The Hoover Dam:
A World Renowned Concrete Monument

David Moore, PE

This paper tells of harnessing a wild river, the construction of a great dam, and its contribution to winning WWII along with playing a critical role in developing the West.

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THE WILD RIVER

By what reason was our nation provoked into damming the mighty muddy Colorado River? It flows in a 1,400 mile course from the high reaches of the western slopes along the Rockies into the Gulf of California in Mexico, draining an area about one twelfth of our country. At times it is a reasonably peaceful river carrying tons of mud and silt, a condition unfit for drinking and poor for irrigation. But as the snow melts, it turns into a raging giant with a high wall of water pushing total destruction in its path.

In the late 1880's, hordes of farmers settled in a large saucer-like depression called the Imperial Valley, located in lower California, next to the Colorado River. In 1896 the California Development Company dug a 60 mile canal to bring water from the Colorado to develop this fertile valley. Here, a wonderful climate permitted abundant harvests of fruits and vegetables to be sent to massive city markets. The outermost farmers received little water in the late dry season while farms near the river were flooded, much like the historical story of the Nile River.

To keep the Colorado River in its banks, dikes were built, but this was to no avail. Floods easily broke up the headworks in 1904, filling the canal with muck; later, the floods sent masses of water overland flooding the lower part of the depression in the valley. This ended up in making the Salton Sea, a 380 square-mile lake. After the dikes were repaired, they were again burst by floods. Then, in 1909 the summer flood made a new channel for the great river in an old riverbed ending up in the Gulf.

Clearly, this wild river could not be controlled. The political forces of the region called upon the Bureau of Reclamation which held the federal mandate assigned in 1902 to build dams for irrigation and soil conservation projects. The solution was to dam this uncontrollable river to end its destruction once and for all. A controlled water supply was essential for the production of the Imperial Valley and to provide drinking water for the continued expansion of major cities in southern California.

In 1914 a stroke of genius placed Arthur Davis at the helm of the Bureau. He was the nephew of Major Powell, the noted explorer of the Grand Canyon, and the stories from this association inspired Davis to harness the unruly river.

As the director, he proposed a dam some 750 feet high to impound two years of average river flow in its reservoir which gave a safety factor for serious floods. This plan was radical by all measures. When the Buffalo Bill Dam (an arched type) was built in 1910, it was considered the highest in the world for that time with a height of 325 feet. Davis did not flinch. In 1922 he joined with Secretary of Interior A. B. Fall in sending the Senate a report describing his high dam in the Boulder Canyon just south of Las Vegas along with the 80-mile All-American Canal which would deliver water to the Imperial Valley. Later, in 1924 the Bureau's chief engineer, F. E. Weymouth, submitted his technical report refining some 70 damsites to the Boulder Canyon or Black Canyon; a board of engineers finally selected the one at Black Canyon. Strangely, the high dam was still called the "Boulder Dam." It was located near the beginning of the lower basin to give adequate control of the river to California, Arizona and Nevada.

Paralleling the time line of technical studies was a grave, irritating problem of allocating water to each state through which the Colorado River ran. Without an agreement, the project was doomed. Greed became rampant when it came to water rights. The governors of the participating states met and agreed to negotiate an interstate compact.

By good choice, President Harding appointed Herbert Hoover to represent the Federal Government on the Interstate Compact Commission of the river basin states. Soon after, he became its presiding officer. Of course, the seven states would bitterly disagree on parceling the water, so Hoover wisely proposed that water be divided equally between the upper and lower basin states, allowing each natural basin to decide the fairness of various state's water rights. The commission members signed this agreement in 1922 making the high dam a reality. The agreement was approved by all the participating state legislatures and the United States showing that democracy works well in our country.

Eventually, it was Hoover's astute negotiations leading to the approval of the compact that turned the corner on building the high dam. For this outstanding achievement, the dam was rightfully renamed the "Hoover Dam" in 1947 by a fair-minded consensus of President Truman (Democrat) and the 80th Congress (Republican). They corrected a naming error (The Boulder Dam) that had crept into the picture.

Finally, in 1928 Congress passed the Boulder Canyon Act (hence the Boulder Dam's name) assigning $175 million to build the project. But being careful businessmen, Congress stipulated this money, except $25 million for flood control, should be repaid at 3 percent interest (a standard for that time) within 50 years.

During the 1920's and 30's, electric power became a dominant power source to drive industrial profits, so as an afterthought in the late planning stages, hydroelectric generators were to be installed and operated by dropping massive amounts of water through penstocks in the dam. This became the ideal source of repayment. The dam provided over 2 million kilowatts of energy to expand the nation's economy in the West and became a vital factor in World War II. By 1976 (40 years of operation) the project had grossed $378 million representing a return to Uncle Sam of over $202 million, an excellent business venture of the Bureau by any standard. In 1986 the project was stamped "paid," but it continues to produce millions for the government coffers.

