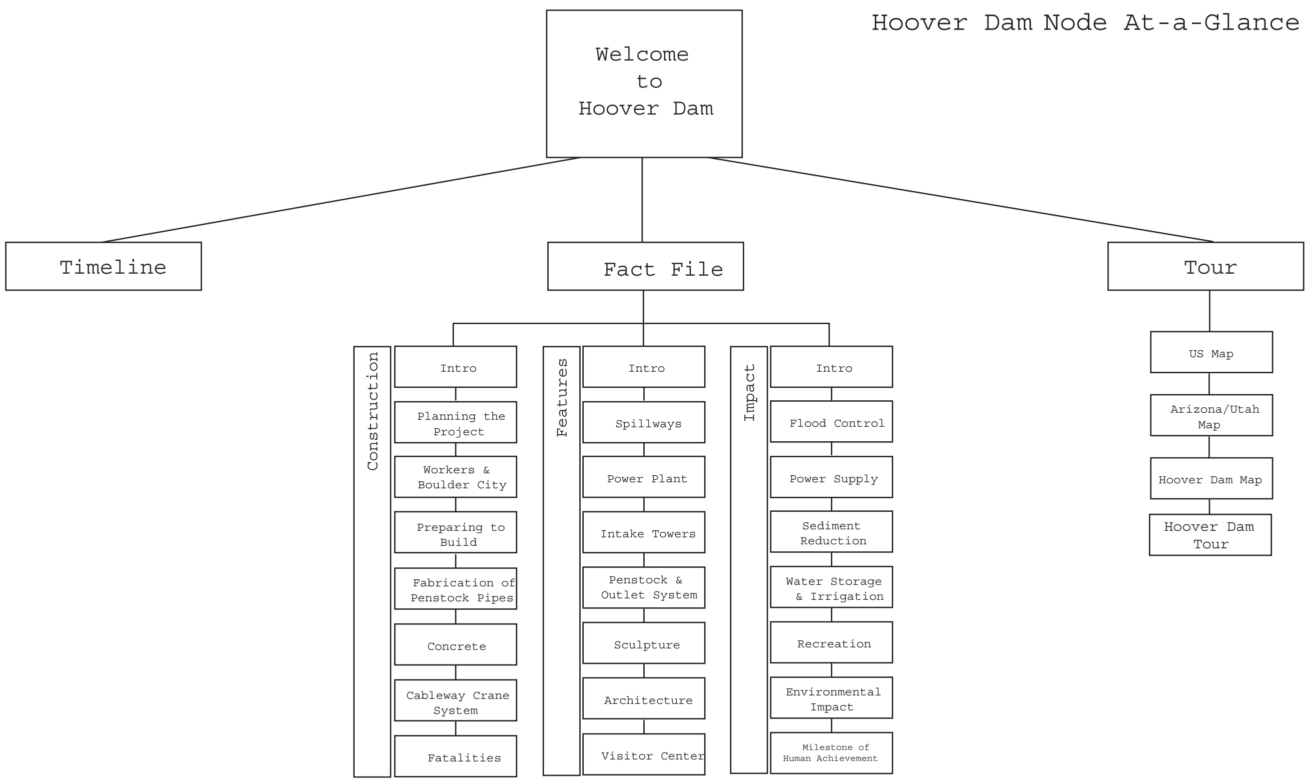
Learning Node Contents

To become familiar with the content within the learning node, it is best to explore the software itself. However, this section provides a printed version of all of the information within the node as a quick reference guide. Information within the Hoover Dam learning node is presented in different learning modalities to meet the needs of many types of learners.

Node Layout

The node is organized into three different sections: Timeline, Fact File, and Tour. The Hoover Dam Node At-A-Glance shows the organizational layout of the software.

Hoover Dam Node At-a-Glance



Timeline

The Timeline enables students to access information about the construction of Hoover Dam in a visual format. Information about each of the phases of construction shows students how this amazing project was completed. Clicking on each section of the Timeline takes learners to information about the different phases of construction. The following pages provide the Timeline content for easy reference.

Fact File

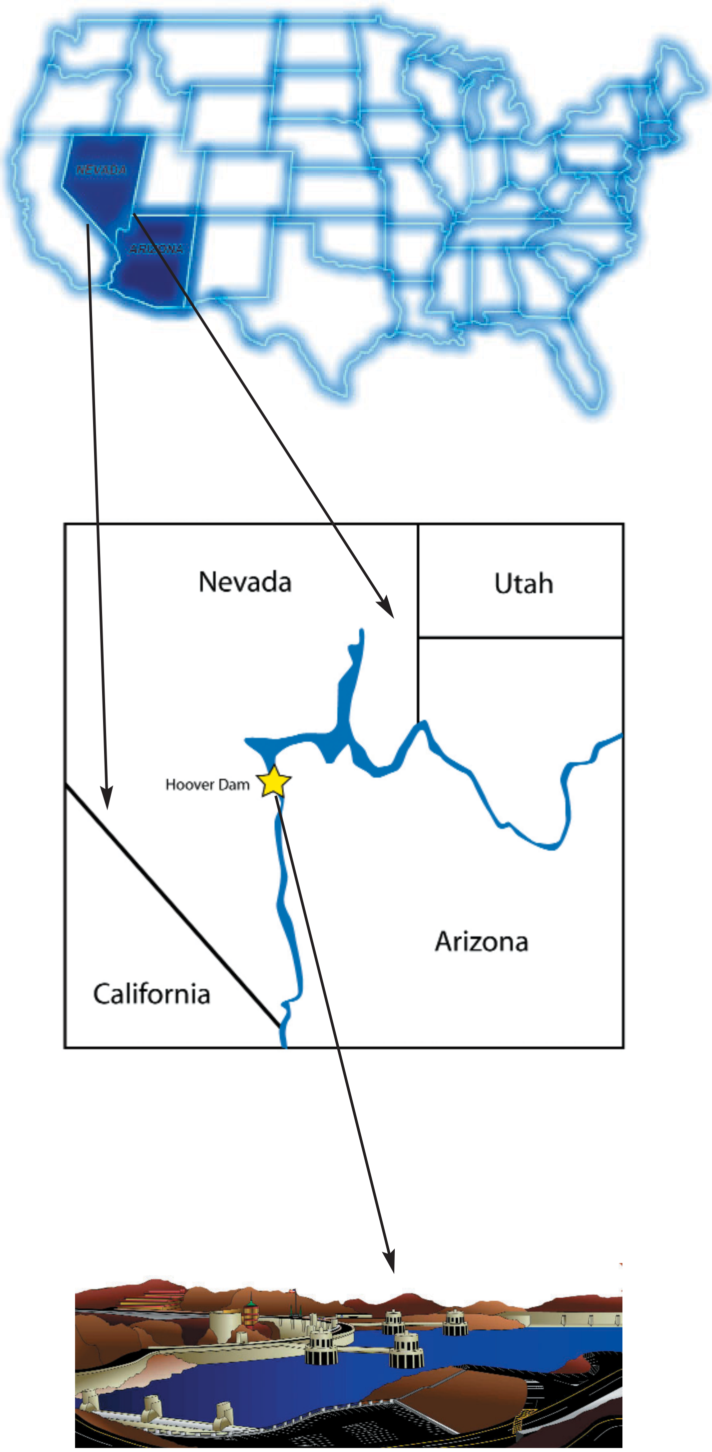
The Fact File section is like an electronic encyclopedia with visual access to three main topics: the construction of Hoover Dam, the features of the dam and the impact of the dam. Each subtopic provides a wealth of information for the learner.The following pages provide the Fact File contents for easy reference.

Tour

The Tour section of the software takes the learner on a virtual fieldtrip of the Hoover Dam. First, a map of the United States helps the user see the general geographic area of Hoover Dam. Then, another map brings them closer to the region. Finally, users see a map of the dam itself and its surrounding features.

Students are then directed to put on the head mounted display and take an immersive tour of Hoover Dam. This tour uses 360 panoramic images to guide students through the dam, as though they were actually there. From within each of the panoramas, students can click on hotspots and link to additional learning content.

Where is Hoover Dam?

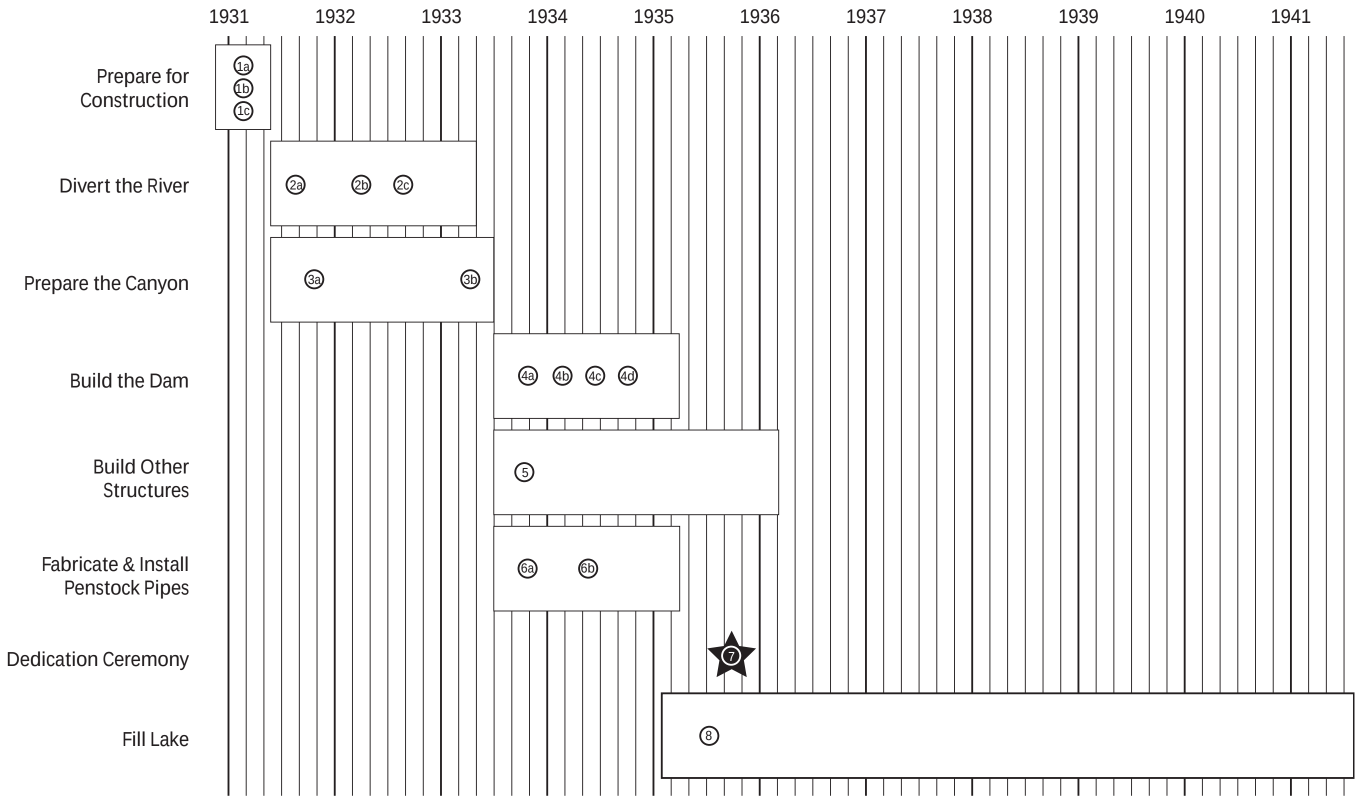


Hoover Dam is located in the Southwestern United States on the border between Arizona and Nevada.

