IN THIS CANYON section of the Gunnison River the dam will be built near the location of the abandoned railroad bridge shown in the picture. The railroad grade will be improved to serve as the access road to the site. The dam and reservoir are upstream from the Black Canyon of the Gunnison National Monument.

Construction starts at Morrow Point

Project in Colorado on Gunnison River includes several "firsts" for the Bureau of Reclamation: double curvature, thin arch dam, underground power plant and free-fall spillway. The $15,436,000 contract went to joint venture of Al Johnson Construction Co. and Morrison-Knudsen Co., Inc.

CONSTRUCTION of the Bureau of Reclamation's first double-curvature, thin-arch dam began in June. The concrete structure is Morrow Point Dam, a major feature of the Bureau's Curecanti Unit of the Colorado River Storage Project in west-central Colorado.

The $15,436,000 contract for construction of the dam was awarded to the joint venture firm of Al Johnson Construction Co. and Morrison-Knudsen Co., Inc. Time allowed for completion of construction is 1,460 days—by May 1967.

The contract for construction of the dam includes another Reclamation first— an underground powerhouse to be built in the left abutment a short distance downstream from the dam. The plant will house two 60,000-kw. generating units.

Morrow Point Dam is on the Gunnison River, a major tributary of the Colorado River. It is near the village of Cimarron, about 22 mi. east of Montrose and 12 mi.

downstream from Blue Mesa Dam, a large earthfill structure under construction by the Bureau as part of the Curecanti Unit. (The article "Work Starts on Blue Mesa Dam" by Grant Blochodg, published in the August 1962 issue of Western Construction, describes the earthfill dam and plan of development of the Curecanti Unit.)

The Bureau's thinnest arch dam, on the basis of width to height, Morrow Point will have a top width of 12 ft. and a base width at the crown section of 52 ft. It will be 465 ft. high above foundation and will have a crest length of 720 ft. and a volume of 360,000 cu. yd. Capacity of the reservoir to be impounded by the dam will be 117,000 ac. ft.

The dam's powerhouse will consist of two 60,000-kw. generators.

By B. P. BELLPORT
Chief Engineer
Bureau of Reclamation
Denver, Colorado

WESTERN CONSTRUCTION—August 1963
Over two million pounds of reinforcing steel will be required.

Access problems
A major consideration in construction of the dam is access to the damsite for the contractor's use. At present, existing access to the site from U.S. Highway 50 is along an abandoned narrow gauge railroad grade going downstream along Cimarron Creek (a tributary of the Gunnison River), then upstream along the river about 3/4 mi. to the damsite. The abandoned railroad grade includes three 1-lane pin-type truss railroad bridges which have been satisfactory for access during preconstruction activity but which are to be replaced or removed to carry heavy traffic loads during construction.

The contract for the dam construction calls for removal of the three bridges and construction of a road beginning at U.S. Highway 50 and running 1.7 mi. to the powerplant. An additional 0.6 mi. of access road is to be constructed to branch from the powerplant road and continue to the crest of the dam. One of the bridges will be replaced by an 86-ft. span steel-beam, concrete deck bridge. Replacement of a second bridge will be obviated by a high fill. The remaining bridge will be abandoned as a crossing is not required.

The access roads will be 20 ft. wide and have a 4-in. gravel surfacing. The road running to the powerplant will have a maximum grade of 10%. Maximum grade of the road branching to the crest of the dam will be 12%. Steel-bin retaining walls are to be installed in certain sections of the road to the crest of the dam to reduce deep cuts in the canyon wall.

Geology of the site
Design of the dam and powerplant is strengthened by one of the most intensive geological investigations ever made by the Bureau at a damsite. The investigations embraced five distinct but correlated methods of testing the foundation and abutment rock—core drilling, laboratory tests of drilled cores, in-situ jacking tests, seismic investigations, and bore hole observation with closed-circuit television.

Geologically, the damsite is situated on the downstream limb of a small transverse synclinal fold which plunges gently into the left abutment. The dam will abut against the upstream-dipping rock sequence comprising this limb of the fold. Rock in the damsite foundation is competent, consisting of alternating lenticular and irregular beds of augen gneiss, quartz-mica schist, augen gneiss, and biotite schist, all of which have been irregularly intruded by pegmatite. The only significant foundation defect is a shallow system of stress relief joints.

The dam and powerplant sites were explored by approximately 7,500 ft. of NX (3-in.) core drill holes and 885 ft. of 6-in. by 8-ft. exploratory tunnels. One exploratory tunnel was driven 100 ft. into each abutment in the direction of maximum thrust from the dam, and a third tunnel was driven the full length of the underground powerplant. Most of the powerplant investigations, including 17 vertical and angled drill holes, were conducted from the powerplant exploratory tunnel. Several small diameter holes were drilled in conjunction with the in-situ rock properties tests and seismic measurements completed in the tunnels.

Observation of the 3-in. drill-hole sidewalls was carried out by a Bureau-owned, 2½-in. diameter, closed-circuit television probe. This direct examination included a study and correlation of the degree and extent of jointing, faulting, folding, and foliation that exist in the foundation rock.

