MANAGEMENT SUMMARY

This report provides a historic context for Army ammunition and explosives storage structures, usually referred to as magazines, in the continental United States. Although there are over 20,000 magazines within the Army real property inventory that were built between 1775 and 1945, these structures have been largely overlooked by cultural resource managers. This study conducted by the U.S. Army Corps of Engineers (USACE), Fort Worth District, and Geo-Marine, Inc., for the Army Environmental Center was designed to create a historic context in which both aboveground and underground magazines (igloos) could be evaluated. Recommendations concerning potentially significant examples of Army ammunition bunkers, including representation of each identified design type, were made.

The original archival and field investigations were conducted by the USACE, Fort Worth District. The archival research conducted at the Library of the Ordnance Museum, the National Archives, the Corps of Engineers Office of History, the Center for Military History, and the John Byrd Technical Library of the Defense Army Ammunition Center, documented that literature related to magazine design and technology is extremely rare. An oral history supplied by Dr. Chester E. Canada of the Department of Defense Explosives Safety Board provided the most useful information. Field investigations involved visits to Savanna Army Depot, Hawthorne Army Ammunition Plant, Picatinny Arsenal, and Frankford Arsenal.

The development of the context and analysis of the real property inventory revealed that ammunition magazines consist of a few basic types that are redundant in both design character and general layout when used in multiples (e.g., at depots). Aboveground magazines, designed for particular classes of ammunition are similar in design throughout the twentieth century. Earth-covered magazines, or igloos, were developed after the 1926 Lake Denmark disaster and became the standard for the storage of high explosives. Design changes were limited and many occurred in response to materiel shortages during World War II or in response to the storage needs of new weapons (chemical, biological, and nuclear). With only a few basic types and an abundance of examples, the preservation of every magazine or depot would be an unwise use of the limited funds available for cultural resource management. It is recommended that those installations with the most comprehensive array of the various magazine designs may be eligible for the National Register under this context. It is recommended that the following installations provide the most comprehensive array of both aboveground and underground magazines with a high degree of integrity: Hawthorne Army Ammunition Plant (A.A.P.), Nevada; McAlester A.A.P., Oklahoma; Pine Bluff Arsenal, Arkansas; Ravenna A.A.P., Ohio; Blue Grass Army Depot, Kentucky; Louisiana A.A.P., Louisiana; Aberdeen Proving Ground, Maryland; Camp Stanley, Texas; and Cornhusker A.A.P., Nebraska. Potentially eligible aboveground or underground magazines, with the exception of isolated structures, exist in groups that may constitute districts, which encompass a number of similar structures within their original setting. The exact number of structures may be arbitrarily defined; however, the number should be sufficient to

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reflect the layout and infrastructure related to the function of the complex and the associated safety concerns. The highly redundant nature of these resources, however, and their evaluation within a national context precludes the preservation of all aboveground and underground storage facilities. Those installations not listed above, but which contain ammunition storage facilities (Appendix A) are considered to have lesser examples of ammunition storage facilities, and may be considered not eligible under this context. However, such property types, in rare instances may have had such an exceptional impact on a State or locality that they could be eligible for the National Register under other State or local themes.

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INTRODUCTION TO THE NATIONAL HISTORIC CONTEXT FOR ARMY AMMUNITION AND EXPLOSIVES STORAGE IN THE UNITED STATES, 1775–1945

Ammunition and explosives storage structures, usually called magazines, are present to some degree at most former and present United States Army installations (Table 1). Ammunition and explosives storage is an area of historical study that has been overlooked in the study of military cultural resources. In general, storage buildings at military installations are a ubiquitous necessity with a mundane function, usually translated into a utilitarian form that lacks excitement to the casual observer. Storage does not usually attract the interest of historic preservation societies or the attention of cultural resources managers. In particular, ammunition storage is especially overlooked, separated by the explosive nature of its contents from the daily activity of military life.

Numerically, ammunition and explosives structures constitute the largest single property type in the current Army real property inventory. Of the estimated 169,000 resources in the Army inventory, over 20,000 are magazines in current use. While there are a number of historic magazines scattered throughout the country at Army forts, the preponderance of magazines date from the World War II-era. As part of the large-scale mobilization efforts for World War II, the Army authorized the construction of 16 new ammunition storage depots and over 10,000 ammunition and explosives storage magazines.

Until the mid-1920s, the Army did not have a standardized approach to the storage of ammunition and explosives. Generally, aboveground warehouse-type structures were constructed to house the volatile materiel. Typically, the magazines were built of stone or brick, which provided a less incendiary environment than timber buildings. For the most part, these magazines were successful in providing isolated, dry, ventilated, and secure storage for ammunition and explosives. However, they did have their limitations, particularly for the mass storage of ammunition and explosives that became common in the twentieth century. Following the disastrous, chain reaction explosion at Lake Denmark, New Jersey, in 1926, it became apparent that the storage of ammunition and explosives required study. In response to the Lake Denmark explosion, a new type of magazine was developed which ameliorated the shortcomings of previous magazines. The new earth-covered, concrete magazines, popularly known as igloos, directed the force of the explosion upward rather than outward, decreasing the chances of sympathetic explosions. Igloo-type magazines continued to be used and built through the 1980s. At that time, a revised design that required less construction material and less land area was designed. This new magazine was designed primarily for use in Europe where land constraints posed a special problem (Howdyshell 1981:5). The majority of magazines currently in use in the United States are igloos or a derived igloo-type magazine.

Although ammunition and explosives structures pale in comparison to other buildings on Army installations that serve more high-profile functions, they are resources that require specialized construction techniques and certain considerations in siting. As a distinct entity, they also have certain terms that apply to them in particular ways. Commonly, ammunition and explosives storage structures are called magazines. The original, late sixteenth-century sense of the word “magazine” meant store. By the mid-eighteenth century, the use of the word began to refer to a “chamber for holding a supply of cartridges in a firearm.” In more modern times, “magazine” has come to mean a “military store for arms, ammunition and explosives.” In the late 1920s, a new type of earth-covered, barrel-arched, concrete magazine was developed that generally became known as an “igloo” due to its similarity in form to the dome-shaped, Eskimo buildings of the same name (Abate 1998:359).