Hoover Dam spans Black Canyon, with the eastern side in Arizona and the western side in Nevada. The closest city, Las Vegas, is 30 miles west of the dam.

More than 20,000 vehicles a day make the trip across Hoover Dam between Arizona and Nevada.

Hoover Dam Construction Timeline



Prepare for Construction

1a - Install railways, roads, power lines, equipment and facilities

Before construction could begin on the dam, civilization had to be forced into the desert. Thirty-four miles of highways and railroads were built to connect the site to the closest city, (Las Vegas). Cars, trucks, and heavy equipment had to be brought in - and many had to be modified for the huge job ahead. Supplies of sand and rock were located nearby, and cement was purchased by the trainload. 222 miles of power lines carried electricity from California to light up the company town and illuminate the construction, which would continue day and night. Machine shops, sharpening shops, and garages were constructed to build and maintain the massive equipment. Gravel screening plants, concrete plants, and air compressor plants had to be built as there was no place nearby to perform these services.

1b - House & transport workers

At the peak of construction, there were 5,218 men working on Hoover Dam. For the first year, they and their families had to live in squalid, unsanitary shantytowns and tent cities. The government had to do something to improve living conditions. In 1932, they moved workers and their families into Boulder City - a clean, modern, well-organized town built by the Bureau of Reclamation on federal land. Boulder City was run like a military outpost, with security gates at the entrance, and rules of conduct that were strictly enforced by Federal Rangers. There were few complaints, though. Everyone in Boulder City had a job, a full stomach, and a roof overhead. Workers built churches in their off-time; Six Companies built schools and a hospital; business men opened shops, restaurants, a theater, and a hotel to meet residents needs.

The contractor, Six Companies, and the Bureau of Reclamation maintained their offices in Boulder City. Families rented small cottages with trees, lawns, and gardens - providing relief from the brutal heat. Eight large air-cooled dormitories, with 172 rooms each, housed the single men. The same company that catered many of the prestigious movie sets of the time ran the mess hall in Boulder City. They could seat 1,300 people at a time, and often served over 6,000 meals a day. [Every week, 18 tons of fresh food was shipped in for the mess hall.]

To get 5,000 men back and forth from work every day, Six Companies installed benches and double-tiered platforms on 10-ton trucks so they could carry 150 men at a time... and the trucks ran round the clock, because there was no such thing as a 5-day work week at the Boulder Dam Project. Everybody worked every day - only Independence Day and Christmas were observed as optional days off

1c - Access the canyon & use the Cableway Crane System

Before construction, surveyors accessed Black Canyon by boat, but boats were not practical for transporting thousands of men around the work site. So workers rigged great, swinging catwalks to cross the 1200-foot-wide canyon; and inclined skidways, called monkey slides, were built to ease men down the 750-foot drop to their stations on the canyon floor.

Lidgerwood Manufacturing Company constructed a permanent cableway for the Hoover Dam that had five times the capacity of any previously made and cost approximately $172,000. The cableway was operated by remote control, with the operator perched in a booth on the side of the canyon. From there, he could place a load of men, material, or equipment anywhere on the dam site. The operating machinery for the cableway was located in the hoist house on the Nevada side of the canyon. The six steel ropes that spanned the canyon were each 3 1/2 in diameter - bigger than a man s wrist. The roller cradle that ran along the supporting cables was as big as a boxcar. When high-scalers needed to be delivered to their precarious perches, it was often the cableway that delivered them in large platforms called, skiffs. Because the timely and accurate placement of men and materials was critical to the success of the project, the cableway operator was one of the highest paid workers at the dam, receiving $1.25 per hour.

2a - Drill the diversion tunnels

Divert the River

With sheer canyon walls on either side, the job of diverting the Colorado River around the dam site meant blasting four tunnels through solid rock. Each tunnel was 56 feet in diameter and approximately three-quarters of a mile long. The engineers at Six Companies created portable scaffolding by attaching platforms mounted with thirty rock-drilling rigs to ten-ton trucks. These trucks, called jumbos backed up to the rock face, workers attached compressed air and water lines to the rig, and thirty drills simultaneously went to work. The sound inside the tunnel was deafening as the drills burrowed 20 feet into the rock face. With a fleet of eight jumbos, construction continued, around the clock, in all four tunnels at once. Thousands of tons of drill steel were used in the tunnels, and sharpening shops, located at the dam site, were kept busy maintaining a steady supply of drill bits. After workers packed the finished holes with dynamite, the jumbo rolled out of the tunnel, and the blast was fired. 2,400 tons of rock broke loose with each blast, while the canyon shook and great clouds of dust rolled into the air. Each blast opened another 17 feet inside the tunnel. After the blast, the tunnels were inspected for safety; then crews moved in with power shovels and hand tools to clear the debris. Long lines of muck trucks hauled the spoil to dumps in side canyons - often backing down the canyon to avoid having to turn around in the narrow gorge. In just under a year, all four diversion tunnels were complete. More than 3,500,000 tons of rock had been removed from the tunnels.

2b - Line the diversion Tunnels

On March 5th, 1932, the bucket brigade went into action as the first load of concrete was poured to start the lining of the inner Nevada diversion tunnel. Trucks and rail cars brought the concrete to all four diversion tunnels in 2 and 4 cubic yard buckets. Gantry cranes transported the concrete inside the tunnels. Then, compressed air guns, using 100 pounds of pressure per square inch, forced concrete above and around huge steel forms. A single section of the steel form weighed 250 tons. Workers poured nearly 1,000 cubic yards of concrete each day until, in just over a year, the three-foot thick linings of all four tunnels were done.

2c - Build the cofferdams

On November 14th, 1932, explosives rocked the canyon and the last barriers to the Arizona tunnels crumbled. As water began rushing through the inlets, trucks pulled out onto a trestle bridge downstream, and began dumping earth and rocks into the river, creating a temporary dam and channeling the entire flow of the river into the diversion tunnels. A second temporary dam was erected further downstream, above the tunnel outlets, and the water between the two barriers was pumped out, leaving the ancient riverbed exposed. Protected by the temporary barriers, trucks and railroad cars, power shovels and rollers worked day and night to erect the permanent cofferdams. Made of earth and rock, lined on the upstream face with concrete, the cofferdams protected the site while dam construction began.

3a - Prepare the canyon walls

Prepare the Canyon

Before construction could begin in the canyon, high-scalers had to cut and blast niches into the canyon walls for the intake towers, dam abutments, and the back walls of the powerhouse and outlet works. Dangling from ropes secured to steel rods, these industrial acrobats used jackhammers to drill powder holes and then loaded them with dynamite for blasting. [PAUSE - for sounds of blasts] As the blasts subsided and the smoke cleared, high-scalers dropped over the canyon rim to clear rock and debris from the walls. Swinging along the face of the cliffs, among the maze of air hoses, electrical lines, and tools, the high-scalers had one of the most prestigious jobs at the site - and one of the most dangerous. But of the 28 men who fell to their deaths during the three years of construction, only 7 were high-scalers.

3b - Excavate the riverbed

Layers of silt, 135 feet deep, had to be excavated from the riverbed to find a solid base for the dam. Author Frank Waters described the scene this way: The vast chasm seemed a slit through earth and time alike. The rank smell of Mesozoic ooze and primeval muck filled the air. Down below grunted and growled prehistoric monsters - great brute dinosaurs, steam shovels and cranes feeding on the muck, a ton at a gulp. And all this incessant monstrous activity took place as if in a world taking shape before the dawn of man. Indeed, during excavation, workers uncovered a deep and narrow gorge, cut during the last ice age, that gave geologists a glimpse into the earth s ancient history. This gorge was used as a key anchor for the dam - an unexpected resource used to increase the stability and strength of the massive structure.

Build the Dam

4a - Screen & wash materials for the concrete

Contractors built a screening and washing plant to provide the project with clean sand and aggregate for concrete. Raw materials from a natural deposit located 6 miles upstream came to the plant in rail cars, and were dumped straight into hoppers. The hoppers fed the material onto conveyor belts, which then took it to the screening plant to be separated into sand, three sizes of gravel, and cobbles 3-9 in diameter. Stones larger than 9 were run through a crusher and screened again. Once classified, the gravel and cobbles were delivered by conveyor belts to separate stockpiles, where they were kept until needed by the mixing plants. Material classified as sand went on to be separated into four more sizes. The very fine sand, considered undesirable, was discarded, and the remaining three sizes were recombined to produce the uniform mixture required to meet the engineer s strict specifications. When the concrete mixing plants ordered supplies, trains carried the sand, gravel, and aggregate to their next destination.

4b - Mix the concrete

The lo-mix plant was the first concrete mixing plant built at the site. It provided the concrete for the lower portions of the dam and the diversion tunnels. The hi-mix plant was built later, immediately above the dam site. The hi-mix plant, the largest and most advanced of its time, produced all of the concrete for the upper levels of the dam. The hi-mix concrete plant was fully automated. High-tech equipment controlled the proportions of ingredients and provided a graphic record of all plant operations. A single operator was able to direct the entire mix from the control deck. The ingredients for the specified concrete batch were selected, weighed, and measured automatically. Conveyor belts carried the sand, rock, and cement (which the government ordered in bulk) to the batching bin where water was added, and the batch was agitated until it was thoroughly mixed. The completed batch of concrete was then loaded into the appropriate size and type of container, and was transported to the construction site by truck, cableway, or train.