Diversion plan
Diversion of the Gunnison River at the Morrow Point site during construction is to be closely allied with the construction of the Blue Mesa Dam. Closure of the Blue Mesa Dam diversion works is expected to take place in December 1964. After that closure date, the flows of the river will be controlled by the Bureau to such an extent that not more than 5,000 cfs. will be released from the dam in 1965 and not more than 8,000 cfs. will be released during the remainder of construction of Morrow Point Dam.

Any damage to any part of the permanent work or to any part of the contractor's diversion or protective works caused by flows in excess of 5,000 cfs. in 1965 and 8,000 cfs. thereafter will be the responsibility of the contractor.
responsibility of the Bureau. Any damage to the contractor's construction plant or equipment which may occur from flows in excess of 5,000 cfs. in 1965 and 8,000 cfs. thereafter will remain the responsibility of the contractor.

The contractor has the option of at least two methods of diverting the river during construction. He may divert the flow of the river through a concrete-lined diversion tunnel in the right abutment, or he may construct diversion channels or flumes in conjunction with diversion conduits through the dam. The final closure structure or structures, whether for conduits through the dam or for a tunnel, are to be designed to withstand a 300-ft. head of water.

If the contractor elects to divert through a tunnel, the tunnel is to be located not closer than 75 ft. from the dam. Permanent closure of the tunnels is to be made by a concrete tunnel plug immediately after contraction joint grouting is completed in the dam.

Should the contractor elect to divert through a diversion conduit or conduits through the dam, the maximum diameter of any conduit is to be 10 ft. Any such conduits used are to be backfilled with concrete, cooled, and grouted after the dam is completed.

The profile of the dam will be nearly symmetrical upon completion of excavation for the abutments. Shallow holes will be drilled on 20-ft. centers to depths of 50 to 70 ft. and grouted under low pressure over the full area of the foundation. Following concrete placement in the dam, a main grout curtain will be formed by grouting holes drilled on 10-ft. centers from the foundation gallery and tunnels in the left abutment to depths as great as 200 ft. A line of drainage holes on 10-ft. centers will be drilled to depths of from 40 to 150 ft. downstream from the main grout curtain.

The dam is to be divided into blocks by vertical transverse contraction joints radial to the axis of the dam to confine shrinkage openings to predetermined planes. With the exception of one 30-ft. block, spacing of the joints will be 40 ft. The joints will be keyed and grouted to assure watertightness and monolithic action of the dam.

Concrete placing

Placement of concrete is expected to begin in the spring of 1965. The Bureau anticipates the placement of concrete will be completed within two construction seasons.

To assist in construction of the dam, Bureau designers, using an electronic computer, have prepared data on the coordinate points for each lift of concrete in each block. The coordinates can be used by the contractor to set forms for concrete placement.

Placement will be in 7 1/4-ft. lifts. Maximum differential levels of adjacent blocks during construction are not to exceed 30 ft., and the highest block is to be not more than 52.5 ft. above the lowest block. The differential between adjacent blocks is to be reduced to not more than 15 ft. prior to the cessation of concreting at the end of a construction season. This requirement will reduce the exposed concrete surfaces to a praticable minimum during the severe cold winter weather at the dam-site where temperatures may drop as low as -40 deg. Rate of placement in any block will be restricted so that not more than one horizontal lift can be placed in 72 hr.

The contractor has the alternative, where practicable, of using gang vibrators to consolidate mass concrete in the dam. As many as five vibrators may be mounted on a tractor which can travel over the freshly placed layers of concrete. The gang vibrators may be used only if they can be readily raised and lowered to eliminate dragging through the fresh concrete and provided all other placement and consolidation requirements are met.

Concrete is to be cooled by river wafer, supplemented by refrigerated water, circulated through 1-in. embedded cooling pipe placed on top of each 7 1/4-ft. lift. About 59 mi. of cooling pipe will be embedded in the concrete. Placing temperature will be limited to 60 deg. maximum. After the temperature of the concrete has been lowered to 40 deg., the transverse contraction joints will be grouted. The concrete will be successively cooled and grouted in 60-ft. lifts. When the proper cooling temperature has been attained and the contraction joints grouted, the cooling pipe will be filled with grout.

Concrete mix design

The thin-arch structure will require concrete designed to obtain a compressive strength of 4,500 psi at 1 year's age. Tests in the Bureau's engineering laboratories in Denver indicate that about four sacks of cement per cubic yard used with a water-reducing, set-retarding admixture (water-reducing agent) will meet this
MORROW POINT DAM

(Continued from page 57)

strength requirement. Approximately 85% proportions for the mass concrete, now under consideration, are:
Portland cement (Type II, low alkali) 4 sacks
aggregate ....... 2,760-2,820 lb.
Sand .............. 660-680 lb.
Water ............... 145-155 lb.

Tests on samples taken from near-by deposits showed that aggregates of suitable quality are available. Maximum size of aggregate specified is 4 1/2 in.

