almost 400,000 acres of lands where once only desert grasses grew, and is one of the most productive agricultural regions in the United States. Throughout the twentieth century, the Boise Project has successfully met the challenge of reclaiming the arid and semi-arid regions of southwestern Idaho and putting them to beneficial use. But as the Bureau of Reclamation enters its second century, new challenges have arisen that must be met. Today, concerns over the environment, fish and wildlife, and the explosive growth of the West are placing new demands upon the West's waters and those who manage them. After almost a century of successfully meeting the challenges before it, the Boise Project stands ready to meet the new challenges of the twenty-first century.

About the Author

William Joe Simonds was born and raised in Colorado and has a clear understanding of the importance of water in the American West and its influence on the development of that region. He attended Colorado State University where he received a BA in History in 1992 and a Masters in Public History in 1995. He lives with his wife and two children in Fort Collins, Colorado.

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76. Memorandum: Max Van Den Berg, Regional Manager of Resource and Technical Services [Pacific Northwest Region], to Manager, Water, Land, and Cultural Resources. 1995 Flood Control Benefits Report, 21 June 1996 (on file in the Land, Recreation, and Cultural Resources Office, Program, Analysis Office, Bureau of Reclamation).

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