DESIGN AND CONSTRUCTION

With construction of the high dam authorized in 1928, activities at the Bureau's office in Denver shifted into high gear. Geological specialists inspected the volcanic bedrock and found fault lines were solid enough to support the structure. Surveying parties fanned out over the reservoir area some 100 miles long to make contour maps showing this area would indeed hold 31 million acre feet of water capacity. It would hold the greatest floods of the Colorado. The office engineering staff was busy making system analyses, drawings, specifications, schedules, and cost estimates. This work was finished in late 1930, six months ahead of the bidding target – hats off to the Bureau's engineers.

All these activities are too voluminous to be detailed here. But we can briefly examine one facet of the Bureau's engineering prowess to best illustrate the technical sophistication that created the dam. Looking back some 75 years, we find engineers of that period had acquired technical skills easily recognized and praised by their modern professional counterparts.

To a few readers, this paragraph may seem too technical and dry to merit a place here. But, we must tell for history something of the design features of this special dam too appreciate the engineering practice. The Bureau describes the Hoover Dam as an arch-gravity type which implies two systems were employed, an early accepted design approach. The arch system acts as a segment of a ring wedged between the walls of the canyon. The gravity system is a little more complex as it deters the dam from sliding and also from an overturning movement.

But there was much more than these simple calculations with details provided by Norman Smith (1). In 1907 the Pathfinder Dam, USA (214 feet high) was the first moderately high, arch-dam to be designed with an unique "arch-dam" analysis. The design considered action of segments of vertical cantilevers and horizontal arches working simultaneously. The object was to gain the same deflection at their point of intersection with a water load on the face and with varying thicknesses of the dam. The cylinder and standard cantilever theories were used giving complex equations to follow. In the late 1920's more complexity was adopted in analyzing the Hoover Dam. This design was called the "trial load." It introduced the elastic theory into the equations. By refining the design, a series of cantilever sections instead of one, along with the action of a fixed arch, as the water load varied became the evolvement of analysis for the dam.

Adjusting the shape of the dam under load to meet the deflection and other conditions was "tricky," presenting the engineers with extremely complex and lengthy work. In those days, there were no computers – only the sliderule and log tables were used extensively. Thus, the Bureau engineers had acquired the knowledge of solving complex equations along with plenty of patience. The Hoover Dam's criteria and calculations, adopted in the late 1920's, have validated the Bureau's engineers as reaching the top of their profession. This massive structure standing at 721 feet high to harness the Colorado shows the worth of yesterdays' careful calculations.

Now, we will turn to the many unusual construction problems. In the midst of our deep depression an important event occurred. On March 6, 1931, the composite bid of $48,890,995.50 for building the Hoover Dam was accepted. This amount is about equal to the present cost of a high performance U.S. Army helicopter. Unskilled labor at the damsite was paid $4.00 per day while present minimum-wage labor cost is a little under $6 per hour. This tells us how history has changed the economy, and how valuable this dam has become.

This bid was won by Six Companies, Inc., known as the "Big Six": Utah Construction; Pacific Bridge; H.J. Kaiser and W.A. Bechtel; MacDonald and Kahn; Morrison-Knudsen; and J.H. Shea. Unknowingly, the Bureau had obtained expertise and services of the best construction managers in the country. The proof is by an example – soon after the dam was finished, World War II began, and "Uncle Sam" called on Henry Kaiser to build and operate shipyards on the west coast. Ships were vital to deliver men and materials to the front. He managed his yards well; a ship a day was launched from his ways proving his true value. Undoubtedly, this brilliancy was greatly enhanced by his experience at the Hoover Dam.