4c - Pour the concrete

As the construction of the dam got underway, the nine aerial cableways became vital to efficient operations. Five of the cableways were connected to towers mounted on railroad tracks. As construction progressed, these cableways could be repositioned to service any part of the dam site. Trains delivered 4 and 8 cubic yard buckets full of concrete to the canyon rim, where the cableway cranes plucked them from the cars and lowered them into place. In this way, on June 6th, 1933, the first bucket of concrete dropped from above to be poured into a box-like wooden form. Before long, the cableway system was delivering a bucket of concrete every 78 seconds. As each bucket was released, puddlers moved in with rubber boots and shovels to evenly distribute the load; then they used pneumatic vibrators to work out the air pockets. 230 interlocking columns would be poured this way, as the process continued, day and night, for two years.

4d - Cool the concrete

If the Hoover Dam had been constructed as one massive concrete block, it would still be cooling. Scientists estimate that it would have taken 150 years for the chemical energy to dissipate, and uneven cooling would have caused enough cracks and fissures to make the dam crumble under the slightest pressure. Building the dam as 230 interlocking, lego-like blocks was the first ingenious step to solving this problem, but it was not enough. As the blocks were poured, they were meshed with one-inch tubing. A refrigeration plant located on the lower cofferdam produced chilled water that was pumped through the tubing, evenly cooling the concrete. After the concrete had cooled, the space between the columns was filled with a water-cement mixture of grout, creating a single, monolithic structure.

5 - Build the powerhouse, intake towers & spillways

Build Other Structures

Wrapped around the base of the dam and the cliffs on either side, the powerhouse is 6 blocks long, 1/2 block wide, and 20 stories high from base to parapet. The roof is 4 1/2 feet thick to protect the building from rocks that fall from the cliffs above.

Graceful intake towers control the flow of water to the powerhouse. Built on niches cut into the sides of the canyon, the intake towers are 250 feet above the old riverbed, so that silt settles below the water intake lines. Trashracks wrap the base of each tower, further insuring a clean, clear water supply to the turbines. Each of the four towers is 395 feet tall, with walls that average 3 1/2 feet thick.

Emergency overflow outlets, called spillways, were cut from the solid rock on either side of the dam. Each concrete-lined spillway is 2 blocks long, 1/2 block wide, and 10 stories high. If the water in the reservoir raises high enough to flow into the spillways, it will be channeled into steeply inclined tunnels that connect to the original diversion tunnels, and then to the river, downstream from the dam. At peak capacity, each spillway would be able to handle water flow equivalent to Niagara Falls.

Fabricate & Install Penstock Pipes

6a - Fabricate the penstock pipes

Everything at Hoover Dam was really big - and the pipes that honeycombed through the canyon walls, feeding the power plant and channeling the water for flood control and irrigation were no exception. The largest of the penstock pipes were 30 feet in diameter and weighed as much as 185 tons. Railroads couldn t carry such heavy loads, so Babcock and Wilcox, the contractor for furnishing and installing the pipelines, built a pipe fabrication plant a mile and a half from the canyon rim. The plant was three blocks long and six stories high. Even the steel plates used to form these pipes were so heavy that only two could be shipped on one railroad car.

Three of these plates were needed to form one thirty-foot section of pipe. For each section, the steel plates were first marked to the designated shapes [pause] then welding-grooves were cut. [pause] A 5,000-ton hydraulic press bent the ends of the plates, [pause] which were then rolled in a vertical press. [pause] After the three plates were welded together to form one twelve-foot section, connection rings were added, and the welds were inspected by a 300,000-volt x-ray.[pause] A 75-ton crane lifted the pipe section into a stress-relieving oven where it baked at 1,150 degrees for three hours - and then cooled for another three hours. Finally, the ends of the pipe section were precisely machined by a huge facing lathe, ensuring a tight fit between sections.

6b - Transport & install the penstock pipes

Once the giant penstock pipes were fabricated, they had to be transported a mile and a half over, 600 feet down, and as much as a third of a mile into the canyon walls. No standard railroad car could handle the task, so a 200-ton trailer was rigged to haul the 185-ton pipes. Two 60 horsepower tractors pulled the trailer to the canyon rim, where the pipe was picked off the trailer by the cableway crane. Ten thick cables secured the pipe as it slowly descended to the tunnel entrance and was laid to rest, sideways, on a specially designed rail car.The pipe section was eased down the tunnel, maneuvered into position, and joined to the adjacent section with pressure pins that were 3 inches in diameter and 7 inches long. The last step in connecting the pipe sections was to pre-stress the joint to be able to withstand the pressures exerted by the 54-degree water that would soon flow through the giant artery.

Dedicate the Dam

7 - President Roosevelt dedicates the dam

In the middle of the depression, in the middle of the desert, people came, like pilgrims to Mecca, to gaze upon the eighth wonder of the world. On September 30th, 1935, President Franklin D. Roosevelt spoke to the 12,000 people who pressed together on the dam crest and abutments to witness the dedication ceremony. This morning, he said, I came, I saw, and I was conquered as everyone will be who sees for the first time this great feat of mankind... This is an engineering victory of the first order - another great achievement of American resourcefulness, skill, and determination... Well done.

Fill the Lake

8 - Lake fills

Two years ahead of schedule, the Hoover Dam was complete. On February 1st, 1935, the diversion tunnels were closed, and the reservoir began to fill. It would take 6 1/2 years for the lake to reach full capacity - almost twice as long as it took to build the dam. The reservoir, named Lake Mead, would grow to be 500 feet deep and 110 miles long - a resource for reliable irrigation, hydroelectricity - and year-round water-based recreation - in the middle of the desert.

Construction of the Dam

Introduction

In a rugged, dry, and desolate canyon that straddles the border between Nevada and Arizona, the Hoover Dam stands as a monument to the pride and ingenuity of the American spirit.

In the middle of the Great Depression, six small-time contractors joined to form one company large enough to manage the huge project, and more than 5,000 workers came together to do the job. In just three years, from 1932 to 1935, the dam that many contemporary engineers said could not be built - was complete.

Planning the Project

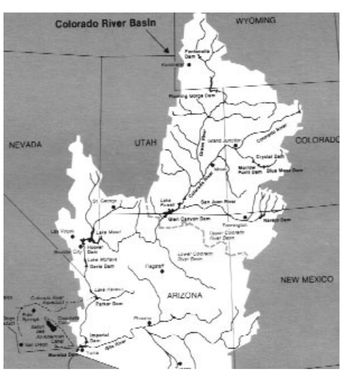
Prior to the building of Hoover Dam, the Colorado River had a wild reputation. When it was quiet, it carried tons of silt, making it unfit for drinking and poor for irrigation. When the snow melted, it would swell into a destructive force that overwhelmed dikes, destroyed farmland, and filled canals with muck.

The government called upon the Bureau of Reclamation, whose job was to build dams for irrigation and soil conservation projects. Bureau engineers surveyed 70 possible dam sites and selected two, Boulder Canyon and Black Canyon, as the best options for the Boulder Canyon Project.

After four years of intensive study, geologists and hydrologists determined that the Black Canyon site was the best choice in every way: accessibility, geological conditions, depth to bedrock, and canyon width and depth.

For 25 years, the states in the Colorado River Basin had fought over water rights. Before the dam could be built, representatives of these seven states would have to reach an agreement.

In 1922, after representatives had been sitting, deadlocked, 10 hours a day for two weeks, Herbert Hoover, then Secretary of Commerce, suggested dividing the river basin into two regions, the Upper and Lower Basin States. The resulting agreement became known as the Colorado River Compact.



Raising money to pay for the largest public works project to date was also an issue. By including hydroelectric generators in the design, the government contracted to sell the power, and by 1976, the dam had repaid the $175 million price tag - plus more than $200 million in profit.

Six construction and engineering firms joined forces to form a new company, appropriately called, Six Companies. One of the government s most respected and experienced dam builders, Frank Crowe, left the Bureau of Reclamation to join Six Companies, and head up the biggest, most ambitious, and most dangerous job of his career.

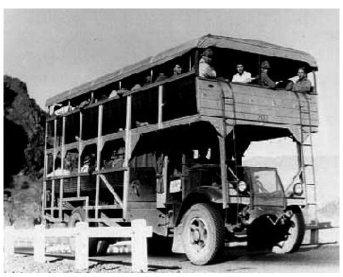
Workers & Boulder City

As soon as the press announced the passing of the Boulder Canyon Project, thousands of men, many with their families, headed for Nevada hoping for jobs - even though work would not begin for a year. It was the middle of the Great Depression and people were desperate for work.

The makeshift town that sprang up in the baked, brown desert near the dam site was dubbed Ragtown. There were no toilets, or clean drinking water, or any other facilities, but by the end of summer in 1931, the population had swelled to 1400. Six Companies erected a group of dormitories called River Camp to help with housing, but something more needed to be done.

Boulder City was constructed under the jurisdiction of the Bureau of Reclamation to house workers and their families. It was a model community in many ways, except that the occupants had no voice in their town s government. Boulder City was on government property, and the government exercised total control.

It was a clean, modern city with 1,050 houses, eight air-conditioned dormitories, and a mess hall that served 6,000 meals a day. Landscaping cut the glare of the summer sun. Inhabitants built churches in their off hours, and schools were added to accommodate families. Independent stores opened up - although prices were fixed by the city manager, Sims Ely.



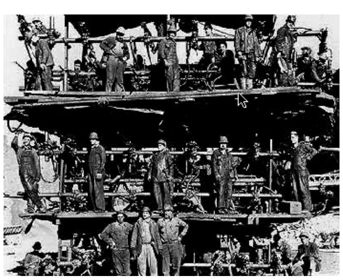
Sims Ely, a former newspaper editor and Justice Department employee, held complete authority in Boulder City. His decisions governed business, law, and morality.Anyone who wanted to drink or gamble had to go to Las Vegas, 30 miles away - and sober up before returning. In five years of construction, only one major crime occurred in Boulder City - a robbery - and the criminals were caught within two hours.

Workers were transported to and from the dam site in two-tiered trucks that could hold as many as 150 men. Construction continued 24 hours a day, 7 days a week, so the trucks ran on regular schedules. Workers had only two days off in the year: the Fourth of July and Christmas.

Preparing to Build

Preparation was essential to success in this barren land. Six Companies built highways, railroads, machine shops, warehouses, and garages to provide accessibility and support for the project. They set up power lines, bridges, and cableways. They constructed two concrete plants along the river.

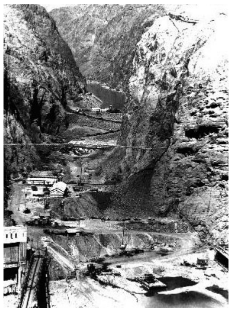
To prepare the canyon walls, high-scalers swung themselves over the canyon rim. Dynamite, jackhammers, and crowbars were lowered to them, and they blasted, drilled, and pried tons of debris from the vertical walls. To protect themselves from falling rocks, the men wore hard hats made of cloth and coal tar.



