Montgomery Locks and Dam, Ohio River
Direct Vertical Lift Gates – Design History
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Prepared for the U.S. Army Corps of Engineers, Pittsburgh District by Lauren McCroskey,
Program Manager, Technical Center of Expertise - Preservation of Historic Structures and Buildings

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ABSTRACT

The completion of Montgomery Locks and Dam on the Ohio River in 1936 introduced the first gated dam to the Ohio River Navigation System, originally comprised of a series of 52 movable wicket dams along the entire 981-mile Ohio River. Montgomery Dam’s vertical lift gates represent a transitional dam technology used on only one other Ohio River replacement navigation facility in the 1930s, the Emsworth Locks and Dams. In 2006, the Army Corps of Engineers Pittsburgh District initiated a dam gate replacement project at Montgomery Dam, precipitated by damage to two gates from a breakaway coal barge accident. All ten original gates will be replaced as funds become available. This study examines the engineering and political factors involved in the historical evolution of controlled crest gate technology on the Upper Ohio River, the conditions and events leading up to construction of the dam, and the degree of influence of the Montgomery gates on subsequent dams built on the river by the Corps. The study also briefly documents the contribution of architect Paul Philippe Cret to the design of Montgomery Dam and other contemporary Corps civil works projects.
Author

Lauren McCroskey is program manager and senior architectural historian for the U.S. Army Corps of Engineers, Technical Center of Expertise for the Preservation of Historic Buildings and Structures (TCX) in Seattle. The TCX is a program of national reach that provides historic preservation services and deliverables to Corps, military and civil works projects, and to other federal agencies throughout the country. Her oversight includes historic preservation policy development and regulatory review where historic built environment resources are affected. Lauren previously held the architectural historian position at three state historic preservation offices, including Washington State, where she coordinated National Register programs. Her Master’s Degree in Historic Preservation from the University of Oregon is supplemented by a certificate in architectural conservation from the University of Pennsylvania, and by an undergraduate degree in Anthropology with an archaeology emphasis.
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Introduction

When loose barges crashed against two vertical lift gates on the Montgomery Locks and Dam spillway in October 2006, replacement of the 71-year old components altered a mundane but critical aspect of one of the Upper Ohio River’s oldest dams, and underscored the engineering importance of the gates’ design. Inspection by the Pittsburgh District of the U.S. Army Corps of Engineers (Corps) found four of the ten lift gates in substandard condition, with severe corrosion of the gate trusses and associated connections, prompting further investigation. Due to a high level of deterioration present in all remaining gates, a schedule was developed to eventually replace all of them. Because the lift gates are components of the historic Montgomery Locks and Dam, the Corps consulted with the Pennsylvania State Historic Preservation Officer (SHPO) pursuant to Section 106 of the National Historic Preservation Act. The replacement action was found to have an adverse effect on the eligibility of the property for listing in the National Register of Historic Places. In order to mitigate the loss of gates that have been replaced, and those yet to be replaced the Corps entered into a Memorandum of Agreement with the SHPO stipulating, among other tasks, the preparation of a monograph examining the historical evolution of controlled crest gate technology on the Upper Ohio, the engineering and political factors involved, and the degree of influence of the Montgomery gates on subsequent dams built on the river by the Corps. The following context frames the conditions and events leading up to construction of the dam, and probes the technical rationale for selecting vertical lift gates to control the pool behind the Montgomery Locks and Dam. The design record is a chronology of practical deliberations and political intervention by stalwart industrial giants, and includes the quiet drama of those who championed their own gate ideas in a competitive engineering climate.

Upper Ohio River Navigation through 1929

Like all great American rivers, the Ohio River has staged many consequential events in the history of marine navigation, industrial commerce and related engineering development. From the earliest years of Euro American settlement, each ferry crossing, keel boat journey, or steamboat trip helped expand the river’s navigation potential; likewise, corresponding failures pushed legislation toward better solutions to ease freight past the river’s menacing shoals and low water predicaments. As lawmakers tallied the successes and failures of the War of 1812, the need for better waterway transportation in the interior of the country became a chief concern for both national defense and economic stability. For some members of Congress, links to the nation’s economic and military health made navigation improvement a logical task of the federal government, a posture that would be championed and derided for decades before agencies such as the Corps of Engineers and Bureau of Reclamation took on full for dam building.

In spite of the unresolved role of the federal sector in waterway management, the private steamboat industry in the Ohio Valley pushed for laws to unsnarl the river obstacles that lay in its path. In 1817, the state of Ohio gathered other navigation interests in the region to form a commission to address improvements between the Ohio River headwaters and Louisville, Kentucky. Surveys and measures to
remove rocks, snags, and deepen channels clogged with sediment, followed. Congress took note and in 1820 boosted these efforts with an appropriation of $5,000.\footnote{Robinson, Michael C. History of Navigation in the Ohio River Basin, pp. 11.} This modest sum was buttressed in 1824 when President James Monroe signed the General Survey Act, followed the same year by the first river improvement funding, which authorized $75,000 and a robust program of planning studies, surveys, and transportation projects. The Army Engineers (Corps) was designated to carry out the actions, and applied innovations from the private sector such as snag clearing boats. Uneven Federal funding for navigation continued through 1865, with interruptions by economic downturns and the Civil War.

In spite of the river’s seasonal fluctuations and natural obstacles, the Ohio waterway was the primary means of conveying goods and agricultural products until the 1850s, when railroads linked the formerly remote “Northwest” states and offered a faster route between inland and coastal markets. Unaccustomed to the higher rates charged for rail shipping, industrialists in the Ohio Valley and beyond were dismayed to watch riverboat freighting marginalized by the railroads. Though slower than rails, vessel transport remained appealing as the cheapest method for carrying raw material from source to production, but could only compete if the entire length of the river was tamed into slack water pools. A desire to trim costs, and not love and lore of a riverboat heritage, compelled business leaders to demand a series of dams to flatten the waters into a placid and reliable channel. But legislative wrangling postponed the Ohio River Navigation System of locks and dams until the end of the nineteenth century.

Decades earlier, one of the Ohio River’s main tributaries, the Monongahela River, demonstrated the benefits of a navigation system for barging minerals to a waiting production base in Pittsburgh. As early as 1817, the desire to exploit abundant coal, coke and sand resources from the upriver mountains of the Monongahela watershed compelled Pennsylvania state legislation to form a navigation system, with the goal of constructing a number of dams to facilitate vessel passage. Though enthusiastically backed by the general public, elected officials, and extractive industries, the Monongahela Navigation Company (MNC) was slow to act upon its charter to attract investment and improve and canalize the river.\footnote{Contextual Essays on the Monongahela River Navigation System: Monongahela River Navigation Improvements as a Factor in Westward Movement, pp. 32-35.} Finally, by 1836, implementation was under way to construct the first in a series of seven locks and dams, which used stone-filled timber cribbing for weirs, cut stone lock walls, and hand turned mechanisms to open and close lock gates (Figure 1). The Corps of Engineers expanded the Monongahela system in 1879 into West Virginia, using concrete as well as one masonry dam.

When the Corps formally acquired the seven MNC facilities in 1897, much of the system was badly deteriorated, with lock chambers that were too small to accommodate larger tow boats. Over the next twenty years, the lower and mid-section structures were replaced with six lock and dam facilities that differed from their predecessors only in the use of concrete for weirs and lock chambers, instead of cut stone. By the 1920s, the agency’s rigorous makeover of the former MNC resulted in an all-concrete...
system of weirs, retaining walls, and lock chambers, as well as steam power technology to operate mechanical components. None of the original MNC lock and dams were left intact. Through World War I, more commercial tonnage was hauled through the Monongahela’s Corps locks and dams through than any other U.S. river system.