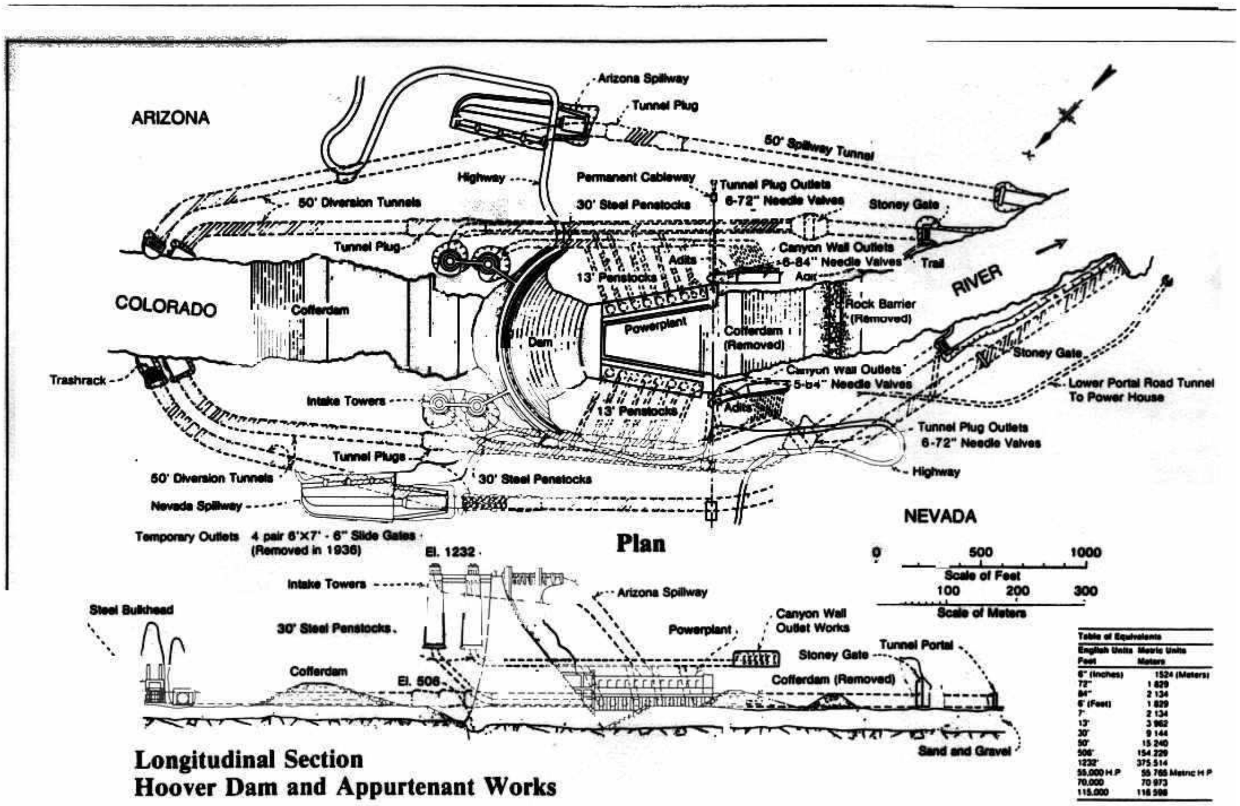
This construction task was truly formidable. There were no precedents to follow in building very high dams. Think of it this way : excellent planning was required under the umbrella of six independent companies with Frank Crowe directing activities to effectively fit all the pieces of the puzzle together at the right time. Outstanding leadership by the Bureau including Walter Young, Chief Engineer, was also essential in building a successful dam; there could be no mistakes.

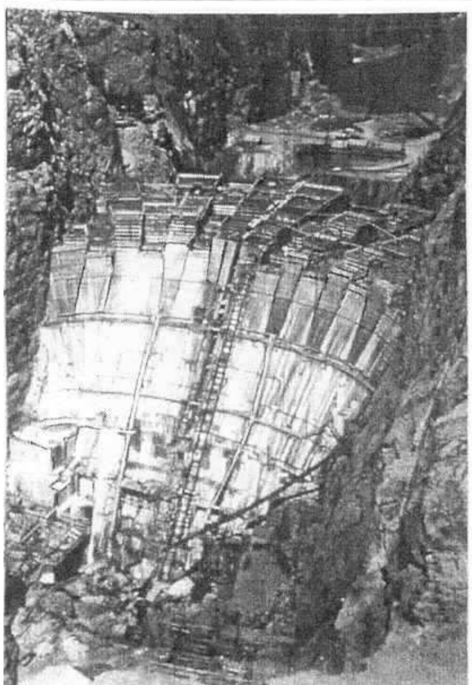
Large quantities of materials must be shipped and stored at the damsite on schedule. There were some 5 million barrels of cement used in the concrete. Structural steel components weighing 9,000 tons, and large steel pipe, along with fittings, weighing 44,000 tons were needed. Sheer numbers alone defined the magnitude of procurement and construction problems facing the contractors.

