HISTORIC AMERICAN ENGINEERING RECORD

Documentation of
The U.S. Bureau of Reclamation's

GRAND VALLEY DIVERSION DAM, 1913-1916

On the Colorado River
Cameo vicinity, Mesa County, Utah

by

Ann Emmons

Under the direction of

Jonathon C. Horn
Principle Investigator

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for

Bureau of Reclamation
835 E. 2nd St.
Durango, Colorado 81301

June 2004

United States Department of the Interior

NATIONAL PARK SERVICE
INTERMOUNTAIN REGION
12795 West Alameda Parkway
PO Box 25287
Denver, Colorado 80225-0287

H40 (IMDE- ONR) HAER

November 5, 2004

Jonathon C. Horn
Alpine Archaeological Consultants, Inc.
P.O. Box 2075
Montrose, CO 81402

Dear Mr. Horn:

We are pleased to inform you that we have reviewed and accepted the Historic American Engineering Record (HAER) documentation for the Grand Valley Diversion Dam in Mesa County, HAER No. CO- 90. We will transmit the documentation to the Library of Congress for permanent storage.

Thank you for providing these documents. We appreciate your commitment to the recordation of our nation's endangered historic resources.

Sincerely,

Lysa Wegman-French

Lysa Wegman- French, Historian
Heritage Partnerships Program

cc:
CO SHPO, HABS/HAER contact

GRAND VALLEY DIVERSION DAM **CO-90**
ONE HALF MILE NORTH OF INTERSTATE 70 AND COLORADO STATE ROUTE 65
CAMEO VICINITY
MESA COUNTY
COLORADO

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
GRAND VALLEY DIVERSION DAM

HAER No. CO-90

Location: One-half mile north of Interstate 70 and Colorado State Route 65, Cameo vicinity, Mesa County, Colorado.

Quadrangle: Cameo, Colorado 1955 7.5-minute

UTM: Zone 12; 734800 mE, 4341050 mN

Construction Date: 1913-1916

Design: Roller gates (and all associated components): Machinenfabrik Augsburg-Nurnberg A. G. (Germany); F. Teichman and C.H. Branscombe, United States Department of Interior Reclamation Service

Dam: E. E. Sands, J. H. Miner; F. Teichman, O.T. Reedy, S. O. Harper

Construction: Project review and oversight: U.S. Reclamation Service

O. T. Reedy, Construction Engineer
J. H. Miner, Project Manager
S. O. Harper, Project Manager

Materials: Cement: Iola Portland Cement Co.
Power: Grand Junction Mining & Fuel Co.
Coal: Grand Junction Mining & Fuel Co.

Manufacturing: Steel rollers: Riter-Conley Manufacturing Co., Pittsburgh
Steel roller Inspection: Pittsburgh Testing Laboratory
Operating hoist, 70' gates: Minneapolis Steel & Machinery Co.
Operating hoist, 60' gate: Link-Belt Co., Chicago
Chain shafts and chains for rolling gates: Lakeside Bridge & Steel Company
Cast-steel toothed racks (piers) and toothed rims (rollers): Machinenfabrik Augsburg-Nurnberg A. G. (Germany)
Electrical equipment for rolling and regulator gates: Westinghouse Electric Co.; General Electric Co.
Canal intake regulator gates: Hinman Hydraulic Manufacturing Co.

Present Owner: U.S. Bureau of Reclamation, Grand Junction, Colorado.

Present Use: The Grand Valley Diversion Dam continues as the key feature of the Grand Valley Project constructed to provide irrigation water from the Colorado River to the semi-arid Grand Valley in the vicinity of Grand Junction, Colorado. Water is diverted by the dam into the Government Highline Canal and distributed to 42,000 acres of land through a series of laterals and ditches.

Significance: The Grand Valley Diversion Dam, constructed between 1913 and 1916, is the key structure of the Bureau of Reclamation's Grand Valley Project, which provides water to 42,000 acres of semi-arid land. At the time of its completion in the spring of 1916, the dam was one of only three American dams to utilize innovative gate technology first employed in Germany in 1902. The Grand Valley dam would later serve as the prototype for the Army Corps of Engineers' massive system of locks and dams on the Mississippi River. The project stands as an early representative example of federal involvement in western land development. The dam's roller gates were built by American manufacturers, from German design, during the early years of WWI; this process of roller-gate design and manufacture contributes to our understanding of wartime disruption of business partnerships and economic development. This relationship and the disruption by WWI resulted in American engineers gaining experience in the design fabrication and erection of roller gates.

Project Statement: This HAER project was undertaken by the U.S. Bureau of Reclamation in order to document the historic features of the dam prior to modification of the easternmost roller bay for the passage of endangered fish. Construction of the fish passage took place during the winter of 2003 and 2004. The fieldwork, historical reports, and photographs were prepared by Alpine Archaeological Consultants, Inc., Montrose Colorado. Jonathon C. Horn served as the Principal Investigator, Gianfranco Archimede conducted the historic research and large-format photography, and Ann Emmons conducted additional historical research and prepared the report narrative.

Historian: Ann Emmons, Missoula, Montana, June 2004.

A. PHYSICAL DESCRIPTION

Summary

In 1913, on the eve of its construction, United States Reclamation Service engineers succinctly described the Grand Valley Project. "The irrigation plan provides for the diversion of water from the Grand [Colorado] River[1] by a dam about eight miles northeast of Palisade, Colorado, into a canal system on the north side of the river, for the irrigation of 53,000 acres of land lying north and west of Grand Junction, Fruita, and Mack, Colorado."[2]

Though acre estimates proved overly optimistic, the project was built largely as planned and today provides for the irrigation of 42,000 acres, planted primarily to fruit, alfalfa, beans, wheat, and sugar beets. Structures integral to the industrial system include the Grand Valley Diversion Dam, 90 miles of canal (with three tunnels), 166 miles of lateral ditches, 165 miles of drainage pipe, two pumping plants, and a small powerplant (3,000 kW) added to the project in 1933 and today leased to the Public Service Company of Colorado. See Figure 1.[3]

In 2003, in compliance with the National Environmental Policy Act and the Endangered Species Act, the Bureau of Reclamation began construction of an upstream fish passage for the endangered Colorado pike minnow and the razorback sucker. Upon completion, this 660'-long concrete passage will project through the ogee weir of the eastern roller bay of the Diversion Dam (see Photographs 4-5). In addition to this alteration of the dam core, the passage and associated guide walls and fish trap will significantly alter the east abutment wing wall.[4]

Diversion Dam

The Grand Valley Diversion Dam extends 25' above and 546' across the Colorado River at the mouth of DeBeque Canyon (aka Gore), from which

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[1] The Grand River was officially renamed the Colorado River in 1921. In the interest of clarity, and except in direct quotes, this current report uses Colorado River.

[2] J. H. Miner, Project Manager, "General Project Statement," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1913, Volume I." Grand Valley Water Users Association, Grand Junction, Colorado, p. 3. [Note: all page numbers refer to the original report, not to pagination added in the subsequent compilation.]

[3] Bureau of Reclamation, "Grand Valley Project," *Project Data* (Denver: USDI Water and Power Resources Services, 1981), p. 3.

[4] U.S. Army Corps of Engineers, *Public Notice Number 200275143* (Application for a Department of the Army permit under authority of Section 404 of the Clean Water Act; Michael Baker, Bureau of Reclamation, applicant), April 9, 2002. See, http://www.spk.usace.army.mil/pub/outgoing/co/reg/pn/200275143.pdf.

point it diverts water to the High Line Canal. The gravity dam[5] is composed of a concrete masonry ogee weir with upstream and downstream aprons, an integrated spillway and canal headgate, and seven roller gates. The dam provides sufficient water storage to allow continual dry-season supply to project lands, while also allowing sufficient wet-season river flow to prevent inundation of the railroad tracks that parallel the river's west bank, a mere 3' above the high-water mark. See Photographs 1-3.

A 546'-long concrete ogee weir forms the main body of the dam. This structure, built between 1913 and 1915 in advance of roller-gate manufacture and installation, extends 6' above the low point in the river bed and is founded on a sand and course-gravel foundation set 10'-15' below grade. The sluiceway and High Line Canal intake structure (see below) are integral to the dam, forming part of the west abutment. Eight massive piers (each designed as two interlocked structures: an upstream and a downstream "nose") extend above the weir and anchor the roller gates that control 480' of the weir crest. The dam is designed to pass a maximum anticipated flood flow of 75,000 cubic feet per second (cfs) and to divert a maximum flow of 1,675 cfs, the capacity of the High Line Canal.

Eight concrete masonry piers extend from the cutoff trench/dam foundation, above the ogee weir, and secure each end of the roller gates. These piers are lettered sequentially, beginning with "a" at the dam's east abutment and continuing to "h" at the sluiceway wall.[6] Each pier is constructed with a lateral recess that holds a gate rack and guards. Every other pier (b, d, f, and h) also supports a gatehouse, or "hoisthouse," that houses the hoisting mechanism for the two adjoining gates. (Hoisting mechanisms only operate one end of the rolling cylinder, with the uniform advance of both ends assured by the toothed rims that engage a rack fixed in the masonry of each opposing pier. Thus, for example, the hoisthouse on easternmost pier b manipulates the west end of the first rolling crest and the east end of the second crest.) The gatehouse on pier h, housing the gate controls for the sluiceway, is larger than the other three and historically provided on-site administrative space and served as the dam's "entrance."

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[5] The Grand Valley dam, engineer F. Teichman reported, "was made unusually heavy to resist sliding." Cited in Editor, "Building the Rolling-Crest Dam Across Grand River," *Engineering News* 76 (July 13, 1916), p. 60. All dams can be classified as one of two dam types: "massive" or "structural." The massive tradition includes all gravity dams wherein stability is provided solely by the weight of the material used. The structural tradition encompasses those dams where stability is provided not be gravity but by structural design, most-often arches or buttresses. Eric B. Kollgaard and Wallace L. Chadwick, eds., *Development of Dam Engineering in the United States* (New York: Pergamon Press, 1988), p. 13.

[6] Pier h functions structurally as the dam's west abutment. Reedy, "Feature History, Grand River Diversion Dam, 1914," File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1914," p. 13.

As at the time of dam construction, a generator set powers the rolling crests and regulator gates.[7] The permanent power plant and auxiliary back-up batteries are located in the detached "power house" set on the training wall just downstream from pier h. See Photographs 3, 6-9.

Auxiliary structures tied to the dam, yet not essential to its design or operation, include heavy riprap placed for a distance of 1200' below the downstream apron (repaired and replaced in 1959); a concrete masonry training wall set below the sluiceway tailrace; an upstream wingwall at the east dam abutment, designed to protect the adjacent, but no longer present, Orchard Mesa Canal bank; paved upstream and downstream banks (to prevent scour); and a pedestrian-access steel service bridge extending the full length of the dam and providing maintenance access to each pier and gatehouse. The service bridge consists of seven three-hinge arch spans, each arch end secured to a dam pier and each span corresponding to the length of the respective roller gates. See Photographs 1, 5, 8, 13. Historic resources associated with dam construction and use, and yet located outside the boundaries of the National Register site, are limited to a small wood-frame caretaker's house and small-scale storage facilities located on the west training wall, between the river and the High Line Canal.

Removed resources include the construction camp once located on the west riverbank, upstream and downstream from the dam (see Photographs 44 and 45). The construction plant (including a cross-river cableway and associated trestles; a pile bridge across the river; and a concrete screening and mixing plant) has also been removed. These resources were designed and built to be temporary and their loss does not adversely affect the integrity of the dam.

Sluiceway and Headgate

The concrete sluiceway, at the dam's west abutment, is also controlled by a rolling gate (see below). Nine gates, each with a 7'-square opening, regulate the flow from the west wall of the sluiceway into the canal; eight of these gates can convey the required capacity of the canal (1,625 cfs), "thus allowing for one gate being out of commission." The gate openings are set 6.25' above the entrance to the sluiceway, assuring that water is drawn from the river's upper strata, where it is less subject to the extensive silt common in the lower strata.[8] See Photographs 6-10.

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[7] The original generators were replaced in 1951.

[8] O. T. Reedy, Engineer, "Grand River Diversion Dam," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1913, Volume I."

Roller Gates

Movable roller gates, or crests, block the river's flow, leading to frequent descriptions of the dam as a "movable dam." The roller gates are mounted between the piers and are designed to rotate between a low point, flush with the sill of the ogee weir, and a high point, 3' above the high water mark, sufficient to allow passage of flood waters and river debris (see Photographs 11-12).[9]. Each roller, in the down position, extends 10' above the crest of the concrete weir, for a total hydraulic height of 14'. Six of the seven roller gates are 70' long and 10' 3" tall, whereas the seventh, controlling the sluiceway at the west end of the dam, is 60' long and 15' 4" tall. This greater height is demanded by the sluiceway sill, set 5' below the crest of the ogee weir, a design that allows water distribution to the sluiceway and canal even during times of extreme low river flow (see Photograph 13).

At their lowered position, the rollers are "sealed" to the dam sill, largely by water pressure and the full weight of the roller, though also by steel silt shields keyed to a sill and pier strip, braced to the crest and sides of the cylinders with struts, and sufficiently elastic that water pressure deflects them against the sill and against the walls of the piers (see Photograph 12). On the Grand River Dam, these silt shields represent one of the few modifications to the standard German design. (See Design and Construction, below.)

The roller gates, with toothed rims attached to each end, extend between piers that house toothed gate racks. The rollers are raised and lowered by means of a heavy chain that is attached to, and partly encircles, the roller and also connects to a large hoist. The hoist mechanisms for raising and lowering the rollers are located in the gatehouses set above the piers (see Photographs 13-15). At the time of construction, the operating mechanism for each gate consisted of a "specially designed" chain with tensile strength exceeding 80,000 pounds per square inch and an electric motor[10] that rotated the main chain shaft and 8-tooth sprocket; both the original chains and the motors were replaced between 1951 and 1959. Each gate can be raised from the lowest to the highest position in only 15 minutes - a point of critical concern on a river prone to flash flood.[11]

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[9] During construction, gates were designated according to support piers. Gate "ab," for example, is suspended between piers a and b.

[10] 10 hp for the 70' gates and 20 hp for the 60' gate. Harper, "Operation of Grand River Roller Dam Proves Satisfactory," *Engineering News-Record* 80 (June 1918), pp. 1225.

[11] Anonymous, "Grand Valley Roller Crest and Accessories Weigh About 280 Tons," *Engineering Record*. 72 (August 1915), p. 209; Harper, "Operation of Grand River Roller Dam Proves Satisfactory," p. 1225.

In 1913, Engineer A. G. Hillberg described roller-gate operation to an interested engineering community. Despite the replacement of worn chains and outdated motors, the Grand Valley gates continue to operate according to this general description:

> A watertight steel cylinder rolls on inclined rails supported in lateral recesses in masonry piers. In its lowered position [the cylinder] serves as a dam and when opened is suspended out of reach of floating matter. It is manipulated by a chain ... wound around one end. The uniform advance of both ends in raising or lowering is insured by gearing, each end carrying a toothed rim engaging a rack fixed on the masonry. ... The operating machinery is placed at one end of the cylinder. ... It consists mainly of a self-locking winch, actuated by an electric motor, with a hand crab for emergency use.[12]

B. PROJECT HISTORY

In 1902, under the leadership of President Theodore Roosevelt and after years of rancorous debate, the United States Congress passed the Reclamation Act. The Act created a federal Reclamation Service[13] and acknowledged both the federal government's legitimate interest in western agricultural development and settlement and also the high cost of irrigating arid western lands.[14] More specifically, the act established that the Secretary of the Interior could fund those reclamation projects deemed "practicable" by agency engineers, provided that sufficient funds were available in the Reclamation Fund (funded through the sale of public lands). Water from a federal reclamation project could be distributed to public and private lands. To receive water, project beneficiaries had to repay annual maintenance costs and return the cost of construction in full, interest free, within 10 years. [15]

Between 1902 and 1930, the nascent Reclamation Service developed and funded 38 projects in 15 states, at a total financial commitment of $394 million. These projects included Colorado's Grand Valley Project. Each project dramatically impacted the economic, social, and cultural history of adjacent communities: "few measures," historian Marc Reisner writes, "can

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[12] Hillberg, "Design of Rolling Dams," p. 654.

[13] The Reclamation Service is restricted to projects in the arid western states east of the Mississippi. From inception in 1902 until 1907, the Reclamation Service was administered through the United States Geological Survey (USGS). In 1907, the Secretary of the Interior established the service as a distinct agency within the United States Department of the Interior. In 1923, the Reclamation Service was renamed the Bureau of Reclamation.

[14] In later versions of the Act, the repayment period has been extended to 50 years. Even with these concessions, only a fraction of construction costs are ever recovered. Barbara T. Andrews and Marie Sansone, *Who Runs the Rivers? Dams and Decisions in the New West* (Stanford, California: Stanford Law School, 1983), pp. 173, 176.

[15] Andrews and Sansone, *Who Runs the Rivers?*, p. 5.The Reclamation Service is restricted to projects in the arid western states east of the Mississippi.

be said to have shaped the politics, the economy, the topography, and the essential character of a region as dramatically as this single piece of legislation."[16]

Three dominant themes run throughout the institutional history of the Reclamation Service, linking the disparate engineering and construction histories of each project: 1) the conflict between private enterprise and the federal government; 2) the tension between the Reclamation Service's promises of agricultural wealth and small, if prosperous, family farms and the realities of corporate land consolidation and fickle weather, market, and stream flow; and, 3) the tension between watering arid land and caring for the native flora and fauna dependent upon the rivers that flow through that land. Each of these themes is represented in the history of the Grand Valley Project.

The General Land Office opened the Grand Valley to settlement on September 4, 1881, less than a month after federal troops removed the Ute tribe to Utah's Uintah reservation and only 10 years after geologists with the USGS Hayden Expedition described the region as "for the most part, a desert."[17] Pioneer settlers immediately began efforts to irrigate the flat and fertile bench lands above the Colorado River, constructing four ditch systems sufficient to water those 45,000 acres "that could be watered at low cost."[18] In 1886, ownership and operation of these ditches and attendant water rights was consolidated under the Grand Valley Irrigation Company, a private enterprise. Eager to capitalize on the potential for increased land values on unirrigated land on the "second mesa," lying above the reach of the existing irrigation systems, the company sought to construct a high line canal "diverting from the north [or west] side of the Grand River and beginning at a point far enough up the canyon to permit the use of a low diversion dam."[19]

The challenge proved daunting to developers who, in league with other developers throughout the West, struggled to attract sufficient funds to construct irrigation facilities in advance of settlement.[20] Immediately following passage of the Reclamation Act, local farmers and representatives

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[16] Quoted in Andrews and Sansone, *Who Runs the Rivers?*, p. 172.
[17] S. O. Harper, Assistant Engineer, "Early History – Previous to 1907," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1913, Volume I."
[18] George Wharton James, *Reclaiming the Arid West. The Story of the United States Reclamation Service*. (New York: Dodd, Mead and Company, 1917), p. 118. James' text is a verbatim transcription of Harper, "Early History – Previous to 1907."
[19] Harper, "Early History – Previous to 1907," p. 27.
[20] See, for example, T. C. Henry, *Chicago Sun Times*, September 7, 1904, reprinted in *Daily News Weekly*, under the headline "Hurrah for the Big Ditch. T. C. Henry Admits Private Plan a Failure and Advises that Government be Invited to Build it." File: Project Clipping File, Grand Valley Water Users Association.

of the Grand Junction Chamber of Commerce requested that the Reclamation Service assume responsibility for the proposed "High Line" project. Chief Engineer A. P. Davis visited the project on June 10, 1902 and reported favorably on its merits and on the region's agricultural potential: "a line can be located and constructed in Grand Valley such that the cost of construction will be less than the value of the lands reclaimed."[21] In one of his first actions under the terms of the Reclamation Act, on July 2, 1902 the Secretary of the Interior directed the General Land Office to withdraw all public domain lands lying within reach of a high line canal from homestead entry, to discourage land speculation.[22]

Ironically, Davis's report would slow project development, as private investors attempted to leverage his praise: assistant project engineer S. O. Harper wrote, "relying upon the favourable reports made by the engineers of the Reclamation Service to secure the capital necessary to build the canal, these persons saw an opportunity to reap promoters' profits, which would be lost if the work were done by the government."[23] The Reclamation Service deferred to private enterprise and entrepreneurial zeal until 1907 when a faction of area businessmen – citing a complete lack of progress on the privately-funded project – again solicited federal involvement. The Reclamation Service again responded with a grand vision. "I know of few localities in the arid region equally attractive for the inauguration of a reclamation project," Secretary of Interior James Rudolph Garfield wrote area citizens. Reclamation Service engineer E. E. Sands excited an enthusiastic gathering of local farmers, politicians, and business men to near riot with his promise that "here were 70,000 acres of the very best land to be found in this wide, wide world, waiting for the government to put water on it."[24]

In late December 1907, the Reclamation Service established an office in Grand Junction and allotted $50,000 from the Reclamation Fund, sufficient to initiate preliminary surveys, preparation of design plans, and right-of-way acquisition. This acquisition included canal right-of-way through lands of the Orchard Mesa Irrigation District, an entity advocating for

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[21] Cited in Harper, "Early History – Previous to 1907," p. 36.
[22] Harper, "Early History – Previous to 1907," p. 11.
[23] Harper, "Early History – Previous to 1907," p. 37; see also James, *Reclaiming the Arid West*, pp. 119-120.
[24] James B. Young, Secretary Colorado State Commercial Association, "Great Prosperity for Grand Valley," *Daily News Weekly*, November 21, 1907. File: Project Clipping File. Newspaper accounts of Sand's speech vary. On November 20, an anonymous reporter quotes Sand as claiming that the land proposed for reclamation "WAS THE BEST LAND IN THE WORLD. Anonymous, "Government's Offer Accepted," *Daily News Weekly*, Grand Junction, November 20, 1907. Emphasis in original.

private construction and hostile to the government's action.[25] In March 1908, to considerable attention in the local press, crews under the direction of assistant Project Engineer S. O. Harper established a base camp in Gore [DeBeque] Canyon, determined possible sites for the diversion dam, and ran the preliminary lines for the first 6 miles of the High Line Canal. Ten months later, on December 10, 1908, Reclamation Service engineers submitted a construction plan to a consulting board of engineers and proposed to begin dam and canal construction the spring of 1909 with private funds secured through a proposed cooperative agreement with the Grand Valley Water Users Association.[26] As specified in the construction plan, the location of the upper 3 miles of the canal would not be publicly revealed until construction began, pending legal settlement with the Orchard Mesa district. The type of diversion dam, dependent upon additional engineering studies and bearing on both water right and right-of-way acquisition, would also not be determined until "the time approached for its construction."[27]

The Reclamation Service approved the plan, signed the cooperative funding agreement with the Water Users Association, and reached tentative agreement with the Orchard Mesa Irrigation Company on the value of its right-of-way and the volume of its water right. In late April 1909 – 23 years after residents first conceived of the project, and seven years after the Reclamation Service's first statement of interest – crews began construction of a temporary camp at the site of one of the three proposed canal tunnels.[28]

All construction halted on May 4, 1909, as the Reclamation Service found itself embroiled not in water or rock, but lawsuit. Unidentified local parties had questioned the legality of the Reclamation Service's cooperative funding agreement with the Water Users Association. Reclamation Service director F. H. Newell submitted the agreement to legal review and on June 2, the United States Attorney General declared the cooperative agreement unlawful. Construction stalled for two years as the Reclamation Service developed alternative funding agreements and, in response to subsequent

[25] For a more complete history of the Orchard Valley Irrigation District, as related to Grand Valley Project development, see Harper, "Early History – Previous to 1907," pp. 9-12.
[26] The agreement is complicated, and not directly relevant to the ultimate design or use of project facilities. In brief, it established that the Water Users Association, to assure rapid project construction, would issue certificates in payment for work and labor and materials furnished. Upon project completion, these certificates would be used to reduce construction charges against land within the project. The Reclamation Service was, in effect, funding the project not through the rapidly diminishing Reclamation Fund but through loans from project users. See Harper, "Early History – Previous to 1907,"pp. 31-33.
[27] Harper, "Early History – Previous to 1907,"p. 19.
[28] Harper, "Early History – Previous to 1907," pp. 17-29.

legal challenges, revised all agreements relative to the value and volume of right of way and water rights secured from private entities.[29]

This legal delay came at considerable cost and risk. By 1910, the Reclamation Fund held insufficient funds to complete approved reclamation projects and the Reclamation Service requested a $30,000,000 loan from the national treasury. Congress approved the loan yet insisted that

> No part of this appropriation shall be expended upon any existing project until it shall have been examined and reported upon by a board of engineer officers of the Army...and until it shall be approved by the President as feasible and practicable and worthy of such expenditure.[30]

Ultimately, very few projects met these conditions.[31] Grand Valley proved one of the few. On January 6, 1911 the Army Corps of Engineers board reiterated the Reclamation Service's earlier assessment that the project was "feasible from an engineering and an economic standpoint," while recommending that construction be delayed pending resolution of water right and right-of-way challenges.[32]

That resolution proved slow. As negotiations lagged, farmers waited: by December 1910, the Reclamation Service reported, only 12 of the 372 owners of patented land and only 72 of the 181 homestead entrymen on the project were living on the land. Of these, a large majority "were waiting for water." Engineer Chas. Hoag continued, "A considerable number of the entries on which no effort was made to comply with the homestead laws have been either relinquished or cancelled. Also nearly all of the resident entrymen mentioned above have availed themselves of the privilege of leave of absence, and hence, are not now living on their claims."[33]

On September 23, 1912, in the face of deadlock and mounting local impatience, President Taft revised the Corps' report to state that construction could begin, at the option of the Secretary of the Interior, absent final resolution of the legal challenges. One month later, to great fanfare, the Reclamation Service marked "the formal opening of construction work" and

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[29] Harper, "Early History – Previous to 1907," pp. 44-46.
[30] 36 Stat. 835 (1911), quoted in Andrews and Sansone, *Who Runs the Rivers?*, p. 178.
[31] Andrews and Sansone, *Who Runs the Rivers?*, p. 180.
[32] Quoted in John Page, Junior Engineer, "Work in 1911," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1913, Volume I." Grand Valley Water Users Association, p. 2.
[33] Chas. S. Hoag, Draftsman, "History to December 31, 1913: Settlement," File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1913, Volume II."

plans continued apace on the final design of the Grand Valley Diversion Dam.[34]

C. DESIGN AND CONSTRUCTION OF THE GRAND VALLEY DIVERSION DAM

Although the Grand Valley Diversion Dam was one of the first American dams constructed with roller gates, the roller-gate technology itself was not pioneering. German engineer H. M. Carstanjen, of Maschinenfabrik Augsburg-Nurnberg A.G (Maschinenfabrik), patented the design in 1902 and, between 1902 and 1914, Maschinenfabrik designed and manufactured rolling crests for 50 dams in Europe, Mexico, and the United States.[35] The Grand Valley roller gates, company engineers assured the Reclamation Service, were designed "in accordance with [Maschinenfabrik's] usual practice."[36] Moreover, Reclamation Service engineers, at the time of construction and in subsequent decades, consistently described the dam itself (or weir) as "standard" and the dam's construction as presenting no noteworthy problems. However, the use of roller gates is significant as an American adaptation of an existing design to a dramatically different climate, one subject to summer drought and flash flood, and as an innovative response to a unique set of geological constraints. This process of adaptation and innovation is representative of the engineering process, where technological innovations are often realized not in dramatic leaps but in small-scale field applications incorporated within tried and trusted design.