While the high-scalers prepared the canyon walls above, workers used jumbos to drill the diversion tunnels through the walls. Jumbos were 10-ton trucks mounted with rock drills. Using a jumbo, workers drilled 30 holes simultaneously, planted the dynamite, and then drove out to await the blast - and their return trip.

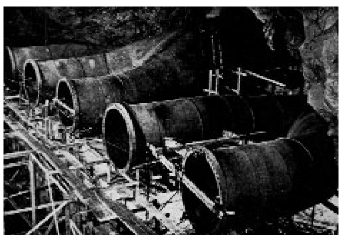
Each blast opened up 17 feet of tunnel space measuring 41-foot by 56-foot. Muck trucks hauled the 2,400 tons of rock to dumps in side canyons - backing down the canyon to avoid having to turn around in the narrow gorge. In total, more than 3,500,000 tons of rock were removed from the tunnels.

Four diversion tunnels were needed, two on each side of the river, to detour the water while the dam and powerhouse were built. Each tunnel was 56 feet in diameter.The average length was three-quarters of a mile.



Once drilling was complete, crews lined the diversion tunnels with three-foot thick concrete walls. The concrete was hauled three-quarters of a mile from the modern plants built by Six Companies for this project. Huge steel forms, weighing 250 tons shaped the concrete linings.

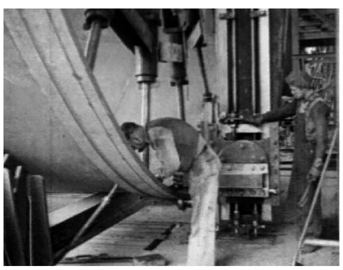
Once water began flowing through the diversion tunnels, two cofferdams were constructed of earth and rock, lined on the upstream face with concrete. The cofferdams forced the river from its ancient channel, providing access to the riverbed, and allowing construction of the dam and powerhouse to begin.



Fabrication of Penstock Pipes

The penstock and outlet system consists of tunnels and steel pipes that carry water from the intake towers to the powerhouse and outlet works. The main supply lines are called headers, the connections to turbines are penstocks, and the conduits to the outlet works are outlets.

The penstock pipes were so big that a two-story house could be built inside. They were so heavy that they could not be transported by rail. Therefore, Babcock and Wilcox, the pipeline contractor, built a manufacturing plant near the dam site. The plant was three blocks long and six stories high.

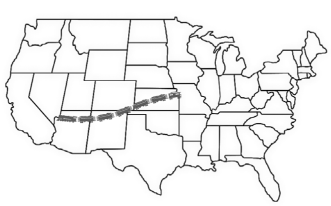


Pipes were made in 30-foot sections out of high tensile steel. A 5,000-ton hydraulic press bent the plates, then a vertical press rolled them into wide arcs. Three of these plates were welded together to form one section. Supporting rings and brackets were added, and all welds inspected by x-ray.

Heating the penstock pipes to 1150(F in a special oven for three hours, and gradually cooling them for another three hours relieved the stresses caused by rolling and welding. Finally, the ends of the pipe were machined to exact specifications by the swinging arm of a huge facing lathe.

The 150-ton penstock sections were loaded onto a 200-ton trailer and pulled by two tractors to the cableway.The cableway lowered the sections into the canyon and placed them sideways on specially designed railroad cars. They were then transported into the tunnels and pushed into position.

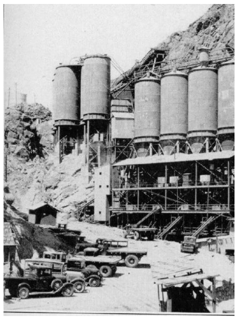
The pipes were joined together with rivets or pressure pins and caulked. Joints were pre-stressed to minimize temperature stresses caused by the cold water that would soon be flowing through them.



Concrete

Concrete is made of sand and crushed rock, aggregate, water, and Portland cement. If all of the concrete ingredients used in the Hoover Dam were loaded onto a single train, as the engine entered the switch yards in Boulder City, the caboose would just be leaving Kansas City, MO.

Sand, rock, and aggregate were excavated from a site six miles upriver. Rail cars hauled the materials to a screening plant, and then to the concrete plants. Water from the river was distilled in a settling basin and pumped into storage tanks. Cement was purchased in bulk and shipped to the concrete plants in boxcars.



The lo-mix plant was located 3/4 of a mile upstream from the dam site, and provided the concrete for the linings in the diversion tunnels and for the lower levels of the dam. The hi-mix plant was constructed later on the canyon rim and produced all of the concrete used in the higher levels of the dam.

Initially, concrete was loaded into 2 and 4 cubic. yards. buckets and then transported by truck from the plant to the work site. Later, electric trains took the place of the trucks. Once the dam structure began, cableway cranes lifted 4 and 8 cubic. yards. bottom dump buckets of concrete and lowered them into place.

Because timing was critical when moving the concrete, crane operators were some of the highest paid workmen on the project, earning $1.25 per hour. As each bucket deposited its 16-ton load, seven puddlers used shovels and rubber-booted feed to spread the concrete.

If the dam had been built in one big block, it would have taken 150 years for the heat released by the curing concrete to dissipate, and the cracks caused by the uneven cooling would have caused the structure to crumble. To avoid these problems, the dam was built in a series of 230 vertical, interlocking columns.

One-inch tubing was placed in five-foot intervals around each column. The tubing distributed chilled water from a refrigeration plant (located on the lower cofferdam) to speed the cooling process. As columns cooled, they contracted. The resulting space was filled with a water-cement mixture of grout.

Cableway Crane System

Transporting equipment, men, and materials over 700 feet down nearly vertical canyon walls was not an easy task. Once again, engineers had to think big. The cableway they created was 1,580 feet long from anchor to anchor. The six steel ropes that spanned the canyon were bigger than a man s wrist, and the roller cradle that ran along the supporting cables was as big as a boxcar.

The loading station for the cableway was near the end of the road and railway on the Nevada side of the canyon. Several landing platforms were cut into the canyon walls for receiving the heavy loads. The cableway operated by remote control, with the operator perched in a booth on the side of the canyon.

Still in use today, the cableway can maneuver loads weighing in excess of 150 tons, traversing the 700 feet into and out of the canyon at 30 feet per minute. During the building of Hoover Dam, 4,360,000 cubic yards of concrete were lowered using this system.

Fatalities

From 1922 to 1942, there were 114 deaths related to the construction of Hoover Dam:

37 - Struck by a falling object

28 - Fell off the dam or the canyon rim

14 - Died from heat prostration

10 - Died in accidental explosions

9 - Died in construction traffic accidents

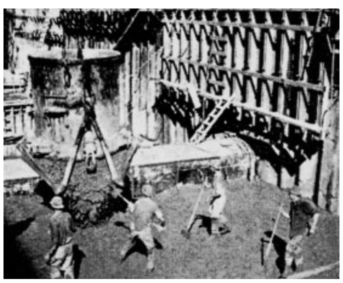
6 - Drowned in the river

5 - Were electrocuted

4 - Died in a rock slide

1 - Died when a concrete form broke

In one near fatal incident, an engineer fell from the canyon rim. Twenty-five feet below, a high-scaler heard the slip and swung out, catching the engineer s leg. Within seconds, another high-scaler helped pin the engineer to the canyon wall. They held him there until a line was dropped, and the engineer was pulled to safety.

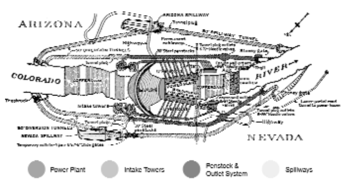


The first and last men to die on the project were J.G.Tierney, who drowned while conducting a geological survey on December 20, 1922 - and his son, Patrick Tierney, who fell from one of the intake towers on December 20, 1935.

No one is buried in the concrete. A bucket of concrete only raised the level of the column 2-6 inches. If someone had inadvertently been knocked down, the six puddlers whose job it was to spread and pack the concrete by walking around on it, would have seen the accident and assisted.

There is one grave located on the dam site: the tomb of a dog - the dam s mascot. He was born under one of the dormitories and grew up to become part of the crew, riding to work each day in a transport truck. In 1941, a company truck rolled over him while he slept underneath. All work was halted for the day.

Features of the Dam



Introduction

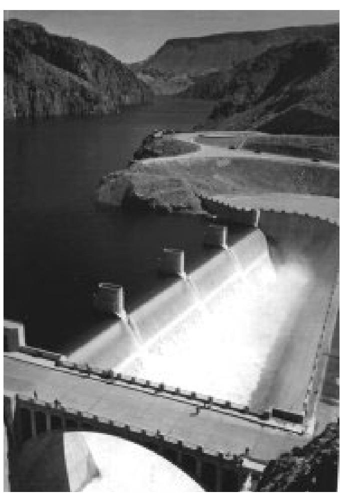
The intricately woven structure of Hoover Dam cannot be fully appreciated by a casual observer. The engineering features are connected by underground tunnel and piping systems and the sheer size of the visible structures makes it impossible to grasp the big picture. Diagrams can help.

There are two spillways at Hoover Dam - one on either side. Their purpose is to drain off excess water from the lake, preventing it from spilling over the top of the dam and onto the power plant below. The spillway tunnels intersect with two of the original diversion tunnels.

At the base of the dam, backed up along each canyon wall, are the two wings of the power plant. The connecting section bordering on the dam itself serves as the office building for operations and management. Water delivered through the penstock piping system turns the turbines on the power plant generators, providing power for markets throughout the Southwest.

There are four intake towers - two on each upstream side of the dam. The towers regulate the flow of clean water through the penstock pipes to the power plant and the outlets below.

The penstock and outlet system includes the tunnels and pipes that direct water from the intake towers, through the canyon walls, to the outlets in the power plant, the plug outlet works, and the canyon wall outlet works. The pipes that empty through the plug outlet works intersect two of the original diversion tunnels.



Spillways

Just as the overflow hole in your bathtub drains off excess water when you fill it too full, the spillways at Hoover Dam (one on each side) drain off excess water from the lake, preventing it from spilling over the top of the dam and onto the power plant below.

When the water level raises too high, four 500,000 pound drum gates are raised (automatically or manually), allowing the overflow to pour into the concrete channels, and down steep spillway tunnels that connect with the original diversion tunnels, and then into the river downstream.