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Table 1
Locations of Military Installations (1775–1945) Referenced in This Document

Military Installation	Military Installation
Aberdeen Proving Ground, MD	Nansemond Ordnance Depot, VA
Allegheny Arsenal, PA	Navajo Army Depot Activity, AZ
Amatol Arsenal, NJ	Neville Island Supply Depot, PA
Anniston Ordnance Depot, AL	Newport Army Depot Activity, IN
Augusta Arsenal, GA	Ogden Depot, UT
Badger Army Ammunition Plant, WI	Old Hickory Powder Plant, TN
Benicia Arsenal, CA	Perriman Ordnance Depot, VA
Camp Stanley, TX	Pig Point General Ordnance Depot, VA
Carlisle Barracks, PA	Picatinny Arsenal (Dover Powder Depot/Lake Denmark Naval Ammunition Depot), NJ
Charleston Army Depot, SC	Pine Bluff Arsenal, AR
Chicago Storage Depot, IL	Portage Ordnance Depot, OH
Columbia Arsenal, TN	Pueblo Ordnance Depot, CO
Columbus Arsenal, OH	Radford Army Ammunition Plant, VA
Coosa River Storage Annex, AL	Raritan Arsenal, NJ
Cornhusker Army Ammunition Plant, NE	Red River Ordnance Depot, TX
Crane Army Ammunition Activity, IN	Redstone Arsenal, CO
Curtis Bay Ordnance Depot, MD	Rock Island Arsenal, IL
Delaware Arsenal, NJ	San Jacinto Ordnance Depot, TX
Dover Powder Depot (U.S. Powder Depot/Picatinny Arsenal), NJ	Sandy Hook Proving Ground, NJ
Erie Howitzer Plant, OH	Savanna Army Depot/Proving Ground, IL
Erie Proving Ground, OH	Seneca Ordnance Depot, NY
Fort D. A. Russell, WY	Seven Pines General Ordnance Depot, VA
Fort Herkemer, NY	Sierra Ordnance Depot, CA
Fort Monroe, VA	Sioux Ordnance Depot, NE
Fort Sam Houston, TX	Sparta General Ordnance Depot, WI
Fort Towson, OK	Springfield Armory, MA
Fort Wingate Ordnance Depot, NM	Susquehanna General Ordnance Depot, MD
Frankford Arsenal, PA	Tooele Army Depot, UT
Hawthorne Naval Depot/Army Ammunition Plant, NV	Tullytown Arsenal, PA
Holston Army Ammunition Plant, TN	Umatilla Ordnance Depot, OR
Indiana Arsenal, IN	Volunteer Army Ammunition Plant, TN
Lake Denmark Naval Ammunition Depot (Picatinny Arsenal), NJ	Watertown Arsenal, MA
Letterkenny Ordnance Depot, PA	Watervliet Arsenal, NY
Longhorn Army Ammunition Plant, TX	West Point, NY
McAlester Naval Ammunition Depot/Army Ammunition Plant, OK	Wingate Ordnance Depot, NM
Middletown Ordnance Depot, PA	Woodberry General Ordnance Depot, [NJ?]
Morgan General Ordnance Depot, NJ	Yorktown Naval Depot, VA
Milan Ordnance Depot, TN	
Mississippi Army Ammunition Plant, MS	

Although ammunition and explosives storage structures are present to some degree at most former and present Army forts, they are located in quantities at Army ordnance depots. According to a 1934 text on Arsenal Organization and Administration, an ordnance depot was a facility for the storage and issuance of ordnance supply. An arsenal, in contrast, was a government-owned and -operated installation for the acquisition, fabrication, and repair of arms and "munitions of war." Arsenals were further broken into two categories: the "manufacturing arsenal" where the primary function was the production of ordnance materiel, and the "field service arsenal" which operated to repair and maintain ordnance materiel. During the nineteenth century, the government maintained numerous arsenals, as well as several armories. Federal armories were used primarily for the manufacture and repair of small arms. Over the course of the nineteenth century, armories developed into storehouses and meeting places for local militia groups. As such, the use of the term for federal facilities became less common over the course of the century (Ordnance School 1934).

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Figure 1. Back view of Hessian Magazine built in 1777, located at Carlisle Barracks (Courtesy of U.S. Army Military History Institute, Carlisle, PA.).