Site-Specific Considerations

At the mouth of the Colorado River's DeBeque Canyon, high-water flows can exceed 50,000 cfs and can dry down to a late-season trickle of less than 1,000 cfs.[37] Site-specific considerations dictating the choice of dam design were two fold: 1) to store sufficient water to allow late-season diversion of sufficient water for irrigation; and, 2) to allow passage of sufficient high spring flow (including flash floods), with sufficient speed, to avoid flooding the Denver & Rio Grande Railroad tracks located immediately adjacent to the river, a mere 3' above water level. The canyon walls were steep and the railroad tracks could not be moved without prohibitive expense (see Photograph 16). On a river susceptible to enormous fluctuation in flow,

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[34] John Page, "Work in 1912," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1913, Volume I," p. 8.
[35] A. G. Hillberg, "Design of Rolling Dams," *Engineering Record* 68 (December 1913), p. 657.
[36] Maschinenfabrik Augsburg-Nurnberg A.G. to United States Reclamation Service, Grand Junction, Colorado, September 16, 1913. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915. Grand Valley Water Users Association, Grand Junction, Colorado.
[37] Miner, "General Project Statement," p. 1. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1913, Volume I."

engineers thus were charged with maintaining a very-nearly constant reservoir level. Engineer S. O. Harper, Project Manager of the Grand Valley Project, described these difficult requirements and the Reclamation Service's engineering solution:

> On account of the proximity of the main line of the railroad which traverses the Grand River Canyon at this point, it was necessary to provide a dam which would raise the level of the river during periods of low flow to the height required for the diversion of the required quantity of water into the project canal and, on the other hand, permit the maximum flood flow, estimated at 50,000 second ft., to pass without flooding the adjacent railroad track. This requirement called for a type of dam with sufficient flexibility to permit the water above to be held at the same level ...regardless of the stage of the river.[38]

During the earliest years of project design, 1902-1903, Reclamation Service engineers envisioned a rubble masonry dam extending 27' above the bed of the river and regulated with sluice gates and "automatic shutters." An associated levee, 1.2 miles in length, and a 1,000'-long tunnel, "to drain the area inclosed [sic] by the levee," would protect the railroad. The design was expensive, allowed significant water loss over the dam crest, significantly encroached upon land and irrigation structures of the Orchard Mesa Irrigation District, and did not assure the protection of the railroad bed to the satisfaction of all concerned parties. On January 7, 1910, Grand Valley Project Engineer E. E. Sands first proposed to Reclamation Service Director Frederick Newell that a "rolling-crest type of moving dam" be adopted (see Photograph 17).[39]

The Colorado River flows not only through a canyon, proximate to a railroad, but also through semi-arid country receiving an average of only 8.23" of rainfall per year and suited to agricultural development only if placed under irrigation. Though less significant than the canyon setting, these climatic considerations also affected dam design. Project engineers envisioned that during periods of drought the entire flow of the river would be diverted to the irrigation canal. Roller gates, unique among the "movable dams" of the period, were virtually impervious: water not lost to leakage would "increase the amount of water the Project could use."[40]

This virtually impervious seal, however, had not been tested in the high-silt conditions of the American southwest. For much of its length the

[38] Harper, "Operation of Grand River Roller Dam Proves Satisfactory," p. 1225.
[39] Reedy, "Grand River Diversion Dam," File: Grand Valley Project, Colorado, "History for Year 1913, Volume I," p. 6.
[40] Miner, Project Manager, to The Comptroller, August 25, 1914.

Colorado River winds through porous sandstone; silt loads, particularly during run-off months, are accordingly heavy. Modifications to the standard roller-gate design included a revised silt shield on each roller, one where "the plate and stiffening beams are not equally curved thruout [sic], but vary from a certain curvature to a straight line."[41] German designers made the change under protest: "the cost of manufacture of the shield will hereby be increased in a not inconsiderable amount... We would further remark that in all previous installations no trouble has been encountered from hindrances to raising by silt accumulations."[42]

Roller Gate Design

Reclamation Service engineers found precedent for successful use of a roller-gate dam not only in Germany but also in Washington state, where the Washington Water Power Company had built a five-gate dam on the Spokane River, using rolling gates designed and manufactured by Maschinenfabrik, and in southern Idaho where the Reclamation Service had recently completed a small, one-gate dam on the Boise Project.[43] In response to queries from the Grand Valley Project engineer, Boise Dam engineers reported that they had found "that a rolling dam was very much cheaper than any gate that we could design" and that procurement of a dam design and components had been a relatively simple matter. Engineer Chas. Paul wrote:

> I opened up the subject by corresponding with the company, which is the Maschinenfabrik Augsburg...Germany, and telling them about what our requirements were. They replied giving a general description of their dam and sending considerable literature which explained it fully and also gave views of rolling dams of various sizes that had been in use for several years. They also offered to give us a preliminary estimate and design for a dam that would fill our requirements and before taking steps to make a contract with them, we obtained this preliminary design and estimate in accordance with their offer. The

[41] More specifically, "the silt bank [was] extended to a height above the fixed crest of 1.62 m. and 1.6 m., respectively, and the shield receded from the silt bank to the corresponding height." Maschinenfabrik Augsburg – Nurnberg to U.S. Reclamation Service, Washington D.C. June 27, 1914, p. 2. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

[42] Maschinenfabrik Augsburg –Nurnberg to U.S. Reclamation Service, Washington D.C. June 27, 1914, p. 2. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

[43] On the Boise Project, engineers desired to back up water to a depth of 8 feet on an unidentified "logway," for irrigation storage, while still providing sufficient room, with the gate open, for log passage. Reclamation Service engineers anticipated that the private Washington Water Power Company would be less forthcoming with information related to design and cost than fellow federal engineers. Most early correspondence related to dam design addresses the Boise River Diversion Dam. D.C. Henny, consulting engineer, to J. H. Miner, Project Engineer, Grand Junction, Colorado, May 7, 1913. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

matter was then turned over to the Washington office and a contract was made.[44]

On the Boise Project, as it would at Grand Valley, Maschinenfabrik offered to either build the dam components for shipment to the United States, or to furnish drawings – with a royalty charge added – to U.S. manufacturers. Boise engineers determined that "the cost would be practically the same and we felt that we would be likely to get a better job if the dam were built by the designers who are thoroughly familiar with that class of work."[45] The choice proved a good one: "we had no trouble whatever in the installation of this dam and the working drawings that they furnished us were very complete."[46]

Following this precedent, on July 26, 1913, Grand Valley engineers submitted site data to Maschinenfabrik and requested a dam design. Maschinenfabrik responded six weeks later with three "schemes": a dam crest comprised of five rollers, each 84' long; of six rollers, each 70' feet long; or of seven rollers, each 60' feet long. The three design options each incorporated an *additional* 60'-long gate at the sluiceway/canal headwall. The three designs varied most notably in the degree of water control and the degree of free passage – the five + one gate version providing the largest unrestricted openings, as typically demanded on a navigation dam, the seven + one-gate version providing the most control over water flow and fluctuation, though at greater cost. Concerned with both cost and water control, and not with navigation, Reclamation Service engineers selected the six + one gate design. Notably, neither the proposed number of gates (the most included on any dam built to date) nor the individual gate lengths (44' shorter than the longest gates then in service) presented any safety problems or unusual difficulties.[47] "The design of the rollers is in accordance with our usual practice," German engineers assured the Americans. "The maximum stress in the roller construction with normal water pressure is between 900 and 1000 kg per square centimetre and increases to about 1250 kg per square centimetre with an overflow 3 feet over the crest of the dam. These stresses are low and may be regarded as perfectly safe."[48] See Photograph 18.

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[44] Chas H. Paul, Reclamation Service, Arrowrock, Idaho, to Construction Engineer, Grand Junction Colorado, re "Rolling Dam," February 25, 1913, p. 1. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.
[45] Paul to Construction Engineer, February 25, 1913, p.2.
[46] Paul to Construction Engineer, February 25, 1913, p.2.
[47] A. G. Hillberg, "Design of Rolling Dams," p. 654.
[48] Maschinenfabrik Augsburg-Nurnberg A.G. to United States Reclamation Service, Grand Junction, Colorado, September 16, 1913. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

Despite Supervising Engineer J. Miner's preference to award roller-gate manufacture to an American firm, the Reclamation Service ultimately determined that the process of bid release and contract award would prove too expensive and too time consuming:[49] William R. King, Department of Interior Chief Counsel, wrote,

> ...from all information available it is believed that little, if any, saving in cost to the United States would result from securing fabrication of the dams by American manufacturers, whereas there would certainly be very material loss of time in preparing drawings and specifications, and in advertising for and acting on proposals with the possibility of very serious further delays on account of the necessary exchange of communications between the German Company and the manufacturers in this country.[50]

On February 14, 1914, Chief Engineer A.P. Davis instructed project engineers to review all final detail drawings submitted by Maschinenfabrik and, upon approval of those drawings, to direct Maschinenfabrik to proceed with manufacturer.[51]

Through the early months of summer 1914, war brewed on the European continent until, in the first week of August, Germany declared war, first on Russia and then on France, and Great Britain declared war, in turn, on Germany. On August 4, Maschinenfabrik alerted the Reclamation Service to possible delays in delivery. Two weeks later, Reclamation Service Director Frederick Newell informed Maschinenfabrik that, "under the unexpected conditions which have arisen disturbing the peace of Europe, we find ourselves under the absolute necessity of making different arrangements and of canceling the order with you."[52]

Immediately, Reclamation Service Comptroller W. A. Ryan sought a means of avoiding the requisite royalty payments and urged engineers to

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[49] Miner wrote, "it is thought that as there will be six rollers practically alike, favorable bids for their fabrication may be received from American manufacturers, and it is desired that American manufacturers have an opportunity to bid on this work before decision is made regarding the manufacturer." Miner to Project Director, Grand Junction, through Supervising Engineer, Denver, December 27, 1913, p. 2. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

[50] Chief Counsel to Project Manager, Grand Junction, February 14, 1914, p. 1. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

[51] Chief Counsel to Project Manager, Grand Junction, February 14, 1914, p. 1. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

[52] Newell to Maschinenfabrik, August 26, 1914. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.

develop their own design that might "perhaps serve our needs as well."[53] Miner declined, after again summarizing the merits of roller-gate design on the Grand Valley Project:

> Roller weirs were selected for installation at the Grand River Dam mainly because they will make a practically water-tight closure of the channel and because of the simplicity and ease with which they may be operated. ... Both [Resident Engineer Reedy and I] are of the opinion that it is not possible to design a movable dam adapted to meet the conditions that will exist at the Grand River Dam better than the roller weirs which have been designed."[54]

Ryan conceded and engineer F. Teichman proceeded "at once" to Washington D.C. where he and assistant C. H. Branscombe "worked over the German drawings to make them conform to American practice of fabrication."[55] See Photographs 19-20.

Most notably, American construction proved "considerably heavier" ("on an average 10% more than the corresponding parts of your design") than German construction, and Teichman solicited the advice of German engineers on addressing resultant design deviations and altered specifications for the weight and strength of the roller chains. This correspondence was cordial and professional, and offers little evidence of the growing animosity between the two nations.[56]

Though adhering to the German firm's design, working drawings of the Grand Valley Diversion Dam roller gates were soon produced without credit to the German designer and patent holder. Historian Charles W. Miller argues that this omission, by both the Reclamation Service and the technical press, closely ties the dam to the "social history of the times during which it was constructed."[57] In fact, while Maschinenfabrik is most-often excluded from post-1914 working drawings, the German firm is prominently credited with design in post-1914 Reclamation Service reports and in the more-

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[53] W. A. Ryan, Comptroller, to Project Manager, Grand Junction, August 17, 1914. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.
[54] J. H. Miner, Project Manager, to Comptroller, August 25, 1914, p. 1. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.
[55] Reedy, "Feature History, Grand River Diversion Dam, 1914," File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1914," p. 29.
[56] See, for example, F. Teichman to Maschinenfabrik, October 2, 1914. File: Technical Correspondence with Maschinenfabrik Augsburg-Nurnberg & Washington D.C., O.T. Reedy Project Engineer, 1914-1915.
[57] Miller, "Grand Valley Diversion Dam National Register Nomination," March 14, 1991, Section 8, p. 1.

reputable engineering journals, including *Engineering News*.[58] If not evidence of bitter nationalism, as Miller suggests, the cancellation of the Maschinenfabrik contract did clearly impact the speed of dam completion, further delaying the delivery of water, and inextricably tying the history of a local project to the larger world war.

Gate Manufacture

Teichman and Branscombe completed revised drawings on October 17, 1914 and immediately let the specifications for seven roller gates and associated operating components to bid (see Photograph 21).[59] Both cost and speed of delivery, the Reclamation Service announced, would be a factor in contract award. In an intensely competitive bid process, 17 American manufacturers submitted estimates; the engineering community deemed the proposal and evaluation process "of interest...owing to the fact this is the first steel roller dam fabricated in this country"[60] and repeatedly detailed the bid list in subsequent accounts of dam construction.

Table 1. Bidders, Cost Estimates, and Proposed Shipping Dates for Gates.

Name of Bidder	Estimate	Dates of Shipment[61]
Reclamation Service estimate	$20,531	1/10/-3/1
Riter-Conley Manufacturing Co., Pittsburgh	$14,958	2/7-3/21
Pennsylvania Bridge Co., Beaver Falls	$17,246	2/15-3/29
Stacy-Schmidt Manufacturing Co., York	$18,771	1/10-3/1
American Bridge Co., Baltimore	$18,771	1/3-3/1
Independent Bridge Co., Pittsburgh	$20,296	1/10-3/1
St. Paul Foundry, St. Paul	$20,824	2/1-3/15
Minneapolis Steel and Machinery Co., Minneapolis	$21,821	1/10-3/1
Milwaukee Bridge Co, Milwaukee	$21,821	1/10-3/1
Chicago Bridge and Iron Woks, Chicago	$21,997	1/10-3/1
Allis-Chalmers Co., Milwaukee	$22,290	1/10-3/1
Reummeli-Dawley Manufacturing Co., St. Louis	$22,877	1/24-3/25
Pittsburgh-DesMoines Steel Co., Pittsburgh	$23,289	2/7-3/1
Kansas City Structural Steel Co., Kansas City, MO	$23,464	3/1-4/19
McMyler Interstate Co., Bedford	$27,922	1/20-3/1
Treadwell Construction Co., Midland	$31,529	1/31-3/7
Whitehead & Kales Iron Works, Detroit	$34,022	1/10-3/1

[58] J. H. Miner, "Project History Introduction," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1915, Volume I," pp. 5-6. See also, Editor, "Building the Rolling-Crest Dam Across Grand River," p. 60.

[59] The operating-component package included chain guards, chain anchors, and base plate. The steel chains and sprocket (including shaft) were manufactured in Germany.

[60] Editor, "Building the Rolling-Crest Dam Across Grand River," *Engineering News*, Vol. 76, No. 2 (July 13, 1916), p. 61.

[61] All dates are 1915.

Name of Bidder	Estimate	Dates of Shipment[61]
William Cramp & Sons, Philadelphia	$50,154	2/13-5/8

Engineers, E. C. Begg and E. A. Moritz, of the Reclamation Service's review board preferred the American Bridge Co.'s bid, noting the rapid delivery and reasonable cost. The Secretary of the Interior instead awarded the contract to the low bidder, the Riter-Conley Mfg. Co. The Pittsburgh Testing Laboratory was assigned responsibility for inspection.[62]

Despite the war, and despite the cancellation of the roller contract, the Reclamation Service invited Maschinenfabrik to bid on the roller hoists (demanding less rationed steel than the rollers, less time-consuming to manufacture, and less-difficult to ship). The German company submitted a bid, considerably higher than those bids received from American manufacturers, and contracts were instead awarded to the Minneapolis Steel and Machinery Co., for the six 70'-long roller hoists, and to the Link-Belt Co., Chicago, for the heavier 60'-long roller hoist.[63]

Unable to develop satisfactory specifications for American manufacture of the steel chains and shaft – in part due to the greater weight of the rollers – Maschinenfabrik was awarded this contract, in a noncompetitive bid. American manufacturers of the hoists were directed to hold the hoists until delivery of the German goods for final assembly of the hoist mechanisms. "The delay in arrival of the accessories," however, proved so great that all hoists were ultimately shipped to the dam site, minus chains and shaft, where gates were assembled with temporary operating mechanisms (see Dam Construction, below). Advertisements for American manufacture of these final components were not issued until September, 1915. Lakeside Bridge and Steel Company of Milwaukee was awarded the contract on November 8, 1915 and promised delivery to the dam site within 60 days.[64]

In August 1914, when the Reclamation Service cancelled its contract with Maschinenfabrik, the toothed racks for the piers and roller rims were almost complete. Upon confirmation that roller gates would be installed, the Reclamation Service arranged for receipt of this portion of the original contract. Shipment was received on January 15, 1915 at which time Reclamation Service and Riter-Conley engineers discovered that the racks had been improperly notched for use in the Grand Valley piers (where each

[62] Reedy, "Feature History, Grand River Diversion Dam, 1915," n.d. File: "History for Year 1915, Volume I," p. 8.
[63] Reedy, "Feature History, Grand River Diversion Dam, 1915," p. 10. The 60' sluiceway roller is 5' taller than the 70' rollers, and thus heavier.
[64] Reedy, "Feature History, Grand River Diversion Dam, 1915," p. 11; Harper, "Feature History, Grand River Diversion Dam, 1915: Continuation," File: "History for Year 1915, Volume I," p. 29.

pier held two gate controls, one to the right, one to the left). Reedy wrote: "it was found that the three pieces each of ten racks had been fitted and match marked all for the left hand instead of five right hand and five left hand. Considerable work was required in re-arranging to form the right hand sets."[65]

Rollers – shipped in pieces – and associated operating components, arrived at the dam site between January and March, 1915. In the preceding two years, Reclamation Service engineers and force-account crews had built a dam to hold them.

Dam Construction, 1913-1916

In July 1916, six months after dismantlement of the construction plant and one year after the first distribution of irrigation water, the editors of *Engineering News* described the "general scheme" of dam construction in the briefest of terms: "to build the sluiceway first and then, diverting the river through it, build the ogee weir and piers."[66] Construction engineer O. T. Reedy and his assistants would provide significantly greater detail in the construction reports that summarized three years of concerted effort. With few exceptions, the following construction history is drawn from their reports.[67]

On June 24, 1913, Reedy transferred to the Grand Junction office and assumed responsibility for dam construction. Reedy would supervise force-account crews composed primarily of local men; over the full course of the two years devoted to dam construction, he reported that "ordinary labor" proved abundant with shortages only during "the annual spring migration to California" and during harvest.[68]

Beginning in August, 1913, Government forces cleared a site for the dam-construction camp on the west side the river, downstream from the dam site; erected temporary buildings; and graded a line for a short railroad spur that would carry equipment and materials from the Denver & Rio Grande tracks to the dam site. Additional construction plant, initiated in August

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[65] Reedy, "Feature History, Grand River Diversion Dam, 1915," p. 11.
[66] Editor, "Building the Rolling-Crest Dam Across Grand River," p. 60
[67] These "Feature Reports" are compiled in "Annual Reports," all on file at the Grand Valley Water Users Association, Grand Junction, Colorado. Unless otherwise indicated all citation page numbers refer to the original report, not to pagination added in the subsequent compilation.
[68] In contrast, "machinists and structural steel erectors" were "shipped" from Denver as needed. J. H. Miner, "Project History Introduction," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1914, Volume I,"p. 2; Miner, "Project History Introduction," n.d. File: United States Reclamation Service, Grand Valley Project, Colorado, "History for Year 1915, Volume I,"p. 4.

1913 and completed by the following spring, included a cross-river cableway and associated trestles; a pile bridge across the river, used both for cross-river travel and for construction of the cofferdam; and a screening and mixing plant for the estimated 25,000 cubic yards (cy) of concrete to be used in dam construction. Both aggregate and sand were mined from a quarry on the east side of the river, approximately 0.75 mile downstream from the dam site. Through the winter of 1913-1914, a 35-horsepower steam engine temporarily powered construction machinery. By spring, power lines had been run from the Cameo coal mines power plant, 3.5 miles downstream of the dam, and a substation constructed at the dam site (see Photograph 24).

Sluiceway and Headworks

On August 15, 1913, Chief Engineer Davis formally authorized construction of the sluiceway and headworks, in advance of final approval of the roller gate design. Reasons for this accelerated start were two-fold: sluiceway and headworks design would largely follow that adopted at the Reclamation Service's Granite Reef Dam in Arizona and presented no noteworthy design challenges (see Photographs 22-23). Moreover, the Reclamation Service proposed to divert the entire flow of the Colorado River through the sluiceway, thus dewatering the dam site; sluiceway construction was the necessary first step to an already-long-delayed project. Taking advantage of the Colorado's late summer low flow, government crews on force account began dry excavation of the sluiceway and associated tailrace. Wet excavation began in November and continued at an accelerated rate until late winter 1914, when crews began placing the first of the sluiceway's 3,875 cy of concrete (see Photographs 24, 25,27, 29). Regulator gates, fabricated to exact specifications and to high praise by Hinman Hydraulic Manufacturing Co. of Denver, were in place by early spring and the Reclamation Service proceeded with construction of the cofferdams that would turn the river's flow through the completed sluiceway.[69]

River Control

Cofferdams, temporary structures designed to divert the river flow sufficient (with the aid of pumps) to dewater the construction site, are generally inelegant affairs. The Grand Valley cofferdam was no exception: a mass of earth and rock, some salvaged from the sluiceway and tailrace excavation, some quarried, was all dumped from the pile bridge to the center of the river until the river turned. Though hoping to have fully diverted the river by the middle of July, exceptionally high (and sustained) flood flows

[69] Service engineers estimated that the sluiceway could carry 8,000 to 10,000 cfs, a typical summer flow. A cofferdam is a temporary dam built to divert a river around a construction site so the dam can be built on dry ground.

during the spring of 1914 compelled the crews to wait until August to complete the cofferdam (see Photograph 24).

Thus delayed, "two team shifts, running from 10 to 30 teams each," raced to complete foundation excavation and the cutoff trench/curtain wall of the main body of the dam before the spring of 1915 and the return of high water. They lost this race, as a freak flash flood on October 3, 1914, on the eve of the first concrete pour in the middle cutoff trench, exceeded the capacity of the sluiceway, overtopped and then breached the cofferdam, before filling the dam-site excavation with water and silt.[70]

Ogee Weir and Piers

While the river flow had not cooperated, river geology proved more kind: crews struck bedrock 2' to 12' higher than anticipated, reducing the necessary excavation and allowing concrete placement on the east abutment in advance of schedule.[71] Reedy reported that the east abutment, the sluiceway, and all but the central component of the cutoff trench and curtain wall had been completed by late winter 1915, when the water began to rise. (Photographs 4-5, showing the dewatered dam site, reveal the east abutment wall, upstream apron, and concrete crest. See also photographs 24, 28-29.) In anticipation of that high water, Reedy had ordered that a central component of the curtain wall, and a 4'-wide section of the downstream apron, be left incomplete, forming a temporary (and ultimately effective) spillway. This gap was filled the summer of 1915.[72]

In the meantime, on November 6, 1914, crews began placing concrete for the first of the eight roller-gate piers (pier f). "The same procedure was followed with all the piers," Reedy reported, and would be described "but once:"

> The pier was poured up to [the elevation of the lower apron of the weir] and forms removed. This is also the bottom elevation of the lower nose and forms for the nose were sometimes placed at this point, but generally were not placed until the mass of the pier had been carried up to the base of the upstream nose. Then the nose forms...were put into position and the lagging for sides of the pier built in between the nose. ...When this lagging had been put in position the outlines of the recesses, which were made in the pier for the purpose of receiving the ends of the roller crests and the racks and guards upon which these

[70] At 15,600 cfs, the flow was 50 percent larger than any fall flow in the 18 years for which the Service had record. Reedy, "Feature History, Grand River Diversion Dam 1914."
[71] Reedy, "Feature History, Grand River Diversion Dam 1914," pp. 17-18.
[72] Reedy, "Feature History, Grand River Diversion Dam 1915," p. 3.

> crests operate, were marked out on the inside of the lagging. Forms for these recesses were then constructed and the pouring of the pier proceeded in lifts of about 4 or 5 feet [see Photographs 30-35].[73]

The piers largely complete, crews poured the upstream and downstream aprons and placed the weir forms.

Miscellaneous Final Construction

By January 1915, concrete had been placed in the weir forms, the piers had been extended to their maximum height, and the dam was essentially complete save for installation of the roller gates, construction of the pier-top gatehouses, construction of the upstream wingwall at the east abutment, and construction of the steel service bridge that would provide pedestrian and vehicular access to the gatehouses. Of these remaining tasks, gatehouse and service-bridge construction proved routine and inspired little discussion or correspondence.[74] Engineers described construction of the Orchard Mesa Canal levee and east-abutment wing wall as not only routine, but also annoying. The wall and levee were designed to protect the intake of the Orchard Mesa Canal, adjacent to the east abutment, from scour. Instead of construction, the Reclamation Service had long hoped to secure an agreement for joint use of the diversion dam, allowing water dispersal directly from the east abutment to the canal rather than from Orchard Mesa's upstream diversion. As of September 1915, "no agreement for joint use of the dam" had been reached and the Reclamation Service proceeded with its legal obligation to protect the existing Orchard Mesa canal.[75]

In contrast, roller-gate installation marked the culmination of all design effort. Engineers waited for delivery of the gates with excitement and apprehension and documented the installation process with precision.

Roller Gate Installation

The 1915 construction report notes with fanfare the February 26 arrival of the first rolling crest. Less enthusiasm greeted their difficult installation: the river was high, the machinery was complicated, farmers and would-be-farmers were loudly impatient for a spring opening of the

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[73] Reedy, "Feature History, Grand River Diversion Dam 1914," pp. 26-27.

[74] Bridge arch sections were shipped manufactured to the dam site, and were "swung into place" by means of the cableway. Beginning in January 1915, crews constructed the concrete-masonry gatehouses located on piers b, d, and f and the detached power house/battery storage house, "according to plan" (see Photographs 3, 31-32, and 37-38). For reasons not detailed in the construction histories, construction of the main (pier h) gatehouse would not be initiated until 1916. M.E. Alderman, "Feature History, Grand River Diversion Dam, 1915 [continued]," p. 19; Harper, "Feature History, Grand River Diversion Dam, 1915 - Continuation," pp. 33-34.