The spillways have been used twice. In 1941, the Arizona spillway was tested. In 1983, snowstorms resulted in runoff 210 percent above normal. The flood crested on July 24th, but the controlled spill continued until September 6th. The flood control caused erosion in the concrete tunnels, but prevented millions of dollars worth of damage in the downstream river corridor.

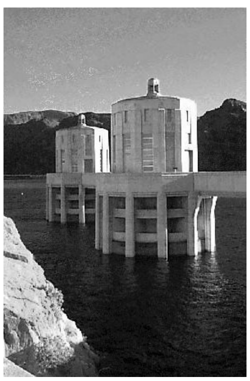
Power Plant

The U-shaped structure at the base of the dam houses the power plant. Nine main generators on the Arizona side and eight on the Nevada side provide power for markets throughout the Southwest. Two smaller generators produce power for operations at the dam. The original turbines were all replaced between 1986 and 1993.

To produce power, water channeled from the intake towers through penstock pipes enters the spiral scroll case of the turbine. The flowing water spins the turbine, which is connected to a shaft. The shaft propels a large electromagnet (the rotor), that spins inside a tightly wound coil of wire (the stator).

The exciter, located at the top of the generator, sends an electric current to the rotor, charging it with a magnetic field. The spinning rotor causes an electric current to build up in the stator. This current leaves the generator at 16,500 volts. It goes next to transformers where it is stepped up to 230,000 volts.

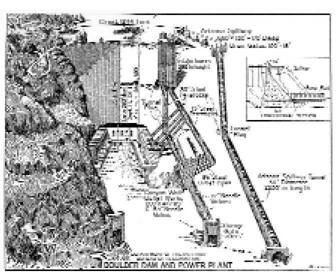
The average power generated annually at the Hoover Power Plant is 4 billion kilowatt-hours. Sixteen high voltage power lines carry the power to Las Vegas, NV; Kingman, Az; and Los Angeles, CA, among others. Chances are, if you have been to Disneyland, you have enjoyed the power of the Hoover Dam.



Intake Towers

When Lake Mead is full, you can see little more than the hoist houses that sit on top of the intake towers, but the towers are actually 395 feet tall. The hoist houses lift and lower the cylindrical gates that regulate the flow of water from the towers, through the penstock pipes, to the power plant below.

The intake towers are built on shelves cut into the canyon wall 250 feet above the riverbed. Silt from the water settles below the towers, allowing only clear water through the gates. Trashracks wrap around the towers, further insuring the clean flow of water through the penstock pipes that ultimately feed the turbines of the power plant.



Penstock & Outlet System

The penstock and outlet system includes the tunnels and pipes that direct water from the intake towers, through the canyon walls, to the outlets in the power plant, the plug outlet works, and the canyon wall outlet works. 14,800 feet of steel pipe, ranging from 8 to 30 feet in diameter, conveys the water for hydroelectricity, irrigation, and overflow.

The 30-foot diameter penstocks connect to the power plant by sixteen 13-foot diameter penstocks. The combined length of these smaller penstocks is 5,800 feet. Water from the penstocks turns the turbines that power the hydroelectric generators of the power plant.

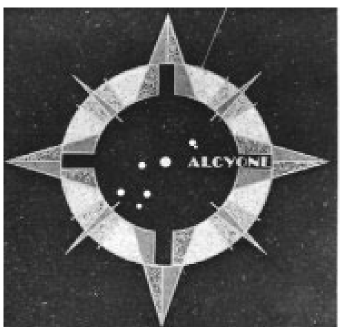
Adequate irrigation is guaranteed through the plug outlet works. From the upstream intake towers, 30-foot penstock pipes channel water into 25-foot diameter pipes, and then into six 72-inch needle valves. The needle valves perforate concrete plugs in the inner diversion tunnels, allowing water to flow through the Stony gates and into the Colorado River below the dam.

Water from the downstream intake towers that is not channeled off for the power plant goes on to the canyon wall outlet works. The 30-foot penstocks flow into 25-foot penstocks, and then into 8-foot conduits, controlled by needle valves in the canyon wall structures. The canyon outlets are used to release excess water or to drain the penstocks for maintenance.

Sculpture

Officials held a national competition to find an appropriate monument for Hoover Dam. Oskar J.W. Hansen won with the Winged Figures of the Republic. These 30-foot bronze statues are seen to represent the visionary spirit of mankind and the building genius of America. Each statue contains more than four tons of bronze.

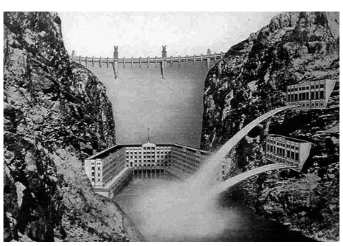
In front of the statues is a star chart showing the exact placement of the stars on September 30, 1935, when President Franklin D. Roosevelt dedicated Hoover Dam. Other important historical dates are also represented, including the building of the pyramids and the birth of Christ. Over 200 brass discs depict the solar system.



Hansen also created the bronze plaque dedicated to those who died during the construction of the dam. They died to make the desert bloom... The United States of America will continue to remember the services of all who labored to clothe with substance the plans of those who first visioned the building of this dam.

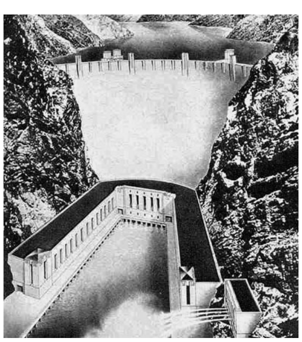
Two more plaques adorn the elevator towers on the dam crest. Each displays five bas-reliefs done in a style that is typical of Art Deco sculpture. The Arizona tower portrays the Native American tribes that inhabit the region. The Nevada tower illustrates the primary benefits of the dam: flood control, navigation, irrigation, water storage, and power.

The High Scaler monument, erected in July 2000, commemorates the courage of the men who built Hoover Dam. Mounted on a 20-foot tall boulder, the bronze figure is shown in the high-scaler s normal work environment - dangling from the side of a cliff. Sculptor Steven Liguori modeled the statue in the likeness of Joe Kine, one of the last surviving high scalers.



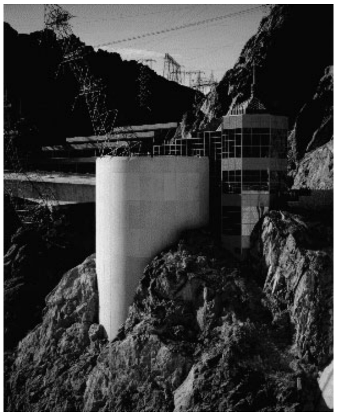
Architecture

Engineers who designed Hoover Dam created a modern wonder in terms of techniques and materials used to accomplish the task that many experts considered impossible. The aesthetics of their design, however, was definitely government issue. Architect Gordon B. Kaufmann was called in to revamp their design to reflect a more modern image.



Kaufmann simplified the plans with a style that was strongly influenced by Modernism and Art Deco. The ungainly eagles that loomed over the dam crest in the engineers design gave way to an elegant play of vertical shadows that sweep the eye up and over the magnificent dam fa ade.

The streamlined spillways, the modernist power plant, and the rocket-like radial fins of the intake towers add to the sense of constant motion that Kaufmann achieved with his design. In 1985, the Hoover dam was honored as one of the most important civil engineering projects in America - and as the largest example of Art Deco Architecture in the world.



Visitor Center

Since 1936, visitors have been able to take guided tours of the dam and powerhouse. By the end of the year, 177,128 people had taken the tour. On June 21, 1995, a new Visitor Center opened to accommodate those coming to see the eighth wonder of the world. In the year 2000, there were 1,276,292 visitors to the dam.

The Visitor Center includes an Exhibit Gallery featuring interactive multimedia presentations about the dam and the surrounding area. An observation deck provides a sweeping view of Hoover Dam and Lake Mead. A self-guided tour of the dam starts on the third floor of the Visitor Center Parking Garage.

Impact of the Dam

Intro

There are five primary reasons Hoover Dam was built: flood control, navigation, irrigation, water storage, and power.

Hoover Dam stabilized the flow of the Colorado River, making it possible to build two smaller dams downstream. Davis Dam, 67 miles downstream, was completed in 1951. It provides water storage to meet our treaty obligations with Mexico, and produces a billion kilowatt hours of power each year as well.

Completed in 1938, Parker Dam is 155 miles south of Hoover Dam. From Parker, water is diverted to the large aqueduct leading to cities in southern California. The power plant at Parker Dam generates 565 million kilowatt hours per year.

Hoover Dam plays a key role in the operation of Davis and Parker Dams. Without Hoover controlling the wild variations in the flow of the Colorado River, the generators downriver would be in constant jeopardy of floods and irreparable damage.

Flood Control

Prior to the construction of the dam, the Colorado River was wildly inconsistent. The water level was determined by precipitation and runoff in the Rocky Mountains of Colorado. Two million acres of land were potentially irrigable along the river, but drought and flood made life miserable for those who tried.

Between 1905 and 1907, after years of drought, floods repeatedly devastated the Imperial Valley - the fertile agricultural region of southern California that relied on the Colorado River for irrigation. The river demolished dikes, filled canals with silt, and ruined farmland. The solution was to dam the river and control the release of water.

Hoover Dam intercepts the Colorado River, and manages the release of water from the reservoir. By stabilizing the water supply in the Southwest, one twelfth of the area of the continental United States has been turned into a highly developed, highly stable agricultural center.

Power Supply

On October 22, 1936, the first generator began producing power at the Hoover Power Plant. Another was deployed on November 14th, and a third on December 28th. By 1939, eleven commercially available units were in operation. The last generator went into action in December 1961, bringing the plant capacity to over 2 million kilowatts.

In its first forty years of commercial power generation, the Hoover Dam produced an estimated 150 billion kilowatts - enough to supply a million residents for twenty years. Generation of this amount of energy in an oil-burning plant over the same time would have consumed approximately 258 million barrels of oil.

The Metropolitan Water District uses about a third of the energy generated at Hoover Dam to pump water across the mountains and desert to southern California. Los Angeles uses about 15 percent of the power, Nevada uses 25 percent, and Arizona uses 19 percent. Many cities in southern California also benefit from the hydroelectricity produced at Hoover Dam.

Every year, the Hoover Power Plant generates about 4 billion kilowatt-hours of energy. Money from the sale of hydroelectricity pays for all of the operation and maintenance costs at Hoover Dam. Arizona and Nevada each receive $300,000 per year from the revenues, and another $500,000 annually is set aside for the development of irrigation and power resources within the Colorado River Basin.