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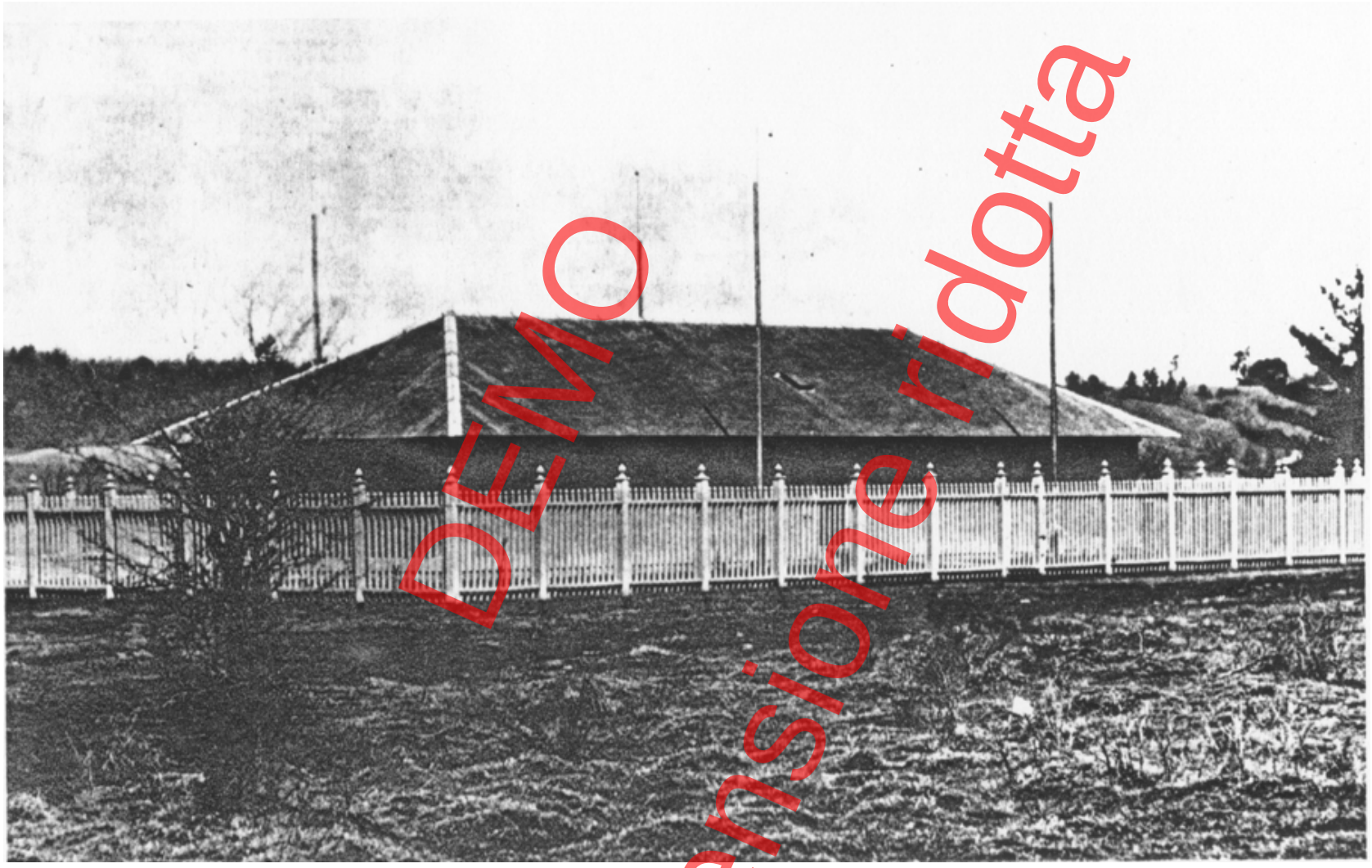

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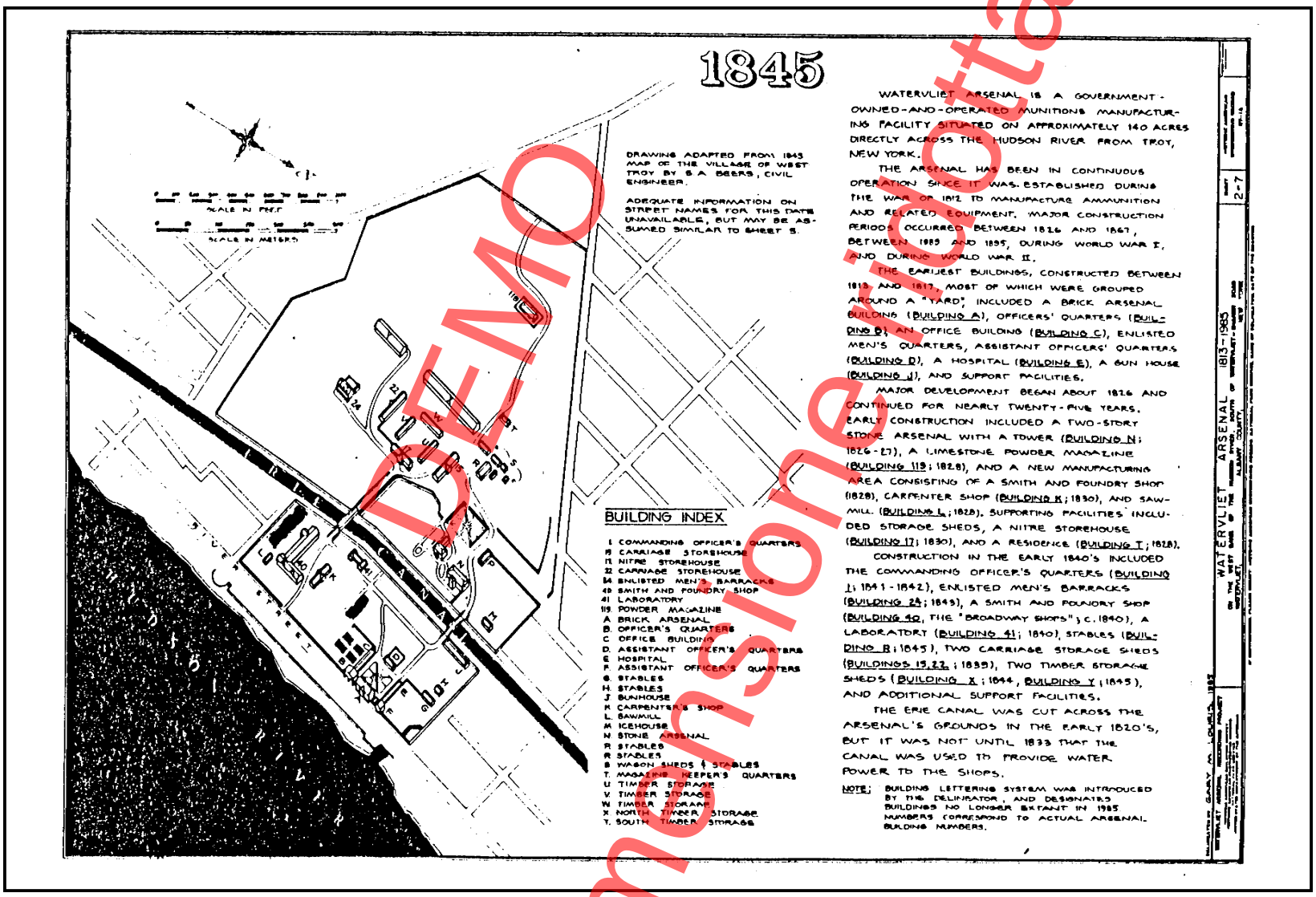
Figure 3. West Magazine at Watervliet Arsenal in New York, constructed in 1849. This is probably the oldest powder magazine in continuous use in the Army. Walls are of limestone and are four feet thick. The fence was a safety measure, and the vertical rods were lightning arrestors. Both features are no longer extant.