The MNC had established a model for a successful lock and dam program, and one that seemed well suited to the Ohio River. But in spite of the company’s success on the Monongahela, conflict between coal and steel interests along the Ohio River at first defied the creation of a similar system just below Pittsburgh. Coal mining contended dams would clog the river with sediment, and create foul waters for nearby communities, but mostly feared the imposition of a time-consuming locking process for moving their loaded barges when open river navigation was possible. In contrast, iron and steel manufacturers favored a reliable passage for their products during the half year when water levels were too low to carry cargo.

Big coal’s desire for reliable river transport on the Ohio River was strongly embedded in the Rivers and Harbors Act of 1866, providing for rigorous new survey work and sophisticated hydrological data that would fill in the gaps of previous studies. Army Engineers continued channel improvement and snag

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3 Contextual Essays on the Monongahela River Navigation System: Inventory of Past and Present Components of the Monongahela River Navigation System in Pennsylvania and West Virginia, pp. 15-24. Identification and evaluation of the system for National Register eligibility undertaken by the Pittsburgh District in 2001 identified only isolated wall remnants of the old MNC. The system of today comprises nine lock and dam facilities, with the oldest dating to 1905; the most recent lock and dam in the system was built in 1996.
removal throughout the decade, but their efforts did not address the extremes of low water seasons, and deeper draft vessels found themselves stranded too often. Knowing the success of the Monongahela River system, engineers called for an Ohio River navigation program — to include locks — with dedicated slack water of six feet from Pittsburgh to Cairo, Illinois.4 Opponents railed at the prospect of stagnant water, potential flooding, and sediment build up. To counter, engineering leaders suggested using moveable dams that could be raised and lowered at preference, a proposal that did little to allay the coal industry’s apprehension for the time delays of barging through locks.

In order to serve the interests of coal and steel, Colonel William E. Merrill, the Army Engineer officer in charge of Ohio River improvements, selected a European prototype that would meet the needs of both, and one that would prove a bold experiment for 19th century American engineers. The wicket or Chanoine dam, was a moveable type of dam with an alignment of wood and metal panels that were anchored and hinged in a concrete base. The gates could be lowered to rest on the river bottom when not in use. In order to hold back water and raise the pool during low flows, individual gates could be lifted via chains pulled from a trestle bridge above, or from a service boat anchored upstream. A variation on the wicket gate principal was the Boule weir. A Boule dam employed a similar system of panels or frames that could also be collapsed onto the river channel. Boule weir frames differed in that they were placed perpendicularly to the river channel and required both the insertion of panels into individual frames, as well as hand lifting. The wicket type of dam was most appealing to the coal industry, since a few moveable gates could be left in the open position creating a chute that enabled vessels to pass freely, without the delay of locking though chambers (Figure 2).

Figure 2. Diagram of a Chanoine/wicket gate dam (left) that was adapted in the 19th century at 51 locations on the entire Ohio River; first used at Davis Island in 1885. By the early 1930s when the Montgomery Dam was contemplated, a variation on the type, a Boule weir (right) was first considered to replace deteriorated wicket structures at dams and locks nos. 4, 5, and 6. (Source: Engineering As Applied To The Canalization Of A River, prepared by the Office of the Division Engineer, Upper Mississippi Valley Division, St. Louis, Missouri, September 1935)

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4 Robinson, p. 25.
In 1885, under the direction of Colonel Merrill, the swift gradient of the Ohio River was corralled just below Pittsburgh with the largest wicket dam built in the 19th century. Design and planning of the Davis Island Lock and Dam marshaled national and international engineering expertise, and would inform the design of all fifty additional wicket dams constructed on the Ohio. Measuring a total length of 1,223 feet from the lock’s river wall to the abutment with 305 wickets, the dam provided the first real remedy to the unpredictable flows and summer trickle that had frustrated navigation for decades. Due to its experimental nature and the realities of geography and climate, the Davis Island structure required continuous repair and modification throughout its history. The service bridge overlying the gates was swept away, and by 1890, the wooden lock gates had stressed the roller mechanisms and track, leading to full replacement with steel gates. By 1914, the structure had become a composite of various replacement and repair events, and was highly deteriorated. Before its replacement in 1922 with the Emsworth Locks and Dams, the Davis Island structure spurred industrial and commercial riverfront development in Pittsburgh, with waters that backed slightly up the Monongahela and Allegheny rivers (Figure 3).

Figure 3. A pilot boat manipulating wicket gates on the Davis Island Dam, June 6, 1904. (Source: Judith Marine Ways Collection)

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5 “Davis Island Lock and Dam,” National Register of Historic Places Nomination Form. Major components of the wicket system had long been removed by 1983 when the Pittsburgh District determined that remaining submerged elements such as the lock land wall posed a hazard to navigation. At this time, the remnant features were documented to standards of the Historic American Engineering Record.

6 Johnson, Leland R., The Davis Island Lock and Dam - 1870-1922, pp. 10–12; p. 86.
Industry's navigation goals were met by the Davis Island structure, but a section of river below the dam and near the mouth of the Beaver River remained a daunting challenge for vessel traffic. A Congressional act in 1888 directed an extension of the 6-foot channel in this stretch of the river, and throughout the next two decades, Army Engineers tackled lower reaches through planning and construction of additional locks and dams using the moveable wicket type. By 1900, 31 additional locks and dams were authorized to achieve the 6-foot navigation channel from Pittsburgh to Cairo, Illinois. Only a few years later, pressure mounted for an even deeper river to accommodate barges with bigger loads that could no longer pass a 6-foot depth, and by 1910, Congress determined that river commerce would be reinvigorated by a 9-foot channel to serve a growing economic trade in steel and oil. Congress authorized the Ohio River Canalization Project in 1922, setting in motion the next phase to convert the river to a 9-foot depth, an objective also being voiced throughout the upper Mississippi River Valley.\(^7\) By 1929, 51 wicket dams had been completed to Cairo, most of which were supplemented with a couple of Boule or bear trap weirs (variations on the Chanoine type) that could be quickly maneuvered to pass rapidly rising water.

Until the 1920s, the upper Ohio River's system of wicket dams was mostly viewed as a success for creating navigable slack water channels and moving vessel traffic up and down the river. But evolving local industry had developed higher expectations for reliable pool levels for loading and unloading cargo at ports and terminals. Although wicket dams were key components of the mandated 9-foot channel, they proved cumbersome to shipping interests and were slow in responding to low water periods. One of the biggest challenges in this upper section of the Ohio River was the steepness of the slope, which created high velocities, quickly filling any weir or losing water capacity before wicket gates could be pulled into place. The largest and oldest of the wicket dams built on the river, Davis Island Lock and Dam, was often implicated for this reason as halting barge traffic headed downstream. When these events occurred, remedies were few. For example, maneuver boats were deployed under steam to raise and lower the wickets, and by 1889 Davis' wicket system was fitted with two wooden bear trap weirs consisting of wooden A-frame units that could be quickly lowered to ease rising water. These were replaced only 16 years later by new bear traps with steel components.\(^8\)

The next Rivers and Harbor Act (1918) authorized the U.S. Army Corps of Engineers (Corps) to replace, wherever appropriate and desired, any of the old moveable barriers with fixed crest dams. As in previous legislation, navigation benefit was identified as the deciding factor for constructing new dams. The first of the replacement structures built on the upper Ohio River was Emsworth Dams, replacing Davis Island Lock and Dam in 1922. Dashields Dam, completed in 1929, replaced wicket dam and lock Nos. 2 and 3. Dashields Dam – and the original Emsworth Dams (replaced in 1938 with gated dams) – were the only two fixed crest types to be built on the Ohio River. In time, fixed crest dams were viewed inadequate for maintaining stable pool levels for coal and steel industry ports that relied upon this stretch of the river.