[75] Harper, "Feature History, Grand River Diversion Dam, 1915 - Continuation," pp.27, 30-32.

headgates, and – worse – chains, sprockets, and shafts, contracted to Maschinenfabrik, had not yet been manufactured and no contract had yet been signed with an alternative manufacturer. Reedy's account of initial installation is quoted at length:

> Complications and delays in receiving steel rack supports, anchor bolts, and other auxiliaries threw the erection of the crests somewhat later in the season than was anticipated. In view of the conditions, and in order to get at the work in the sluiceway as soon as possible, the following program was decided upon late in February:
>
> 1. Construct sub-cofferdam from pier 'c' upstream to main cofferdam, and demolish the latter ... in front of spans 'ab' and 'bc.'
>
> 2. Erect rollers 'cd,' 'de,' and 'ef,' and at the same time, by placing heavy rock with the cableway, across the sluiceway channel, turn the river thru spans 'ab' and 'bc,' and begin work in the sluiceway; that is, finish the concrete abutment 'h' and pier 'g,' place the paving in the tailrace and erect the [sluiceway] roller.
>
> 3. When the three rollers between piers 'c' and 'f' should be erected raise them out of danger and demolish the cofferdam in front of them, at the same time rebuilding the cofferdam in front of spans 'a' to 'c.' As soon as the water is turned from the two latter spans, begin the erection of rollers in them and upon their completion demolish the cofferdam above them.[76]

A Mr. R. O. Brown, Reedy continued, was placed in charge of installation. Brown, traveling with "five picked men," arrived at the construction camp on March 10 and "at once" began inspecting and sorting the myriad pieces associated with the cylinders and the operating mechanisms. On March 25, crews installed the first of the rollers ('cd'):

> The two ends were swung into approximate position on the false work by the cableway, and with bars and jacks the proper teeth of the racks and rims were brought into mesh. The two adjacent pieces were then joined to the ends and held to place with barrel pins and fitting-up bolts....When the riveting was completed on the roller proper, not including shield and end shields, the roller was raised to a position giving eight feet clearance above the weir.[77]

Here the rollers would briefly stay, temporarily braced by "12" x 12" Oregon fir posts, one under each end," while welders riveted the shields to

[76] Reedy, "Feature History, Grand River Diversion Dam 1915," pp. 15-16.
[77] Reedy, "Feature History, Grand River Diversion Dam 1915," pp. 15-16.

the rollers. Throughout this effort, *Engineering News* reported, "extreme high water threatened the safety of the falsework and only quick work saved the situation."[78] From March 1915 until Lakeside Bridge and Steel Company's October 1916 delivery (a year delinquent) of the permanent fixtures, temporary shafts and chains secured the gates in place (see Photograph 39).[79]

On June 29, 1915, the Reclamation Service formally celebrated project completion, a mere two days after installation of the final (sluiceway) roller gate and a long 14 years after the project's initial conception. Appropriate to the dam's larger social, economic, and political purpose, dedication rituals focused on the release of water through the headgates, to the completed canal, and on to project farms. Draftsman M. E. Alderman wrote, "Chairman Fitzgerald of the Committee officiated as master of ceremonies, handling the clutch lever which started the raising of one of the canal headgates by means of an electric motor installed for temporary use."[80] See Photographs 40-49.

A year later, Reclamation announced the 99.6 percent completion of the dam and headworks, at a total cost of $512,896, "substantially" more than initial estimates.[81] Despite the cost, project Engineer S. O. Harper reported complete satisfaction with the dam's design and operation:

> One year's service of the large roller crest dam across the Grand River, built by the United States Reclamation Service as a part of the Grand Valley Project in western Colorado, has demonstrated that the largest example of this comparatively novel type of diversion dam is well suited for the conditions existing on this river.

Most importantly, the dam successfully permitted the spring passage of flood water while assuring minimal leakage during periods of water storage and, thus, effective distribution to project lands (see Photographs 50-51).[82]

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[78] Editor, "Building the Rolling-Crest Dam Across Grand River," p. 63.
[79] John C. Page, Assistant Engineer, "Feature History, Grand River Dam, 1916," File: History for Year 1916, Vol. I, n.p. (p. 4).
[80] M.E. Alderman, "Feature History, Grand River Diversion Dam, 1915 [continued]," p. 19. Alderman reported that dedication-ceremony attendees included members of the House Appropriation's Committee, the Reclamation Commission, the "Chief of Construction" [Reedy?], directors of the Water Users Association, local Reclamation officials, and "citizens."
[81] Harper, "Examination and Surveys 1907 to 1909, Inclusive" in "History for Year 1913, Volume I," p. 16; Page, "Feature History, Grand River Dam, 1916," n.p. (p. 4).
[82] Harper, "Operation of Grand River Roller Dam Proves Satisfactory," p. 1225-1226.

If the costs of construction were greater than estimated, both farm yields and the volume of irrigated lands proved less than hoped.[83] In 1907, the Bureau of Reclamation and local land boosters had estimated that 70,000 acres of fertile mesa could be placed under water. In the wake of survey crews and cost estimates for pumping water to the highest-elevation lands, this estimate dropped to 53,000. In 1924, almost ten years after water came on line, a Congressionally ordered Bureau of Reclamation Fact Finding Commission set the arable acreage on the project at 23,320, set the per-acre construction cost at $83.45 (significantly higher than 1913 estimates of $30-$40 per acre), and revised project-users' repayment schedules to a sliding scale, over a 40-year period. Essentially, limited acreage was carrying the construction bonds and operating costs of a system planned and built to serve 53,000 acres. Laboring under the burden of these costs, project users reported few funds for necessary operation and maintenance of project facilities, including the diversion dam: "in the matter of operation and maintenance costs and payments," the president of the Water Users Association informed Bureau of Reclamation officials in 1938, "we are in worse position than in repayment costs."[84]

The Water Users Association consistently, and ultimately successfully, advocated for construction of power- (and profit-) generating facilities sufficient to increase project revenues and to pump water to additional higher-elevation project lands. In addition, the Association entered into a cooperative agreement with the Orchard Valley Irrigation District, whereby Orchard Valley lands would be supplied with water diverted from the Government's High Line Canal (at a point of diversion 4.5 miles south of the Grand Valley Diversion Dam) and project construction and maintenance costs shared accordingly. By 1948, the project provided "full irrigated service" to 36,945 acres and "supplemental service" to an additional 7,000 acres along the Mesa County and Palisade Irrigation Ditches.[85] If not in volume, this acreage generally complies in location with historic project plans: most lies north of the Colorado River and north and west of Fruita, Grand Junction, and Mack, Colorado, along the first and second terraces above the Colorado River. A small percentage lies south of the river within the Orchard Mesa Irrigation District. These numbers have held constant: today, the Bureau of Reclamation reports irrigation of 33,368 acres of "Government Project Lands"

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[83] See, for example, Grand Valley Water Users Association to Commissioners (Charles A. Lory; William R. Wallace, George T. Cochran," January 12, 1938, pp. 10-12. File: Grand Valley Water and Grand Valley Project Histories by the Grand Valley Water Users Association, 1938, 1943, 1945.

[84] Grand Valley Water Users Association to Commissioners, pp. 10-12. File: Grand Valley Water and Grand Valley Project Histories by the Grand Valley Water Users Association, 1938, 1943, 1945.

[85] File: "Grand Valley Project, History and Operation & Maintenance Reports, 1940s-1950s," passim; Bureau of Reclamation, "Grand Valley Project," *Project Data*, p. 2.

and supplemental supply to 8,580 acres in the Mesa County and Palisade Irrigation Districts.[86]

Between 1916 and 1949, burdened with limited funds, the Bureau of Reclamation and the Water Users Association reported no significant modifications to the dam's design or operation; maintenance efforts were focused instead on the canal, tunnels, siphons, and lateral ditches (prone to slump and infill) and on necessary construction and expansion of project power and pumping facilities. In 1949, the Bureau of Reclamation turned responsibility for operation and maintenance of the aging system to the Water Users Association. With project works and equipment "in poor condition," the Association and the Bureau initiated a cooperative Rehabilitation and Betterment Program and, in 1951, completed the first-stage rehabilitation of the 35-year old diversion dam.[87] That stage included:

- installation of enlarged silt shields on the roller cylinders, reducing leakage and increasing (by 4") the dam's hydraulic height;
- replacement of the original A/C motors and controls associated with the roller and regulator gates;
- "overhaul" of all roller-gate chains;
- repair of seven of the nine regulator gates;
- repair of leaky gatehouse roofs.[88]

More significant repairs were competed between 1957-1959, when the Water Users Association, in association with the Orchard Mesa Irrigation District and under contract with the Bureau of Reclamation:

- Replaced the original roller-gate chains;
- Excavated, filled, and placed riprap in the river channel immediately below the dam;
- Repaired, replaced, or placed new concrete in the dam, spillway apron, cutoff walls, and diversion headworks;
- Replaced, repaired, cleaned, and painted metal parts and surfaces of the dam and diversion works;
- Replaced gatehouse windows with glass block, "making the structures weather tight."[89]

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[86] Bureau of Reclamation, "Grand Valley Project, http://www.usbr.gov/dataweb/html/grandvalley.html#general
[87] Anonymous, "Highlights of the Operation and Maintenance Program, 1948-1958," File: "Grand Valley Project, History and Operation & Maintenance Reports, 1940s-1950s," p. 3.
[88] Anonymous, "Grand Valley Project Annual Project History, 1951-1958," File: "Grand Valley Project, History and Operation & Maintenance Reports, 1940s-1950s," pp. 3-29.
[89] H. F. Bahmeier, Project Manager, "Final Report on Rehabilitation and Betterment, Fiscal Years 1958-1959," File: "Grand Valley Project, History and Operation & Maintenance Reports, 1940s-1950s," n.p.

These modifications can all be classified as general maintenance and repair and did not significantly alter dam design. Similarly, the 1970 construction of Interstate 70 along the east bank of the river, through DeBeque Canyon, is consistent with the historic concentration of transportation facilities immediately adjacent to the river. In 1991, at the time of National Register listing, the National Park Service determined that the dam retained excellent integrity.

In 2003, the Bureau of Reclamation initiated construction of a more-substantial alteration: a fish-passage channel, allowing migration of the endangered Colorado pike minnow and razorback sucker to critical upstream habitat, and an associated upstream fish trap, preventing migration of exotic species (see Photographs 4-5). As designed, this 660'-long concrete passageway will breach the crest of the ogee weir in the easternmost of the dam's seven bays. A concrete retaining wall will run the length of the passage and a track rack will be installed at the upstream "exit." The passage will provide a minimum flow of 130 cfs, at a minimum water depth of 2'; a dam designed to form an impervious seal and to, if necessary, "divert the river's entire flow,"[90] is now being modified to allow for a minimum constant flow of 130 cfs and for deliberate breach of the dam barrier.[91]

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[90] Miner, Project Manager, to The Comptroller, August 25, 1914.

[91] U.S. Army Corps of Engineers, *Public Notice Number 200275143*, April 9, 2002; Bureau of Reclamation, "Final Environmental Assessment: Endangered Fish Passage Project at the Grand Valley Project Diversion Dam and Fish Screen at the Government Highline Canal" (Grand Junction: Upper Colorado Region, Western Colorado Area Office, March 2003), pp. 8-10.

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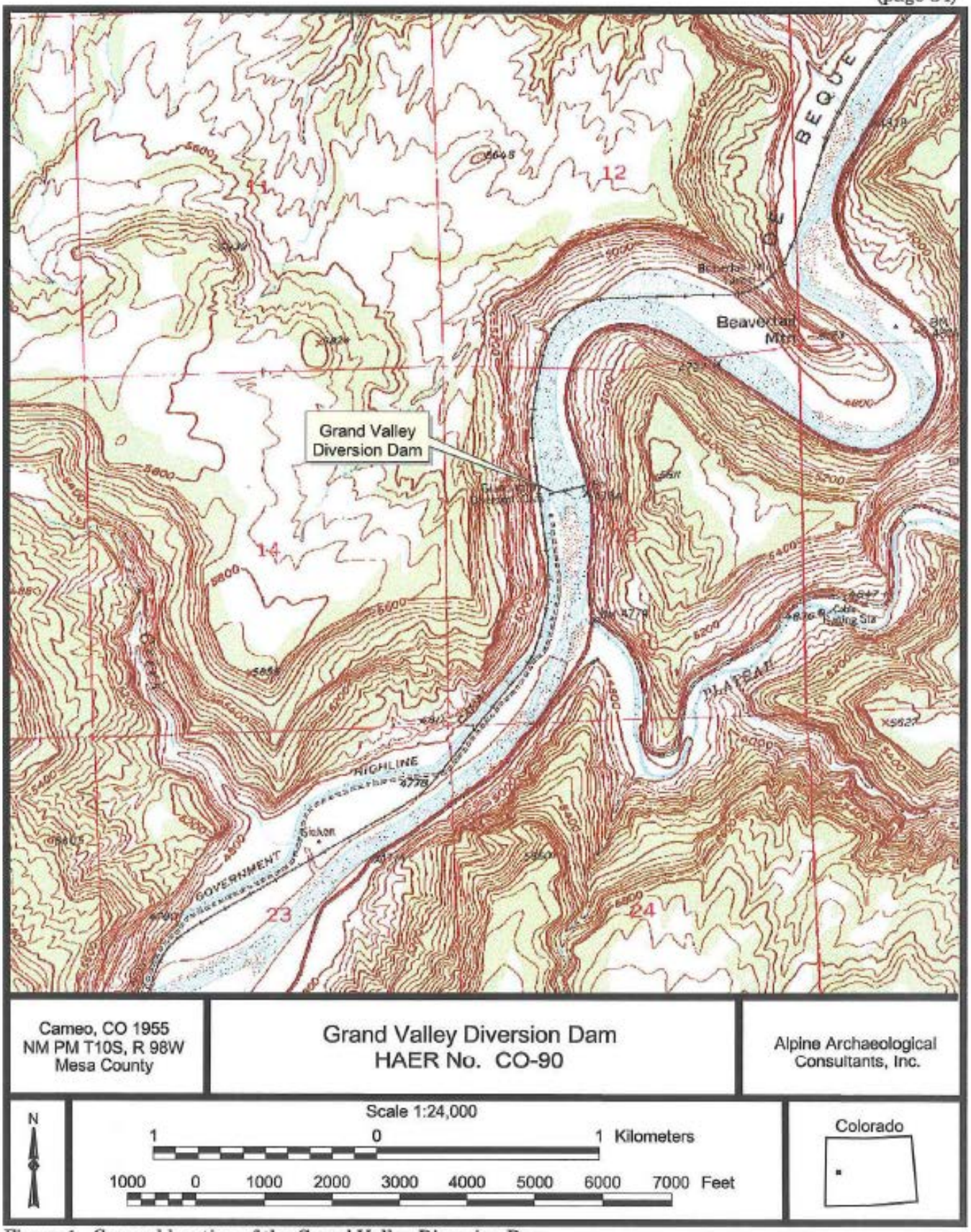


Figure 1. General location of the Grand Valley Diversion Dam.

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

GRAND VALLEY DIVERSION DAM HAER No. CO-90
ONE HALF MILE NORTH OF INTERSTATE 70 AND COLORADO STATE ROUTE 65
CAMEO VICINITY
MESA COUNTY
COLORADO

Documentation:
14 exterior photographs
1 interior photograph
19 photographic reproductions of historic photographs
17 photographic reproductions of original construction drawings
5 measured drawing of dam
34 data pages

Gianfranco Archimede, photographer, Winter 2003-2004.
Original photographs and plans for CO-90-16 thru CO-90-51 are in possession of Grand Valley Water Users Association, Grand Junction, CO.

CO-90-1 OBLIQUE OVERVIEW, LOOKING NORTH-NORTHEAST, OF SOUTH ELEVATION OF DIVERSION DAM, SHOWING ALL SEVEN ROLLERS, FOUR GATEHOUSES, AND FOUR PIERS. NOTE ALSO THE PAVED WEST RIVER BANK AND TRAINING WALL.

CO-90-2 OBLIQUE OVERVIEW, LOOKING NORTHEAST, OF SOUTH SIDE OF DIVERSION DAM, SHOWING WESTERN PROFILES OF TOWERS, PIERS, AND ROLLERS. NOTE LATERAL RECESSES IN PIERS FOR GATE OPERATING MECHANISMS. SOUTHEAST SLUICEWAY WALL IN FOREGROUND.

CO-90-3 OBLIQUE VIEW, LOOKING EAST-NORTHEAST, OF MAIN GATEHOUSE, MAIN ENTRANCE, AND BATTERY STORAGE HOUSE. EAST SIDE OF CANAL WALL IN FOREGROUND.

CO-90-4 OBLIQUE OVERVIEW, LOOKING EAST-SOUTHEAST, OF FISH LADDER CONSTRUCTION ACTIVITY AFTER DEWATERING OF NORTH SIDE. THE EAST ABUTMENT WALL, CONCRETE CREST, AND NORTH SIDE APRON ARE EXPOSED. EASTERNMOST ROLLER GATE (RAISED POSITION) AND SERVICE BRIDGE AT UPPER RIGHT.

CO-90-5 OBLIQUE VIEW, LOOKING SOUTH, OF THE CONCRETE CREST AND APRON AFTER DEWATERING OF NORTH SIDE. THE EAST ABUTMENT WALL, IS AT LEFT. EASTERNMOST ROLLER GATE (RAISED POSITION) AND SERVICE BRIDGE AT TOP.

CO-90-6 OBLIQUE OVERVIEW, LOOKING SOUTHEAST, OF NORTH SIDE OF DIVERSION DAM, SHOWING WESTERN PROFILES OF TOWERS, PIERS, AND ROLLERS. NORTHEAST SLUICEWAY WALL IN FOREGROUND.

CO-90-7 OBLIQUE OVERVIEW, LOOKING WEST-SOUTHWEST, OF NORTH SIDE OF DIVERSION DAM, SHOWING EASTERN PROFILES OF TOWERS, PIERS, AND ROLLERS. HEADWORKS IN BACKGROUND.

CO-90-8 OBLIQUE OVERVIEW, LOOKING SOUTH, OF THE WEST SIDE (OUTLET) OF HEADWORKS AND THE BEGINNING OF THE GOVERNMENT HIGH LINE CANAL. MAIN GATEHOUSE AT CENTER.

CO-90-9 OBLIQUE VIEW, LOOKING WEST-NORTHWEST, OF EAST SIDE (INLET) OF HEADWORKS, SHOWING NINE SLIDE GATES. MAIN GATEHOUSE AND SERVICE BRIDGE AT LEFT, RAILROAD GRADE IN THE BACKGROUND.

CO-90-10 OBLIQUE VIEW, LOOKING SOUTH-SOUTHEAST, OF THE WEST SIDE (OUTLET) OF HEADWORKS. MAIN GATEHOUSE ON RIGHT.

CO-90-11 OBLIQUE VIEW, LOOKING EAST-NORTHEAST, OF TOP SIDE OF DIVERSION DAM. SERVICE BRIDGE ON LEFT, GATEHOUSE AND ROLLER GATE (RAISED POSITION) ON RIGHT.

CO-90-12 OBLIQUE VIEW, LOOKING WEST, OF TOP SIDE OF DIVERSION DAM, ALSO SHOWING EASTERN PROFILES OF PIERS AND GATEHOUSES. ROLLER GATE (RAISED POSITION) ON RIGHT. NOTE DETAIL OF EXTENSION SHIELD THAT, WHEN LOWERED TO A SECURE POSITION AGAINST THE DAM SILL, CREATES A VIRTUALLY IMPERVIOUS SEAL.

CO-90-13 OBLIQUE VIEW, LOOKING WEST-SOUTHWEST, OF TOP SIDE OF DIVERSION DAM, SHOWING ROLLER GATE OPERATING

MECHANISM (WITHIN PIER RECESS) AND LIFT MECHANISM (WITHIN GATEHOUSE). SERVICE BRIDGE IS ON RIGHT, AND 60-FOOT-LONG ROLLER GATE (RAISED POSITION) OVER SLUICEWAY IS ON LEFT.

CO-90-14 PROFILE VIEW, LOOKING WEST-SOUTHWEST, OF PIER AND ROLLER GATE LIFT MECHANISM. ROLLER GATE IN FOREGROUND IS IN LOWERED POSITION. SERVICE BRIDGE IS IN UPPER RIGHT.

CO-90-15 OBLIQUE VIEW, LOOKING SOUTHWEST, OF ROLLER GATE HOIST MECHANISM SITUATED IN THE EASTERNMOST GATEHOUSE. THE HOIST CONTROL PANEL IS AT LEFT.

CO-90-16 "NO. 64. VIEW OF GRAND RIVER LOOKING ALONG THE AXIS OF PROPOSED DIVERSION DAM. H.T.C., AUG. 20, 1913."

CO-90-17 "U.S. RECLAMATION SERVICE, GRAND RIVER DAM, TOPOGRAPHICAL MAP OF DAM SITE AND CONSTRUCTION PLANT. SEPTEMBER 15, 1914

CO-90-18 COPY OF PLAN WITH NO TITLE BLOCK. "RECD – 6-28-'14" IN PENCIL ON LOWER RIGHT CORNER. THIS DATE, TWO MONTHS PRIOR TO CANCELLATION OF THE RECLAMATION SERVICE'S CONTRACT WITH MACHINENFABRIK, SUGGESTS THAT THE DRAWING WAS PREPARED BY THE GERMAN FIRM.

CO-90-19 "U.S.R.S., GRAND VALLEY PROJECT, COLO. SPROCKET, SHAFT AND CHAIN FOR 70 FT. ROLLER HOIST. MAY 14, 1915." NOTE THAT ON THIS AND OTHER WORKING DRAWINGS OF THE ROLLER GATES, THE GERMAN MANUFACTURER/PATENT HOLDER IS NOT ACKNOWLEDGED.

CO-90-20 "U.S.R.S. DEPT. OF THE INTERIOR. GRAND VALLEY PROJECT – COLORADO. GRAND RIVER DIVERSION DAM. CONTROL FOR ROLLER HOISTS. 20 MAY 1915."

CO-90-21 "DEPT. OF INTERIOR UNITED STATES RECLAMATION SERVICE GRAND VALLEY DIVERSION DAM ROLLING CREST SECTIONS OF 70' ROLLER SPECIFICATIONS NO. 285 JANUARY 1915"

CO-90-22 "DEPT. OF THE INTERIOR, U.S. RECLAMATION SERVICE, GRAND VALLEY PROJECT - COLORADO. OPERATING MECHANISM FOR REGULATOR GATES. GRAND RIVER DAM." NO DATE SPECIFIED.

CO-90-23 "DEPARTMENT OF THE INTERIOR U.S. RECLAMATION SERVICE GRAND VALLEY PROJECT – COLO. GRAND RIVER DIVERSION DAM CANAL GATES – AUTOMATIC CONTROL." NO DATE SPECIFIED.

CO-90-24 "NO. 146. LOOKING WEST ALONG DAM. EAST SIDE ABUTMENT." NOTE SLUICEWAY AND HEADGATES AT CENTER REAR OF PHOTOGRAPH; COFFERDAM AT CENTER RIGHT; AND THE SCREENING AND MIXING PLANT AT LOWER RIGHT. RAIL CARS ARE ON THE RAILROAD GRADE IN BACKGROUND.

CO-90-25 "NO. 148. DIVERSION GATES." THESE ARE THE 9 HEADGATES TO THE MAIN LINE CANAL. NOTE THE CROSS-RIVER CABLE WAY AND ASSOCIATED PIER.

CO-90-26 "NO. 149. DIVERSION DAM. PANORAMA. SEE NO. 150."

CO-90-27 "NO. 144. GRAND VALLEY DIVERSION DAM, SHOWING HIGH CANYON WALLS."

CO-90-28 "DEPARTMENT OF THE INTERIOR U.S. RECLAMATION SERVICE GRAND VALLEY PROJECT, COLO. GRAND RIVER DAM AND HEADWORKS GENERAL PLAN REVISED AUG. 13, 1914 AND AUG. 29, 1914"

CO-90-29 "NO. 147. FORMS IN PLACE. EAST SIDE ABUTMENT AND CONCRETING PLANT."

CO-90-30 "UNITED STATES RECLAMATION SERVICE, GRAND RIVER DAM, PIER "A" AND EAST SIDE REGULATOR GATE WALL." NO DATE SPECIFIED.

CO-90-31 "U.S. RECLAMATION SERVICE, GRAND RIVER DAM, PLAN & ELEVATIONS GATEHOUSE – PIER 'B,' APRIL 19, 1915."

CO-90-32 "U.S. RECLAMATION SERVICE, GRAND RIVER DAM, DETAILS OF PIER 'B,' OCT. 14, 1914."

CO-90-33 "U.S. RECLAMATION SERVICE, GRAND RIVER DAM, DETAILS OF PIERS 'C' & 'E,' OCT. 10, 1914."

CO-90-34 "U.S. RECLAMATION SERVICE, GRAND RIVER DAM, DETAILS OF PIER 'G,' SEPT. 29, 1914."

CO-90-35 "U.S. RECLAMATION SERVICE GRAND RIVER DAM DETAILS OF PIERS 'D' & 'F,' OCT. 25, 1914."

CO-90-36 "UNITED STATES RECLAMATION SERVICE, GRAND RIVER DAM, PLAN & SECTIONS OF POWER-HOUSE." NO DATE SPECIFIED.

CO-90-37 "DEPT. OF THE INTERIOR, U.S. RECLAMATION SERVICE, GRAND VALLEY PROJECT – COLO., HOUSE FOR STORAGE BATTERY DIVERSION DAM. 5-24-1916."

CO-90-38 "UNITED STATES RECLAMATION SERVICE GRAND RIVER DAM SIDE ELEVATION & SECTIONS GATE HOUSES – PIERS D & F." NO DATE SPECIFIED.

CO-90-39 NO. 170. ROLLER CREST DAM. GRAND VALLEY PROJECT. 1915." NOTE CROSS-RIVER CABLEWAY, AN IMPORTANT COMPONENT OF THE CONSTRUCTION PLANT.

CO-90-40 "NO. 167. ROLLING CREST DAM. GRAND VALLEY PROJECT. 1915."

CO-90-41 "NO. 169. CONGRESSIONAL PARTY VISITING THE ROLLER CREST DAM IN 1915. DEDICATION."

CO-90-42 "NO. 175. VIEW SHOWING REGULATOR GATES AND TEMPORARY EQUIPMENT FOR HOISTING THE SLUICEWAY ROLLER. F.E.D. JUNE, 1916."

CO-90-43 COPY OF HISTORIC PHOTOGRAPH ON FILE AT GRAND VALLEY WATER USERS ASSOCIATION. NO DATE OR CAPTION WAS AVAILABLE. NOTE CONFINED CANYON, AND DIFFICULTY OF RELOCATING TRANSPORTATION ROUTES.

CO-90-44 "NO. 172. GENERAL VIEW OF THE DAM, LOOKING DOWNSTREAM FROM THE EAST END. F.E.D. JUNE, 1916."

COMPARE THIS HISTORIC IMAGE, TAKEN UPON DAM COMPLETION (1916), WITH CURRENT-CONDITION PHOTOGRAPH NO. 1. THE DAM RETAINS A REMARKABLE DEGREE OF INTEGRITY OF DESIGN AND SETTING.

CO-90-45 "NO. 182. GRAND VALLEY DIVERSION DAM. JUNE, 1917. R.B.D." STRUCTURES ON THE WEST SIDE OF THE RIVER BELOW THE DAM ARE THREE BUNKHOUSES, A MESS HALL, HOSPITAL, DOCTOR'S RESIDENCE, ENGINEER'S RESIDENCE, AND OUTBUILDINGS.

CO-90-46 "NO. 187. GRAND RIVER DIVERSION DAM. JUNE, 1917. R.B.D."

CO-90-47 "NO. 176. VIEW OF ROLLER A-B, SERVICE BRIDGE AND POWER HOUSE FROM UPSTREAM SIDE. F.E.D. JUNE 1916."

CO-90-48 "P8-400-564 GRAND VALLEY PROJECT – VIEW OF GV DIVERSION DAM ON COL. RIVER COMPLETED IN 1915 BY BOR TO DIVERT WATER TO IRRIGATE THE GRAND VALLEY PROJECT. 7-18-58 BY STAN RASMUSSEN." NOTE INTEGRATION OF THE DAM AND CANAL HEADGATE AT CENTER LEFT, PROXIMITY OF THE RIVER AND RAILROAD TRACKS AT LOWER LEFT, AND GATEKEEPER'S HOUSE ON LOWER RIGHT.