WATERVLIET ARSENAL IS A GOVERNMENT-OWNED-AND-OPERATED MUNITIONS MANUFACTURING FACILITY SITUATED ON APPROXIMATELY 140 ACRES DIRECTLY ACROSS THE HUDSON RIVER FROM TROY, NEW YORK.

THE ARSENAL HAS BEEN IN CONTINUOUS OPERATION SINCE IT WAS ESTABLISHED DURING THE WAR OF 1812 TO MANUFACTURE AMMUNITION AND RELATED EQUIPMENT. MAJOR CONSTRUCTION PERIODS OCCURRED BETWEEN 1816 AND 1867, BETWEEN 1889 AND 1895, DURING WORLD WAR I, AND DURING WORLD WAR II.

THE EARLIEST BUILDINGS, CONSTRUCTED BETWEEN 1813 AND 1817, MOST OF WHICH WERE GROUPED AROUND A "YARD", INCLUDED A BRICK ARSENAL BUILDING (BUILDING A), OFFICERS' QUARTERS (BUILDING B), AN OFFICE BUILDING (BUILDING C), ENLISTED MEN'S QUARTERS, ASSISTANT OFFICERS' QUARTERS (BUILDING D), A HOSPITAL (BUILDING E), A GUN HOUSE (BUILDING J), AND SUPPORT FACILITIES.

MAJOR DEVELOPMENT BEGAN ABOUT 1816 AND CONTINUED FOR NEARLY TWENTY-FIVE YEARS. EARLY CONSTRUCTION INCLUDED A TWO-STORY STONE ARSENAL WITH A TOWER (BUILDING N; 1826-27), A LIMESTONE POWDER MAGAZINE (BUILDING 119; 1828), AND A NEW MANUFACTURING AREA CONSISTING OF A SMITH AND FOUNDRY SHOP (1828), CARPENTER SHOP (BUILDING K; 1830), AND SAWMILL (BUILDING L; 1828). SUPPORTING FACILITIES INCLUDED STORAGE SHEDS, A NITRE STOREHOUSE (BUILDING 17; 1830), AND A RESIDENCE (BUILDING T; 1828).

CONSTRUCTION IN THE EARLY 1840'S INCLUDED THE COMMANDING OFFICER'S QUARTERS (BUILDING 1; 1841-1842), ENLISTED MEN'S BARRACKS (BUILDING 24; 1843), A SMITH AND FOUNDRY SHOP (BUILDING 40, THE "BROADWAY SHOPS"; c.1840), A LABORATORY (BUILDING 41; 1840), STABLES (BUILDING R; 1845), TWO CARRIAGE STORAGE SHEDS (BUILDINGS 13, 22; 1839), TWO TIMBER STORAGE SHEDS (BUILDING X; 1844, BUILDING Y; 1845), AND ADDITIONAL SUPPORT FACILITIES.

THE ERIE CANAL WAS CUT ACROSS THE ARSENAL'S GROUNDS IN THE EARLY 1820'S, BUT IT WAS NOT UNTIL 1833 THAT THE CANAL WAS USED TO PROVIDE WATER POWER TO THE SHOPS.

NOTE: BUILDING LETTERING SYSTEM WAS INTRODUCED BY THIS DELINEATOR, AND DESIGNATES BUILDINGS NO LONGER EXTANT IN 1985. NUMBERS CORRESPOND TO ACTUAL ARSENAL BUILDING NUMBERS.

Figure 4. 1845 Map of Watervliet Arsenal. The West Powder Magazine, Building 119, is separated from the other buildings at Watervliet.

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Although the government closed some arsenals following the Civil War, it continued to expand the facilities at others through the end of the century. In 1879, a 2,400-square-foot powder magazine was constructed at the Rock Island Arsenal. The structure had a clear height of 12 feet 6 inches. The magazine was constructed of wood frame walls with a brick veneer. It had a stone foundation set on bearing rock. The magazine had a wood floor and a wood roof deck covered with slate shingles (Figures 5 and 6).

In 1898, the Army undertook its first overseas troop movement in support of the Spanish-American War. New arsenals were established to support this venture, both stateside and overseas. By the turn of the century, the Army had 13 installations that manufactured and supplied ordnance. In addition to the Springfield Armory in Massachusetts; the Frankford, Rock Island, Watertown, and Watervliet arsenals were all engaged in the manufacture of ordnance and provided supply and maintenance support. Field service arsenals were located at Allegheny, Augusta, Benicia, Columbia, Fort Monroe, Indianapolis, New York, and San Antonio.

TWENTIETH CENTURY—WORLD WAR AND STANDARDIZATION: DEVELOPMENTS OF AMMUNITION AND EXPLOSIVES STORAGE

American Table of Distances

Among the twentieth-century developments in the storage of ammunition and explosives was the development of distance tables. In June 1909, Colonel B. W. Dunn, Chief Inspector of the Bureau of Explosives, brought to the attention of explosives manufacturers the need for changes in the locations of magazines as related to certain other resources. The resulting conference then appointed a special committee formed by the Association of Manufacturers of Powder and High Explosives to investigate the matter. The work of the committee resulted in the establishment of the American Table of Distances for Inhabited Buildings and Public Railways in December 1910. Subsequently, further study was undertaken concerning the distance needed between structures containing explosives and public highways. Thus, in 1914, the American Table of Distances for Inhabited Buildings, Public Railways and Public Highways was issued (Appendix B) (Assheton and Coy 1919).