Underground powerplant

Morrow Point Powerplant is being constructed as an underground installation for economic and engineering reasons and to provide year-round construction at the damsite. (A conventional surface plant would have necessitated shutdown of construction during the long, cold winter season.) To achieve economy in the lengths of the penstocks, the powerplant was placed as close to the intake structures as possible.

The underground powerplant chamber, to be excavated in massive rock about 400 ft. below the ground surface, will be about 221 ft. long and 57 ft. wide and will vary in height from approximately 65 to 134 ft. Reinforced concrete will be placed within the chamber to support the generating equipment.

A metal ceiling will be installed for the entire length of the powerplant chamber. However, the walls of the chamber above the elevation of the generator floor will remain as exposed rock. A structural steel runway will be installed for the plant's 300-ton overhead traveling crane.

Construction of the powerplant will be carried out in two stages. The first stage of construction, which is part of the prime contract of the dam, will include excavation of 45,400 cu. yd. of rock for the powerplant chamber, placement of 3,700 cu. yd. of concrete, 315,000 lb. of structural steel, 469,000 lb. of reinforcing steel, and installation of the traveling crane. Second-stage construction, expected to begin in January 1966, will be carried out under a separate completion contract.

Excavation for the powerplant chamber is required to be done by the "smooth bore" or "cushion blasting" technique to minimize fracturing of the rock. A cable tunnel will provide access to the crown of the powerplant chamber and thus permit excavation of a pilot drift down the crown of the opening. After the arch above the springing line is excavated, bench-type excavation may be used. The access and draft tube tunnels will provide additional accessibility for excavation of the powerplant chamber.

Grouted, expansion anchor-type rock bolts are to be used as the primary and permanent support for the arch roof and sidewalls of the chamber. The bolts will be installed and tensioned as close to the excavation heading as practicable. Wire mesh will be pinned to the roof arch to prevent small rock spalls from dropping out.

A tunnel to be used to ventilate the powerplant was constructed under a previous contract for exploration purposes. Under the prime contract, a short length of concrete lining will be constructed at each portal. A transverse concrete bulkhead will be constructed in the tunnel near the powerplant chamber and a louver will be installed in the bulkhead.

Access to the completed powerplant will be through a 20-ft.-wide, 150-ft.-long tunnel extending from the approach area to the underground chamber. The floor of the tunnel will be lined with concrete; the roof and sidewalls will remain as exposed rock. Grouted rock bolts and wire mesh will support the roof of the tunnel.

The transformers are to be placed underground in a vault provided by the extension of the powerplant chamber at the level of the generator floor. High-voltage (230-kv.) cable will carry the power to the substation which is to be constructed adjacent to the approach area and access tunnel.

Free-fall spillway

A feature of the Morrow Point Dam construction, unique in Bureau experience, is the dam's free-fall, orifice-type spillway. Four 15- by 15-ft. openings are to be constructed in the top central part of the dam to serve as the spillway. Water flowing through the openings will fall more than 350 ft. to a pool retained in a reinforced-concrete stilling basin at the toe of the dam. A 65-ft.-high weir is to be constructed 320 ft. downstream from the axis of the dam to maintain the 60-ft.-deep pool which will reduce the impact and turbulence of the water falling from the great height. The stilling basin floor will have a maximum thickness of 6 ft. and will be about 160 ft. wide. Study of models of the spillway in the Bureau's hydraulic laboratory confirmed design studies that there will be no possibility of damage to the dam or afterbay channel by the falling water.

The spillway will have a combined maximum capacity of 41,000 cfs. Each opening will be controlled by a 15-ft. wide by 16.83-ft. high fixed-wheel gate.

Outlet works

The dam's outlet works will comprise one 4- by 4-ft. stainless steel-lined conduit through the dam. Control of the flow through the conduit will be maintained by 3.5- by 3.5-ft. slide gates in tandem. Capacity of the outlet works will be 1,500 cfs. Discharges will be directed into the stilling basin at the toe of the dam.

Two 13.5-ft.-diam. steel-lined penstocks are to be installed in tunnels excavated in the left abutment rock. The penstocks will convey water from the intake trashrack structures in the left abutment to the powerplant turbines.

The contractor is not required to construct camp facilities at the damsite. However, if he elects to provide such facilities, he will be permitted to use for construction camp purposes and for construction plant, storage, and incidental purposes any land available in the vicinity of the damsite which is the property of the Government, except such areas that have been reserved for special purposes. The contractor is required to have a fully equipped infirmary at the job-site.

Personnel

Floyd E. Dominy, whose offices are in Washington, D.C., is Commissioner of the Bureau of Reclamation. The Curecanti Unit is in the Bureau's Region 4; F. M. Clinton is Regional Director at Salt Lake City, Utah.

J. D. Seery is Project Construction Engineer for the Curecanti Unit. His office is at the Unit headquarters on U.S. Highway 50, 19 mi. west of Gunnison. Howard E. Smith is the Bureau's Resident Engineer for Morrow Point Dam construction; his field office is at Cimarron.

WESTERN CONSTRUCTION—August 1963