CO-90-49 "NO. 190. GRAND VALLEY DIVERSION DAM. DIVERSION GATES, WATER FLOWING INTO HIGH LINE. JUNE, 1917. R.B.D."

CO-90-50 "NO. 173. VIEW OF ROLLER A-B RAISED TO MAXIMUM HEIGHT, AND ADJOINING HOIST HOUSE. F.E.D. JUNE, 1916."

CO-90-51 "NO. 184. GRAND RIVER DAM. JUNE, 1917. R.B.D."

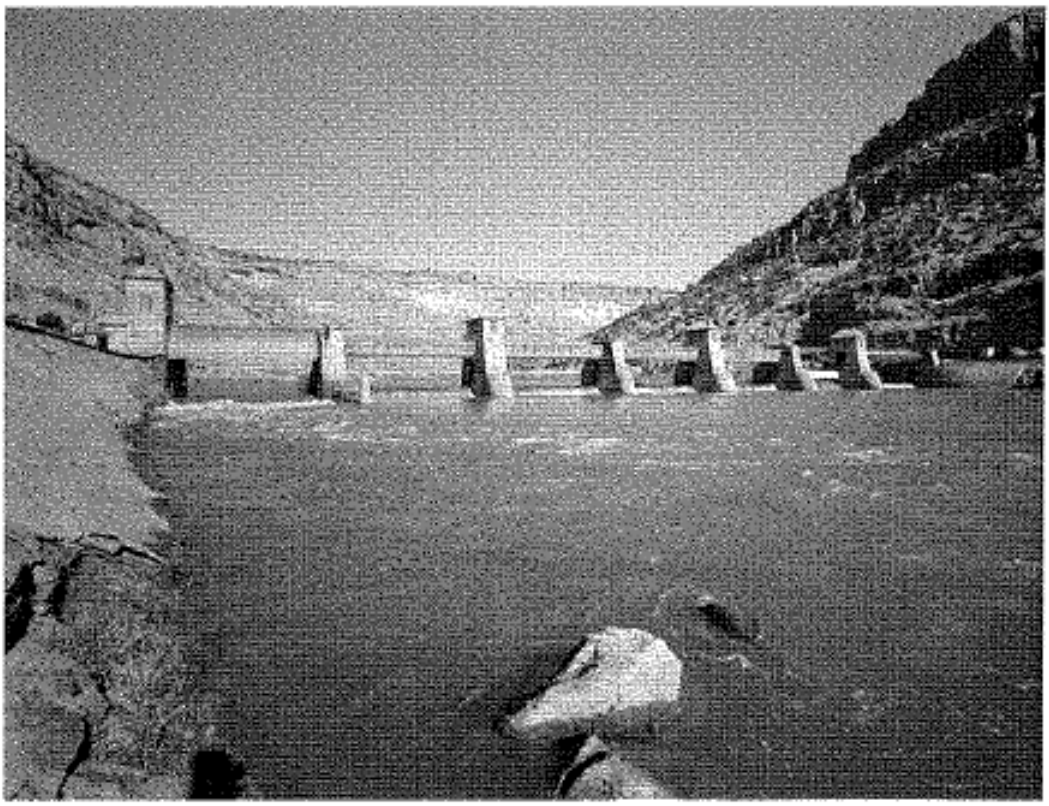
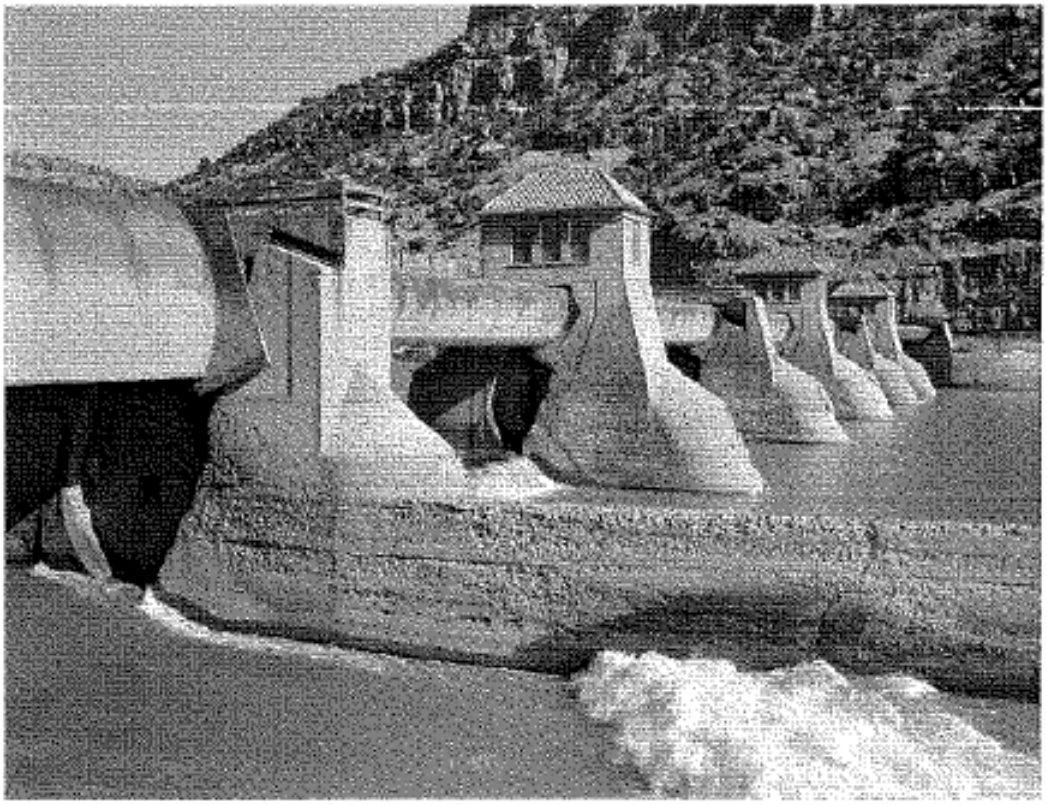


Photo 1



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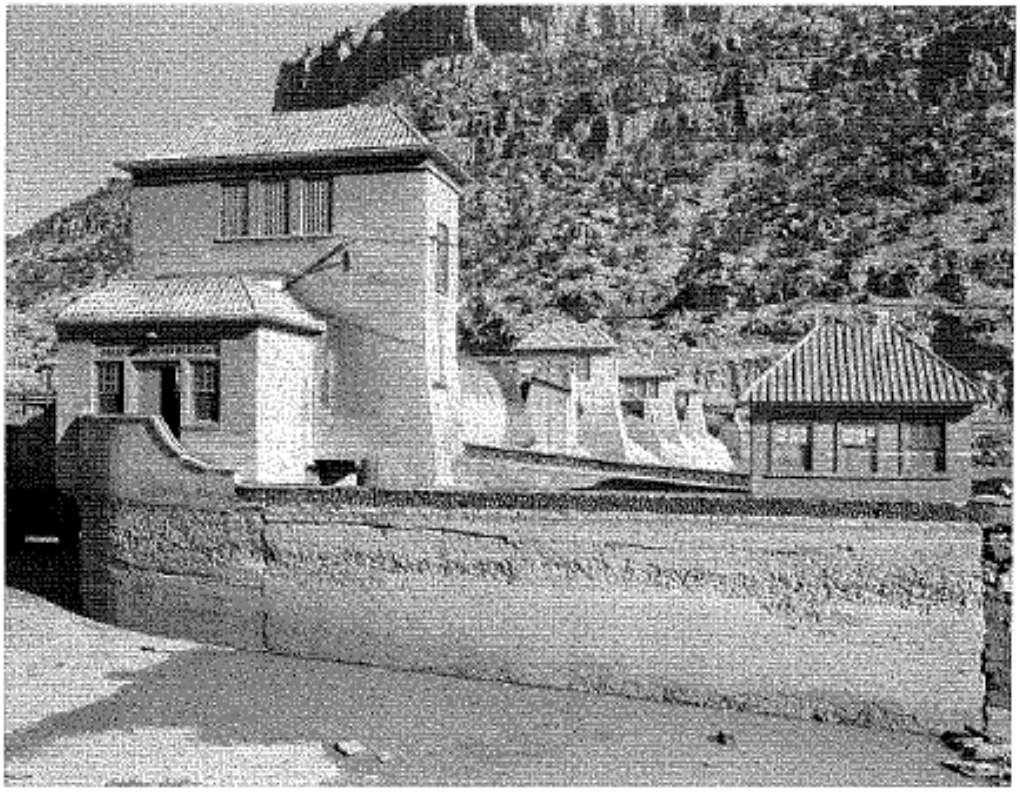

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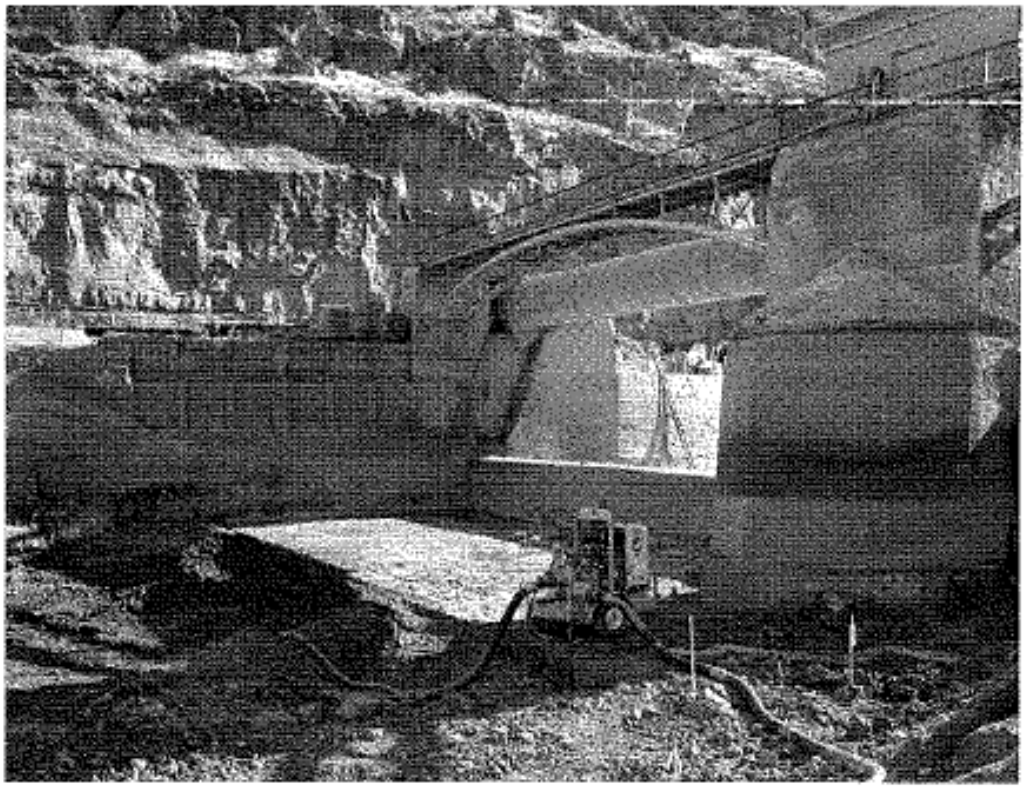

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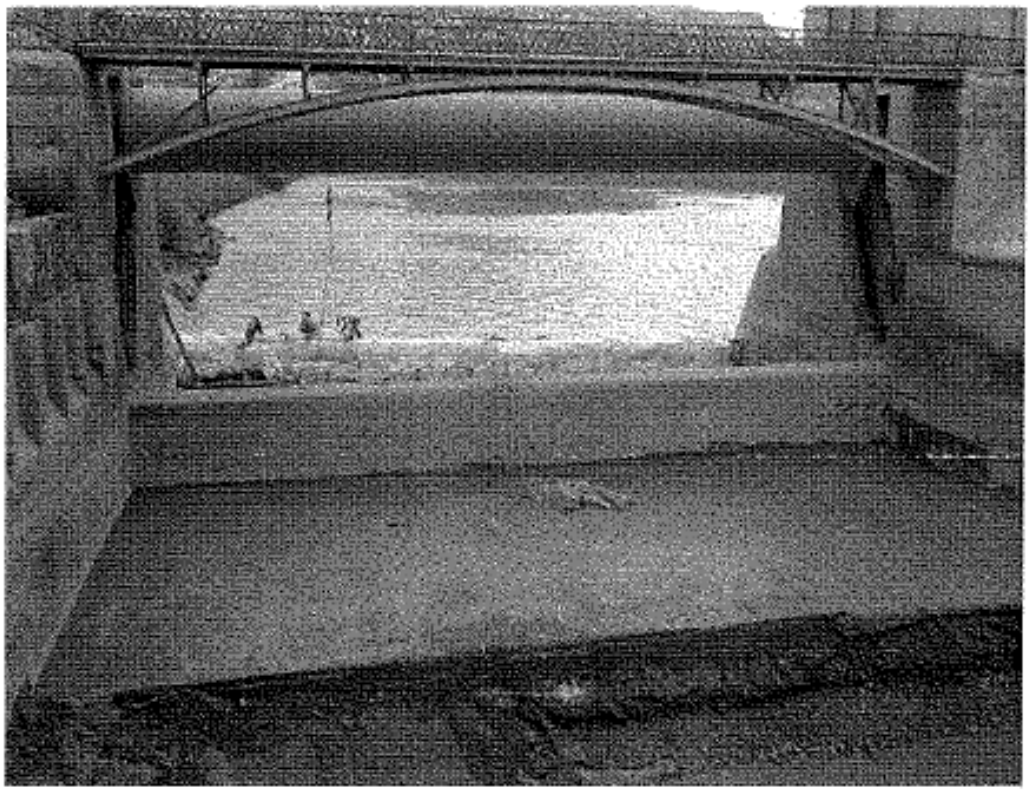

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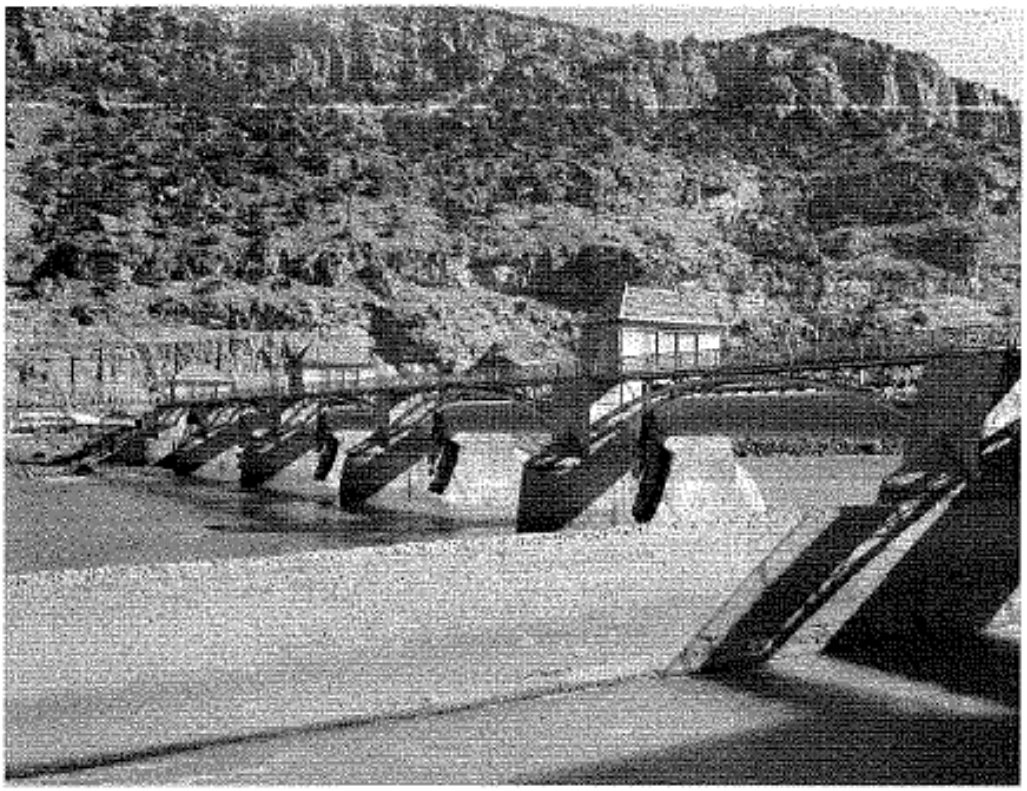

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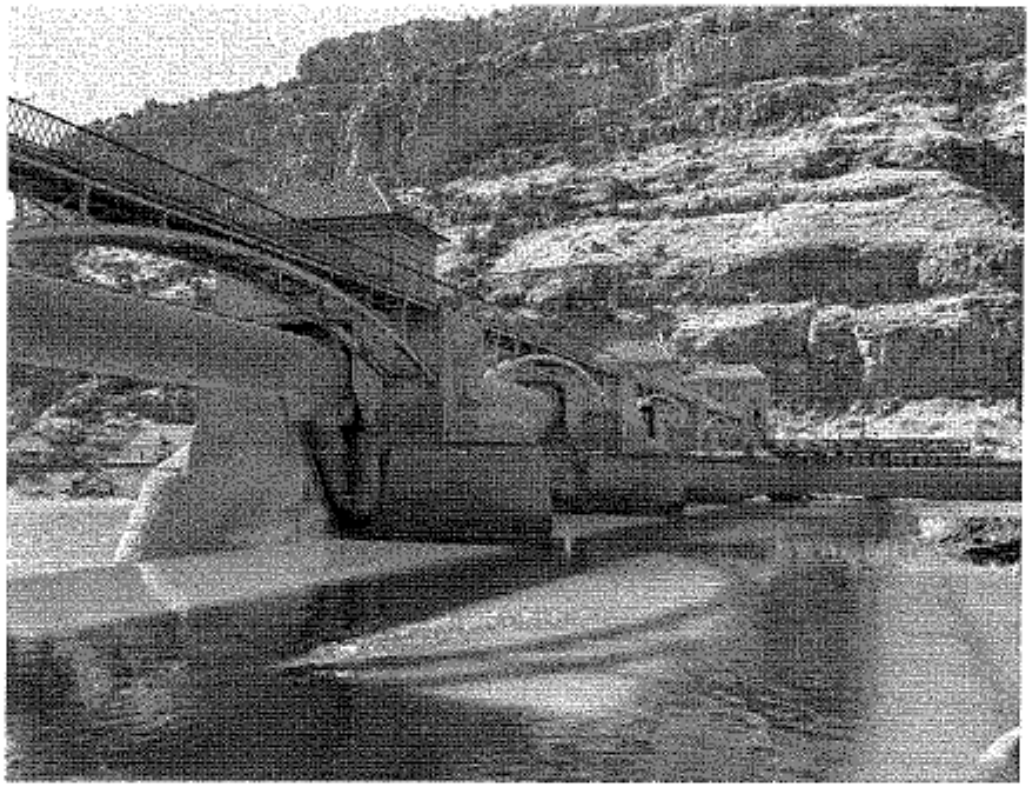

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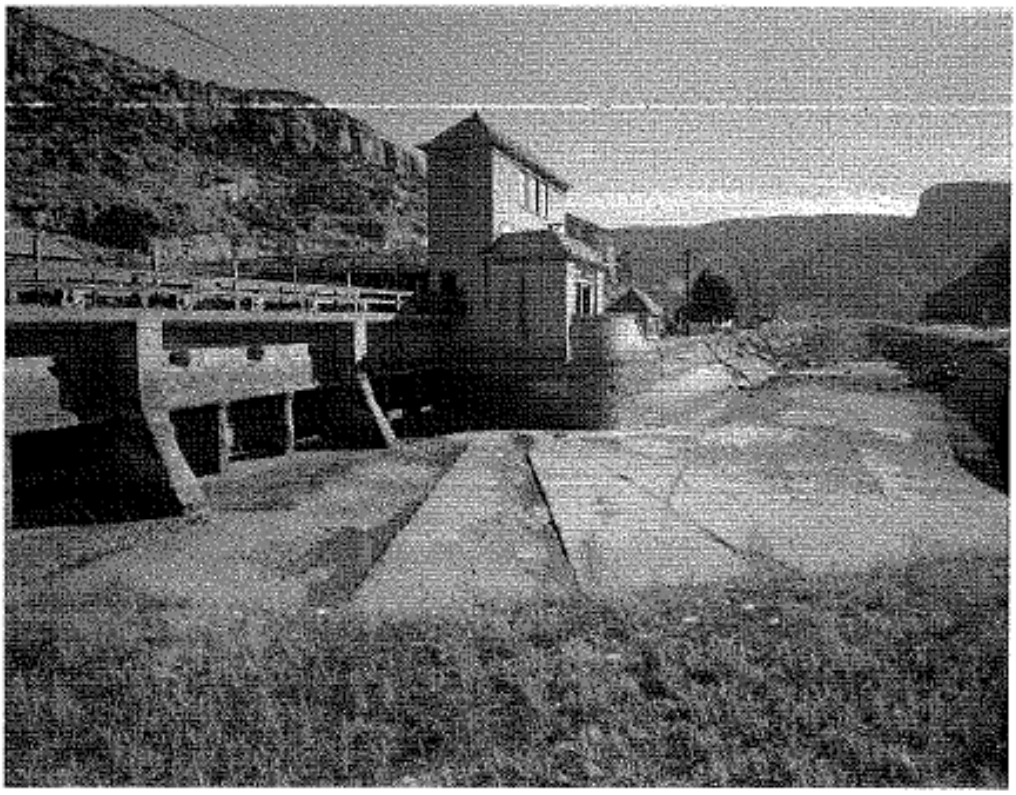

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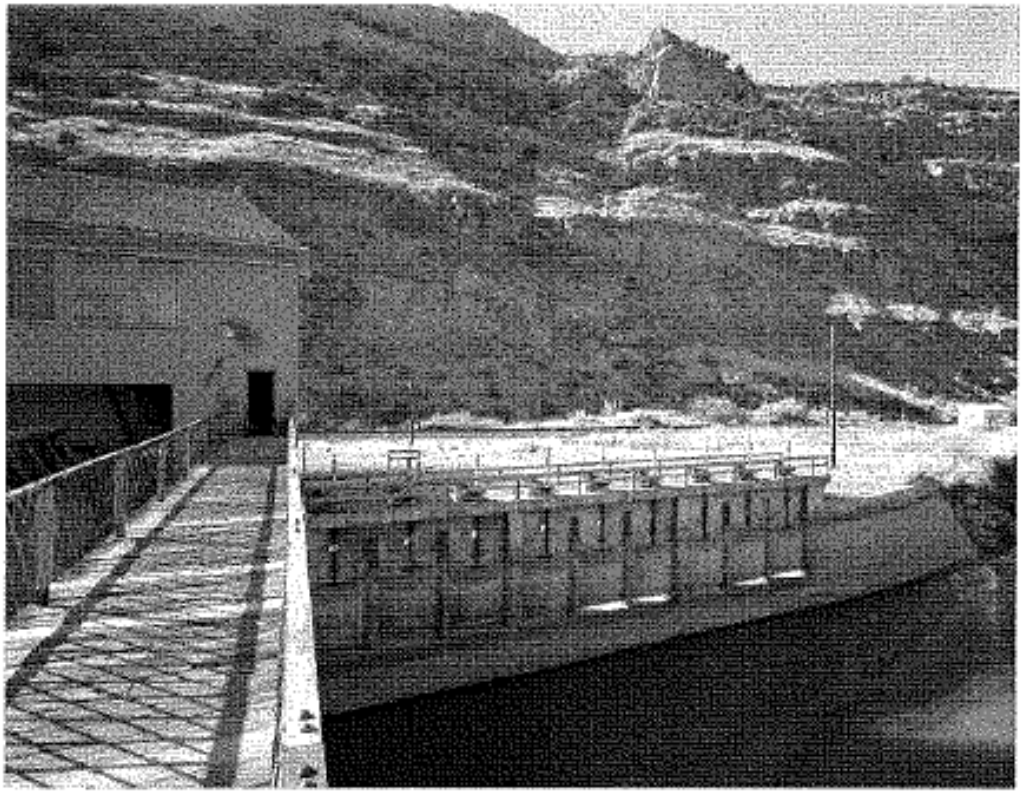

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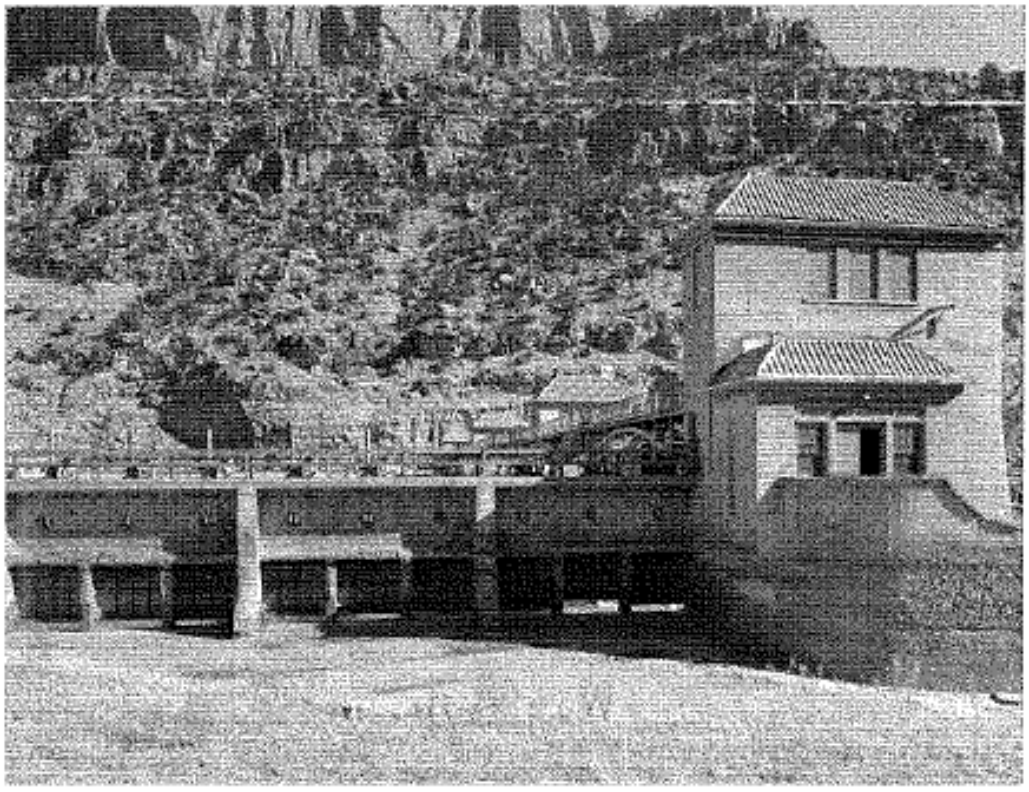