In establishing the American Table of Distances for Inhabited Buildings and Public Railways, the committee determined that distance requirements utilized in foreign countries did not meet the needs of the United States or even provide a basis upon which to formulate the American distances. As such, the committee undertook an intensive worldwide study of explosions and their effects. The committee compiled statistics concerning explosions ranging in size from very small amounts of explosives to nearly a million pounds. Additionally, it looked at the manufacture, storage, and transportation of explosives domestically and abroad over a period of nearly 50 years. All recommended distances were for barricaded magazines. The barricades could be natural or artificial but needed to screen the magazine from other buildings, railways, and highways. The committee recommended that distances between non-barricaded magazines and buildings, railways, and highways be doubled (Assheton and Coy 1919).

The most important feature in establishing the distances between magazines and inhabited buildings was the distance at which “substantial structural damage” occurred on buildings in the vicinity. Substantial structural damage was based on two basic requirements: first, that the resulting damage to the property could not be readily repaired, and second, that risk to life and limb was caused by damage to an integral portion of the building. Minor damage, such as the breaking of window glass or falling plaster, was not considered in establishing the distance table. Possible damage due to flying missiles was also not factored into the table. In determining the recommended distances, the structural strength of the building before the explosion was not evaluated. The recommended distances between barricaded magazines and inhabited buildings ranged from 15 feet for magazines storing 1,000 to 5,000 blasting caps to 2,705 feet for structures storing 475,000 to 500,000 pounds of other explosives (Assheton and Coy 1919).

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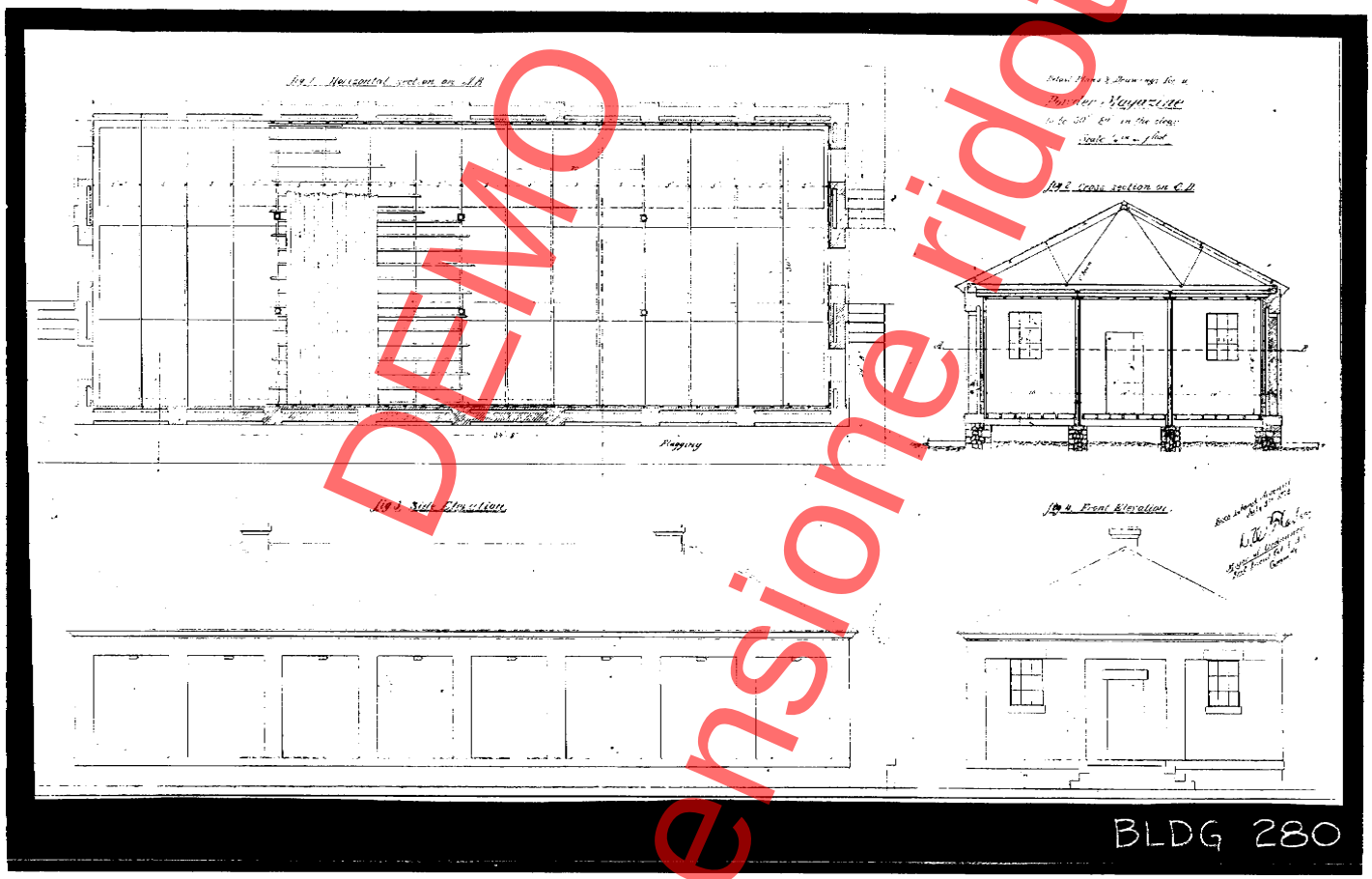

Figure 5. Detail plans and drawing for Powder Magazine (Building 280) at Rock Island Ordnance Center.