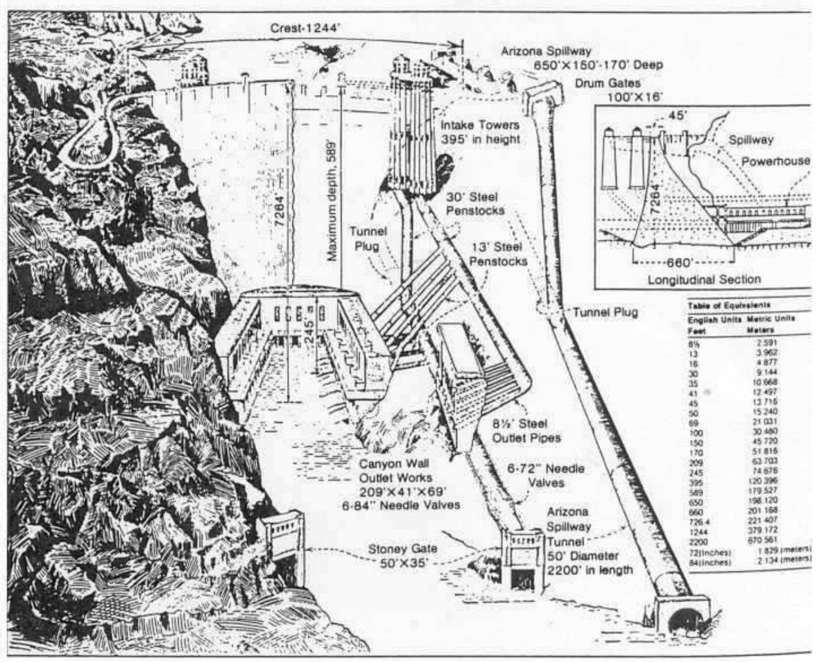
But there were still more problems. Housing for the workers, who eventually peaked at 5,218, was needed before any work began. This meant houses, roads, water and sewer lines became the first act of construction in the hot Nevada desert. Eventually, this housing complex would be known as Boulder City. Building a railroad some 34 miles from Las Vegas to the damsite was given high priority. It was the only way to bring in large, heavy equipment along with masses of materials.

Ingenuity was displayed by the engineers in building special devices to match unusual tasks, illustrated as follows. Think of the period this way; two years prior, the Model-T-Ford was in favor with the American public, and mechanical brakes stopped all automobiles. Thousands of workers were mobilized and transported to the dam around the clock. To carry these people to the dam, large trucks were modified with decks of seats to hold 150 men at a time. There were no off-the-shelf devices to dig large rock tunnels. Again, large 10-ton trucks were modified to support platforms holding 30 drills which were used to prepare the rock face for dynamiting tunnels through the canyon walls. Massive spider-like webs of steel wire cable were stretched from towers high over the dam to lower concrete, large pipe, and men down the sheer cliffs into the canyon.

The discussion of dam construction is divided into three major segments: the diversion tunnels and penstocks, the concrete-arched structure, and the power plant. There appears no reason to repeat significant dam configuration data, since they appear in the functional view of the dam shown below. However, some numbers and the pictures below have been used from the US Bureau of Reclamation's booklet, Hoover Dam – Fifty Years (2) to clarify certain functions. It is emphasized that work was active within these segments at the same time, but at various rates to match installation dates.







Above, Hoover Dam under construction in 1933.

By June 1931, just three months after signing the contract, sufficient housing facilities were in place. The Big Six meant business so their highest priority turned to diverting the river. The work space under the dam must be completely free of water, muck, and loose rock before the first bucket of concrete could be placed. To achieve this, the Bureau’s plan was to drive two large tunnels through each side of the canyon around the damsite. Imagine the problem facing the Big Six in driving a hole, 56 feet in diameter (about the length of an average home) through solid rock around the dam.

How did the contractors overcome this challenge? They used the custom-built rig previously described with water and compressed air lines attached to operate its battery of 30 drills. Holes were run into the tunnel face. A ton of dynamite was loaded in the holes, and the face was "fired." The canyon walls shook violently, and 2,400 tons of rock pieces tumbled into the tunnel at one time. Trucks removed the rock. The rig was moved 17 feet forward. The process crept on around the clock. The rough rock walls needed protection from high torrents of the river, so a crew handling a reusable massive steel form followed the miners putting on a three foot concrete lining. This jumbo of human activity was occurring in all four tunnels. Indeed, the contractors were serious about building the high dam.

The Bureau’s engineers cleverly designed four diversion tunnels for a multi-purpose piping system. The first purpose was to divert the entire river. After the concrete dam was finished, all four diversionary tunnels were plugged with concrete allowing the water level to rise on the dam. Two of these tunnels are assigned to carry flood waters, one on each side, connecting a spillway on that side with the downstream river. The other two diversion tunnels, one on each side of the dam, were modified to hold a large penstock pipe. The steel penstock was connected to one of the high intake towers positioned in front of the dam.

To clarify this picture, there are four of these intake towers, two on each side of the dam, delivering water out of the reservoir to the powerhouse by penstock pipes. There is a main penstock, 30-foot in diameter, leading from each of the four towers which feed water to small penstocks, 13-foot diameter, serving the turbines in the powerhouse. Truly, the quality of the Bureau’ engineering professional talent is told by the success of this complex giant piping system in operation.

While these figures are purely descriptive, it is important to recognize the contractor’s difficulties and his prowess in fabricating and installing such huge steel pipes. Pipes of that size could not be shipped in standard railroad cars. So the Big Six accepted the challenge and built a pipe fabrication plant near the dam. Perhaps its toughest assignment was to bend 3-inch-thick steel plates into 30-foot diameter penstock sections.