Sediment Reduction

Before Hoover Dam was built, water from the Colorado River was poorly suited for drinking because it carried so much silt and sediment. Many farms along the river used the water for irrigation, but keeping the canals free of sediment buildup was a constant problem.

During the construction of Hoover Dam, engineers had to take the high sediment content into consideration. The four intake towers were built on shelves that were cut into the canyon walls 250 feet above the original riverbed - high enough to provide a catch basin for silt and sediment, and ensure that the water running through the intake gates would be clean.

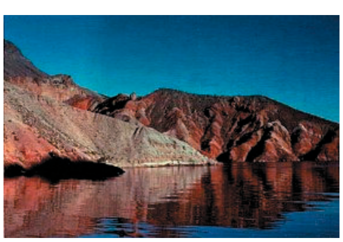
Downstream from Hoover Dam, the Colorado River is comparatively clean and clear now, leaving its load of silt behind in Lake Mead. Between 1935 and 1963, 91,500 acre-feet of sediment was deposited in Lake Mead each year. With the addition of Glen Canyon Dam, 370 miles upstream, the life of Lake Mead is indefinite.

Water Storage & Irrigation

Because of Hoover Dam, floodwaters no longer devastate the Colorado River Basin. Instead, the annual runoff of late spring and early summer is collected in the reservoir and held until needed for irrigation, drinking water, and the many daily uses that people have come to take for granted.

As the states within the Colorado River Basin need water, they place orders with the dam authority, and water is released accordingly. In a normal year, 7.5 million acre feet of water are allotted among the lower basin states, with an additional 1.5 million acre feet guaranteed to Mexico.

Water released through Hoover Dam is used in Arizona, Nevada, and California. Because power generation is considered secondary to flood control and irrigation, the quantity of water available for release through the power plant is, in part, based upon the water orders received.



Recreation

Lake Mead is the largest reservoir in the United States. It is 115 miles long and has 550 miles of shoreline. Situated in the middle of the desert, it is a unique recreational resource.

Every year, millions of visitors come to the desert to enjoy boating, sailing, windsurfing, fishing, water-skiing, swimming, sunbathing, and camping.

Lake Mead is named for Dr. Elwood Mead, who served as Commissioner of the Bureau of Reclamation throughout the building of Hoover Dam until his death in January 1936. On October 13, 1936, the National Park Service assumed administration of the Lake Mead Recreation Area.

Prior to the development of Lake Mead, the National Park Service had maintained parks, monuments and historic areas as a means for Americans to understand their heritage. Lake Mead was the first park to be developed as a recreational facility.

Environmental Impact

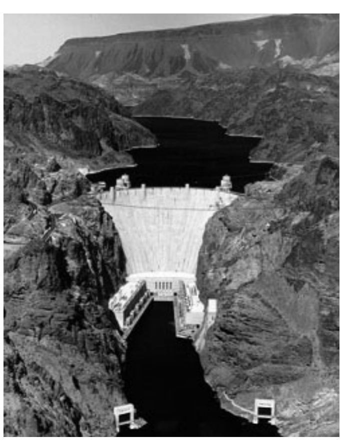
Those who oppose dams point out that man-made lakes cover thousands of acres of cropland and force entire towns to relocate. In the case of Hoover Dam, however, there were very few inhabitants in the desolate area that became Lake Mead. People did not move to the area until after the lake had filled, creating an abundant and reliable water source.

Because of Hoover Dam, the Bureau of Reclamation has been able to transform more than 10 million acres of desert into cropland, yielding barley, corn, wheat, sugar beets, cotton, and more. As an indirect consequence, though, many farmers in other parts of the nation suffered financial losses due to competition with the low priced crops produced on government land.

While sediment reduction has improved the water supply to the growing population of the Southwest, it has also devastated the delta jungles of Mexico. Before Hoover Dam was built, the Colorado River provided rich silt deposits to the delta, which supported abundant plant and wildlife. Today, the delta is a desert, and the wildlife is gone.

While Lake Mead has become widely known for sport fishing, most of the game fish have been introduced by humans, including salmon, trout, catfish, sunfish, and bass. Only three of the eight native fishes of the Colorado River are still relatively common. The other five are listed as endangered species.

According to the United States Committee On Large Dams (USCOLD), hydropower is the most plentiful and efficient renewable energy resource. It is twice as efficient as fossil-fueled power.The July 1996 USCOLD Newsletter states that if all of the energy produced by hydropower were produced by coal, pollutants from coal would increase by 16 percent.



Milestone of Human Achievement

The arch-gravity design of Hoover Dam had never been used before - and it became a model for the design of high dams. Innovation was key at every stage of building Hoover Dam: designing the intricate piping system that would power the hydroelectric plant; providing the refrigeration to cool the interlocking concrete columns; and installing huge cableway cranes to move men and equipment are just a few of the challenges faced and conquered.

Hoover Dam was the largest public works project of its time. It provided employment during the Great Depression, and it made the growth and development of the Southwest possible. But the story of Hoover Dam is greater than the bare facts.

The story of Hoover Dam is one of ingenuity, pride, and efficiency. It is about everyday Americans becoming heroes as they battled insurmountable odds just to get the job done. The story of Hoover Dam is about great ideals and monumental achievement.

Hoover Dam Tour

W elcome to Hoover Dam. We re in Arizona now, but if you look across the lake - that s Nevada. More than 20,000 vehicles a day make the trip across the dam between these two states. Annually, about a million and a half of those travelers stop on their journey to visit this awesome place. W e re about to join them.

Take a minute to look around. Look over the wall to your right. We ve got a great view of Lake Mead from here. This is the lake formed by Hoover Dam, as it interrupts the flow of the Colorado River. The lake is 115 miles long and has 550 miles of shoreline. People come from all over the country to play in the water here. But if you look at the hills around you and across the lake, it s still obvious that this is a desert. Imagine what this place would be like without the lake!

W elcome to Hoover Dam!

Hoover Dam is an awe-inspiring structure. The sheer size of the great concrete barrier is enough to make most people stop and wonder about the capabilities of mankind. But the story goes so much deeper.

The work of the civil engineers who designed the systems that would conquer a hostile canyon and control a wild river -

The sheer tenacity of the men who built the dam in the middle of nowhere -

The art and architecture of the dam - the finishing touches that caught the spirit of the desert and the men who dared to challenge it...

All these things contribute to the saga of Hoover Dam. As we show you around today, you ll have many opportunities to take side trips that will reveal even more about the history and the inner workings of the dam. Let the wonder of Hoover Dam overtake you. Enjoy yourself... Welcome to Hoover Dam.

This is the Arizona side spillway. There s another one just like it on the Nevada side of the dam. The spillways are a very important safety feature: they act like the overflow drain on your bathtub. The tops of the spillways are 27 feet below the top of the dam, so if the lake gets too full, the water flows into the spillways instead of going over the top of the dam, which would cause a lot of damage. They re usually dry, like this one, but during floods, each spillway could handle the equivalent of Niagara Falls. Look down at the end of the spillway, under the bridge. You can see the steep drop-off of the tunnel that would channel water around the dam, connecting to the original diversion tunnels - and then into the river below.

While we re here, look at the design of the bridge over the spillway and compare it with the design of the circular towers that you see extending out from the dam into the lake. Those are the intake towers. Notice the graceful, vertical details on each structure. The similarity is no accident. The architecture of the dam is strongly influenced by the Art Deco style that was popular during the 1920s and 1930s. We ll point out more examples of this design as we go.

What is a spillway?

Gouged into the volcanic rock on either side of the dam are two spillways. The spillways are essentially drainage ditches, 650 feet long and 170 feet deep, with four 500,000-pound drum gates along the edges. As the water level rises in the reservoir, float valves automatically raise the steel gates, allowing the lake to back up an additional 16 feet. If the lake continues to rise, the water flows over the gates, protecting the dam. If the water gets more than seven feet over the top of the gates, the water pressure will automatically push the gates down, allowing a 23-foot spill. The gates can also be operated manually if greater control is desired.

W ater flowing into the spillways plunges 500 feet down steep concrete channels that join with the original diversion tunnels, and then into the river below.

Preparing for Construction

Preparing the canyon for construction meant blasting four diversion tunnels through hard walls of volcanic rock. The tunnels were lined with concrete, and the last barriers removed. As water began rushing through the tunnels, trucks pulled out onto a trestle bridge and began dumping earth and rocks into the river, creating a temporary dam and channeling the entire flow of the river into the diversion tunnels. The temporary dam was replaced with permanent cofferdams, and the ancient layers of silt between the cofferdams were excavated, exposing the solid base of the riverbed.

Meanwhile, high-scalers cleaned the canyon walls. Dangling from ropes secured to steel rods, these daring men used jackhammers to drill powder holes and then loaded them with dynamite for blasting. As the blasts subsided and the smoke cleared, they dropped over the canyon rim to clear the remaining rock and debris.

Altogether, over 5,500,000 cubic yards of rock, silt, and debris were removed from the canyon walls and the riverbed. With the solid rock exposed, the concrete of the dam structure would be able to bond with the rock. Construction could begin.

Look over the wall and down (down, down). It s 726 feet to the bottom - you re not afraid of heights, are you? We re now standing 171 feet higher than the top of the Washington Monument in Washington, D.C. The building you see way down there at the bottom of the dam is the power plant. This is one of the biggest electrical generating facilities in the southwestern United States. Power from Hoover Dam is used throughout the states of Arizona and Nevada as well as in parts of southern California. Welltake a look around the generator room at the end of the tour.

Now, let your eyes sweep up the right side, following the curve of the dam. That s a lot of concrete! In fact, there s enough concrete in the dam to build a 2 lane road from Seattle, Washington to Miami, Florida. Without concrete, Hoover Dam would not be possible.

See how the dam connects to the walls of the canyon? Before the dam could be constructed, loose rocks needed to be cleared off of the canyon walls. Special workers were required for this job. They were called high-scalers. These men climbed down into the canyon, hanging from ropes, and used jackhammers and dynamite to strip away the loose rocks. Look down one more time, and imagine dangling out over the canyon walls suspended from a

Recipe for a dam.

To build Hoover Dam, combine one part Portland cement, two and a half parts sand - not too fine - one and three-quarters parts fine gravel, one and a half parts intermediate gravel, one and two thirds parts coarse gravel, two parts cobblestones, and one half part water to make 4,440,000 cubic yards of concrete.

Mix thoroughly, and pour into wooden forms to create 230 interlocking columns.

Cool evenly, and fill seams with grout.

When done, your dam should be 660 feet wide at the base (that s as wide as two football fields placed end to end) and 45 feet wide on top (about half the length of a football field). Be sure to cool your dam evenly and completely, or it will split, crack, and crumble.