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\(^7\) Robinson, pp. 25-29.

\(^8\) Ohio River Main Stem Historic Contextual Study, Chapter I, pp. 193-197.
Planning of the Montgomery Lock and Dam

Big coal had always had much at stake in how the waters of the Ohio River and its tributaries were managed. By the end of the nineteenth century, water-borne transport of passengers and materials at Pittsburgh harbor totaled nine million tons; the principle item was coal. Most loaded boats at the time were approaching a draft of nine feet, with heavily loaded coal barges drawing between 8 feet, 3 inches and 9 feet, 9 inches. Rivers at low stage during the dry months often stranded coal fleets that waited to descend the Ohio. Although the old system of moveable wicket dams had deepened the river channel and offered some predictability, the 9-foot depth was rarely constant and inconveniences remained. The Davis Island Dam raised the Allegheny River mouth to an 8-foot navigable depth, previously impassable to steam craft during dry periods. At the same time, when the Davis Island wickets were laid down during low water, depths in Pittsburgh harbor were reduced 3 or 4 feet, making the passage of an 8-foot draft vessel impossible in a 5-foot channel.\(^9\) The problem would remain downstream of Davis Island Dam until the next wicket dam (No. 6) was built in 1904 at river mile 29 (Figure 4).

Flashboards applied to fixed weir crests on the Monongahela River and Allegheny River provided some relief for coal transport on those passes, but offered only short term solutions.\(^10\) Flashboards consisted of vertical panels or wood boards placed along the dam crest and loosely held in place by pins or pipes inserted into sockets. Boards were designed to bend when water reached a certain height to pass excess water and were intended to be sacrificial; if lost they could either be recovered downstream or cheaply replaced. Somewhat labor intensive like wickets, panels were lifted or placed from a trestle or overhead cableway, or from service boats. The flashboard system had an affinity with the wicket gate method, but created a semi-moveable dam in place of an entirely moveable dam.

As a new system of dams for the Ohio River was under consideration, local industry pushed much of the conversation for navigation improvement. Burgeoning steel production at Pittsburgh had become one of the river’s most influential customers, with great interest in better conveyance of both raw materials and finished products. Principal among these enterprises was the Jones and Laughlin Steel Corporation. Begun in 1905, the fully integrated steel mill covered seven miles along the river north of Pittsburgh. The company owned coal mines in western Pennsylvania, and expanded its operations along both sides of the Monongahela River, eventually playing a critical role in the World War II economy and the labor movement. For a time after World War I, Jones and Laughlin was the second-largest manufacturer of steel in the United States.\(^11\)

Steel companies had long relied upon both river-borne transport and railroad freighting, but by 1920, both Pittsburgh and Cleveland interests joined forces to protest what they believed to be unfair rail rates.

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\(^11\) A profile of the Jones and Laughlin Steel Industries is discussed in the Lehman Brothers Collection, Contemporary Business Archives, Harvard Business School, retrieved 14 July 2015 from: http://www.library.hbs.edu/hc/lehman/company.html?company=jones_lahughlin_industries_inc
Figure 4. Elevation profiles for current locks and dams (solid line) and former dam locations on the Upper Ohio River, 1885-2011. Original dams 1-9 and respective pools are shown with a dashed line. (Source: U.S. Army Corps of Engineers, Pittsburgh District)
Among other decisions that sided with big steel, the Interstate Commerce Commission ruled that the rates of the Aliquippa and Southern railroad between Jones and Laughlin’s plants were “unreasonable and duly prejudicial.” The victory over railroad freight rates, however, did not abate Jones and Laughlin’s quest for better navigation for barging its material along the Ohio River, and the company remained a major champion of dam improvement near their plant at Aliquippa, just upstream of the future Montgomery Island project.

By the late 1920s, the three wicket dams at Lock and Dam Nos. 4, 5, and 6 on the Ohio were failing and replacement was imminent. The relationship between the fixed weir at Dashields Locks and Dam, opened in 1929, and the pool further downstream had also become a major point of contention. Although this section of the river had mostly been maintained at the required 9-foot clearance, shippers in the vicinity found the water level beyond the pool of Dam No. 4 inadequate for their landings and terminals, and formally declared that a pool elevation no less than 684 feet was necessary for conducting business, and unofficially conceding a height of 682.

Pre-planning correspondence by Pittsburgh District engineers acknowledged widespread demands for greater consistency in water levels, and showed a commitment to building a fixed dam with a navigation lock in this section of the river. One of their first tasks was to explore the suitability of the river bed to support a dam. Of the two sites under consideration in the vicinity, Montgomery Island was determined by borings tests as possessing the best base rock at a reasonable elevation.

Because the shipping industry had been accustomed to moving cargo unobstructed through the lowered navigable wicket dams, the prospect of having to lock their fleets through another fixed dam was not entirely welcomed. Companies also believed their vessels traveling up and downstream could become stalled if the river flooded and exceeded the height of lock walls. For this reason the Corp’s Cincinnati Division Engineer requested careful study of an appropriate lock wall height in order to minimize delays for barge traffic.

Figuring bedrock stability and determining lock size were far simpler tasks than choosing the best system for maintaining a reliable river depth. Although construction of the Montgomery Dam marked an abandonment of the wicket gate system, the decision to incorporate lift gate technology to control water was by no means immediate. Through the fall of 1930, file memoranda and correspondence between the Pittsburgh District and the Cincinnati Division revealed careful deliberation about an older method of controlling the pool, as the utility of a flashboard system placed atop a fixed crest dam consumed much of the debate.

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12 *Iron and Steel Review*, February 24, 1921.
13 W.H. McAlpine, Head Engineer, Louisville Engineer Office, Memorandum to Colonel Bain, Pittsburgh Engineer Office, September 15, 1930. This memo cites the Jones and Laughlin Steel Corporation as dissatisfied with the water level in the pool at Dam No. 4, acknowledging the company’s official desire of 684 feet. McAlpine also states the “off the record” position of shippers to accept a minimum height of 682 feet.
14 Correspondence to the Division Engineer, Cincinnati Ohio from the District Engineer, Pittsburgh, 25, 30 April 1928 discusses the lock height, and the integrity of the river foundation and required borings related to construction of a fixed dam at Montgomery Island, Ohio River.
15 Ibid.
16 Ibid.
Flashboard systems had been used up to that time in any number of public and private ventures where water control was necessary, and internal comments of the Pittsburgh District noted the merits of flashboard systems on hydroelectric dams of the period, specifically the McCall Ferry and Susquehanna River dams. But the link between flashboard functionality and turbine capacity was not relevant to the Ohio River situation. Engineers, did however, observe that flashboard were being used elsewhere in the district during low water times to provide added navigable depth, but were normally only one or two feet in height, and used only in the fall just before the ice season. With the exception of Allegheny Dam No. 1, which was a wicket type with bear trap weirs built in 1903, all of the Allegheny River dams had fixed crests of concrete, or a cribbing structure that could be fitted with flashboard when necessary. Annual reports by the Chief of Engineers noted that flashboard were placed on several dams on the Monongahela and Allegheny rivers during low water periods in order to elevate Pittsburgh Harbor and accommodate loaded coal boats.\textsuperscript{17}