Placing the 12-foot long sections, some weighing 185 tons and others 135 tons, into the plugged diversion tunnels along with smaller penstocks in their lined tunnels was another major challenge. A 250-ton-capacity cableway was built which swung the pipe section over the canyon and lowered it with 10 cables coming from the cablecar. The largest sections were locked together with 3-inch-diameter pins; smaller sections were joined with hot-rivets. The workers found it hard work to drive the 3-inch diameter pins into their locking holes because of the great size.

We are getting ahead of our story. Going back to November 1932, prior to installing these penstocks, low cofferdams were spanning the river at the ends of the work area. Gates of the diversion were opened which turned the river, bypassing the dam. The contractors did not waste time. Shovels, drag lines, and ten-ton hauling trucks were busy removing some 500,000 cubic yards of muck from the river bed. On the cliffs, dangling on lines overhead, high scalers were also busy cutting and blasting loose pieces of soft, weathered rock. Think of its importance – all weathered rock on the walls and foundation of the canyon must be removed so the concrete will bond to the rock face. A pathway for high-pressure leakage must be prevented at all costs. Disaster with failure of this high dam was unthinkable.

A few months later in June 1933, a milestone was made when the first bucket, containing eight cubic yards of concrete, was poured in the forms of the foundation key of the dam. Prior to this time, two large concrete plants were erected near the dam on the plateau. Closely associated with the processing of concrete, the contractor solved many problems such as the procurement, handling, and storing materils;5 million barrels of cement, large quantities of sand and gravel, 45 million pounds of reinforcing steel, and components of the concrete forms were eventually used in building the dam.

Let us look at the size of this massive structure: it is 726.4 feet high (the height of a 60-story skyscraper); 660 feet wide at the base (2 football fields); 45 feet wide at the top; and a crest length of 1,244 feet (4 football fields). Building this dam required a very efficient operation. Work was frantically paced at 24 hours a day.

The large concrete plants had the capacity of producing 16.5 tons of aggregate with cement and water in one minute. This operation delivered an average of 160,000 cubic yards a month to the damsite. On the peak day, 10,462 cubic yards of concrete was poured to set the record. By the final pour, 4,360,000 cubic yards of concrete were lowered from the unique cableway system into the dam and appurtenant works. Visualize the size of this feat: it would be like building a 16-foot concrete highway from San Francisco to New York, and in the period when the Lincoln Highway crossed the country with gravel roads which were slowly being converted to an all-weather, asphalt surface for the first time.

Building this high dam was truly untried; a series of uneven separate columns were erected and keyed to each other. The columns on the outside (upstream face) of the arc were 60 feet square, while those on the inside were 25 feet square to round the contour of the dam. The Bureau’s engineers permitted only 5 feet of concrete to be placed in the forms at one time, which was cured for three full days before the next lift (block) was placed. After the blocks were cured, they hardened and shrunk. Then, a liquid grout of wet sand and cement was pressure pumped into the space between blocks of the columns making a solid structure.

Heat in the new dam became a major concern. Unknown to many, upon mixing concrete, much heat is generated in the chemical reaction of any large concrete placement like a dam. As the concrete cools, it shrinks and cracks. Obviously, the Bureau engineers did not want their dam leaking through this oversight; they had enough serious problems at hand without inviting more.

These astute engineers tackled the problem with unusual vision. They conceived of a giant cooling plant that would cool the entire dam. As the concrete was poured,

1-inch diameter steel pipes were placed 5-feet apart. This maze of piping, some 580 miles in the final stage, lead to a cooling tower that pumped ice water (37 ° F) into the system at 1,000 gallons per minute. Next to the tower was a giant refrigeration plant which produced 1,000 tons of ice a day; it could have easily been the world’s largest. With this apparatus working well, the dam was cooled in 20 months instead of over a century. With it, viewing the dam nearly 65 years later, there are no obvious cracks.

As mandated by Congress, the sale of electric power paid for constructing the dam. This was brilliant because abundant low cost energy stimulated the development of big cities and their industries in the southwest. Producing power at Hoover Dam is a simple plan. Four concrete intake towers, just upstream of the dam, draw in the Colorado River which is sent down large steel penstocks to turn each turbine assembly in the powerhouse. This turbine acts like a giant waterwheel turning a generator with a 115,000 horse power thrust. Eventually, 17 generators were installed to match the demand for power from 1936 through 1961. The total generating capacity of the dam is 1,407,300 kilowatts.

The powerhouse has two wings, one on each side of the dam. They are large concrete structures, 650 feet long and 245 feet high, sharing spaces for the generating units. Between these wings in the downstream area is an office complex housing the management and operational facilities.