We're across the street now, and the buildings you see at the end of the walkway are the Arizona side intake towers. There's another set just like them on the Nevada side. From here, you can only see the hoist houses that make up the top four stories of each tower. The hoists control two gates in each tower, one at the bottom and one in the middle, allowing water to be drawn into the power plant for use in producing energy. The 395-foot tall towers stand on notches cut into the canyon walls 250 feet above the lake bottom. Since we can only see the tops of the towers, this is a good indication of the depth of Lake Mead.

How does a tower help make power?

Four intake towers stand as sentries on the upstream side of Hoover Dam. These reinforced concrete towers control how much water is allowed to pass into the penstock and outlet system to spin the turbines of the power plant and to fulfill the obligations for water supply and irrigation. Each tower controls one-fourth of the supply of water for the power plant. Each tower is 82 feet in diameter at the base and 63 feet in diameter at the top. They are 395 feet tall and sit on shelves cut into the canyon walls 250 feet above the original riverbed. Building the towers above the bottom of the reservoir allows sediment to collect below the inlet gates and ensures that water passing through to the power plant is clear.

Two water inlet gates are located 250 feet and 350 feet below the top of each tower. The higher gates are still deep enough that fish don't swim at that level, and the bottom gates are low enough that water could be taken in to feed the turbines of the power plant long before the lake was full. The cylindrical gates are each 32 feet in diameter, 11 feet high, and weigh 1,473,000 pounds. The protective trash racks that wrap around the towers weigh 1,756,000 pounds each. The four towers combined contain 93,674 cubic yards of concrete and 15,299,604 pounds of steel.

How does the water get from here to there?

The penstock and outlet system includes the tunnels and pipes that direct water from the intake towers, through the canyon walls, to the outlets in the power plant, the plug outlet works, and the canyon wall outlet works. 14,800 feet of steel pipe, ranging from 8 to 30 feet in diameter, conveys the water for hydroelectricity, irrigation, water supply, and overflow.

The 30-foot diameter penstocks are connected to the power plant by 13-foot diameter penstocks. Water from the penstocks spins the turbines that power the hydroelectric generators of the power plant.

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Water from the downstream intake towers that is not channeled off for the power plant goes on to the canyon wall outlet works. The 30-foot penstocks flow into 25-foot penstocks, and then into 8-foot conduits, controlled by needle valves in the canyon wall structures. The canyon outlets are used to release excess water or to drain the penstocks for maintenance.

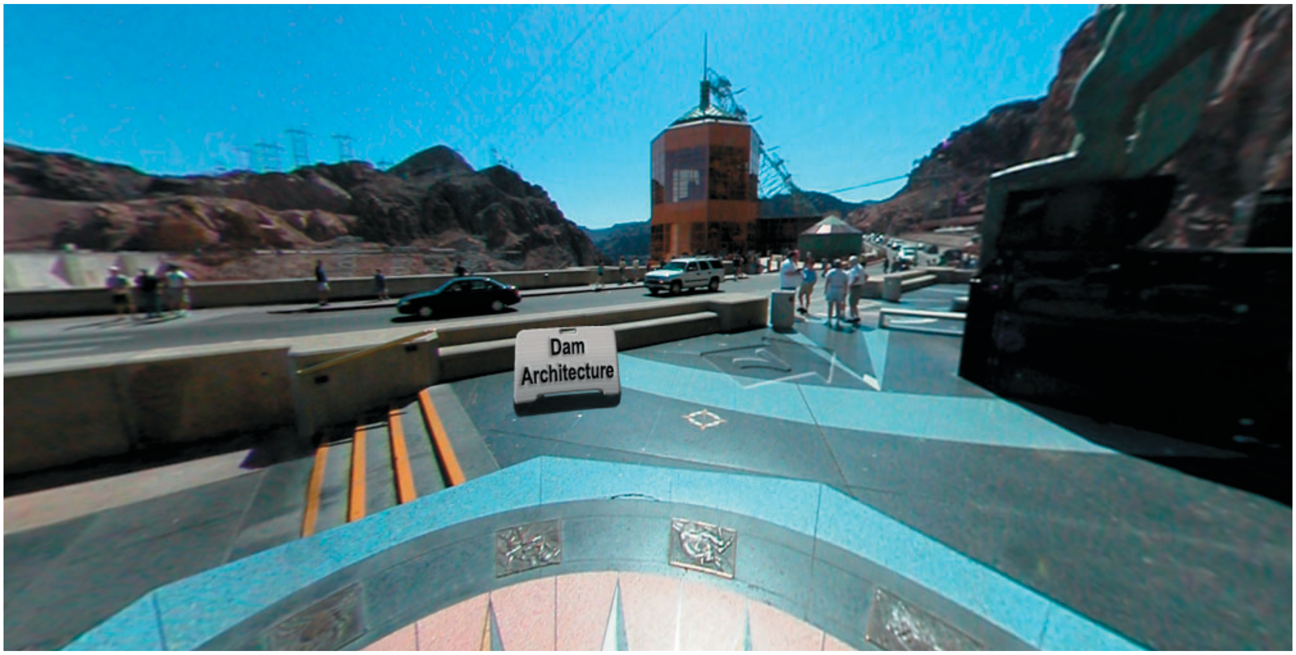
Now we re in Nevada, and from here, if you look over the edge of the dam and to the right, you can see the Nevada intake towers - just like the towers we saw on the Arizona side. Over the edge to the left, is the old exhibit building. It was built in 1937 to house public exhibits, but in 1941, the Army took over, and used it as a headquarters building for the duration of World War II. The Hoover Dam was an important resource during the war, providing power to build weapons and airplanes. To protect the dam, tours were suspended, traffic over the dam required an army escort, and riflemen were placed on the surrounding cliffs day and night. Now, the building is used, once again, for its original intent. Displays are changed and updated regularly.

From where we re standing, you can see just a little bit of Lake Mead, but there s a lot more to the lake than what you can see from here. Lake Mead is the largest reservoir in the United States, and contains enough water to flood the entire state of New York with a foot of water. In addition to providing water for the power plant and irrigation for parts of the southwest, the lake is an excellent place for recreation of all kinds.

Lake Mead

When Hoover Dam was first proposed, the intention was to tame the wild Colorado River - to control the seasonal flooding and provide consistent irrigation and water supply to the Southwestern states. Hydroelectricity was a late addition to the plan - the convenient afterthought that paid the tab and proved to be a key factor in opening the Southwest to development. As the reservoir started to fill, officials in the Bureau of Reclamation and the Department of the Interior began to realize that another unexpected benefit was taking shape. Named for Dr. Elwood Mead, who served as Commissioner of the Bureau of Reclamation from 1924 until his death in January 1936, Lake Mead was a unique recreational resource. On October 13, 1936, the National Park Service assumed administration of the Lake Mead Recreation Area.

Prior to the development of Lake Mead, the National Park Service had maintained parks, monuments, and historic areas as a means for Americans to understand their heritage. Lake Mead was the first park to be developed as a recreational facility. Every year now, millions of visitors come to the desert to enjoy boating, sailing, windsurfing, fishing, water-skiing, swimming, sunbathing, and camping.



This is Safety Island, an area that commemorates the people involved in building the dam. You re standing on a large marble compass, surrounded by the twelve signs of the zodiac. Can you find your sign? Look down at the beautiful floor pattern. This is just one of many decorative floor designs found throughout Hoover Dam and in the adjacent buildings. From here, we can also see a bronze plaque, designed by Oskar Hansen, the same artist who created the winged figures that are the centerpiece of the dam s artwork. This plaque honors the men who were killed during the construction of the dam.

The art you see here is typical of the Art Deco style that you also saw in the spillway and intake tower designs. Hoover Dam has been honored as the largest example of Art Deco Architecture in the world.

Honor those who helped create Hoover Dam

There are several plaques and inscriptions around the Hoover Dam. Most are dedicated to the men who built the dam, as is the bronze plaque you saw on Safety Island. That particular plaque, honoring the men who died during the construction of the dam, reads, They died to make the desert bloom. The United States of America will continue to remember that many who toiled here found their final rest while engaged in the building of this dam. The United Sates of America will continue to remember the services of all who labored to clothe with substance the plans of those who first visioned the building of this dam.

At the base of the towering flagpole between the Winged Figures, another inscription reads, It is fitting that the flag of our country should fly here in honor of those men who, inspired by a vision of lonely lands made fruitful, conceived this great work and of those others whose genius and labor made that vision a reality.

Two more plaques adorn the elevator towers on the dam crest. Each displays five bas-reliefs cast in concrete. The Nevada tower illustrates the primary benefits of the dam: flood control, navigation, irrigation, water storage, and power.The Arizona tower portrays the Native American tribes that inhabit the region. The inscription reads: Since primordial times, American Indian tribes and Nations lifted their hands to the Great Spirit from these ranges and plains. We now with them in peace buildeth again a Nation.

Other plaques along the dam s crest include one that recognizes Hoover dam as an Engineering Monument, and another that provides information about the dam s political and engineering history.

Architecture of the Dam

As architect Gordon B. Kaufmann designed Hoover Dam, he did not specifically decide to create an Art Deco structure. His intent was to make an aesthetically pleasing and modern fa ade for the dam. With the new materials and techniques that were used in the construction of Hoover Dam, however, it was perhaps natural that the architectural style that emerged came to be recognized as a classic example of Art Deco.

The Art Deco movement celebrated living in the modern world - a world that, in the 1920s and 30s was experiencing the rise of technology and speed. Geometry, simplicity, and vibrant colors typify the architecture and art of the period, as do objects made from both exotic and mass produced materials.

Streamlined shapes derived from the principles of aerodynamics and repeating and overlapping images reflect the influence of machines on the artistic expression of the era. Other famous buildings that reflect the Art Deco style include: The Chrysler Building and the Empire State Building.

Here, on either side of a 142-foot flagpole, are the Winged Figures of the Republic, two large bronze statues, designed by sculptor and artist Oskar Hansen. They are a symbol for the creation of Hoover Dam and a tribute to man s building genius. In the words of the artist, the building of Hoover Dam, belongs to the sagas of the daring...therefore, they wear the look of eagles. Each statue is 30 feet tall and contains more than four tons of bronze. They re some of the largest monumental bronze sculptures in the United States. It s rumored that if you rub their toes, it ll bring you good luck in Las Vegas.

At your feet, in front of the monument, are the official plaques and mottoes from the seven states of the Colorado River basin and the American Bald Eagle. The eagle has forty-eight feathers in each wing, representing the forty-eight states that made up the United States in 1935.