Though flashboard were found to be effective when upstream depths were reduced, it was observed that “putting flashboard on the dams . . . is an uncertain and otherwise unsatisfactory expedient.\textsuperscript{18} Their temporary nature was also viewed unfavorably since panels were often lost. For example, in early June 1919, 20-inch flashboard placed atop Dam No. 2 on the Allegheny were almost immediately destroyed by a storm after the river swelled 18 feet.\textsuperscript{19}

At the same time flashboard were under consideration for a fixed crest dam to replace Lock and Dam Nos. 4, 5, and 6, moveable dams with wicket gates were still extolled as a more positive type of operation. Engineers cautioned that the placement of higher flashboard would complicate the coordination of pool levels and potentially limit navigation. Another drawback of a flashboard system was the likelihood that winter winds would buffet the panels and encourage ice buildup, a consequence that had already been proven on the wicket dams.

The pivot point at which the options of installing a new moveable dam or using flashboard on a fixed crest were overruled has not been precisely located in the planning record for Montgomery Dam. Managing an optimum pool to serve local industry was clearly a determining factor, but Corps engineers were slow to cast off the older moveable systems. Internal memos reveal that another wicket-type, a Boule weir was strongly considered, and although initially more costly than a fixed crest dam with flashboard, was believed to have greater stability and ease of operation.\textsuperscript{20} A Boule dam, however, offered only a small variation on the principle of the older wicket dams, and like all moveable dams, required the hazardous maneuvering of pilot boats to raise the panels.

Perhaps most influential in the decision to drop the flashboard option was the expressed need of the Jones and Laughlin Steel Corporation to have a constant pool elevation for conducting work at its

\textsuperscript{17} H.E. Anderson, Associate Engineer. Memorandum on the “Aspects of high flashboard in connection with fixed dam, Ohio River, below Dashields Dam.” October 4, 1930. United States Engineer Office, Pittsburgh, PA.


\textsuperscript{20} H.E. Anderson.
Aliquippa, Pennsylvania, plant. Proposals to use standard 3-foot flashboards on a fixed crest dam were not favored, as the boards could only raise the water level to 680.5 feet, about 1.5 feet below the height the company deemed necessary for loading barges. Four-foot panels would be preferable, but offered less stability. A Boule weir had greater potential than flashboards for achieving a pool height close to the industry’s unofficial minimum of 682 feet. But in his memo of October 4, 1930, Pittsburgh District associate engineer, H. E. Anderson, carefully weighed the strengths and weaknesses of both methods, concluding that both Boule and flashboard systems were too dangerous for this high gradient stretch of the Ohio River and far less practical than a permanent dam. In spite of earlier and vigorous advocacy within the Pittsburgh District for a flashboard system, Anderson’s final recommendation was a permanent crest dam with a pool elevation of 677-679 feet, a level below corporate expectations.

In the ten years since construction of Emsworth Dams in 1922, and two years after completion of Dashields Dam in 1929, the shipping industry had adapted to the practice of locking their barges through dams. Some dissatisfaction over varying water levels continued, however, and coal and steel interests were skeptical of a designated pool reaching only 679 feet if the older wicket dams were removed. At first, Corps planners cautioned against a pool elevation that exceeded the 679 foot mark, since higher water levels were thought to endanger private property at West Bridgewater near the mouth of Beaver Creek, and had the potential to flood a large number of cellars along the river. In a public hearing, other objections to a higher pool came from private land and agricultural businesses over the potential flooding of bottomland, and from mining interests such as the Welch Bright Company Mine, that feared higher water would back up into their mines.

By 1931, interest in protecting personal property was no longer mentioned in correspondence. The position of the Jones and Laughlin Steel Corporation – along with other businesses in this stretch of the river – triumphed once again in memoranda about the pool elevation, with an acknowledgement that the company’s coal terminals would be stranded by lowered water between Dashields Lock and Dam and a new structure at Montgomery Island. Corps planners acquiesced to their demands, recommending a fixed crest at 667 feet, to include gates that could achieve a total summit of 682 feet that would not demand retrofitting or alteration of industry ports, docks, and rail linkages.

Although careful study had eliminated one method of controlling a single pool in place of Lock and Dam Nos. 4, 5 and 6 – and a likely break away from the antiquated wicket gates – the choice of gate to operate atop a fixed crest dam was still unresolved. Deliberations over the right gate technology to fit a new dam at Montgomery Island involved another gate type that was thoroughly studied by Pittsburgh District engineers. In a report submitted to Corps headquarters in Washington D.C., the Pittsburgh District advocated a “lifting roller top” dam with roller drums 15 feet in diameter. In August of 1931 principal engineer W. Arras submitted four comparative studies of expected discharges from both a

21 J. W. Arras, Principal Engineer. Memorandum on the “Use of flashboards at Montgomery Dam.” October 11, 1930, United States Engineer Office, Pittsburgh, PA.
22 H.E. Anderson.
23 W.H. McAlpine, Head Engineer, Louisville Engineer Office, Memorandum to Colonel Bain, Pittsburgh Engineer Office, September 15, 1930.
25 W.H. McAlpine.
fixed crest dam of 677 feet, and a fixed crest structure with state-of-the-industry roller gates that could raise the pool to the desired 682 feet.

A roller gate system involved large metal cylinders set between piers that were raised via overhead chains to permit water spillage. A Swedish invention later patented by Germany, roller gates were first applied in America in 1914 by the Washington Water Power Company for three spillways crest gates at its dam on the Spokane River in Washington. The earliest examples were non-submersible types that could only be raised from the fixed crest, but eventually, submersible gates that extended upward from the river floor were developed. In 1916, the Bureau of Reclamation was the first federal agency to use the gates at its Grand Valley Diversion Dam in Colorado. Two decades would pass before a Corps dam was fitted with the rolling cylinders.

During this same period, just as rollers were contemplated for the Montgomery Dam in the fall of 1930, the Mississippi Valley Division of the Corps opted for the more expensive cylinder gates to create a system of navigable slack water pools along the upper Mississippi River. Completed in 1934, the massive Rock Island Lock and Dam was the Corps’ first project to be fitted with the innovative gates. Part of the Corps’ charge to maintain a 9-foot channel on the Mississippi, the Rock Island structure remains the largest of its type, and was joined a year later by the Gallipolis Dam (now Robert C. Byrd Locks and Dam) on the Ohio river milepost 279.2 and by three locks and dams on the tributary Kanawha River of West Virginia. Although roller gate systems were viewed as more reliable than the wicket gates they were replacing, they were costly and only a few were built in the United States before the industry shifted in favor of tainter gates around 1940 (Figure 5).

A detailed analysis prepared by the Pittsburgh District cited the corporate benefits of a maximum pool height. The interests of industry leaders such as Jones and Laughlin Steel again provided much of the rationale for the District’s proposal to use roller gates in a fixed crest Montgomery Dam. Roller gates could be quickly activated to raise or lower the pool, which made them well suited to the extreme flooding pattern of the Upper Ohio River, and thereby ensured greater reliability for the industry mandated 682 foot elevation. The gates had also proven reliable in severe cold and icy conditions, and could be manipulated by motors and chains, without the dangers of a manned trestle or service boat.