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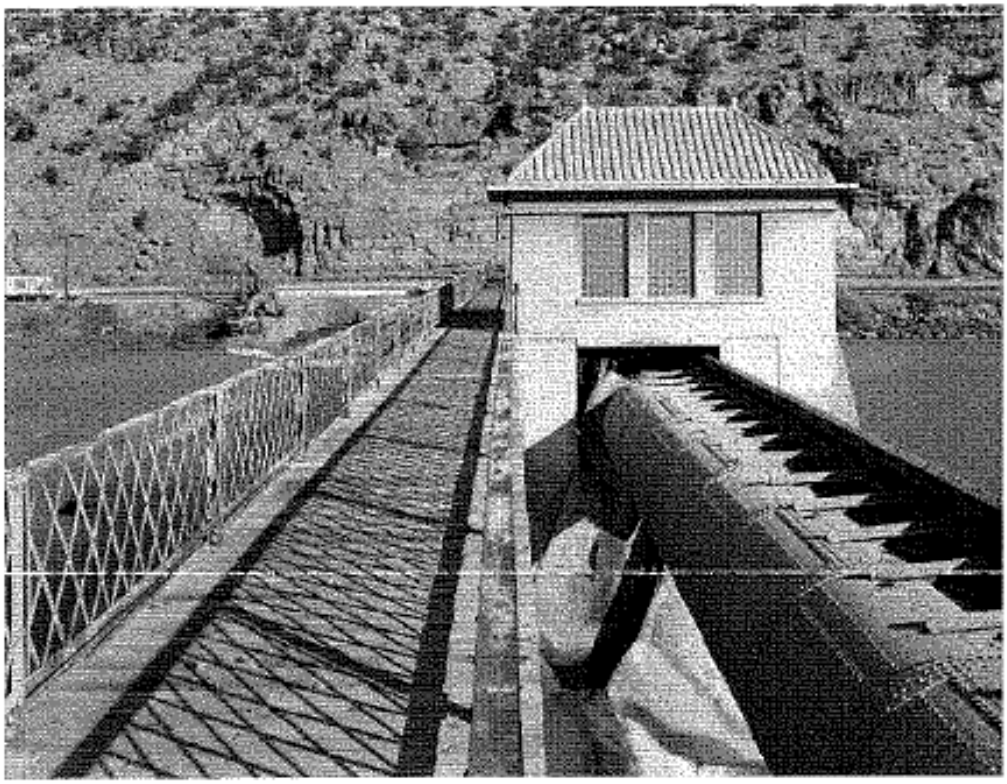

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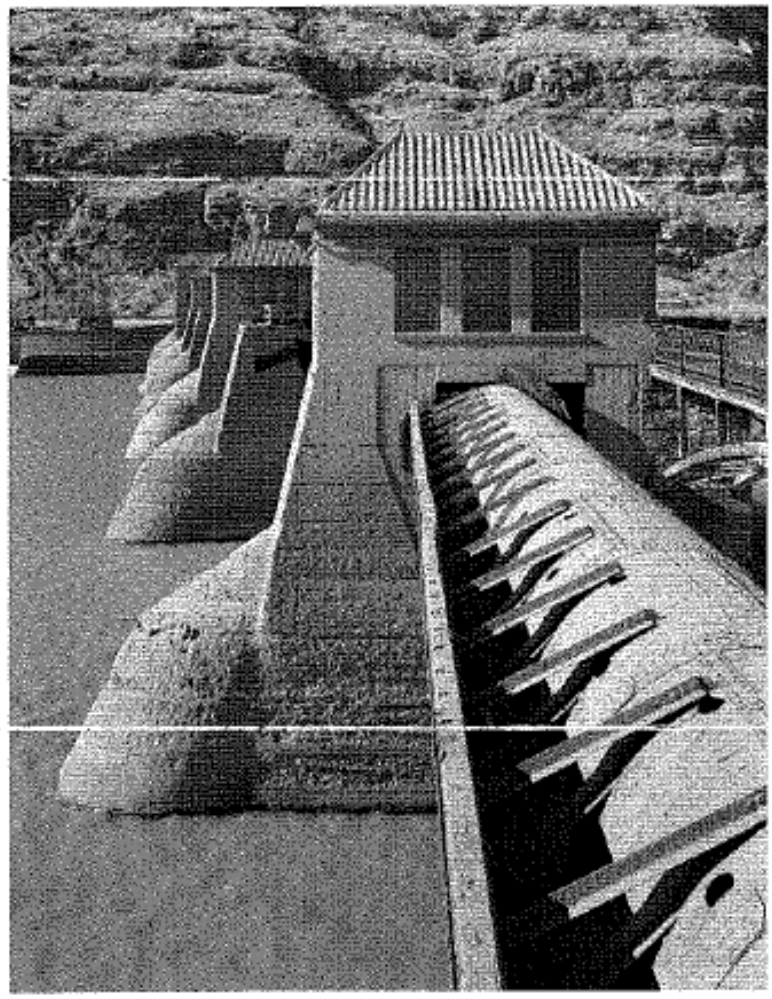

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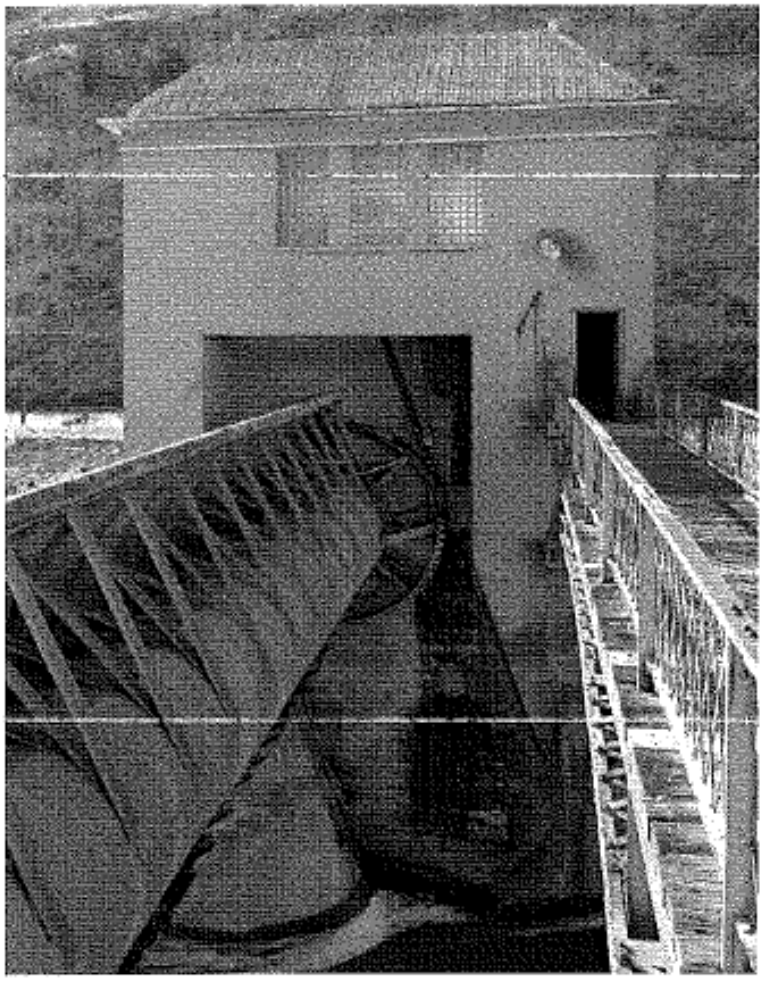

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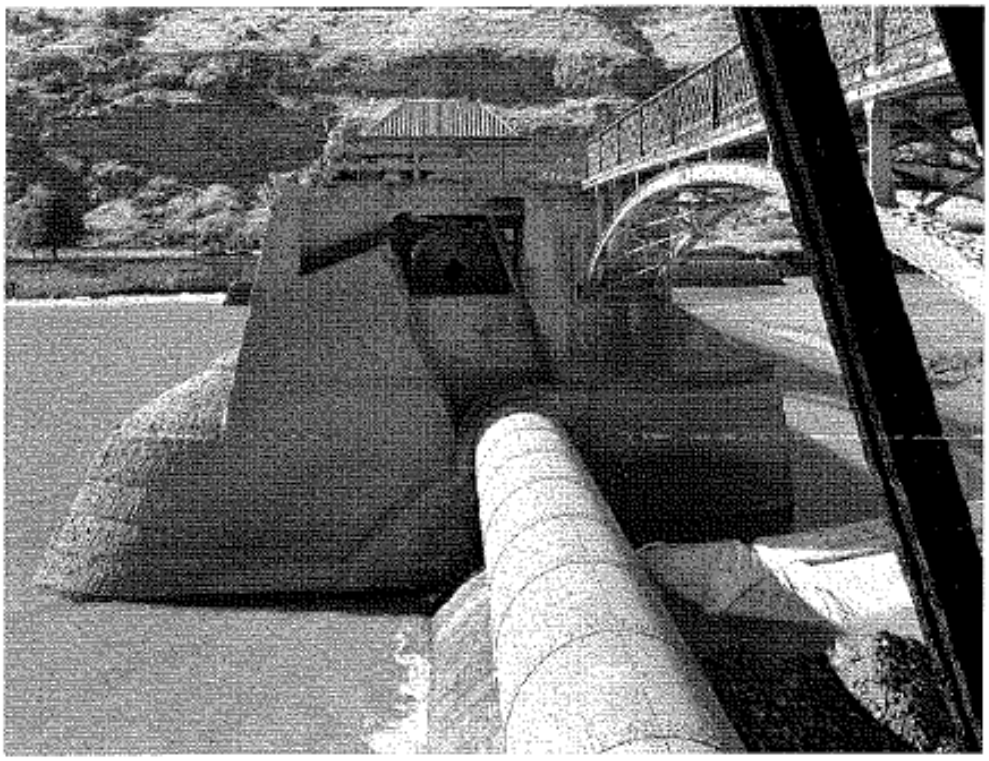

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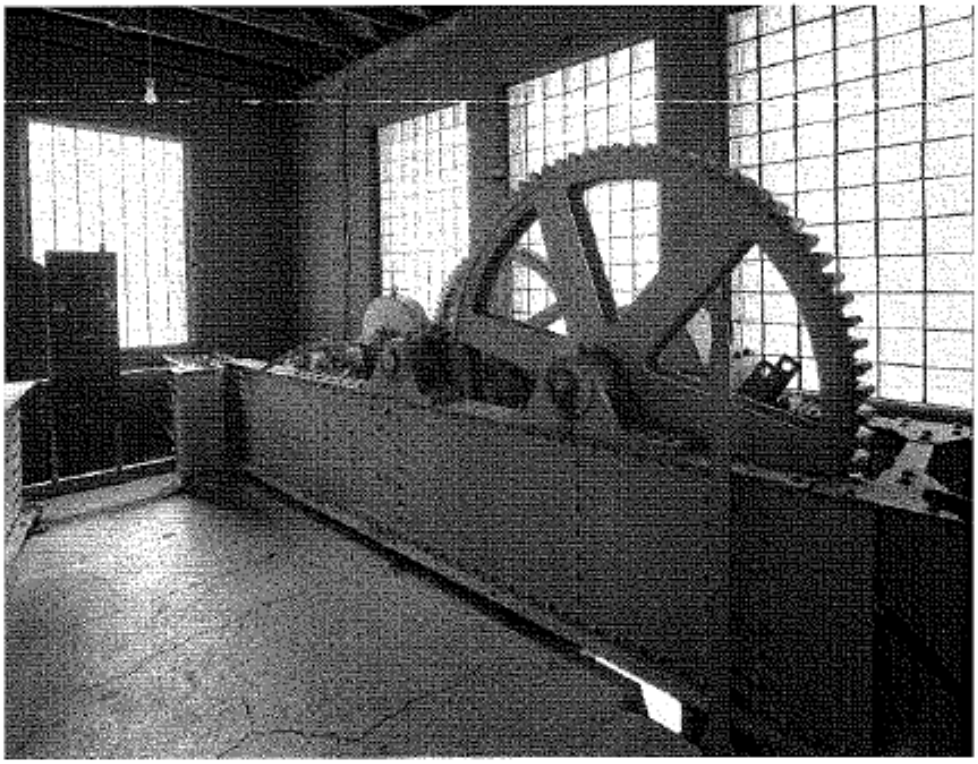

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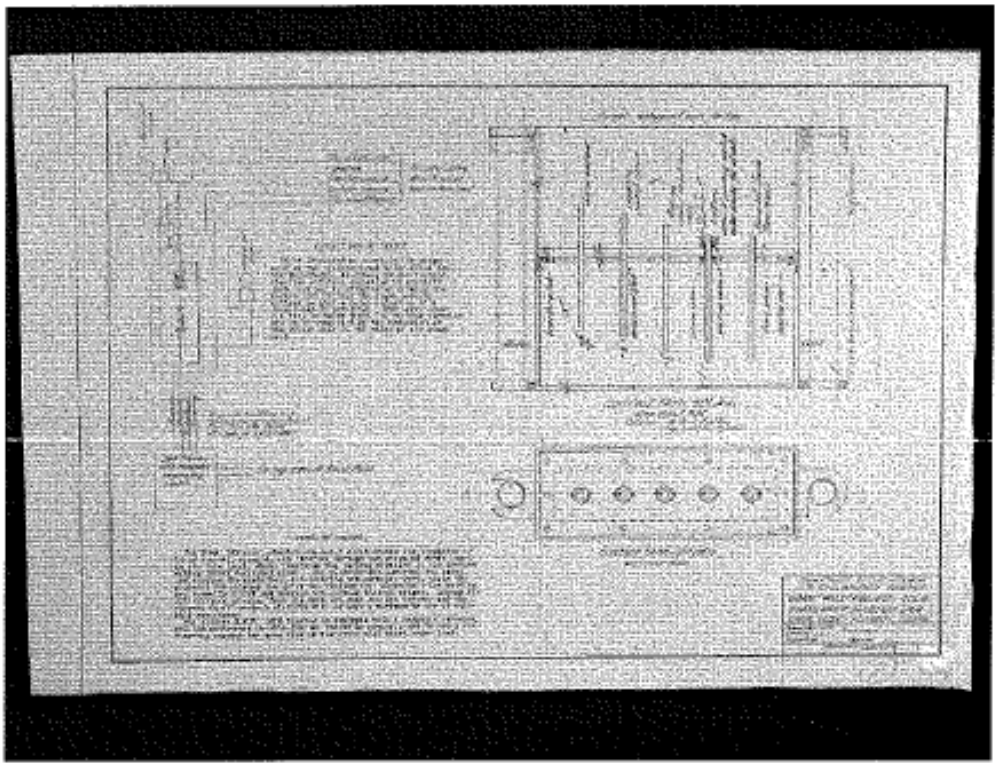

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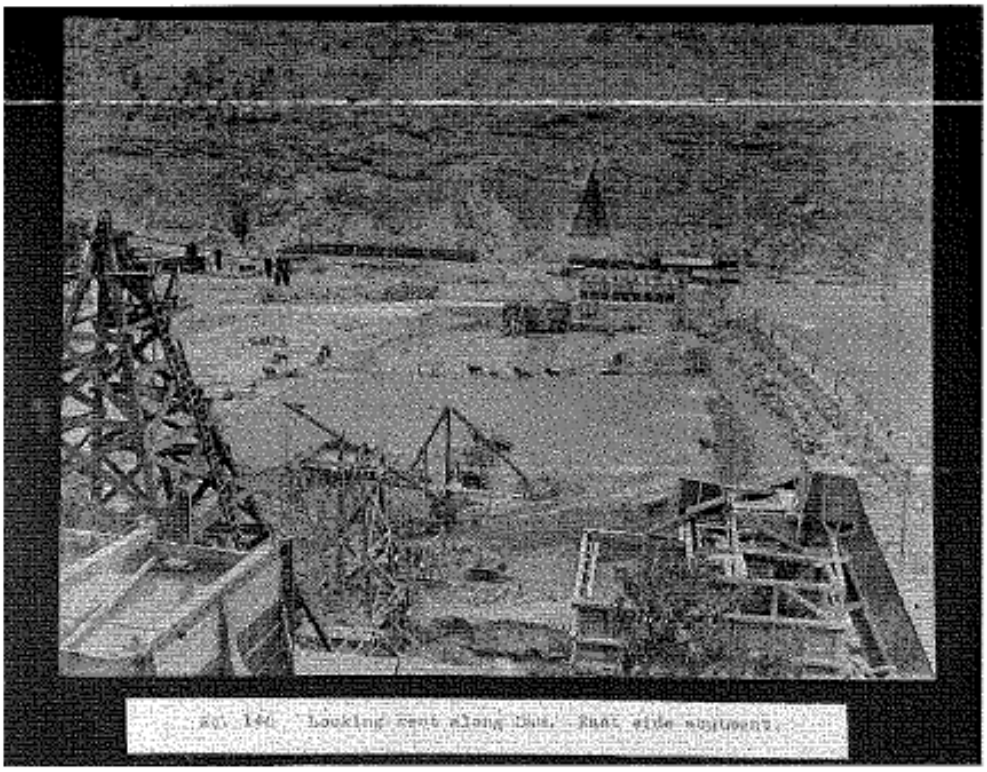

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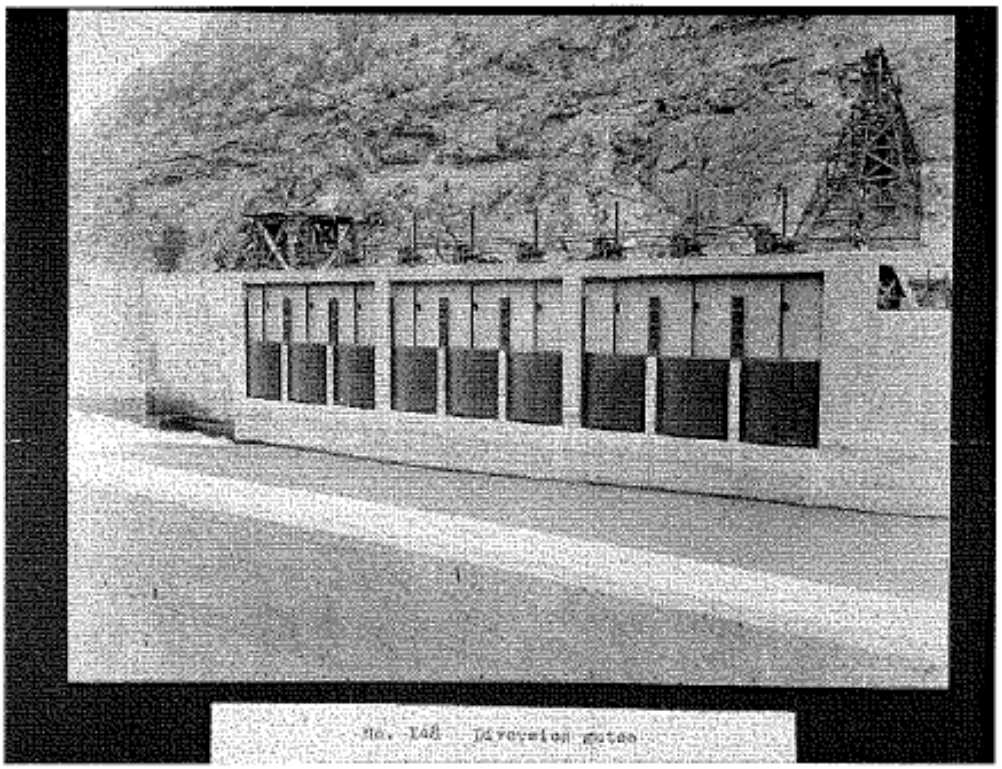

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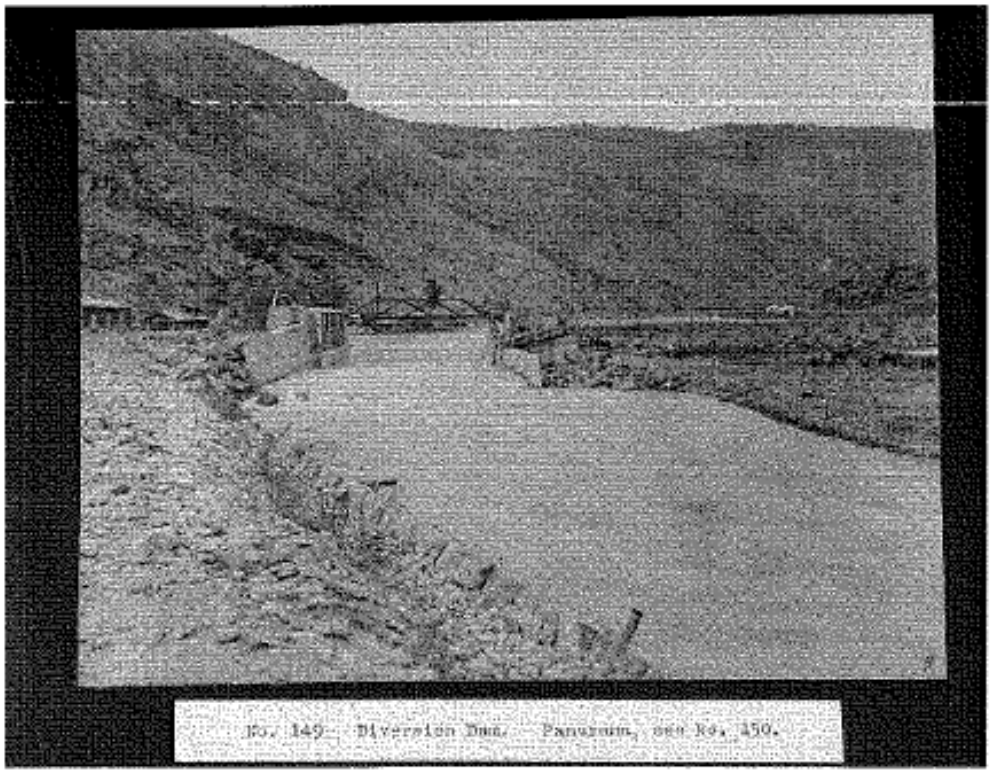

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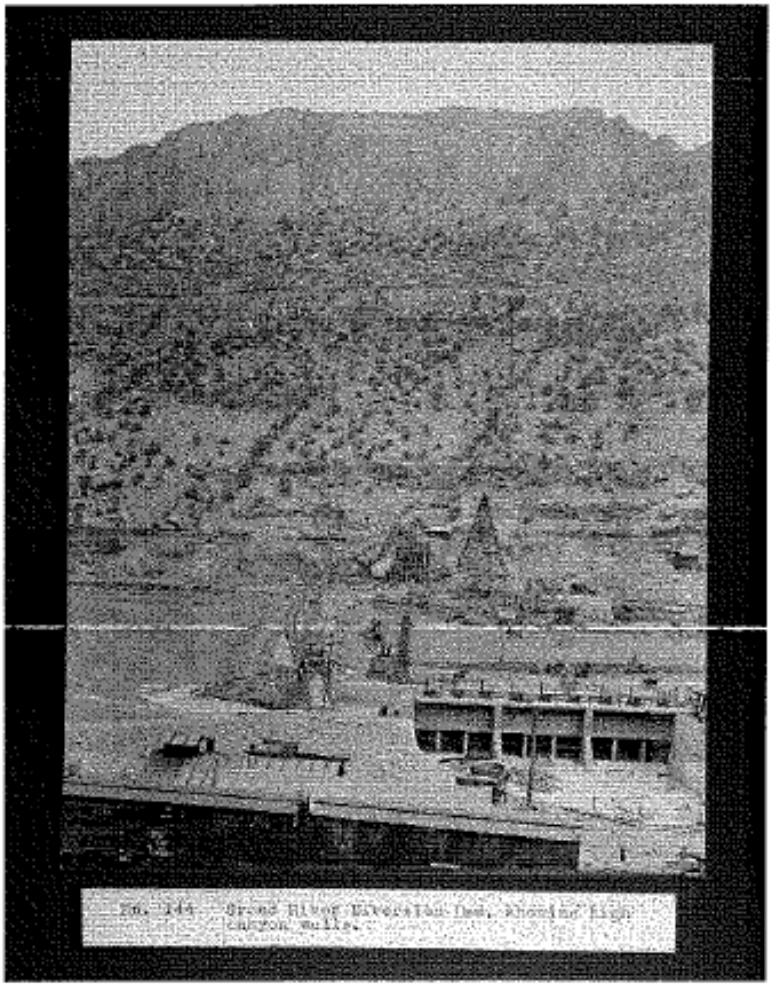

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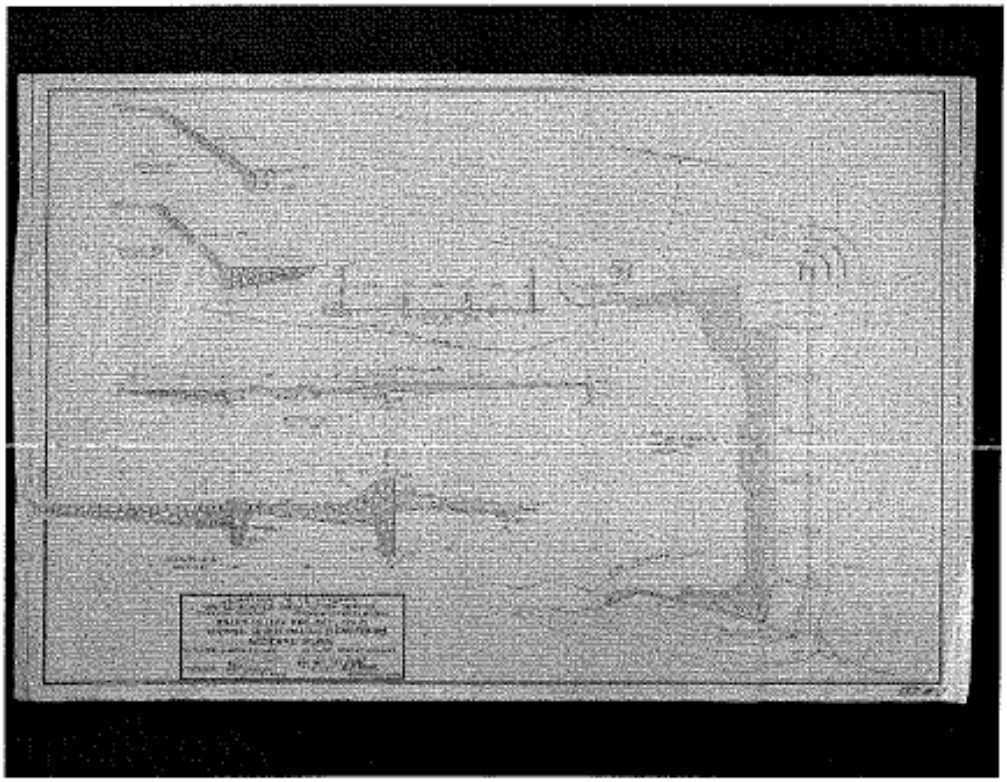