Directly in front of the monument, set into the floor, are over 200 brass discs. They represent the brightest stars visible from this location. The larger the disc, the brighter the star. This is exactly how the sky looked on September 30, 1935: the day President Roosevelt dedicated Hoover Dam.

Consult the star chart for the Hoover Dam

The star chart you see in front of the Winged Figures is a map of the heavens, exactly as they appeared on September 30, 1935, when President Franklin D. Roosevelt dedicated Hoover Dam. The solar system is represented so accurately that astronomers could use it to calculate the location of the Pole Star for the next 14,000 years. Future scientists will be able to look at this chart and figure out on what date the dam was dedicated. Other important historical dates are also represented, including the building of the pyramids and the birth of Christ.

The 200 brass discs used to simulate the stars are inlaid in terrazzo tile like that which is found throughout the dam buildings. Terrazzo is a kind of mosaic made of marble chips, outlined with brass or aluminum divider strips.

Tours were first conducted through Hoover Dam and the power plant in 1936. That year, 177,128 people toured the dam. Now, more than a million visitors a year take the tour and millions more drive across the dam on their way to or from Las Vegas and beyond. In 1995 the new Visitor Center you see across the street opened to accommodate the crowds. The Visitor Center houses exhibits, movies, and guided tours that help people learn more about this incredible dam.

To the right of the Visitor Center and across the street, you can see a stand of palm trees. These are part of a cactus garden planted by the film crew shooting the Chevy Chase movie, National Lampoon s Vegas Vacation. They wanted the entrance to look more desert-like, so they planted this garden. The fact that these types of cacti don t grow in the Mojave Desert is beside the point.

Don t miss the Visitor Center!

Even during construction, people would come to Black Canyon to watch the dam being built. During the Great Depression, people drew strength from observing the amazing things men could achieve when they worked together. On May 11, 1936, seven months after President Roosevelt dedicated the dam, a guide service began taking visitors on tours of the dam and powerhouse. By the end of the year, 177,128 people had toured the facility. In October of 1936, the government authorized charging admission for tours, and, early in 1937, the Bureau of Reclamation started giving official tours, charging 25 cents per person.

In 1995, a new Visitor Center and parking garage were built to accommodate the people who came to see the eighth wonder of the world. Now, more than a million people visit Hoover Dam every year.

The Visitor Center offers displays, films, and exhibits about the construction and operation of the facility, the history and ecology of the area, and the impact of the dam on the environment and economy of the southwest. Tours are still available as well.

Here on the observation deck, we have a spectacular view of the face of the dam and the power plant below. Notice the simple lines of the architecture and the way the vertical lines of structure and shadow sweep your eye up and over the edge of the dam. This is, again, an excellent example of Art Deco design. The original plans called for huge statues of eagles to perch, like gargoyles on the dam s crest, and the streamlined building below would have looked like an old-fashioned county courthouse. Architect Gordon Kaufmann simplified the engineers design to create the modern image you see now.

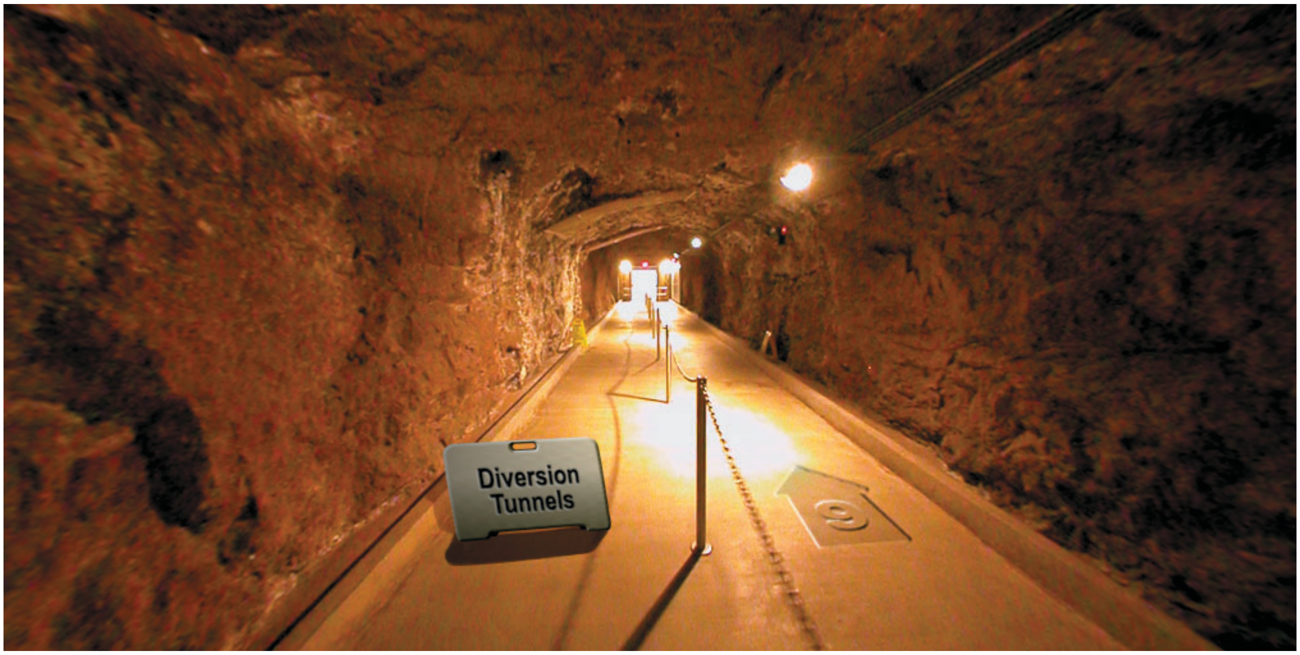
As we ve explored Hoover Dam today, I m sure you ve noticed the large towers guiding the transmission lines out of the canyon, carrying power to the cities that use it. They re all around you. It s hard to believe that hydroelectricity was an afterthought at Hoover Dam. Originally, the project was intended to provide flood control and irrigation in the Colorado River Basin. Hydroelectricity was added as a brilliant idea to make the project pay for itself which it did within forty years of operation.

Imagine how much heavy equipment had to be lowered into the canyon to build the power plant. A special cableway crane system was built for this purpose. From here, you can see the six large cables that carry the cableway s roller cradle stretching across the canyon. The cableway can lower more than 150 tons down 750 feet to the bottom of the canyon. This is the world s largest and oldest operating cableway crane system, and it is still in use today for removing and repairing heavy equipment.

Power up at the power plant!

The U-shaped structure you see at the base of the dam is the power plant. Each wing of the plant is 650 feet long, and sits 150 feet above the normal water level, but that s 299 feet (nearly 20 stories) above the power plant foundation. The roof is four feet thick, made of reinforced concrete, to protect the building from rocks falling from the cliffs above. The wings of the power plant house 17 main generators. These are Francis-type vertical hydraulic turbine generators. They provide power to cities throughout the southwest. Two smaller generators are driven by Pelton water wheels. They produce the energy for the lights, pumps, cranes, compressors, and other electrical equipment used at the dam. You ll have a chance to learn more about the generators when you visit the generator room at the end of the tour. Altogether, the plant has a rated capacity of 2,998,000 horsepower, which translates as 2,074,000 kilowatts.

The base of the U-shape - the part right at the bottom of the dam - is an office building, housing the management and operations departments. In all of the galleries of the plant, there are 10 acres of floor space.



W e ve just taken an elevator ride 500 feet down into hard rock. This tunnel is 250 feet long. It will take us into the generator room on the Nevada side of the power plant. Look around you can see how this tunnel was built by blasting right through the rock. Many other parts of the dam were created the same way.

Who uses the electricity from the dam?

It is virtually impossible NOT to notice the mammoth silver towers climbing out of the canyon and leading off in every direction from the power plant. Every year, the Hoover Power Plant generates about 4 billion kilowatt-hours of energy. Who uses all of this power? Where do all of these transmission lines go?

The Metropolitan Water District uses about a third of the energy generated at the dam. They use the electricity to power the giant pumping system that carries water across 300 miles of mountains and desert to the arid cities of southern California.

The next largest customer is Los Angeles, which uses 15 percent of the dam s hydroelectricity. Las Vegas is also directly serviced by the Hoover Power Plant. As a whole, Nevada uses about 25 percent of the plant s generated energy; While Arizona uses about 19 percent. Cities in southern California that are powered by the Hoover Dam include: Burbank, Pasadena, Anaheim, and Riverside, to name just a few.

Money from the sale of hydroelectricity pays for all of the operation and maintenance costs at Hoover Dam. Arizona and Nevada each receive $300,000 per year paid from revenues, and another $500,000 annually is set aside for the development of irrigation and power resources within the Colorado River Basin.

We re now standing in the Nevada wing of the power plant. On the marble floor is another of the decorative motifs. This one was designed by Allen True, an artist from Denver who realized that many of the geometric designs found in the local Native American art shared aesthetic concepts with the Art Deco style of the dam. Drawing inspiration from sources such as Acoma bowls and Pima baskets, he chose centrifugal themes for the terrazzo artwork tying the ancient patterns of the southwest to the modern engineering of the spinning turbines that power the generators. If you look at the generators, you ll see another of True s artistic contributions the bright red shells of the generators. The color would command attention under any conditions, but on the giant beating hearts of the power facility, it is particularly striking.

Here on the Nevada side, there are eight of these generators on the Arizona side; there are nine. As you look down at the generator units, you are seeing less than half their true size. They re over 70 feet tall, the equivalent of a seven-story building, and you re only seeing the top 30 feet. Each weighs more than two thousand tons and can take up to three years to assemble. The generators you see today are upgrades from the original generators installed in 1936. Each produces about 133,000 kilowatts of electricity enough to power about 100,000 homes.

How do you turn water into electricity?

As you stand in the generator room, you are seeing less than half of each generator. The exciter is at the very top, and the red generator shell covers the rotor and the stator.

One floor down, a thirty-foot shaft extends from the turbine up to the rotor.

To produce hydroelectricity, water channeled from the intake towers through penstock pipes enters the spiral scroll case of the turbine. The flowing water spins the turbine, which is connected to a shaft. The shaft propels a large electromagnet (the rotor), that spins inside a tightly wound coil of wire (the stator).

The exciter sends an electric current to the rotor, charging it with a magnetic field. The spinning rotor causes an electric current to build up in the stator. This current leaves the generator at 16,500 volts.

It goes next to transformers where it is stepped up to 230,000 volts before it is sent out over sixteen high voltage power lines to cities all over the southwest.