A 1933 plan for the Montgomery Dam shows both a roller gate and a direct lift gate depicted alongside upstream and downstream elevations of the dam. Next to the roller gate detail the hand written notation, “NOT USED” appears (Figure 6). Given the juxtaposition of the two gate types on this page, it appears a final decision to drop roller gates for lift gate technology was still undecided a year after construction began.

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26 National Register of Historic Places nomination form for The Grand Valley Diversion Dam.
27 By 1930, ten roller gate dams had been built in the United States by municipal governments and federal agencies. The Corps adapted both non-submersible and submersible roller gates on the Upper Mississippi River Project throughout the first half of the 1930s; and on West Virginia’s Kanawha River, built four high lift roller gate dams.
28 In a report on “Third Fixed Dam, Ohio River, Pittsburgh District,” (September 3, 1931) the Division Engineer enumerated the merits and shortcomings of various pool heights and gate types, concluding with a recommendation for the use of roller gates on the planned Montgomery Lock and Dam.
Figure 5. This perspective section of the Montgomery Dam depicts a type of roller gate, and an alternative pier design. The sketch’s date of January 1934 coincides with the last deliberations over the use of roller gates.  
(Source: U.S. Army Corps of Engineers, Pittsburgh District)

Figure 6. A 1933 drawing of the upstream and downstream elevations of the dam includes details for two spillway gates types. Although both a roller gate system and direct lift gate type are shown, the roller gate detail (left) bears a hand written note, “NOT USED.” (Source: Montgomery Island Dam General Plan, Page 6, U.S. Engineer Office, Pittsburgh, PA, September 18, 1933)
In the four years since planning for the Montgomery Lock and Dam began, almost all gate types then available had gained favor for at least a brief moment. Consideration had moved first from replacement with another moveable wicket or Boule gate weir, to the merits of flashboards on a fixed crest, and finally to the new technology of roller gates for stabilizing the pool. Direct lift gates never appeared in early discussions about the best means of passing water over a new dam, and did not become the final choice until planners pondered the feasibility of one last alternative, a novelty gate developed by in-house expertise of the Pittsburgh District, whose design adapted the principles of an American gate type that was gaining respect among Corps engineers (Figure 7).

The Tainter gate principles were refined by Wisconsin lumberman Theodore Parker, who later sold his design to American hydrology engineer, Jeremiah Burnham Tainter. Tainter, who modified mill pond dams in Wisconsin for his lumber employer, Knapp, Stout and Company, adapted Parker’s design and received a patent for it in 1886. In profile, Parker’s radial arm gate consisted of a partial “wedge” of a cylinder, buttressed by metal trusses that pivoted from trunnions to manipulate the flow of water. The convex face of the gate was oriented upstream, and by nature, helped to open and close the gates with minimum of power.

Figure 7. Profile sectional model of a modified Tainter gate by Pittsburgh District, Chief Mechanical Engineer, William Sidney. The gate at left is in the resting position on the river bottom; at right the gate is lifted from the skin plate’s top edge, and also from a trunnion pin that can be raised via a separate channel. The freeing of the trunnion in a moveable channel enabled the gate to be raised completely above the fixed crest. (Source: U.S. Army Corps of Engineers, Pittsburgh District, dated, November 15, 1933)
The Corps first used taintor gates in 1889 on small dam and flood control projects, but viewed the type as inadequate for larger dams with major impoundments. Chief mechanical engineer of the Pittsburgh District, William Sidney, began experimenting with his own version of the taintor gate, a type that incorporated a pivoting convex plate that not only rotated against the upstream flow, but was also lifted vertically from trunnions to fully open the gate above the crest. Uniting the taintor gate with a vertical lift concept resulted in the “Sidney gate,” a term recognized today in the Pittsburgh District for its first use in one gate in the back channel section of the Emsworth Locks and Dams (1938). The Emsworth Dams, originally two fixed crest sections split by Neville Island, were replaced in 1938 with a moveable crest to raise normal water levels and stabilize the pool.

By October of 1933, Sidney’s special gate had drawn attention from the Office of the Chief of Engineers in Washington D.C. A memo sent from Lieutenant Colonel Edgerton at the Corps’ head office to the Division Engineer of the Upper Mississippi Valley Division in St. Louis requested serious review and consideration of the “Sidney gate” as an alternative installation on the planned Montgomery Dam. Edgerton’s interest was prompted by Otis Novey, consulting engineer for the American Bridge Company, who championed the gate as “variable and practicable” and asked that the type be included in the dam’s specifications. Unfamiliar with the merits of the gate, Edgerton asked for further investigation into its reliability and operation. Promptly following the directive from headquarters, Principal Engineer for the Pittsburgh District, Charles Wellons, forwarded his recommendation to St. Louis. Wellons described the gate as,

“... generally following the design and operation of a taintor type, except that the bearings upon which the gate swings are mounted in slots in the piers and are so arranged that the entire movable structure, including the bearings, may be raised vertically after the lower edge of the face of the gate has been raised above the normal pool.” He further extols the type as offering, “greater clearance for floods than is permissible with the conventional type of taintor gate ... and presents decided advantages in respect to economy of construction and operation.”

St. Louis Division Engineer, George Spalding endorsed the gate on October 23, 1933, as having great merit and supported its experimental use on a dam with a low lift. Spalding commended Sidney for his innovative spirit and encouraged him to gain a patent of the device “to protect the interests of Mr. Sidney and those of the Government.” Further endorsements followed, with Pittsburgh District Engineer Major W. D. Styer requesting authorization for the experimental installation of one Sidney gate in the Montgomery Island Dam in November 1933. Placement was to be on the fixed weir section next

30 The Sidney Gate was also used in 3 of 5 gates on Monongahela River Dam No. 4 in 1967.
31 “Use of lifting taintor gates on Montgomery Dam.” Memorandum provided to the Division Engineer, Upper Mississippi Valley Division, St. Louis, MO. October 14, 1933.Lieutenant Colonel Glen Edgerton, Office of the Chief of Engineers, Washington.
32 Ibid.
33 In a memorandum dated October 23, 1933, Colonel George Spalding, St. Louis District Division Engineer endorses the use of a lifting taintor gate on Montgomery Dam, and requests that a patent be obtained for the Sidney gate design.
to the abutment. Days later, Division approval was soon obtained from St. Louis, with final authorization yet to come from the Chief of Engineers in Washington D.C.

On November 27th, momentum halted abruptly with word from Lieutenant Colonel Edgerton that approval would be withheld pending an investigation of a European patent for the same gate type. Up to this time, the Sidney gate was assumed to be unique and proprietary. However, correspondence with the British firm of Ransomes and Rapier Limited revealed the company had obtained a patent (No. 229,980) for a modified tainter system in March of 1925, though no gate had actually been installed and evaluated since (Figure 8). Ransomes and Rapier had fabricated their prototype “radial sluice gate” and planned to fit it to the spillway of a new dam on the River Lagan in Belfast, Ireland. Upon review, Sidney conceded that his concept gate had been “anticipated” by the British company, and though small aspects of his design differed, concluded there was too little distinction to pursue a patent.