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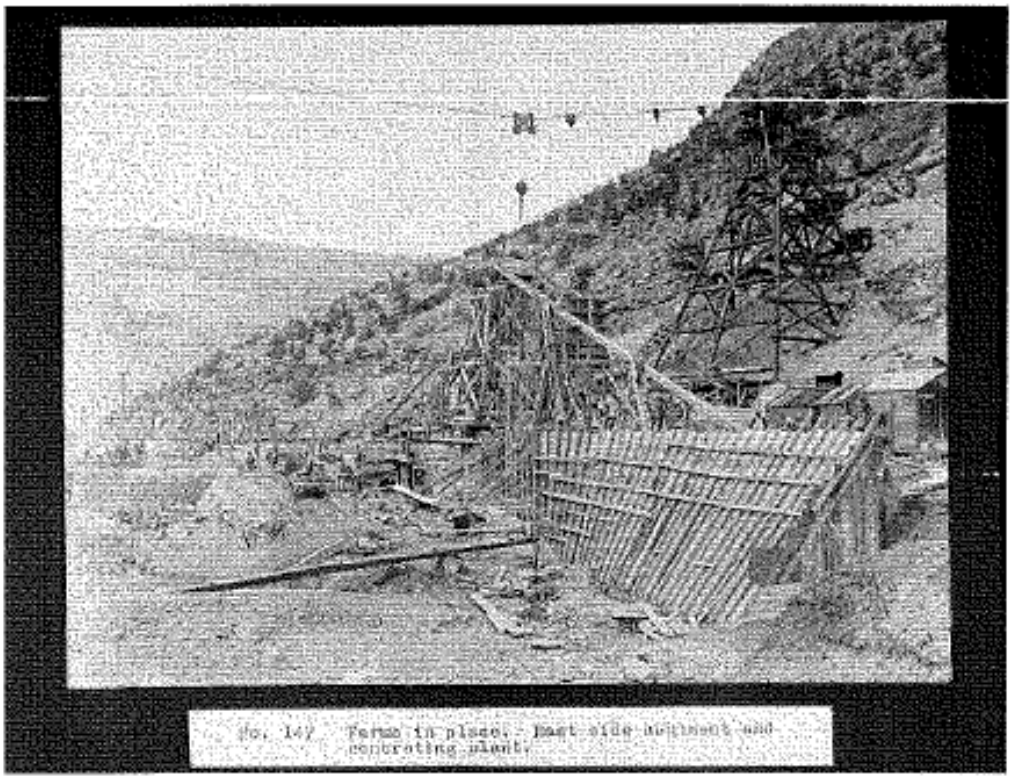

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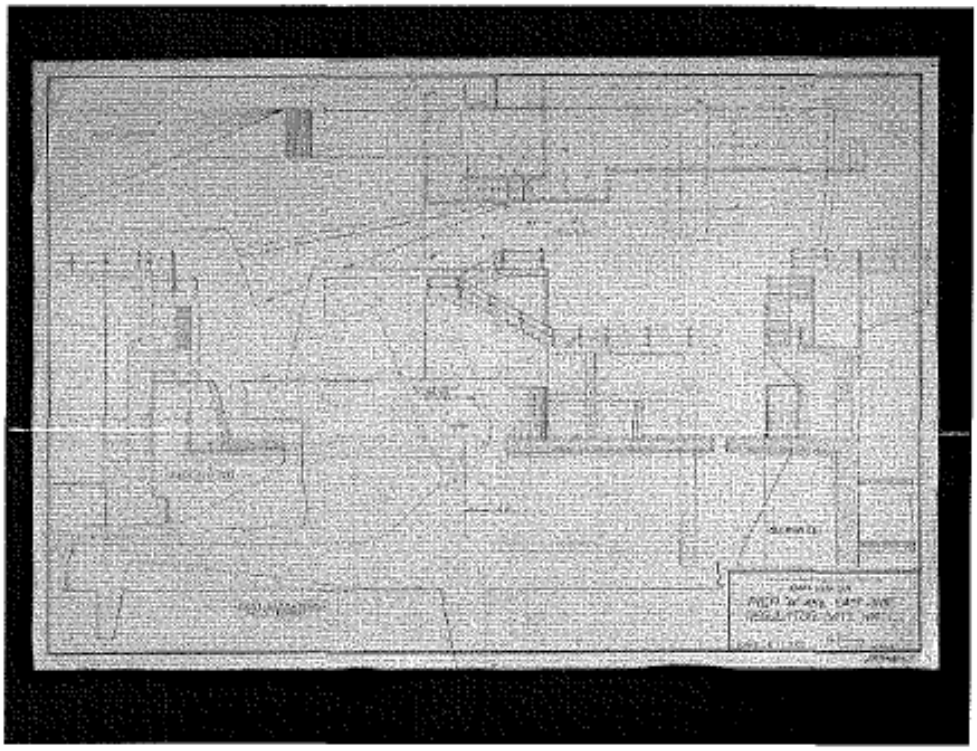

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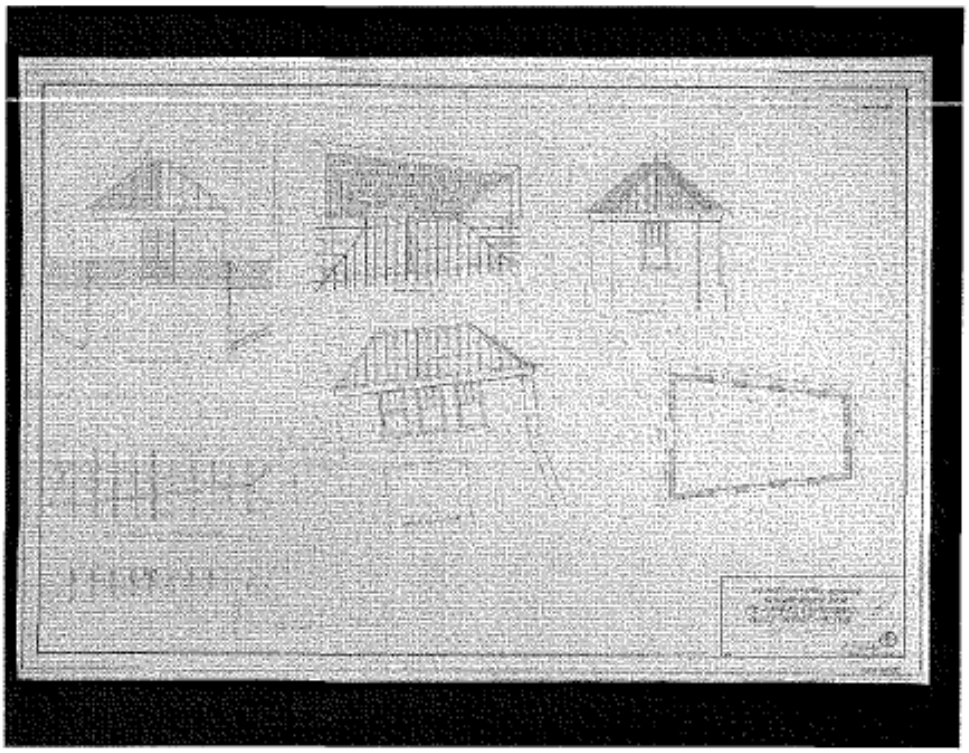

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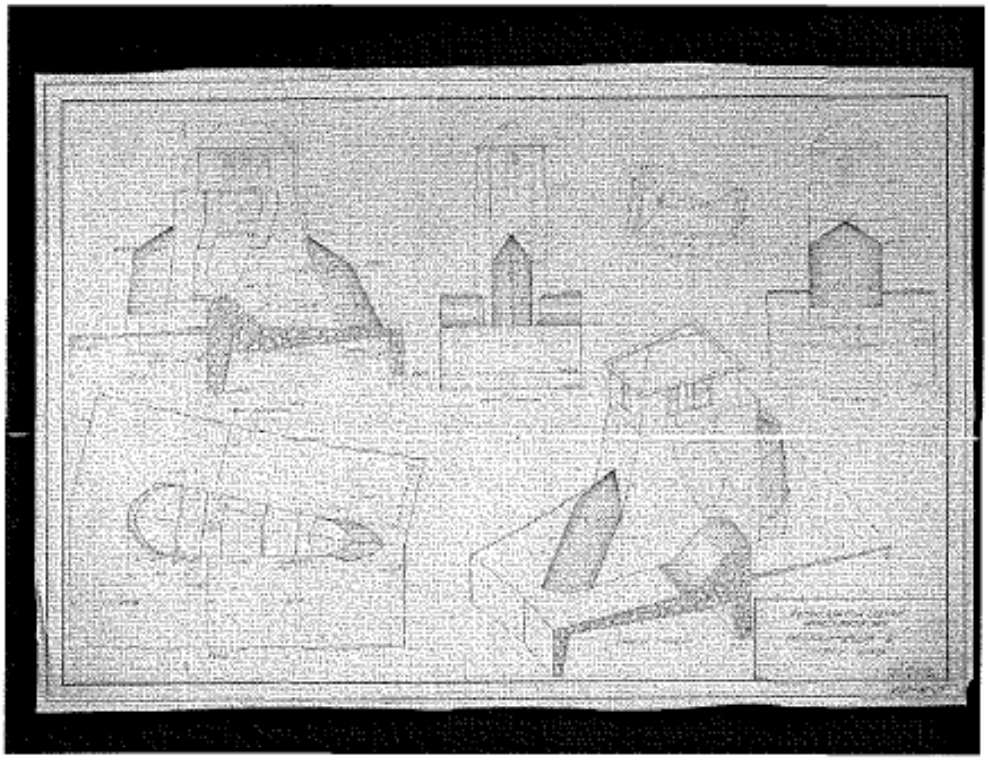

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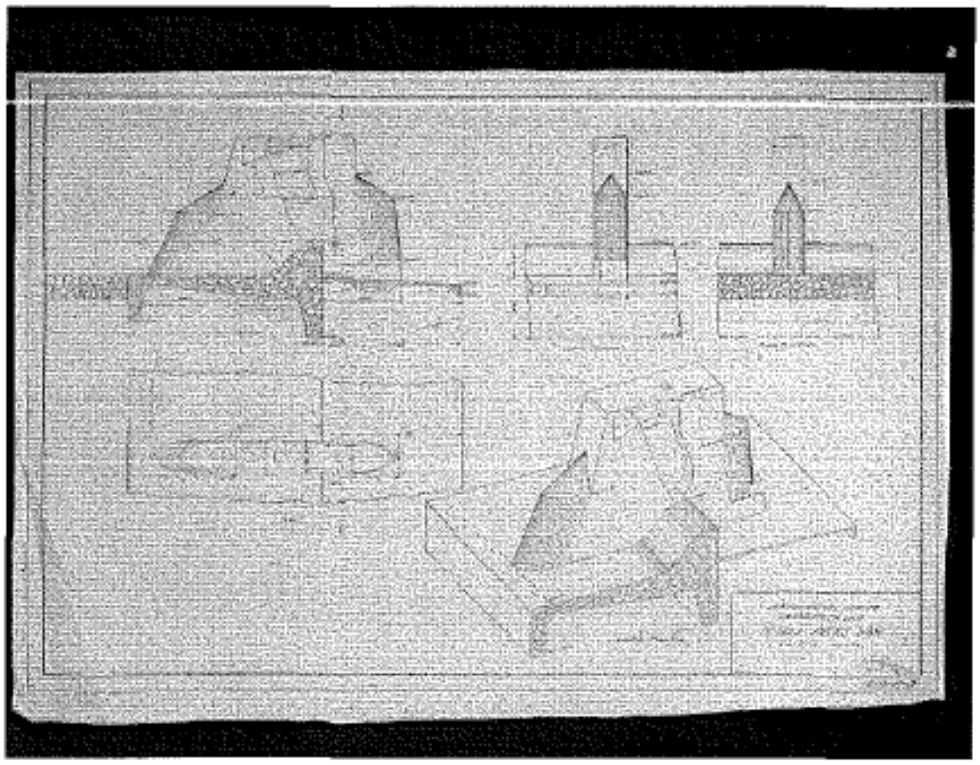

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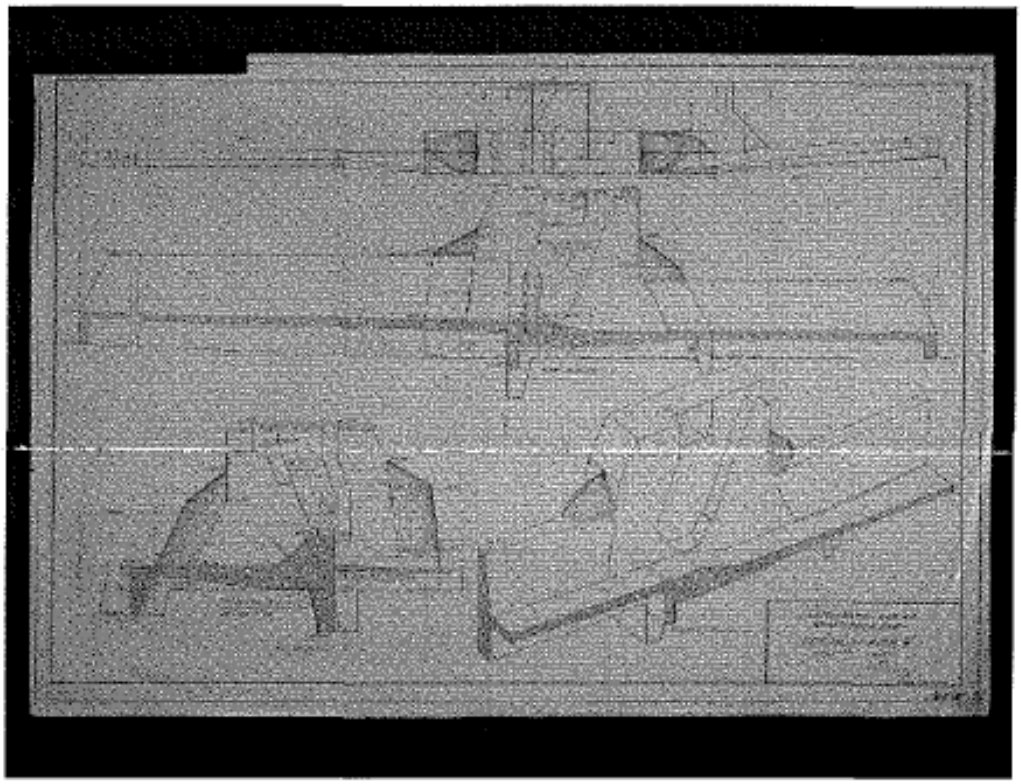

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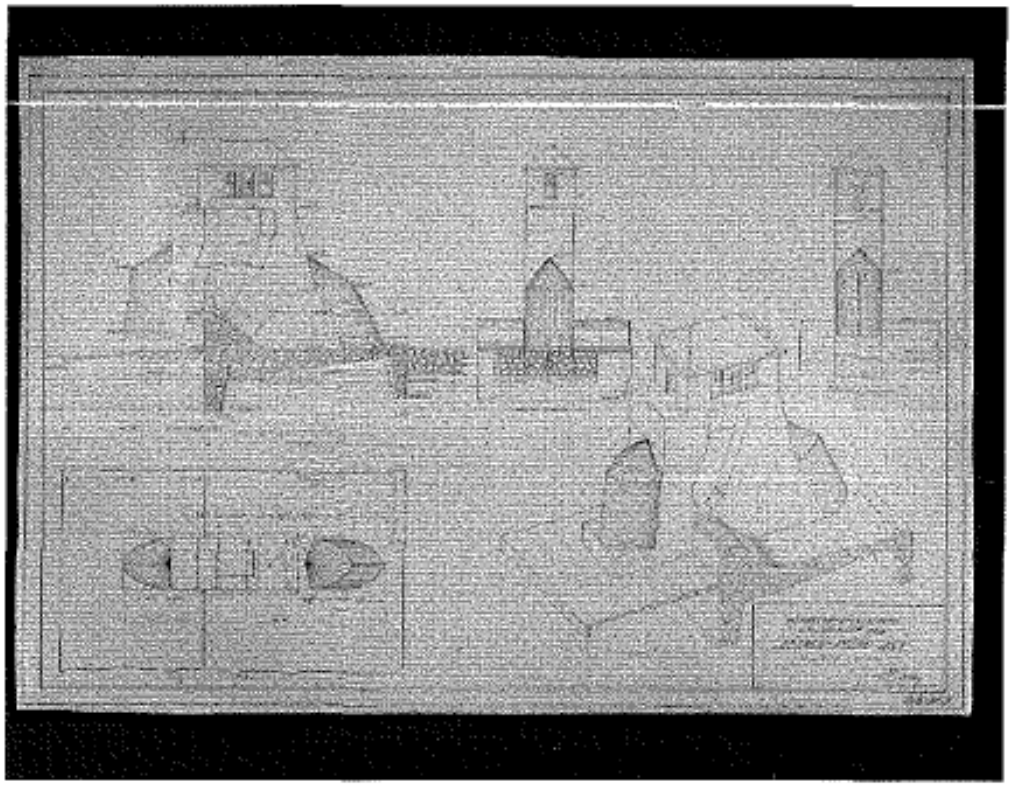

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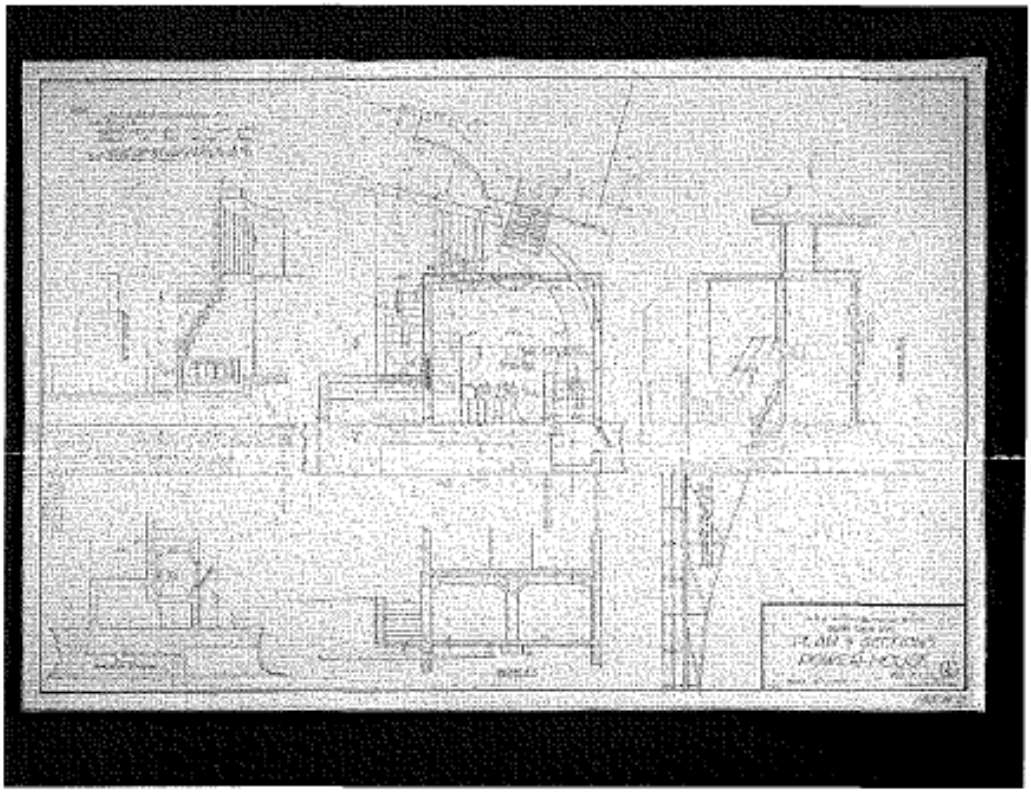

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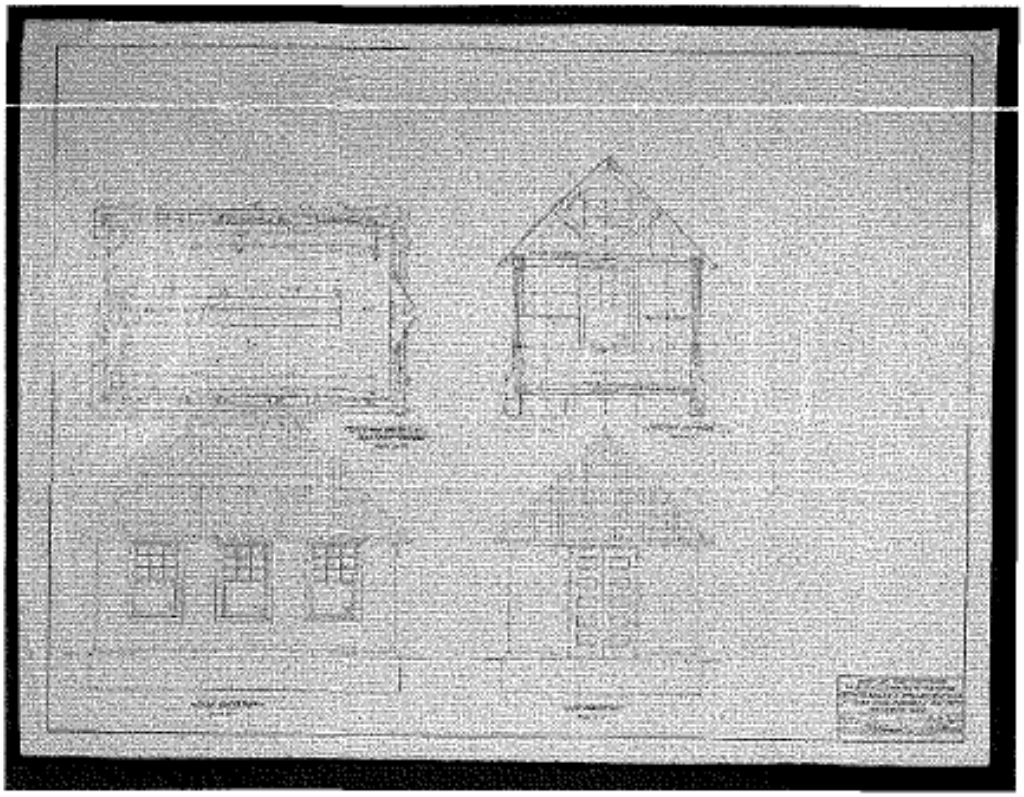

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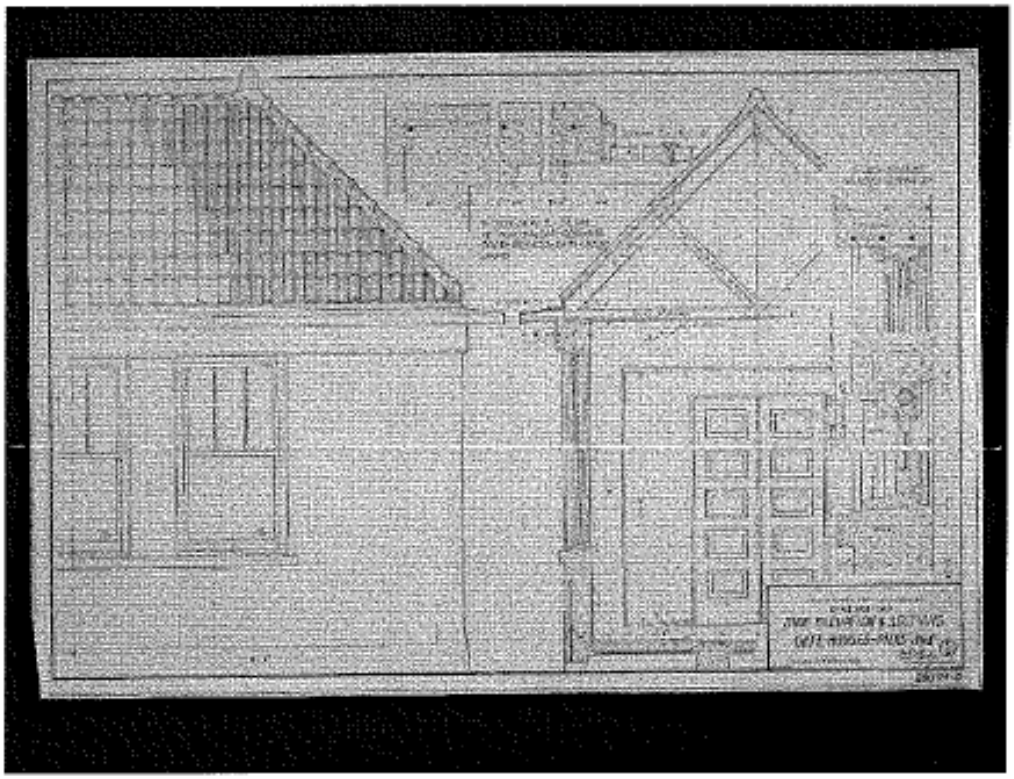

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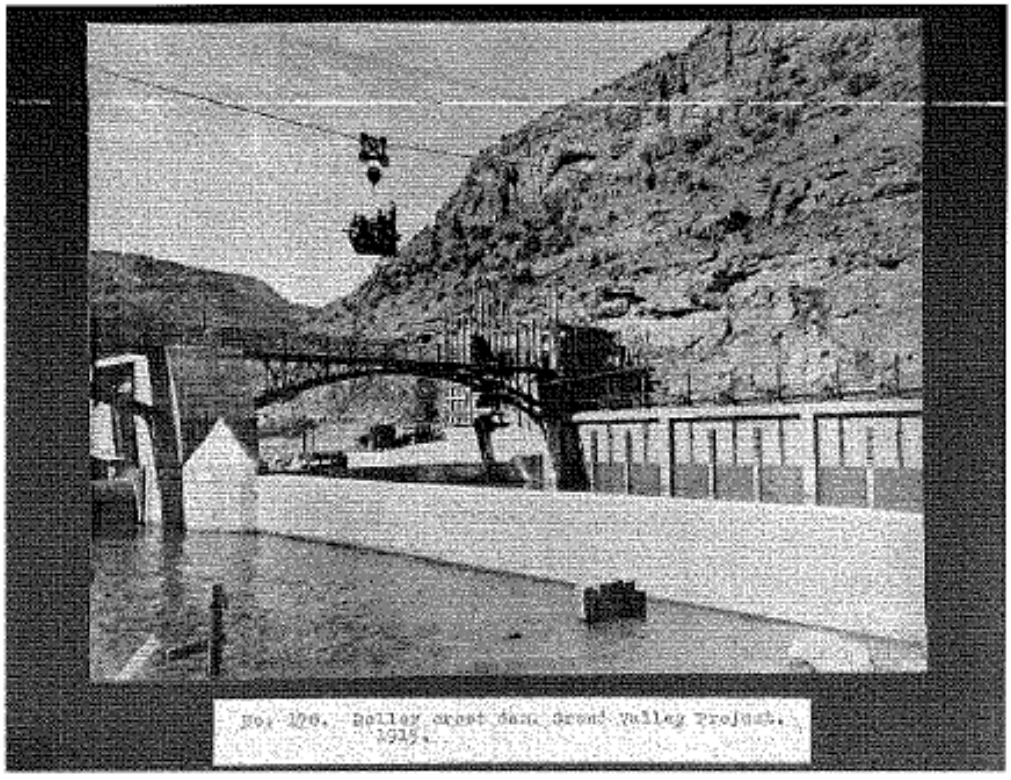