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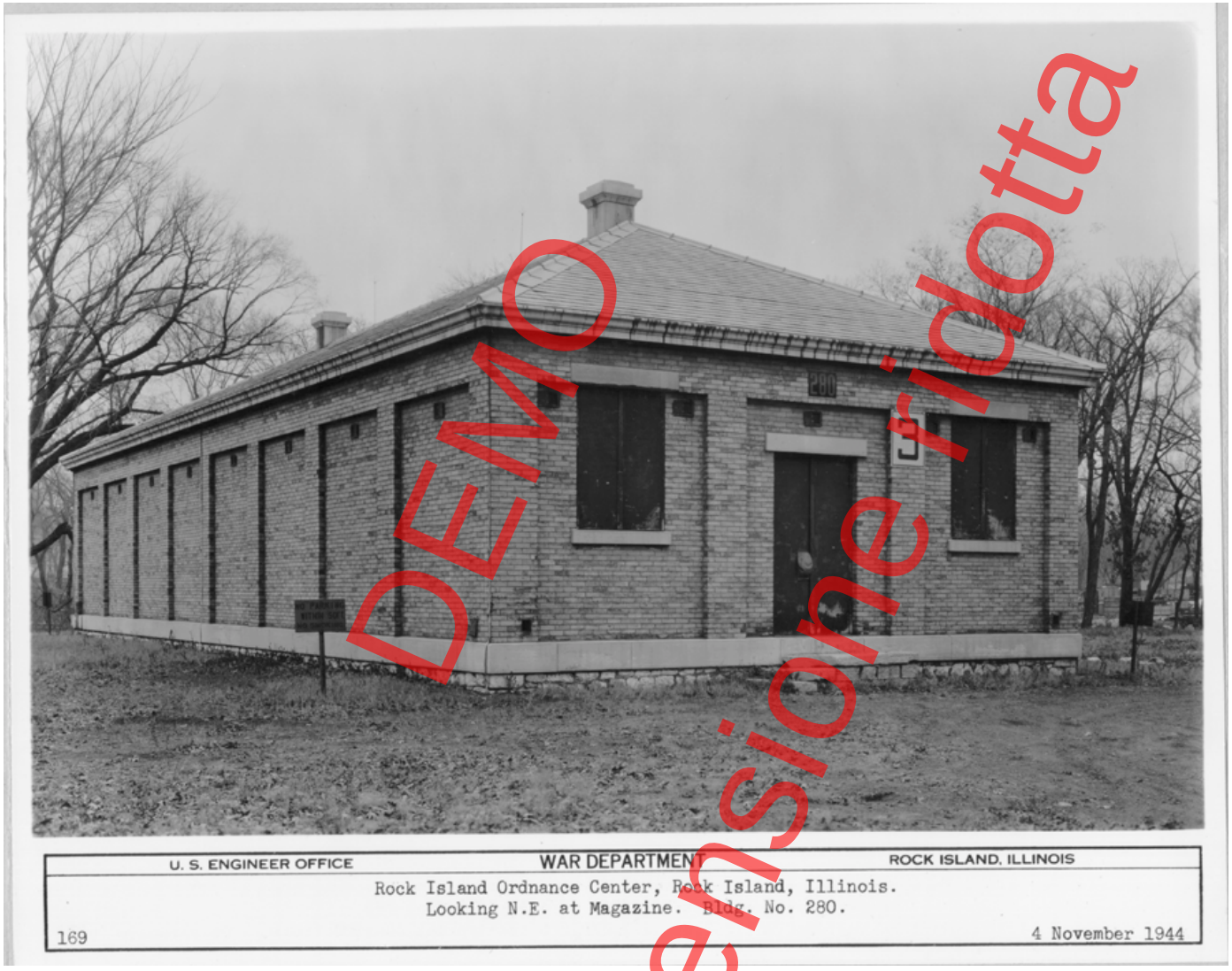

Figure 6. Powder Magazine (Building 280) at Rock Island Ordnance Center.

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The committee encountered difficulty in establishing distance tables between barricaded magazines and public railways due to a lack of data concerning explosions involving passenger trains. As such, they concluded that distances between magazines and railroads should be established by using 60 percent of the distance between magazines and inhabited buildings. This conclusion was based on comparing the relative smaller size of railroad cars that would be exposed to concussion and the greater strength of the railroad cars to resist the concussion. Additionally, the committee believed that trains, which were only temporarily in the presence of magazines due to their transient nature, required less distance than buildings, which were constantly at risk because of their stationary nature. As such, the distance table called for distances between magazines and barricaded public railways of only 10 feet for those structures storing 1,000 to 5,000 blasting caps, but ranged to 1,620 feet for magazines storing 475,000 to 500,000 pounds of other explosives (Assheton and Coy 1919).

To reduce the risk of danger to persons traveling along public highways, the committee studied over 100 explosions, involving nearly 350 people. Of the total number of explosions studied, nearly 60 explosions contained accounts of about 150 people who were exposed to the direct effects of the explosions by being in the open. In determining the distance table for public highways, the committee used the resistance of the human body to an explosive wave. The committee looked at the amount of explosives involved in the various explosions, the distance at which the persons in the open were located at the time of explosion, and the effect on the person(s), which ranged from being killed to being merely "stunned." The results of the study determined that barricaded magazines containing 1,000 to 5,000 blasting caps should be located at least 5 feet from a public highway. The distance widened to a maximum of 810 feet for magazines containing 475,000 to 500,000 pounds of other explosives (Assheton and Coy 1919).

The Great War

The distance tables were developed by and for private explosives manufacturers. At the time, the federal government and the Army were not as concerned due to the lack of military need. Following the end of the Spanish-American War in 1900, the Army was engaged in peacetime activities until the 1916 Mexican Expedition. However, this was quickly followed by the declaration of war with Germany on 6 April 1917. Because of the relative inactivity of the previous nearly two decades, the Army was not prepared in terms of ordnance or other supplies to outfit the needed troops. The lack of physical plants and the introduction of new warfare methods and technology prevented the rapid manufacture of scarce war materiel. Compounding the problem was the lack of a widespread industrial base in the United States from which the tools of war could be obtained. Although certain private American firms had been providing the Allies with munitions since the beginning of the war in 1914, there was little excess capacity to supply American troops in 1917. As such, to supply the United States troops, agreements were made with Allied nations to provide certain equipment and supplies until American shops could be brought into production. Due to the use of French-made metric weapons early in the American involvement in World War I, artillery and ammunition had to be interchangeable between American and French equipment.