![Figure 8. Comparison of two modified tainter gates. Left - The British engineering firm of Ransomes and Rapier patented its “Improved radial sluice gate” on March 15, 1925. (Source: Rapier and Ransomes Limited, 32 Victoria Street, Westminster, London SW1, Patent No. 229,980); Right - The skin plate of William Sidney’s gate was raised in nearly identical manner by means of both an outer cable lift, and trunnion pin that could move up and down in a vertical channel. (Source: The Headwaters District, p. 248)](image)

34 “Installation of a modified tainter type of lift gate as one spillway section of Montgomery Island Dam.” Memorandum provided to the Chief of Engineers, U.S. Army, Washington, D.C. November 14, 1933, W.D. Styer, Major, District Engineer, Pittsburg Engineering Office.
35 In a memo from Lieutenant Colonel Edgerton on November 27, 1933, the Chief of Engineers requested investigation into the status of a European patented gate type of nearly identical design; the Division in St. Louis is instructed to cease the application of the Sidney gate.
36 Correspondence from Ransomes and Rapier Limited, 32 Victoria Street, Westminster, London SW1 to Captain Hugh J. Casey, U.S. Embassy, Tiergartenstrasse 30, Berlin, Germany, March 6, 1934.
In spite of the patent revelation, Pittsburgh District and Division leadership remained committed to a test application of Sidney’s gate. But authorization from the Chief of Engineers to proceed was withheld until the British firm could provide a report on the success of its radial sluice gate installation on the Irish dam. Following this last exchange between the Pittsburgh District, Division, and Washington, D.C. in February 1934, the trail of correspondence ends, presumably because the Ransomes and Rapier report was not forthcoming and Corps planners needed to move ahead.\(^{37}\)

Although the plan to use the gate on the fixed crest Montgomery Dam was dropped, a 1/5 scale model of Sidney’s gate was tested at Allegheny Dam No. 3 in 1935. Engineers were pleased with its performance, which led to the installation in 1937 of one of the gates on the back channel dam at Emsworth, next to Neville Island.\(^{38}\) This single 100-foot span, modified tainter was the only use of the Sidney Gate on the Upper Ohio River. In 1967, the use of three Sidney Gates on Monongahela Dam No. 4 marked the end point of Pittsburgh District’s application of the gate in its system.\(^{39}\)

**Direct Vertical Lift Gates – The Final Choice**

As foundation work and other preparations were under way through the fall of 1933 and early winter 1934, internal memoranda reveal a winnowing process wherein almost every available gate technology was thoroughly probed and finally dismissed until lift gates remained the last and best prospect. During this period, the creative tainter hybrid of William Sidney was on the cusp of approval for testing on the Montgomery Island project, but was dropped when data about the performance of the British prototype could not be obtained. Corps leadership abandoned the innovative gate, but in the end, retained one half of its hybrid design, the lift gate. It seems the lifting aspect of Sidney’s gate had helped focus the gate solution for the Montgomery Dam to a vertical lift mechanism. This late adjustment was easily accommodated between the piers that had already been designed for the fixed crest elevation.

The principals of the lift gate had been used for hundreds of years for controlling water in various settings and operations, and relied upon the simplicity of vertically placed panels set into channels that were raised and lowered, first using hand mechanisms and later with motor driven devices. Each gate or bulkhead was framed with trusses or built up girders to support a skin plate that moved within vertical slots channeled in the piers. A number of variations on the lift gate developed, including a broom or caterpillar type that featured side wheels arranged in a continuous rotation that attached to the chain and hoisting apparatus.

One of the great benefits of a lift gate was the ability to pass with relative ease, large and hazardous chunks of ice that formed in river channels. Along the upper Ohio, extreme winter conditions produced masses of ice that broke apart and had to move through dams. When first proposed, roller gates gained

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\(^{37}\) Instruction to hold off on installing the Sidney gate at the Montgomery Dam appear in memos from Lieutenant Colonel R. G. Powell, Division Engineer, St. Louis, December 28, 1933; and from Lieutenant Colonel Edgerton, Chief of Engineers, Washington, D.C., February 3, 1934.


\(^{39}\) The experimental Sidney gate was removed in 2006, in conjunction with Emsworth Dams’ rehabilitation; prior to replacement was documented to standards of the Historic American Engineering Record in 2005.
favor partly for their durability in icing seasons, but lift gates offered a greater advantage in that pieces could be fed beneath the gate leaf in the safest and most efficient manner.

Patents and engineering manuals of the era (1930s) described “slide or sluice gates” or vertical lift gates as appropriate for low head discharges, generally up to 120 feet, with small fluctuations in water levels of ten feet or less (Figure 9). Gates were composed of either iron or steel cast in a single piece to endow the greatest strength. Formulas specified the desired thickness for a given width and corresponding stress, and consistency in thickness was emphasized in order to prevent uneven stress loads. Dam engineers cautioned that higher head dams would impose greater stresses on the gates and components. Given this cautionary note, the use of vertical lift gates at Montgomery’s relatively high head was somewhat ambitious.

Site preparation for construction of the Montgomery Locks and Dam at mile marker 31.7 on the Ohio River began in 1932, enabled by a double walled timber coffer dam. In the fall of 1933, reports called for two separate contracts: Part A encompassed the masonry work consisting of 163,000 cubic yards of concrete work, and Part B covered the gates and associated machinery and electrical features. The

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Figure 9. A number of patents and recommendations for sluice or slide gates were available by the time Montgomery Dam was constructed. Left – A small 4-6 foot slide gate designed by the U.S. Reclamation Bureau was shown in, Design of Dams by Frank W. Hanna and Robert C. Kennedy McGraw-Hill Book Company, Inc., New York and London: 1931. Right – Erwin B. Philips’ 1928 patent used a “caterpillar” of revolving wheels lifted from cables at either side of the gate.

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41 “Dam Contract Will be Split – Montgomery Job May be Awarded to Two Companies,” Pittsburgh Post-Gazette, November 14, 1933, p. 21.
lack of a decision about the spillway gate type may have accounted for the separate contracts, which were unusual for the time. By January of 1934, the two-part contract seemed to have collapsed into one, as the Booth and Flinn Company was awarded as low bidder for the project at $2,500,000.\textsuperscript{42}

Because historical data had shown the Ohio River at flood and non-flood stage to range as much as 80 feet near Cincinnati, Montgomery’s gates demanded at least a 5-foot clearance from the point of flooding to the bottom of the gates when fully raised. Such a fluctuation would press the Montgomery gates beyond the capacity of typical lift gates and require substantial framing and some adjustment.\textsuperscript{43} As a result, the trapezoidal shaped gates were used, each measuring 100 feet in width and 16 feet in height, and constructed of riveted steel trussing, with timber seals at the bottom and sides. To ease water and ice passage and reduce the compressive force, the trussed bulkheads were enclosed on all sides and tapered at each end, as were the sealed surfaces (Figures 10, 11).

\textbf{Figure 10.} Montgomery dam’s piers were fitted with direct vertical lift gates with fixed rollers raised between slots in the side piers. Trapezoidal in profile, gate surfaces were tapered to reduce the pressure of the flow, and trussing was completely enclosed to prevent icing. Architect Paul Cret’s minimalist Art Deco piers features battered profiles and stepped-in caps. (Source: Engineer Office, Pittsburgh, PA, September 18, 1933, Pittsburgh District Engineering Files; and The Headwaters District, p. 246)

\textsuperscript{42} Pittsburgh Post-Gazette, January 11, 1934, p. 19.