Over the years, the average annual generation for the plant is about 3.5 billion kilowatt-hours. Sixteen high voltage power lines, one rated as high as 500,000 volts, leave the Hoover Dam carrying power to its markets. Some serve cities directly like Las Vegas; Kingman, Arizona; and Needles, California, while others distribute power to large power grids like the ones at San Bernardino, Los Angeles, and the Davis-Parker powerplant complex. The powerline from San Bernardino, some 222 miles away was constructed to deliver power needed to build the dam. When the dam was completed, the line was used to send power back. This was the spirit of economic cooperation that built the West.

Not only are cities and industries served directly with power from the Hoover Dam, it is little known that 35.3 percent of its firm power is assigned to the Metropolitan Water District (MWD) for their pumps. This giant pumping system, planned in 1928, provides water through its Colorado River Aqueduct, which transverses some 300 miles of mountains and desert to reach major municipalities in southern California. Later by 1982, water from the storage of Hoover Dam was delivered to Las Vegas from the Robert B. Griffith Project, a product of Nevada State Legislature. This served to develop the spectacular Las Vegas area with Nevada’s share of the Colorado River Compact water agreement. Thus, you can easily see that a vision of using electricity sales to pay for the dam indirectly turned the main key in opening up the West.

The contractors are always in action. They were allowed seven years to built the dam, powerplant and appurtenant works. The last bucket of concrete was poured in May 1935 and close to a year later, March 1936, all remaining work was finished. The job was two years ahead of the construction target for which the contractor was awarded $369,000 as a bonus. Hats off to the "Big Six" contractors who challenged the odds of building the first high dam and won.

A NATIONAL VALUE

This is the untold account of Hoover Dam’s important contribution to winning WWII. In October 1936, only seven months after the dam was completed, the first generator was operating. By the end of 1939, over half of the generating units (nine) were on line. In June of the same year the Los Angeles grid, comprising of the city of Los Angeles and southern California Edison, was connected to the plant. Warclouds for WWII were clearly on the horizon following Hitler’s invasion of Poland. Fear was in the air. The United States was drafting men into the army and was desperately trying to arm after a decade of anti-war protests. It was a frantic race. Energy to run the war industries in southern California was sorely needed.

Four more generators were soon ordered, but it takes time to make these special handcrafted, large units, so only three quarters (1,034,800 kilowatts) of the total design capacity was available during the war. By comparison, it takes about 1.5 kilowatts to run a lathe in a war plant, showing the dam’s importance to the Los Angeles grid. Energy for war industries is a most powerful factor in victory.

This thought can be easily overlooked, as was the case with the German General Staff. Their lesson was given in an analysis by the Hoover Institute at Stanford (1951) from captured war documents. The Germans had made a terrible blunder in vastly underestimating our productive capacity in war plans with the United States. In fact, our country not only supplied weapons to our forces, but also to England, Russia, and others. This was an incredible challenge, and the source of power from the Hoover Dam played a significant role in weapon production.

There are many facets of Hoover Dam’s part in supporting the war effort; two areas, power for the war industries in the Los Angeles communities and power for a giant magnesium plant, clearly stand out. G. D. Nash’s investigation noted: "The capacity of new facilities (Pacific Coast) installed during the war years was more than the total available capacity in 1940. In the Southwest, war industries were receiving from Boulder Dam (Hoover Dam) 50 percent of the power they required. The giant Basic Magnesium Plant at Las Vegas consumed fully one-fourth of Boulder Dam’s output... Without the electricity, aircraft and shipbuilding industries would have been severely hampered" (3).

Not widely known, magnesium is required to harden and strengthen aluminum used in all airframes including our warplanes and is needed in unconventional war munitions. For this reason, the government built the Henderson Plant near Las Vegas in 1941 to process nearby ore deposits of magnesium. Back in 1939, production was very limited with Dow Chemical, the major processor, contributing only 7 million pounds. This amount is compared with the 368 million pounds required in the war-year 1943 when there was a large demand for fighters and bombers, showing the critical need for the magnesium plant at Las Vegas.

A major part of Hoover Dam’s low-cost power was assigned to the electrolysis process at the Henderson Plant to separate the metal from its ore. This required large amounts of electricity. When the war was over, the plant had supplied a quarter of the country’s demand for this metal, truly a significant and vital contribution.

Abundant, low-cost hydroelectric energy readily available from the Bureau was an important motivation that helped transform the Pacific Coast into a manufacturing center for planes and ships. During the war, the west coast produced 125,823 out of the 273,528 aircraft, or 46 percent of the nation’s output. Much of this production came from the Los Angeles area where North American Aviation built over 40,000 planes. This company and three other aircraft plants received their power from the Los Angeles grid which, in turn, is connected by three lines to the Hoover Dam. San Diego had three plants building aircraft, and one of these, Consolidated Vultee, produced 30,752 planes in the war. Undoubtedly, power interchanges in southern California provided some power to San Diego, marketed by the Metropolitan Water District. The District was given power by the Hoover dam. Thus, we can trace Hoover Dam’s contribution in the victory.