At the beginning of America's involvement in the Great War, the Ordnance Department had 11 arsenals in operation. These consisted of arsenals at Augusta, Georgia; Benicia, California; Frankford, Pennsylvania; New York, Picatinny and Raritan, New Jersey; Rock Island, Illinois; San Antonio, Texas; Springfield, Massachusetts; Watertown, Massachusetts, and Watervliet, New York. The Army also conducted proving ground activities at Sandy Hook, New Jersey. It quickly became apparent that these facilities were not able to handle the demands of a full-scale, modern war. Because the proving ground at Sandy Hook was located away from the coast and did not have direct rail connections, the Ordnance Department purchased 35,000 acres near Aberdeen, Maryland, for a new proving ground. The first test shot was fired on 2 January 1918 at the Aberdeen Proving Ground. Initially, the Aberdeen Proving Ground mission was acceptance testing of field artillery, trench mortars, antiaircraft guns, ammunition, and

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railway artillery. Due to the great demand, two additional proving grounds were quickly established at Erie, Ohio, and Savanna, Illinois.

During the war, the Ordnance Department also greatly expanded the nation's arms, ammunition and explosives manufacturing capabilities. The government had responsibility for the construction of many new facilities, but it also relied on private firms to meet the demand. By the end of the war, America had become so proficient in the production of smokeless powder and high explosives that the munitions debts to other Allied countries were paid using these materials. In 1918, there were 92 plants engaged in the manufacture of powder and high explosives in the United States. The government constructed sixteen of the 92 plants. Additionally, there were 93 loading plants in operation. New Army depots were established at Aberdeen, Maryland; Neville Island, Pennsylvania; Tullytown, Pennsylvania; and at the Old Hickory Powder Plant, Tennessee. While manufacturing facilities were made available at the Rochester Arms and Gun Plant, an additional facility was constructed at Erie, Ohio. The success of the artillery in World War I was credited in part to the Ordnance Department's constant and continuous provision of ammunition.

As the manufacturing of ammunition and explosives escalated, the need for storage facilities also rose, and as the war progressed, the Ordnance Department acquired land at various depots to build 625 magazines. Various types of magazines were designed to store ammunition, smokeless powder, primers and fuses, or high explosives. An example of a magazine built during this period was Magazine L-13 at the Rock Island Arsenal. This magazine was one of seven similar structures built at the arsenal. Magazine L-13 measured 30-by-20 feet and stood 8 feet 6 inches tall. It had 600 total square feet. The magazine had a concrete foundation on bearing rock and walls of tile and steel under a stucco finish. The floor was concrete and the flat roof was pitch and gravel. The structure was designed with two globe vents and sat on a 5-foot surrounding concrete slab apron (Figure 7).

World War I ended on 11 November 1918. The Ordnance Department at that time consisted of two services—the Manufacturing Service and the Field Service—and controlled 10 arsenals, one armory, one storage depot, two supply depots, one Howitzer plant, one arms and gun plant, three proving grounds, one powder plant, and 11 general ordnance depots. To the Manufacturing Service were assigned the Frankford, Picatinny, Watervliet, and Rock Island arsenals; the Chicago Storage Depot; the Erie Howitzer Plant; the Rochester Arms and Gun Plant; and the Springfield Armory. The Field Service received responsibility for the Amatol, New Jersey; Augusta, Georgia; Benicia, California; Raritan, New Jersey; San Antonio, Texas; and Tullytown, Pennsylvania arsenals; the Aberdeen, Maryland; and Neville Island, Pennsylvania supply depots; the Aberdeen, Maryland; Erie, Ohio; and Savanna, Illinois proving grounds; the Old Hickory Powder Plant, Tennessee; and the Charleston, South Carolina; Curtis Bay, Maryland; Delaware, New Jersey; Middletown, Pennsylvania; Morgan, New Jersey; Perriman, New Jersey; Pig Point, Virginia; Seven Pines, Virginia; Sparta, Wisconsin; Wingate, New Mexico; and Woodberry, New Jersey general ordnance depots.

With the end of the war, overseas shipments of ammunition and explosives were discontinued. As production was at full capacity right up to the end of the war, materiel quickly began piling up in warehouses and on docks. Combined with the large shipments of ordnance returning from overseas and the impending demobilization, the government had a huge inventory of ordnance materiel worth more than one billion dollars. However, the government did not have sufficient storage facilities available.

Overall, there were three basic categories of ammunition and explosives storage structures by World War I. The most prevalent category of magazine was aboveground magazines. Usually rectangular in shape, these structures had either gabled or flat roofs. The structures were constructed using masonry (often tile) or corrugated asbestos on a wood frame, or using ordinary wood-framed construction. The floors were at-grade or at railroad car-floor level.