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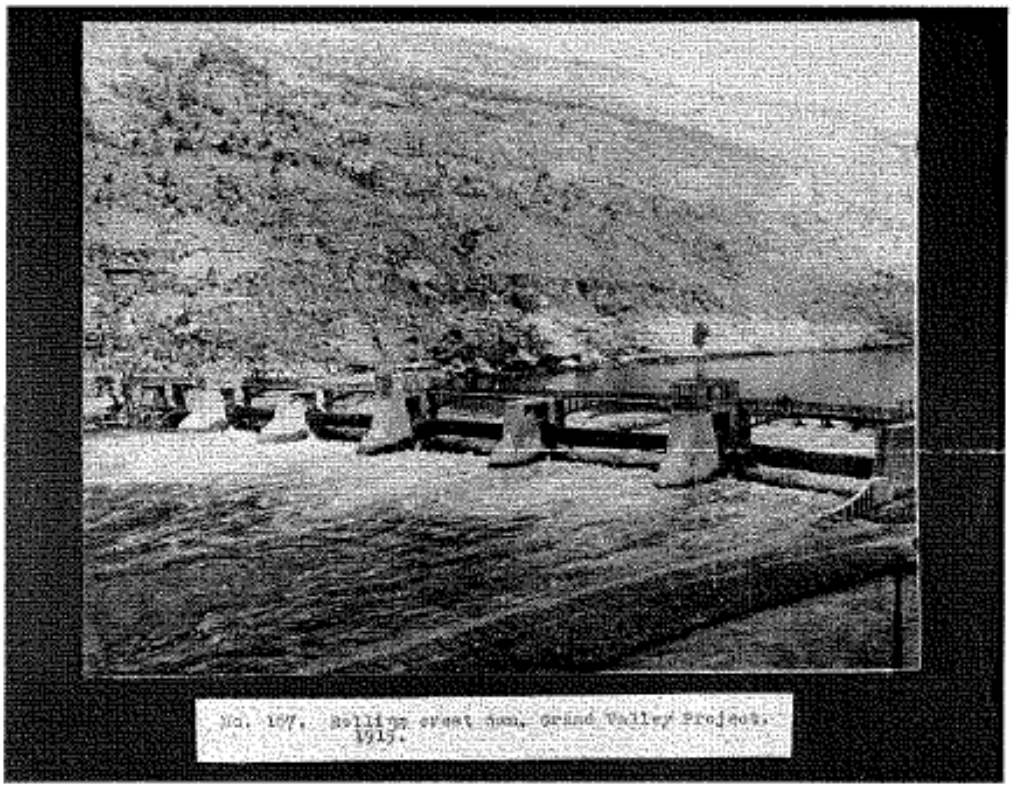

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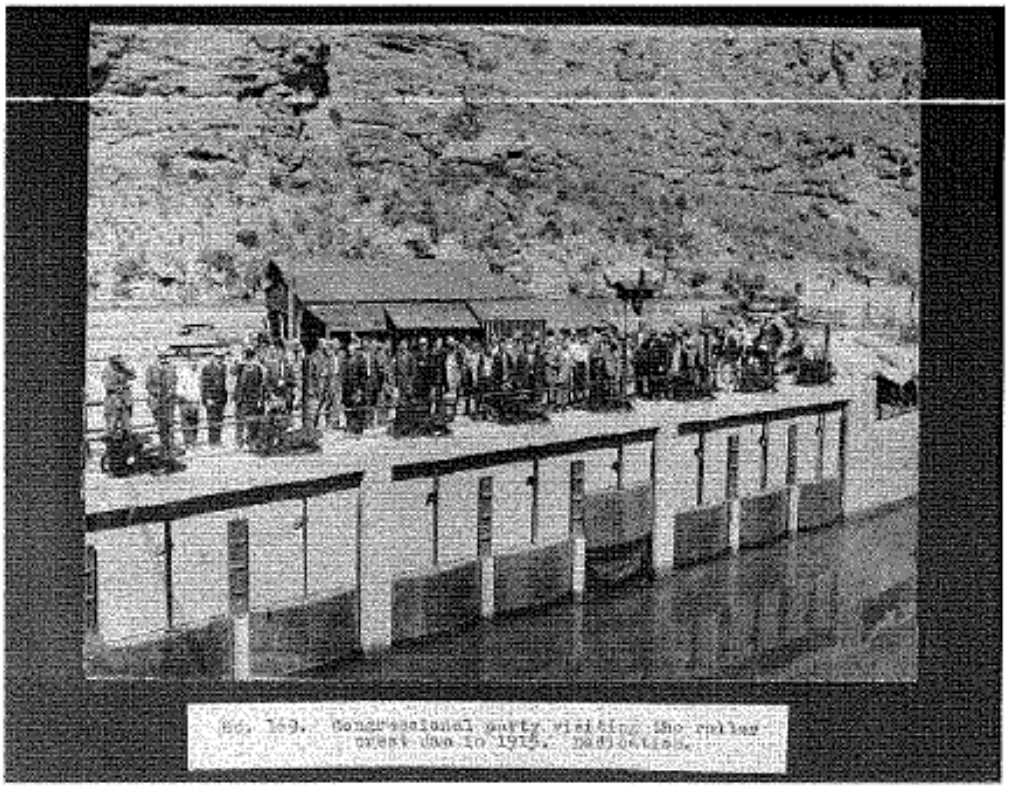

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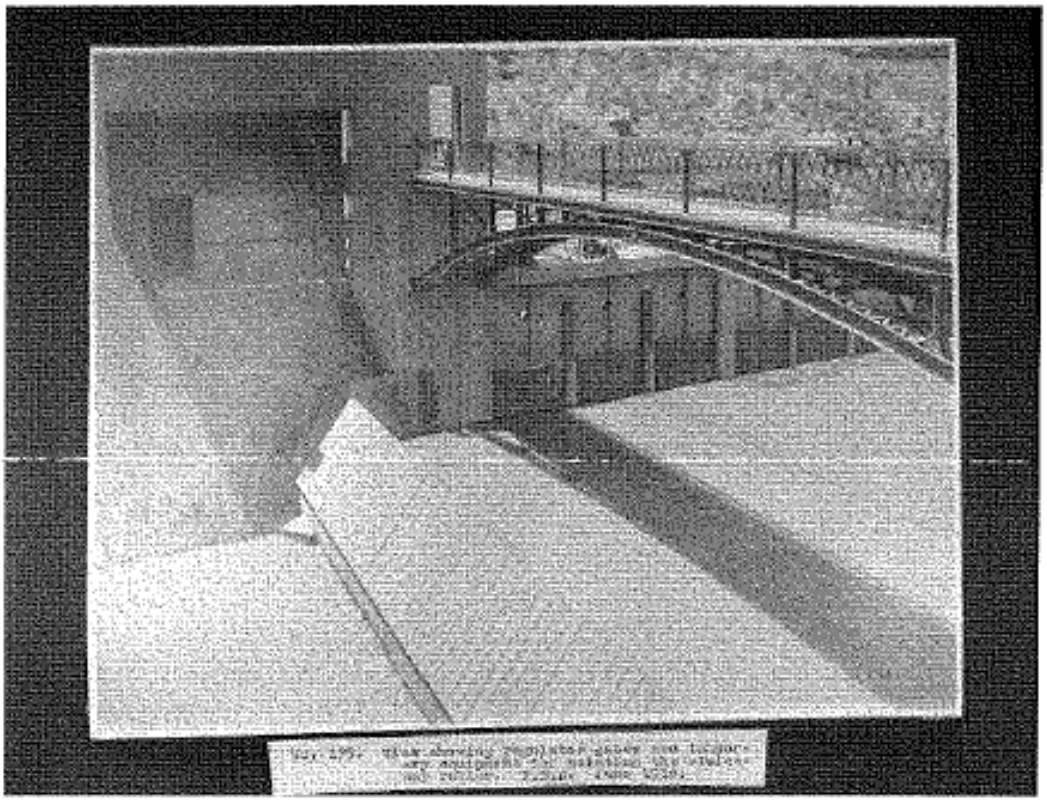

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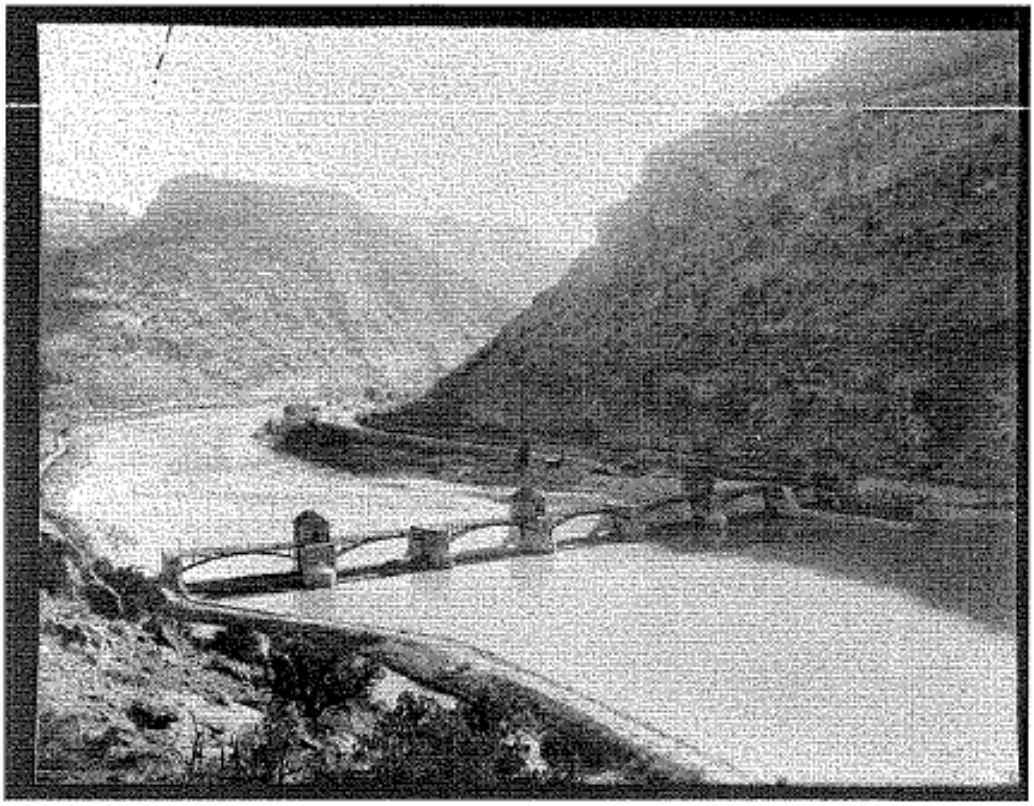

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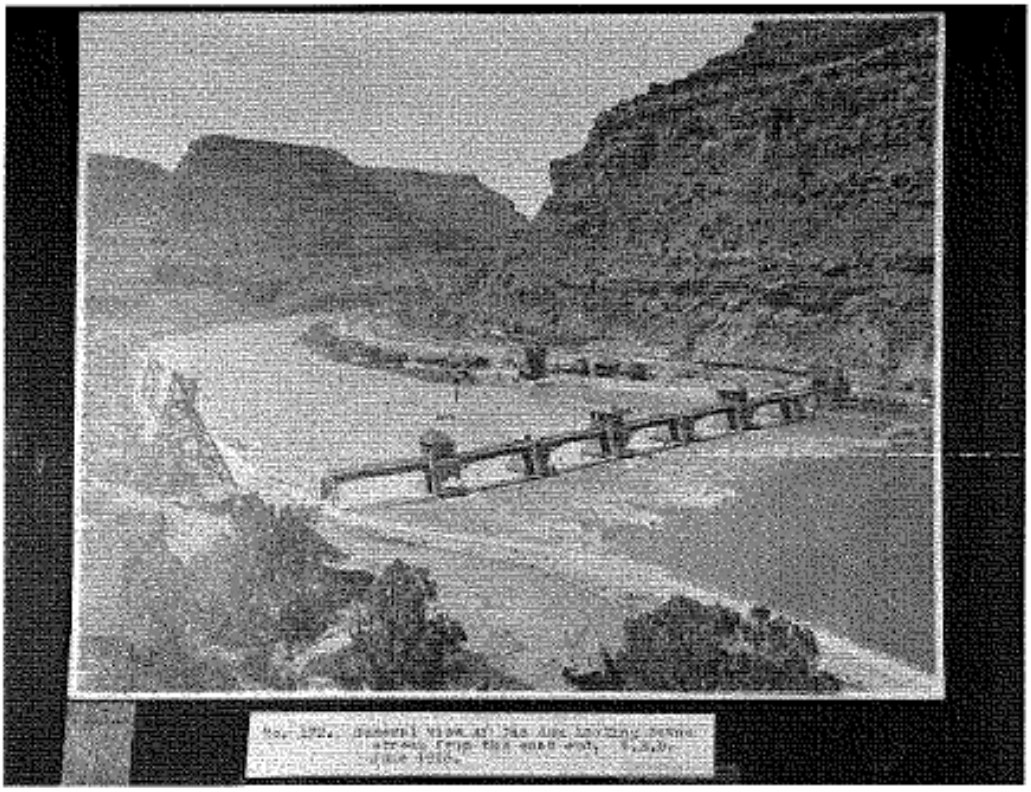

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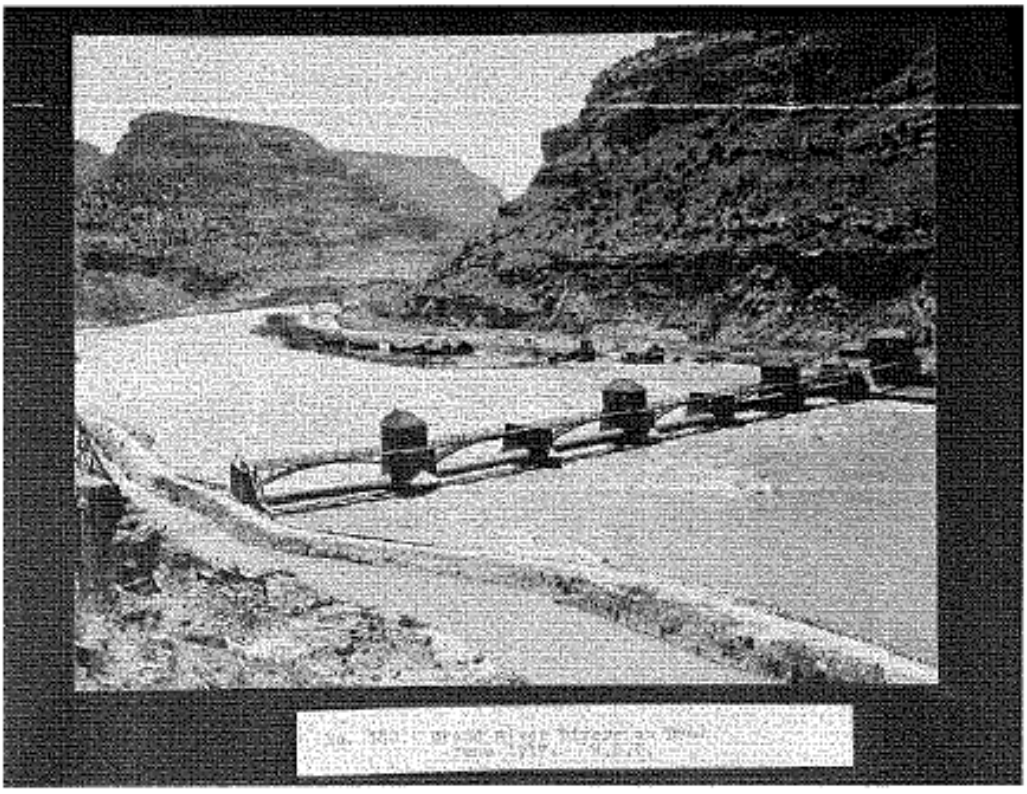

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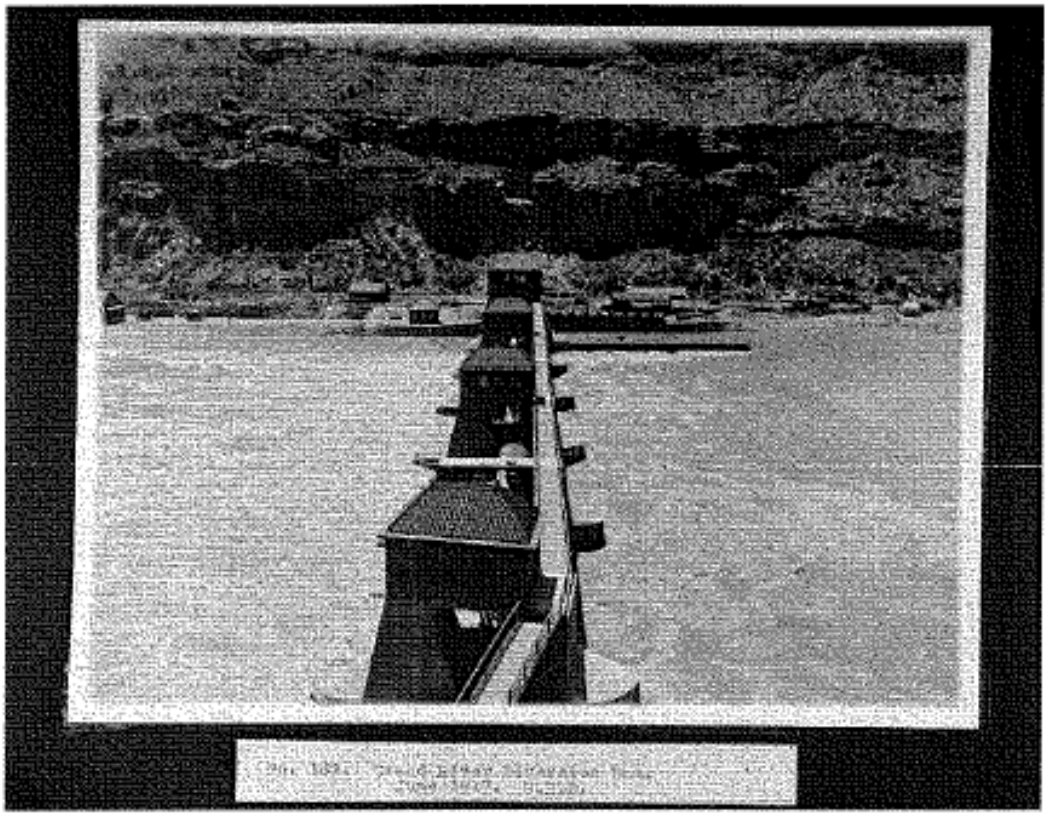

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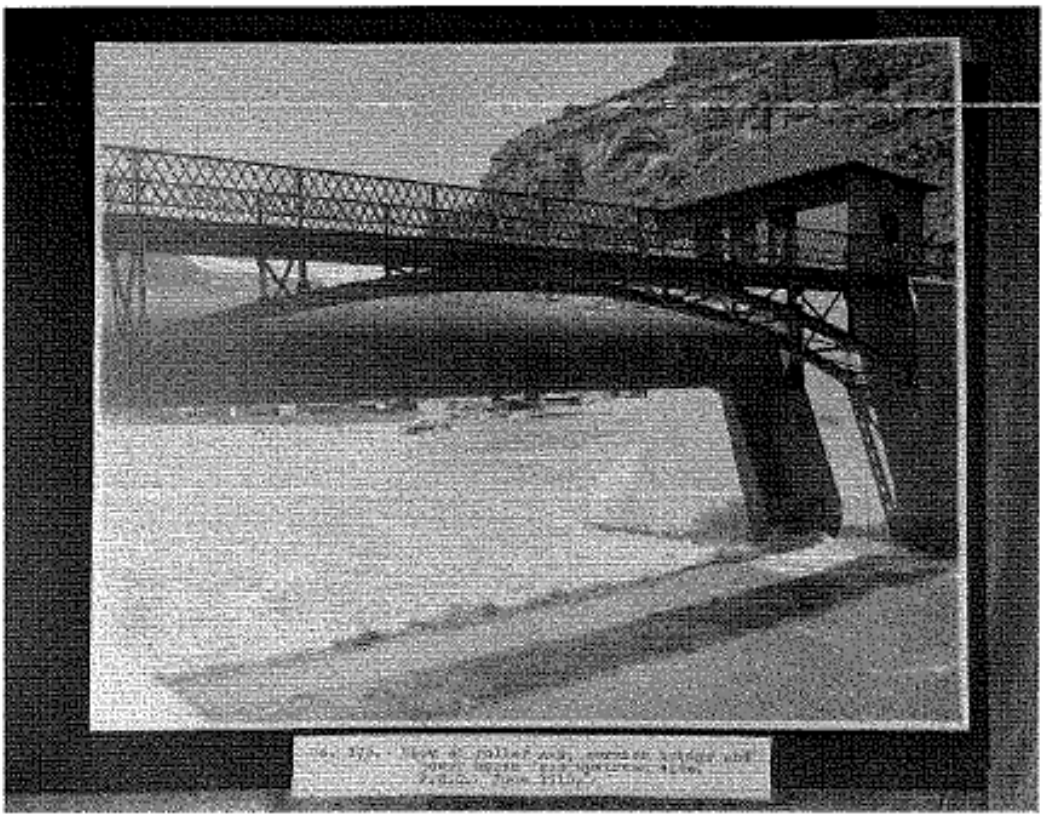

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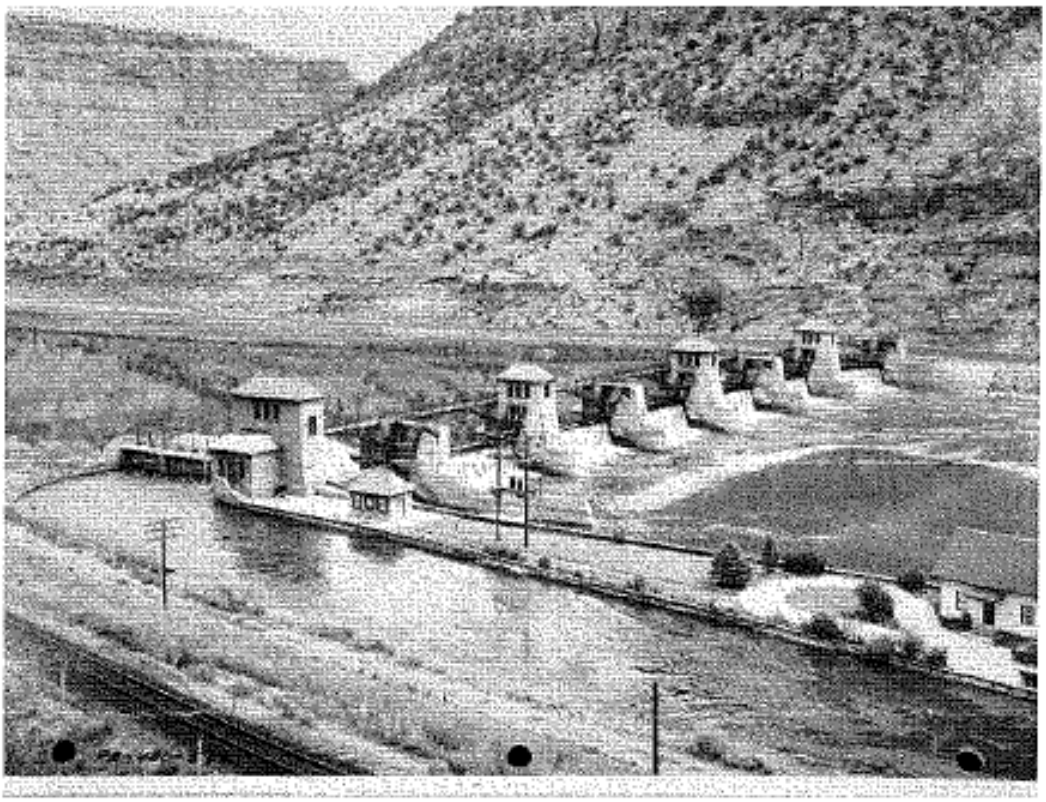

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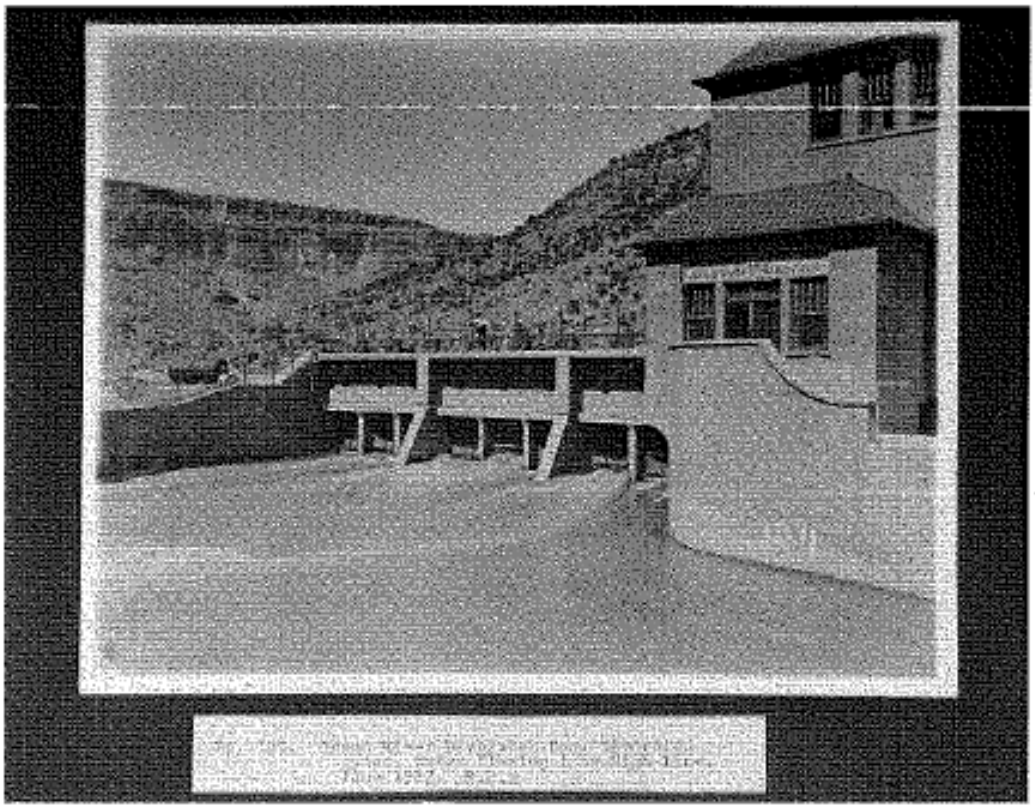

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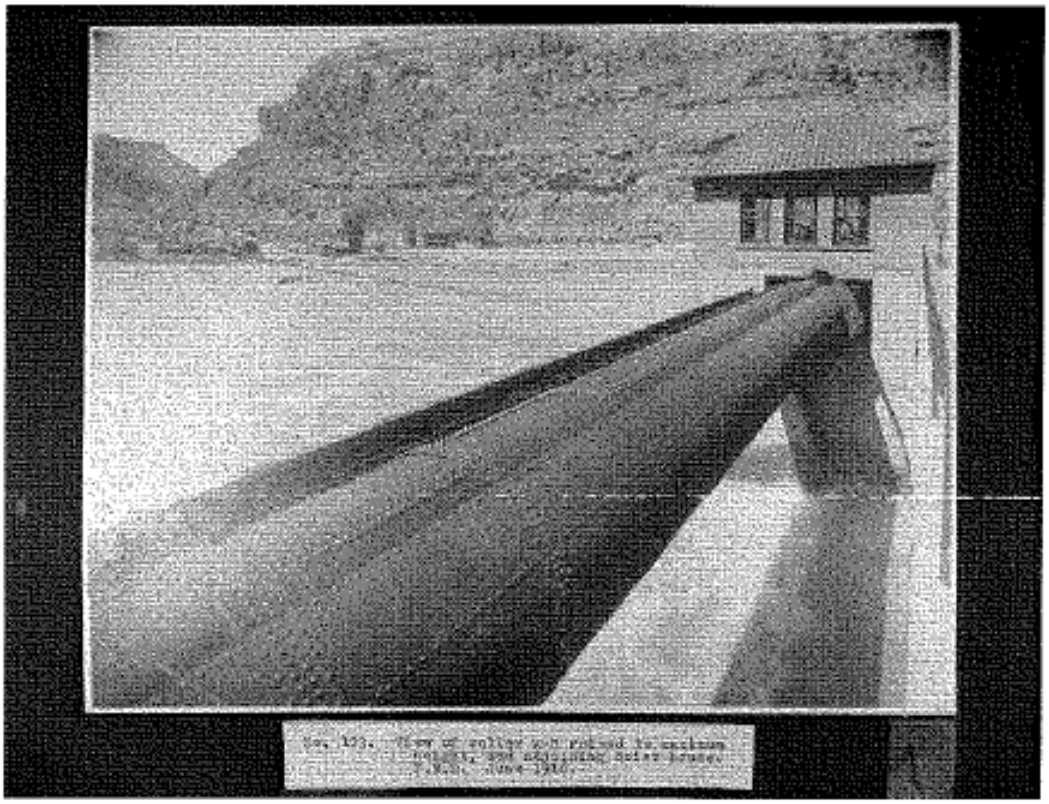