Figure 11. Left: Insertion of a vertical lift gate into one of the bays, April 1935. Right: Construction photograph showing downstream view of a lift gate from the concrete apron, April 1935. Note the tooth-like battens, designed to dissipate water turbulence. (Source: U.S. Army Corps of Engineers, Pittsburgh District)

They were maneuvered via slotted channels provided in the concrete piers, and powered from above by two electro-mechanical hoist motors with chain drives to lift the gates. Motors were specially synchronized to ensure that each side of the plate was raised at exactly the same pace. Originally exposed to the elements, the hoist mechanisms were enclosed in metal housings during a 1980s rehabilitation. When in the closed position, each of Montgomery’s lift gates could contain an impressive 15-foot-high column of water. Montgomery included both “modern” hoist machinery for lifting the gates, as well as a nineteenth-century style, trussed steel bridge with a track for a locomotive to lift and move the maintenance bulkheads (Figure 12).

Locks of reinforced concrete with miter gate openings were located on the south bank of the river, and consisted of a main chamber for commercial barges that measured 110 feet by 600 feet, and a smaller auxiliary chamber (56 feet x 360 feet) for passing personal watercraft and smaller vessels. Also part of the original design and construction was the powerhouse, and an operations building, both flat-roofed concrete buildings sited at the south end of the dam. When completed in June 1936, the overall length of the dam was 1,376.75 feet and consisted of the controlled weir of concrete piers and vertical lift gates, flanked at each bank by two 109-foot-wide fixed concrete weirs. Today, a contemporary service building on the south bank of the river is the one non-historic property at the site. Outwardly, the Montgomery complex shows few changes from its original design, aside from an extension of the lock guide walls 600 feet, upgrading of some machinery, and electrification of dam controls.

Just after the Montgomery gates were lifted in to place, design work began to install the same vertical lift gates at the new replacement dams at Emsworth. Altogether, the Emsworth Main Channel and Back Channel Dams contained 13 lift gates of similar dimensions, measuring 102 feet by 11 feet. These two
locations were the only application of direct vertical lift gates on the Ohio River system, as tainter gates soon became the preferred choice in the Pittsburgh District and throughout the Corps. Montgomery and Emsworth Dams were among the few Corps facilities that were fitted with vertical lift gates during this period; others were Bonneville Dam on the Columbia River (1938), Dam No. 17 on the Warrior River, and Savannah Bluff.

Since installation, Montgomery’s lift gates have performed as intended, but with years of exposure to various loading and environmental conditions and damage from objects such as trees and debris passing over the dam, have experienced metal breakdown and corrosion. As funding has allowed, repairs have been made to selective gates and riveted connections. Before 1980, the most critical repair needs had been in the two gates near the center of the dam that have been operated most often. In 1980, a major repair effort was undertaken on all gates, including upgrades to the hoists and hoist housings. During the following years, Corps engineers were aware of continued deterioration, but without adequate funding, and owing to the difficulty of inspecting the gates, could not begin a robust evaluation until 2006. The dire state of the gates’ condition was made dramatic when errant barges crashed into the dam, damaging Gates 4 and 8 beyond repair. At this time, Gates 5 and 6 were found to be the most compromised, and it was confirmed that all remaining gates were incapable of withstanding the stresses

Figure 12. View from downstream showing original lift gates, lift gate motors atop piers, and service locomotive, September 1945. (Source: U.S. Army Corps of Engineers, Pittsburgh District)

set up just by normal hydraulic loads. Gates 4 and 8 were replaced in 2008 with state-of-the-industry lift gates to meet contemporary Corps engineering standards and resist the stresses of well-formed horizontal ice. Other gates received repairs to some components and connections that were accessible, but not full scale replacement. As of this writing, the Corps has completed plans and drawings to further repair and fully replace all remaining gates when funding becomes available.\textsuperscript{45}

**Taintor Gates**

Deep into the planning phase for the Montgomery Island Dam there was lingering indecision over the appropriate gate type to use, with no clear path toward lift gates. At a fairly late hour, as site preparations were underway and contracts were let, engineers were still examining alternatives. Finally, in early winter of 1934 the dam’s spillway crest and piers were fitted with the first direct vertical lift gates used on the Upper Ohio River. But the use of vertical lift gates on the Montgomery and Emsworth projects seems to have had little impact on the Ohio River navigation system. Timing may have been against the age old principle, as ongoing refinement of the taintor gate coincided with many of the Corps’ large scale projects.

Jeremiah Taintor’s prototype gate had been in existence for over 50 years when Montgomery Locks and Dam was completed. The gate’s pie wedge shape and convex face had proven highly advantageous in balancing water pressure on the upstream side, and the rush of water made them relatively easy to maneuver. They were also less costly to install than the novelty roller gates that had gained favor for their ability to pass ice and other river debris. But icing problems had been associated with earlier taintor gates, and because gate leaves had generally been limited to spans of less than 35 feet their application to the Corps’ ambitious Mississippi and Ohio River projects was not immediate. The planned 9-Foot Channel Project of locks and dams on the Upper Mississippi River, for example, would require long 100-foot spans that well exceeded the taintor gate standard.

In the early 1930s, the Corps conducted rigorous experimentation with the basic taintor principles, producing several design variations for use on the Upper Mississippi. The first of the taintor gates were non-submersible types that could only be lifted upward above the pool; later in the decade, non-submersible taintor gates that fully extended to the channel floor were developed to ease the passage of ice chunks common to some regions of the country.

The taintor gate evolution was accompanied by another advancement: the introduction of electric motors to raise and lower dam gates eliminated the metal trestle bridge that had carried crane locomotives to service gates on earlier dams, including wicket types. The operation of taintor spillway gates could now be conducted from above by hoist motors placed on the piers. Montgomery Locks and Dam also utilized the newer hoist motors for lifting its spillway gates. Two machine were provided at each side of a gate, and made operable with guide wheels, lift chains and sprockets, and worm gearing,

\textsuperscript{45} The Corps provided an overview of the current status of all gates in, “Montgomery Dam Gate White Paper: Replacement of Montgomery Dam Vertical Lift Gates,” U.S. Army Corps of Engineers, Pittsburgh District.
as well as a brake on either end of the forward motor shaft. Montgomery Locks and Dam was transitional in this respect; progressive hoist technology for raising spillway gates was implemented alongside a traditional, heavily trussed trestle bridge for lifting bulkheads. The large federal dams of later years no longer featured a separate trussed bridge for a locomotive, instead fitting a motorized gantry crane directly on the concrete structure, above the powerhouse outlet or upstream intake.

The Corps’ improvements with taintor gates enabled greater spans, more efficient use of steel, and accommodations for the icing that was so common in the region, all of which affirmed the type as the most cost effective and best performing option. Research and experimentation with these gates dominated the engineering scene in the early to mid-1930s, and pushed all other gate types into obsolescence as their efficiency of operation made them the gate of choice for the remaining projects on the Upper Mississippi, and for other scheduled Corps dams of the period. Roller gates and direct vertical lift gates were casualties of the taintor gate revolution, fading from use not so much because of deficiency, but because another type proved superior in performance and reduced cost.

**Architectural Design**

The dams that replaced the old wicket structures on the Ohio River flexed engineering muscle to appease industry and create a more efficient navigation system of fewer dams and more reliable pools. Improved weirs and gate devices were not the only innovations that left a mark on these dams. In the few places where architects could animate concrete, utilitarian spaces and surfaces took on international aesthetic movements. In the 1930s, federal dams captured a piece of the Art Deco/Art Moderne design trend on a large scale, specifically in spillways, powerhouses, and intake towers. Landmark examples included Hoover Dam in Nevada, with its iconic intake towers that rise out of the reservoir like new age pavilions.