Not only were planes produced in great numbers, ships were urgently needed and built. President Roosevelt asked for 10 million tons of ships to be made in 1943, and it was done. Visualize the problem this way – if the average merchant ship was 10,000 tons this request would translate into launching nearly three vessels a day for the nation. The nation responded. The Pacific Coast yards accounted for 52 percent of all tonnage produced.

The Calship yards at Los Angeles were the largest in the country. No other than S. P. Bechtel was its owner. It was Bechtel who headed a major contracting force in building the Hoover Dam a few years earlier. He had mastered the art of the assembly line and mass production, consistently meeting his production goals. Think of the shipyard in the Los Angeles electric grid. It used electricity sent from the Hoover Dam to weld steel plates on ship hulls in assembly lines. Off of these lines came the thousands of ships used to successfully fight the war.

Let us turn to another part of this unusual story – unconventional weapons made from the product of the giant magnesium plant at Las Vegas. The Army Air Corps needed a bomb of mass destruction, so entire cities could be destroyed in one raid. In secret research, they developed the M-69 incendiary bomb which could set fire to any flammable material including wooden factories and bamboo houses in the compact cities of Japan and the wooden structures in Germany. It was a cluster bomb composed of many small bombs, a wicked affair, which could be spread out over a large area, presenting a major threat to the enemy.

This bomb was just right for the large, long-distant B-29 bombers. Each of these planes could carry 24,500 pounds of the M-69 cluster bombs. When dropped, these bombs could scatter in a pattern of 8,333 small bombets per square mile. Once ignited on contact, they were inextinguishable by water or other measures. What were these bombs composed of - a mixture of jellied petrol, oil, sodium nitrate, and our main ingredient, magnesium powder. It worked very well.

Daylight bombing at high altitudes on the cities of Japan had failed, so the tough General Curtis Le May, head of the Bomber Command, switched tactics. Henceforth, low-level night attacks, with minimum armament to crowd in more bombs, was ordered. The first trial was on March 9, 1945, when 279 bombers dropped these incendiary bombs on Tokyo, completely destroying the center of the capital by a fire storm that killed 84,000 people; it would match the destruction given by the atomic bombing (4). The Emperor could see the flames of his capitol from the palace window, which made a lasting impression for ending the war.

The exact batch of magnesium used in the bombs that destroyed Tokyo remains unidentified. However, the quantities of magnesium involved in making these bombs indicates more than one source was employed. We can assume, with some assurance, that some of this magnesium powder came from the plant at Las Vegas using electricity from Hoover Dam.

After Tokyo was destroyed, General Le May’s bombers used the incendiary bombs on Nagoya, Osaka, Kobe and Nagoya over the next few nights. Finally, General Le May had received only two atomic bombs, and there were no more. He was a true professional soldier, who carefully measured his enemy and played his cards well. His B-29's dropped both atomic bombs within three days on the 6th and 9th of August, completely destroying Hiroshima and Nagasaki; his gamble paid off. The Emperor thought Le May had more of these terrible bombs and surrendered ending the war. Gratefully, we were spared more casualties. Our veterans’ hats are off to those who planned and built the important Hoover Dam with its critical assistance in the war effort.

The great war showed only part of the Hoover Dam’s priceless value to our nation. It continues to serve in the production of an abundance of food, essential drinking water, and electricity from Hoover and downstream dams – all brought about by controlling the mighty Colorado.

Along with authorizing the construction of the Hoover Dam, Congress also included building an All-American Canal system which connected the Imperial and Coachella Valleys with the Colorado River. From these valleys and others in this region comes fresh vegetables and fruits to feed our people throughout the nation the year around. Other crops like alfalfa, hay and seed are easily grown.

This large canal, 232 feet wide, winds 80 miles to serve 460,000 acres of farmland in the Imperial Valley. A branch routing, the Coachella Canal, serves 58,200 acres in the Coachella Valley. A study of the value of crops produced in these valleys from 1943 to 1985 showed a worth of over $8 billion, an excellent return of the $48,890,995 spent by the government to build the Hoover Dam that controlled the river making this feat possible.

But there is still more acreage affected by controlling the river flow with the high dam. The list is significant: the Yuma Project of 68,000 acres, the Gala Project of 93,000 acres, the Yuma Auxiliary Project (connected to the Gala) of 3,400 acres, the Palo Verde irrigation District of 92,000 acres, and the Colorado River Indian Reservation of 75,000 acres. Roughly, three quarters of a million acres of cultivated land has been enhanced in productivity by the Hoover Dam. Think of the families on the farms who have a good income, and all the food they produced for the American table, as the result of harnessing the Colorado.