Photo 50

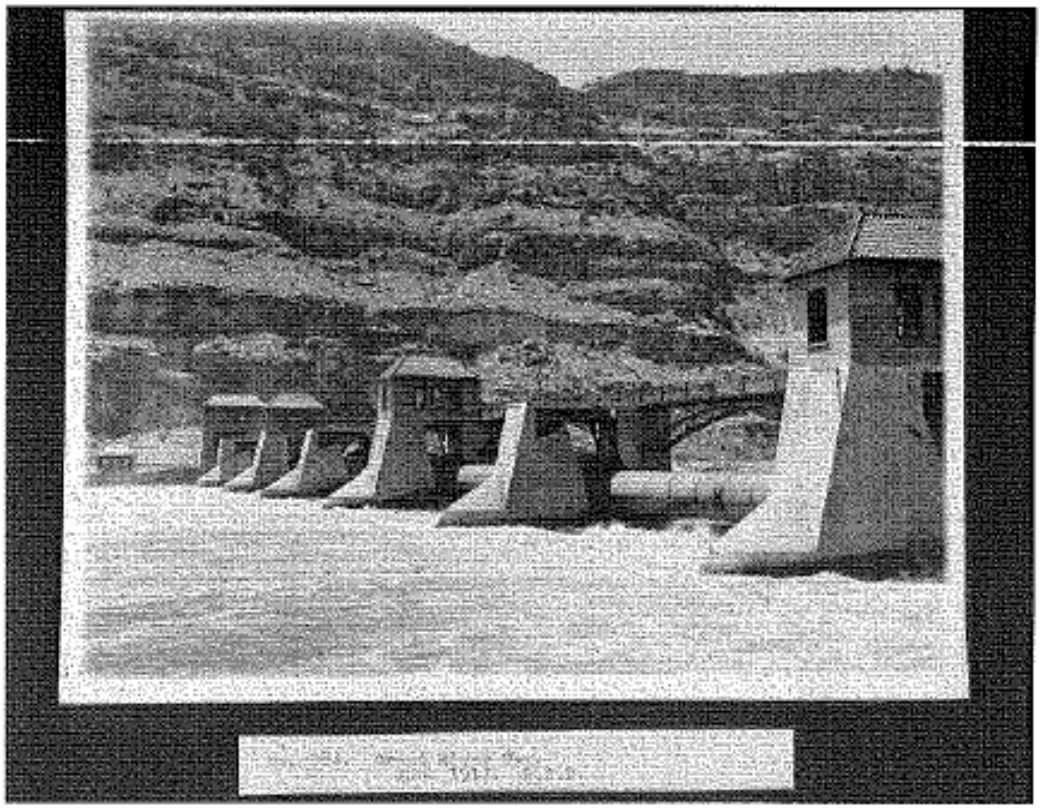
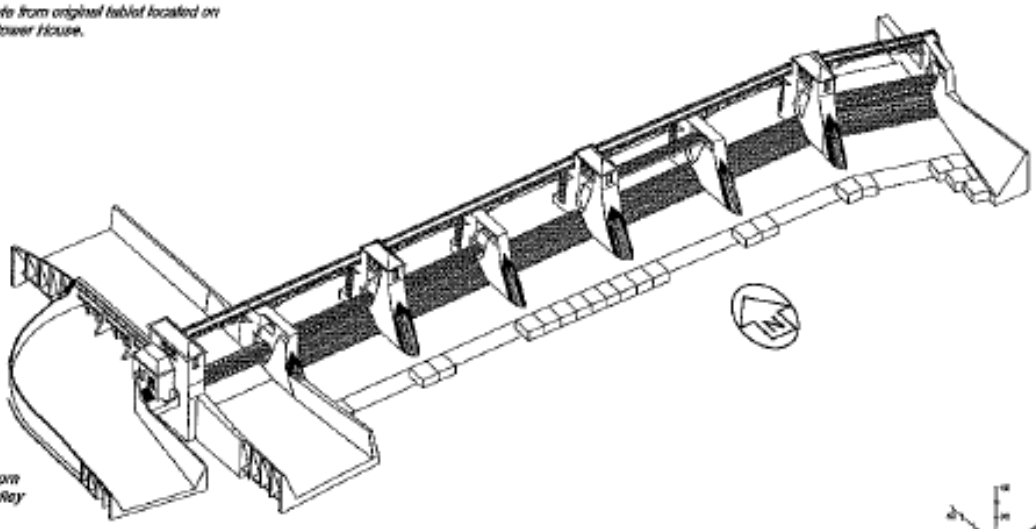


Photo 51

UNITED STATES RECLAMATION SERVICE
— 1915 —
GRAND VALLEY DIVERSION DAM

Lettering style from original tablet located on outside of Power House.

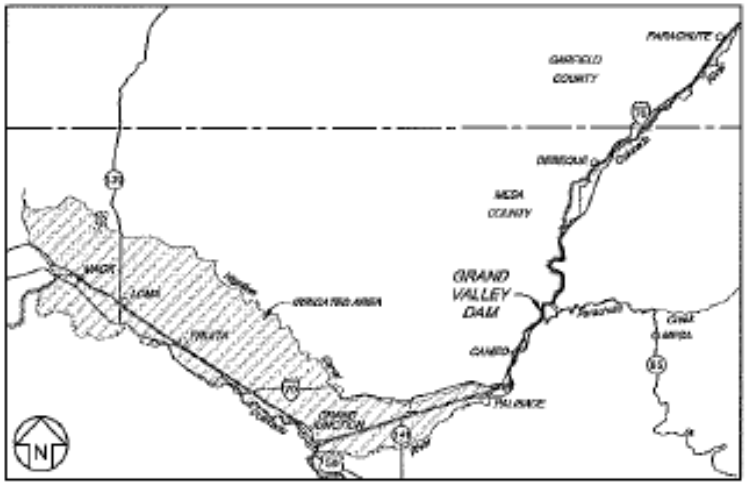


Isometric taken from original Grand Valley Diversion Dam drawings.

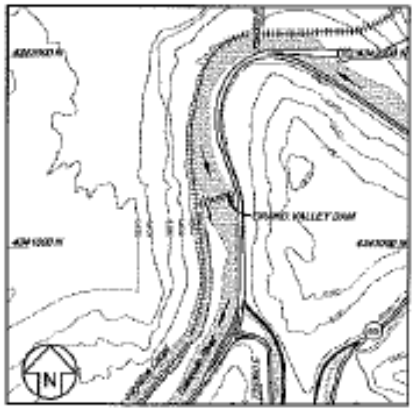
ISOMETRIC
SCALE: 1"=40'

The Grand Valley Diversion Dam, constructed between 1913 and 1916, is the key structure of the Bureau of Reclamation's Grand Valley Project, which provides water to 42,000 acres of semi-arid land. At the time of its completion in the spring of 1916, the dam was one of only three American dams to utilize innovative gate technology first employed in Germany in 1902. The Grand Valley dam would later serve as the prototype for the Army Corps of Engineers' massive system of locks and dams on the Mississippi River. The project stands as an early representative example of federal involvement in western land development. The dam's roller gates were built by American manufacturers, from German design, during the early years of WWI; this process of roller-gate design and manufacture contributes to our understanding of wartime disruption of business partnerships and economic development. This relationship and the disruption by WWI resulted in American engineers gaining experience in the design, fabrication and erection of roller gates.

This HAER project was undertaken by the U.S. Bureau of Reclamation in order to document the historic features of the dam prior to modification of the easternmost roller bay for the passage of endangered fish. Construction of the fish passage took place during the winter of 2003 and 2004. The fieldwork, historical reports, and photographs were prepared by Alpine Archaeological Consultants, Inc., Montrose Colorado. Jonathon C. Horn served as the Principal Investigator, Ueintanco Archimede conducted the historic research and large-format photography, and Ann Emmons conducted additional historical research and prepared the report narrative. Kudos Cad Designs Inc. prepared drawings from data provided by Alpine Archaeological Consultants, Inc.



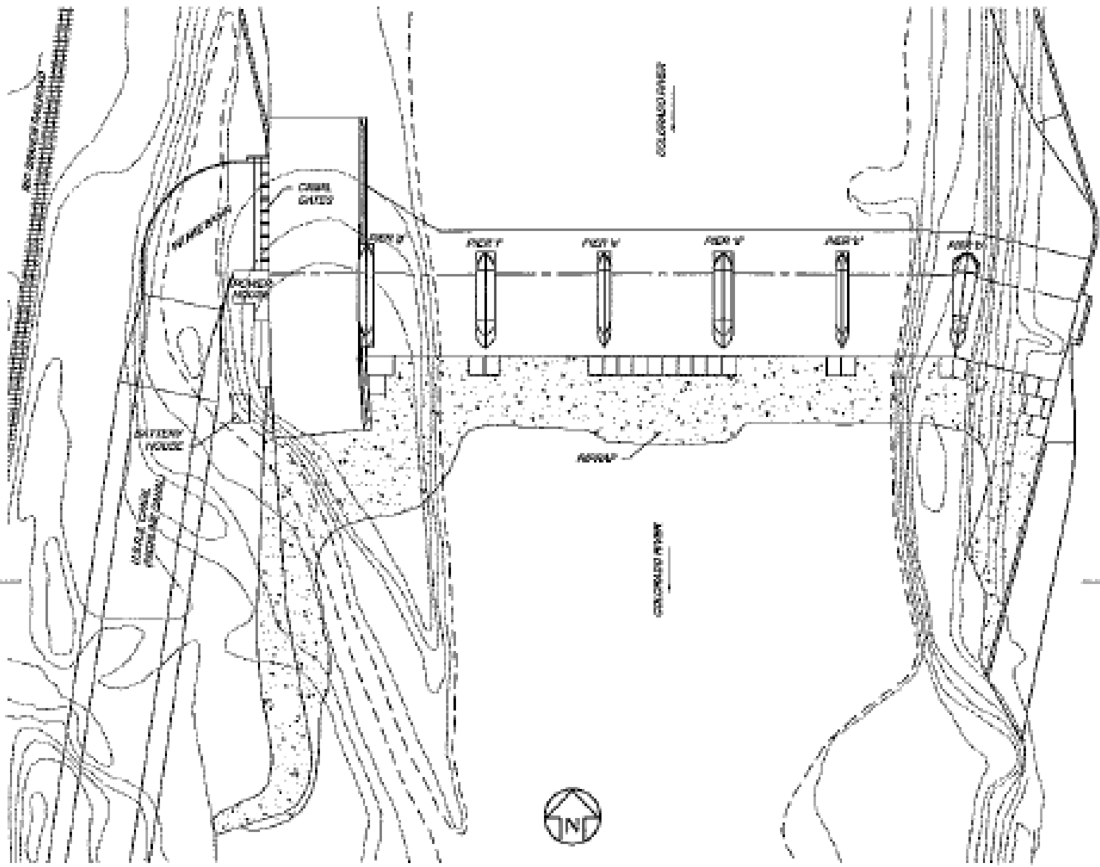
AREA MAP
SCALE: 1"=2000'



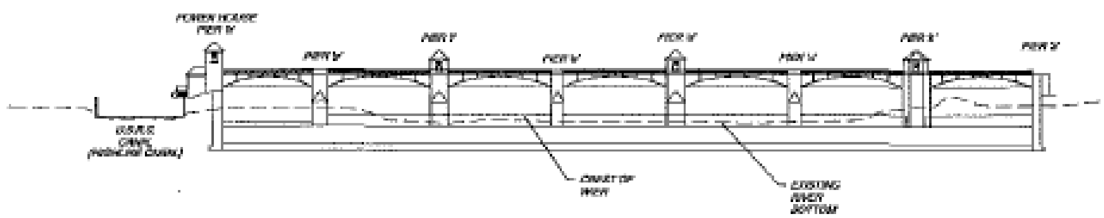
VICINITY MAP
SCALE: 1"=1000'

Drawn on: ALPINE ARCHAEOLOGICAL CONSULTANTS, INC.
PLOTTED CAD DRAWING BY: JOHN

INTERMOUNTAIN REGIONAL OFFICE / DENVER	GRAND VALLEY DIVERSION DAM		HAER	HISTORIC AMERICAN ENGINEERING RECORD
	CAMEO VICINITY	MESA COUNTY COLORADO	1 = 5	CO-90



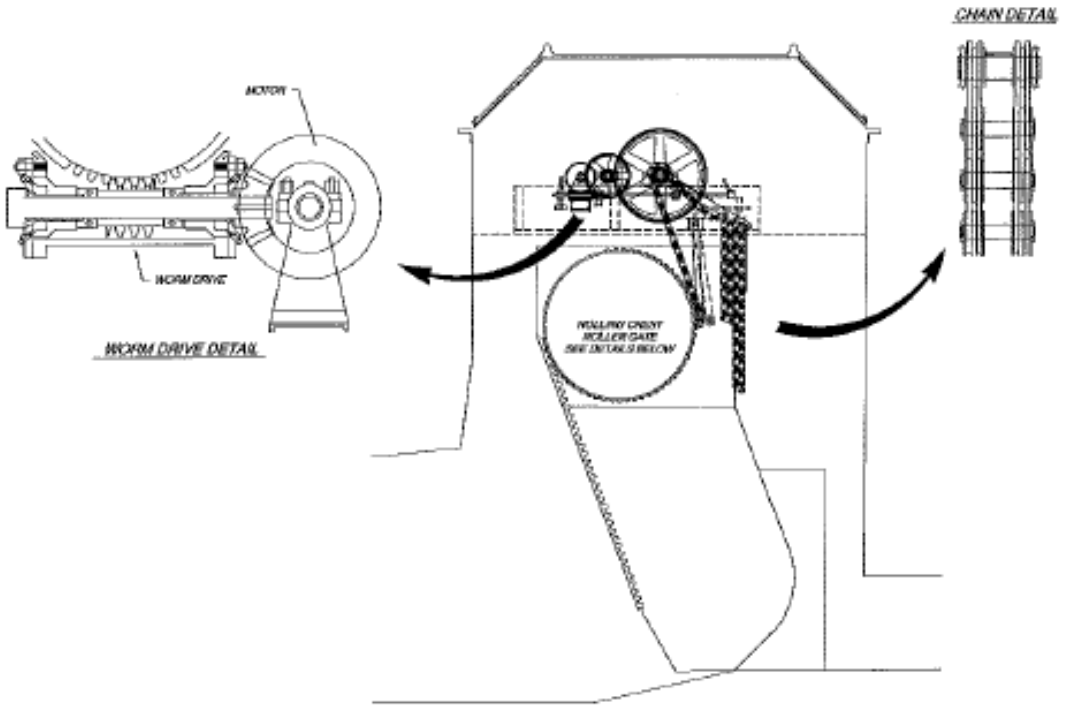
SITE PLAN
SCALE: 1"=40'



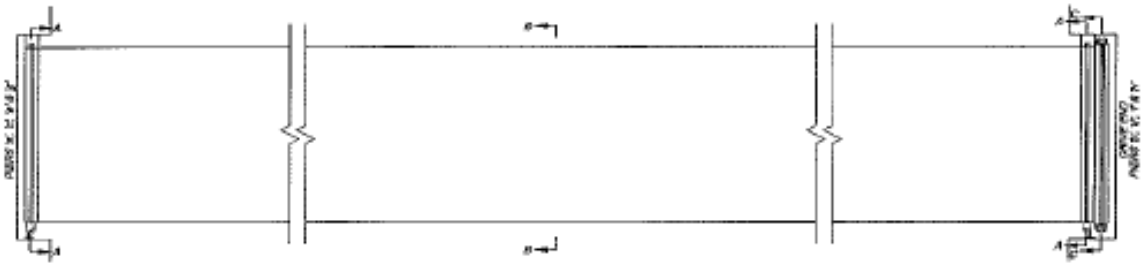
SECTION A-A
SCALE: 1"=40'

ALPINE ARCHAEOLOGICAL CONSULTANTS, INC.

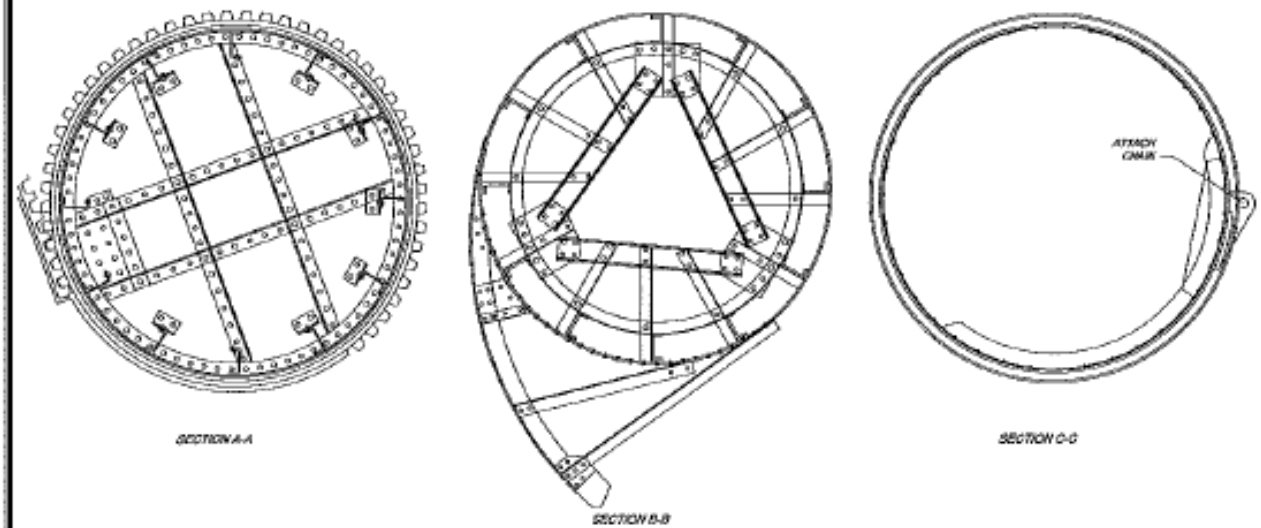
INTERMOUNTAIN REGIONAL OFFICE / DENVER	GRAND VALLEY DIVERSION DAM	2 of 5	HISTORIC AMERICAN ENGINEERING RECORD
	CAMEO VICINITY MESA COUNTY COLORADO		CO-90



ROLLER HOIST MECHANISM
SCALE: 1"=5'



ROLLING CREST ROLLER GATE - PLAN
SCALE: 1"=4'



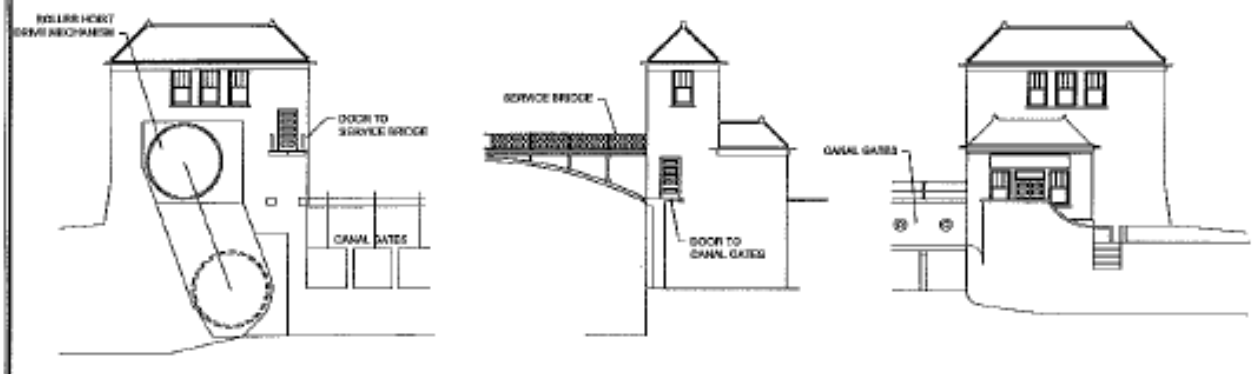
SECTION A-A

SECTION B-B

SECTION C-C

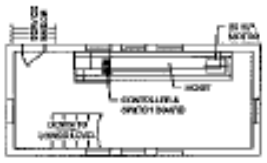
ROLLING CREST ROLLER GATE - SECTIONS
SCALE: 1"=4'

INTERMOUNTAIN REGIONAL OFFICE / DENVER	GRAND VALLEY DIVERSION DAM		3 of 6	HISTORIC AMERICAN ENGINEERING RECORD CO-90
	CAMEO VICINITY	MESA COUNTY COLORADO		

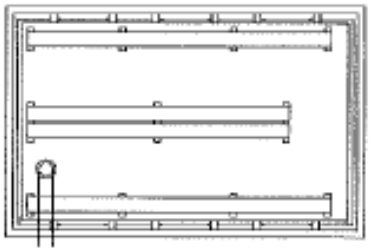


EAST ELEVATION/SECTION NORTH ELEVATION WEST ELEVATION

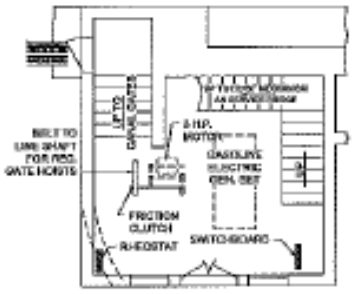
POWER HOUSE
SCALE: 1"=10'



UPPER LEVEL PLAN

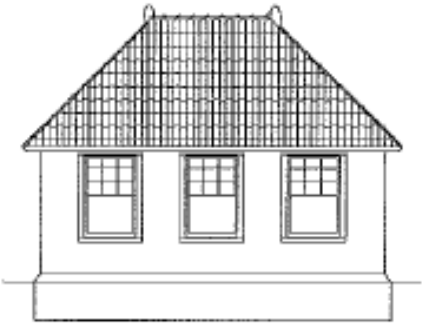


FLOOR PLAN



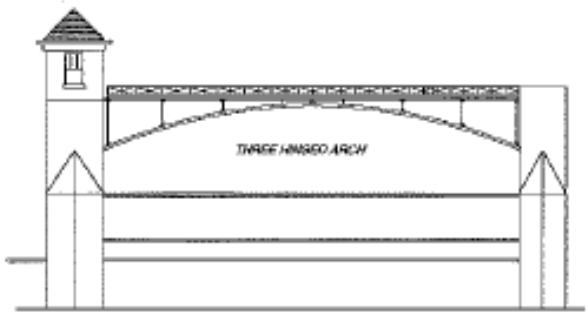
LOWER LEVEL PLAN

POWER HOUSE OPERATING MACHINERY
SCALE: 1"=5'



EAST ELEVATION

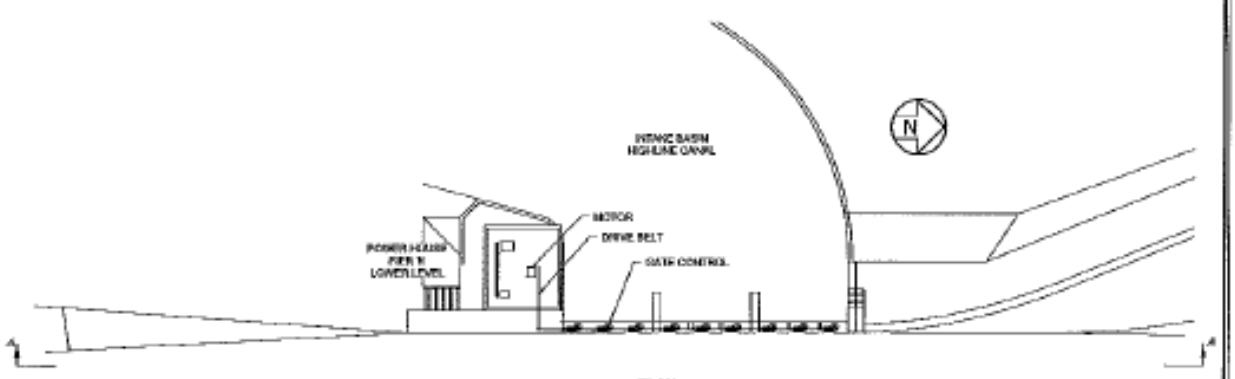
BATTERY STORAGE BUILDING
SCALE: 1"=3'



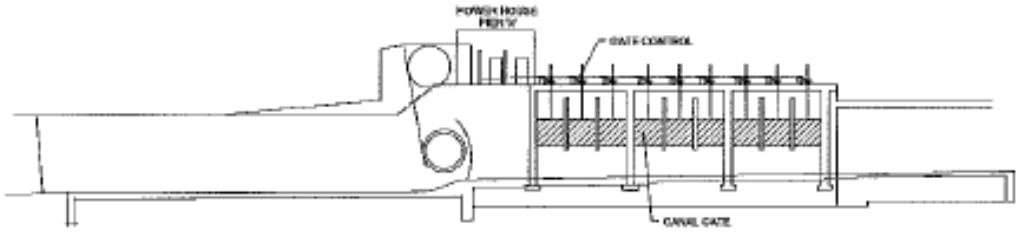
TYPICAL SPAN - STEEL SERVICE BRIDGE
SCALE: 1"=10'

Surveyed: ALPINE ARCHAEOLOGICAL CONSULTANTS, INC.
RIVERSIDE CAD DESIGNS INC., 2004

INTERMOUNTAIN REGIONAL OFFICE / DENVER	GRAND VALLEY DIVERSION DAM	SHEET 4 OF 5	HISTORIC AMERICAN ENGINEERING RECORD	
CAMEO VICINITY	MESA COUNTY COLORADO		CO-50	



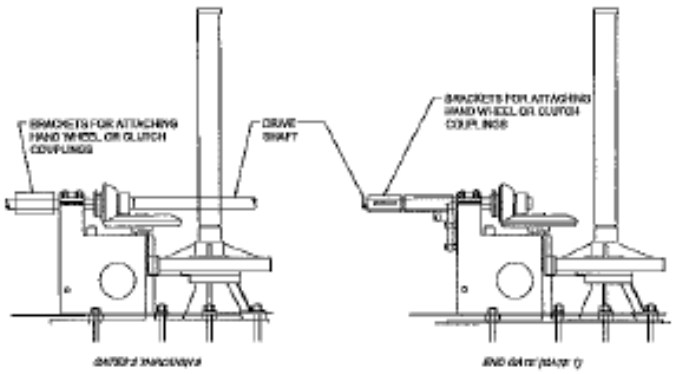
PLAN



SECTION A-A

DIVERSION GATES
SCALE: 1"=16'

PLAN



ELEVATIONS

GATE CONTROLLER
SCALE: 1"=1'

Owner: NATIONAL PARK SERVICE, INTERMOUNTAIN REGIONAL OFFICE / DENVER	GRAND VALLEY DIVERSION DAM		SHEET 5 of 5	HISTORIC AMERICAN ENGINEERING RECORD CO-90
	GRAND VICINITY	MESA COUNTY COLORADO		