When Montgomery Dam was contemplated, some regional dams and appurtenances showed lingering influences of classical design, while others forged bold Art Deco statements. On a tributary of the Ohio River, the Muskingum River’s system of 14 flood control dams built in the 1930s featured intake towers with revivalist themes in the classical mode, while others sported contemporary geometry and robust Art Deco ribbing (**Figure 13**). Modernist design influences were felt throughout the country on flood control and multi-purpose dams such as the Tennessee Valley Authority (TVA) dams and Oregon’s Depression era icon, Bonneville Dam (1938).

Having already established careers in civic works, prominent architects were eager to lend their signature to many of these high profile projects. The TVA, for example, employed Hungarian born architect, Roland Wank, to apply his version of modernism to its Engineering Design Division. Wank rejected classicism in favor of stark modernity that spoke of democratic ideals, believing that buildings

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46 Ohio River Main Stem - Chapter 1, p. 103.
47 Gateways to Commerce: The U.S. Army Corps of Engineers’ 9-Foot Channel Project on the Upper Mississippi River, CHAPTER VII From Rollers to Taintors: The Changing Technology of the 9-Foot Channel Project.
and structures, and even spillways bays should not look back to history or connect with local idioms, but reflect national ideals that fit into any landscape.\footnote{48} His position challenged old thinking Corps engineers, who slowly warmed to Wank’s modern industrial designs. His rendering of the Chickamauga Lock and Dam, and reworking of the design for Norris Dam became progressive symbols of the TVA’s mission to bring electrification and flood control to underserved rural populations. In spite of outward simplicity, the Montgomery Locks and Dam also bears the imprint of an esteemed American architect of the early twentieth century who also became a revered practitioner of industrial design.

**Paul Philippe Cret, Architect**

Born in Lyon France in 1876, Paul Philippe Cret was a product of classical European training in the mode of L’Ecole des Beaux Arts. He brought his Ecole training to Philadelphia in 1903 as part of an American recruitment of Beaux Art educated designers and art critics, and was appointed Professor of Design at the University of Pennsylvania that same year. In the 1920s, as Modern ideas filtered in to the design community, Cret melded the academic precepts of classical architecture with clean lines and uncluttered surfaces. His designs retained the formality and symmetry common to buildings of the past, but swept away ornament, achieving a signature Modernism that drew interest from unexpected admirers such as Soviet Russia and Nazi architect, Albert Speer. He became a U.S. citizen in 1927 and was appointed to the School of Architecture at the University of Pennsylvania. He opened a highly

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influential private practice, receiving numerous commissions for civic buildings, monuments, and bridges, and was frequently hailed as the American leader of Beaux Arts architecture.\textsuperscript{49}

The bulk of Cret’s work was non-residential and best suited to large scale monumental statements. His design for components of the Delaware River Bridge in the early 1920s was his first collaboration with engineers, a relationship he repeated in future project work on bridge spans in the region, including the iconic Benjamin Franklin Suspension Bridge in Philadelphia. Throughout his career Cret remained faithful to classical principles, even as the growing taste for Modernism converted scrolled capitols, drapery, and medallions into simple abstract features.\textsuperscript{50} Having established a reputation for civic works, Cret gained the confidence of Corps engineers who sought an artistic hand to refine their purely functional works. In the 1930s he was assigned as architectural advisor for the Corps’ dams and associated buildings such as lock keeper residences. Cret lent his mastery to several Corps projects, including the Tygart River Dam in West Virginia (\textit{Figure 14}), and Bonneville Dam on the Columbia River (1938). His conceptual presentation for the Bluestone Dam on West Virginia’s Kanawha River influenced the eventual design for the sweeping spillway face and dam crest treatments. Architectural flourishes on all of these projects are minimal, detected only in stepped-in spillway caps and railings, incised lines, and streamlined operations buildings.

Cret’s contribution to the Montgomery and Emsworth Dams is also subtle. Because these structures had few places where architectural details could root, the piers often became the focus of expression (\textit{Figure 15, 16}). At both projects, spillway piers are rounded and battered on both the upstream and downstream faces, terminating on the downstream side in stepped-in half cones “capitals.” At Montgomery, the powerhouse and operations buildings are similarly sleek and unornamented, retaining classical formality and symmetry with spare Art Deco styling referred only in plain wide cornice bands and deeply recessed window and door openings. Unlike his contemporary Roland Wank, Cret merged both classical and modern ideas in a way that was highly palatable to those who favored a pastiche of history and modernity.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure14.png}
\caption{Many of Paul Cret’s industrial designs were rendered with sleek geometry and spare ornament in the Art Deco tradition. Sweeping lines lend subtle drama to his sketch for the downstream face of the Corps’ Tygart Dam on the Ohio River in West Virginia. (Source: Cret Collection, Athenaeum of Philadelphia, Local ID No. CRE332D-SK6, 1-10-1940)}
\end{figure}


\textsuperscript{50} Ibid.
Figure 15. Architect Paul Cret’s upstream elevation drawing for the Emsworth Locks and Dams, showing proposed pier details. Rounded piers are stepped inward at the top, creating streamlined “capitals” of modest Art Deco styling typical of Cret’s Depression era civil works designs. (Source: Cret Collection, Athenaeum of Philadelphia, Local ID No. CRE303-SK5A, 4-3-1936)

Figure 16. Sketch of the Emsworth Locks and Dams, Main Channel by Paul Cret. Nearly identical to his Montgomery design, the fixed crest with eight vertical lift gates were set into rounded battered piers, and featured a trussed service bridge for lifting and servicing bulkheads. (Source: Cret Collection, Athenaeum of Philadelphia, Local ID No. 27-P5-303-001, no date)
Conclusion

The use of direct vertical lift gates at Montgomery Island marks a technological shift between the antiquated wickets of European origin and the American-born tainter gates that would dominate future spillway design by the Corps and other federal agencies. Reasons for the eventual but short-lived application of lift gates on only two Ohio River dams – Montgomery Locks and Dam and Emsworth Locks and Dams – can be tied to several factors, including the hydrographic realities of the locale, pressure by leaders of industry with specific navigation needs, and ongoing advances in gate design. Montgomery’s lift gates were perhaps an expedient solution to a well-debated moveable crest problem, but had little influence on Corps lock and dam projects that followed. Throughout the country, tainter gates quickly assumed the lead for both practical reasons and cost considerations, and made most of the older principles of spillway control obsolete.

Planning for Montgomery Locks and Dams was not confined to the functionality of gates. The engagement of Paul Cret for the Montgomery and Emsworth projects signifies the Corps’ Depression era commitment to elevate civil works with contemporary style and refinement, and to keep pace with other federal project of higher profile. His modest detailing of the Montgomery and Emsworth piers may not be detectable to a wide audience, but lends visual interest to an otherwise repetitive line of concrete monoliths. So far, they remain the durable framework for the retrofits that often take place in the spaces in between, where spillway gates and mechanical operations are most prone to the forces of water and the changing standards of industry.

Figure 17. Downstream views of the Montgomery Dam (left) and one of Emsworth Dam’s Main Channel spillways, showing rounded piers with cone-like “capitals.” Both reflect Paul Cret’s use of subtle details in monumental concrete. Montgomery’s piers were altered with an additional step cut into the pier, just below the motor housing. Other modifications and repairs have been made to hoist motors, service bridges, and to the gates themselves. (Source: Left, Author’s photo; Right, U.S. Army Corps of Engineers, Pittsburgh District)
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