Los Angeles grew so rapidly in the early 1920's that a water shortage was readily apparent. Thus, the California Congressional Delegation looked toward the construction of a high dam on the Colorado River for a firm water supply and supported building the Hoover Dam. In 1928 as the Hoover Dam construction was authorized, 11 southern California cities formed the Metropolitan Water District (MWD) to fulfill their vision. This required building the Parker Dam along with a 300-mile aqueduct crossing the mountains into California to deliver the water.

In 1940, this MWD's Project was completed. It worked well, and was just in time to serve new war industries together with additional people arriving in the war period. Presently, over 125 city, municipal, and county water districts receives water from the MWD project. The system reaches as far south as the city of San Diego. A study in 1983 showed some 13 million people enjoyed an access to 296 billion gallons of water for that year coming from the Colorado River. It is said that operating the Hoover Dam with its controlled water releases to the Parker Dam was critical to the drinking water and industrial expansion of the rich southern California cities.

Details of the hydroelectric power supplied by Hoover Dam have been told, but there is another interesting energy picture connected with this dam. Two dams downstream produce power through the controlled release of water from Hoover Dam which could be considered as its auxiliary power. Davis Dam is only 17 miles downstream from the Hoover Dam. In 1951 it was completed, a little late due to the war. The purpose of this dam is to provide water storage to meet our treaty obligations with Mexico. The 200-foot high dam made of earth and rock produces a billion kilowatt hours of power each year from its 225,000 kilowatt powerhouse capacity. A power line ties the dam's grid to that of the Hoover Dam.

The other downstream dam is the Parker Dam which is 155 miles south of the Hoover Dam. Water is diverted to a powerhouse with a generating capacity of 120,000 kilowatts. The power output is 565 million kilowatt hours per year. At the same time, water is diverted to the large aqueduct leading to the cities in southern California. Not well known, the Hoover Dam supplies one third of its power to the MWD system for pumping water through the aqueduct directly tying the Hoover Dam to the MWD system and the drinking water of California cities.

It is easy to see that Hoover, Davis, and Parker Dams operate together controlling the river to make power. The million and a half kilowatt hours per year generated by these lower dams are a significant economic factor to the West and directly related to building and operating of the Hoover Dam.

The critics of the Hoover Dam must stand in the shadow and shout, for they have not studied the real contribution that this dam has made to our national welfare. Some say socialism was at play. Others say bureaucrats mastered the task of conquering the wild river. Still others say the government money should not be spent on this foolishness. But when we needed the energy from the dam to win the war and the world's freedom, it was ready and played its essential role.

Farsighted leaders like President Hoover, a Republican, and President Roosevelt, a Democrat, put differences aside for the common good of our country and directed the building of the high dam. The wild Colorado was indeed harnessed. The astute Congress asked that the dam pay for itself, and it has. Many times it has repaid the nation not only in dollars, but in low-cost power for industrial development, drinking water for expanding California cities, a controlled water supply to serve southwest farms that feed our people, and to erase the flood fears that once plagued those living along the banks of this mighty river.

Yes, when we, the people of the United States, summarize the benefits of the high dam, we can ask our future leadership to follow the example of those who planned and built with great integrity the unconventional Hoover Dam. Hats off to all the old-timers who challenged the odds and conquered the mighty Colorado by the creation of an engineering marvel.

About the Author: David Moore, PE (1999)

Professional Engineer, Graduate of Stanford University

Professional Experience in Water Resources:
Bureau of Reclamation (Wyoming)

Big Sandy Dam (Earth) Project Report and River Utilization

Fontenell Dam (Earth) Project Report, River Utilization, Flood Studies, and Canal Design

City of Denver

Dillan Dam, Blue River (Earth) Project Plans and Design

Idaho Power (International Engineering, Inc.)

Oxbow Dam (Concrete High Dam) Spillway Design

Brazil (International Engineering, Inc.)

Tres Marias Dam (Earth) Design of Earth Embankment and Spillway

City of Palo Alto (Thesis – Stanford University)

Pescadero Dam (Earth) Complete Project Plan; Design of Dam and Conveyance System (The Dam was Constructed)

WWII – The author went over the beachheads of Saipan and Tinian in 1944 with the Seabees. The B-29 bombers flew from these islands to drop incendiaries and the atomic bombs on the critical Japanese cities; a salute to all who planned and built the marvelous high dam.

References:

(1) Norman Smith, A History of Dams, Citadel Press, Inc., N.J., 1972, p. 221.

(2) All dam data and pictures were taken from the Bureau of Reclamation's booklet, Hoover Dam – Fifty Years, prepared by the Bureau's professional engineering staff. Denver, CO, 1985.

(3) B.D. Nash, World War II and the West: Reshaping the Economy. University of Nebraska, Lincoln, NB, 1990, p. 149.

(4) Cristy Campbell, Air War Pacific. Crescent Books, New York, 1990, p. 161.

dmoore@romanconcrete.com
www.romanconcrete.com