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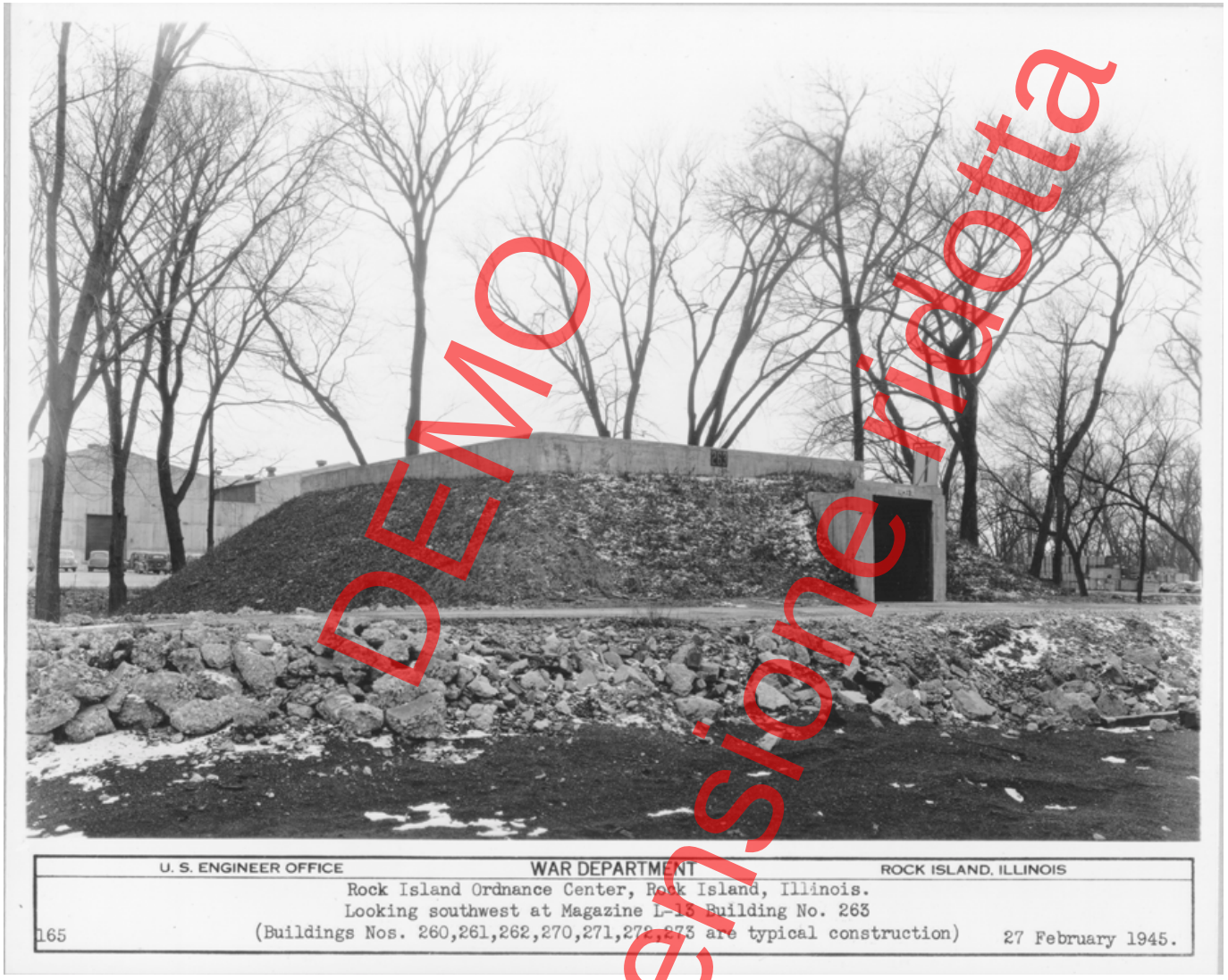

Figure 7. Magazine L-13 at Rock Island Ordnance Center.

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Occasionally, separate barricades were erected around the magazines so that safety distances could be reduced. Another type of storage structure was the casemate magazine. These magazines were masonry vaults that were fortified, sometimes in hills. Casemate magazines were used only at coastal artillery installations. The final category of storage resource in use by World War I was a dump. Consisting of open stacks of ammunition, this category of storage was seldom used except in wartime.

Part of the problem in storing the surplus ammunition after World War I was the different requirements needed for the six classes of ammunition. Each class of ammunition was stored in a prescribed type of aboveground magazine based on its explosives potential. The first class included finished ammunition and loaded components. The second class was composed of smokeless powder used in bulk and in the form of separate ready-made propelling charges. Fuses and primers made up the third class of ammunition, while the fourth class consisted of high explosives such as T.N.T., picric acid, explosive D, and tetryl. Sodium nitrate and inert components such as empty shells, boosters, and metallic components of fuses comprised Class Five. The sixth class of ammunition consisted of small arms ammunition.

Class One ammunition was stored in standard ammunition magazines. The principal characteristics of this type of ammunition were great weight and moderate sensitivity. Overall, shells below six inches were not subject to mass detonation. Although it was possible for shells of six inches and larger caliber shells to detonate en masse, it was unlikely unless there were a fire. Typically, the standard ammunition magazines measured approximately 50-by-20 feet. The magazines were spaced 300 feet to 400 feet apart. The structures were of hollow tile construction. The concrete floors had a permissible floor load of at least 1,000 pounds per square foot. Due to the tonnage of ammunition and the weight of an individual shell or package, standard-gauge railroad tracks were always provided to these magazines. The standard ammunition magazine presented a fireproof exterior and was constructed so that in the event of an explosion, the walls and roof would break up into small fragments. As such, there was no danger of large masses of debris being thrown any appreciable distance (Reed 1995:40).

Smokeless powder, Class Two ammunition, was assigned to magazines of lighter construction than standard ammunition magazines. Although smokeless powder was not explosive, if it was ignited it burned with an extremely intense heat. A typical smokeless powder magazine measured about 32-by-96 feet. The usual capacity of this type of magazine was 500,000 pounds of powder, although the actual capacity was limited only by the necessity for limiting losses in case of fire. Smokeless powder magazines were located 300 feet apart. They were constructed with asbestos siding and gypsum slab roofs. This type of magazine had wooden floors. Due to the 300-foot spacing between magazines and the fireproof exterior of the magazines, the threat of fire spreading from one magazine to another was limited (Reed 1995:40).

Fuses and primers were also stored in magazines measuring 32-by-96 feet. The distinguishing characteristics of Class Three ammunition were great sensitivity, high cost, and the fact that the destruction of a comparatively small amount in bulk would render useless a relatively large amount of other components. Similar to smokeless powder magazines, Class Three magazines had hollow tile walls, gypsum slab roofs, and wooden floors. Again, these magazines were spaced 300 feet apart. Due to the characteristics of this type of ammunition, the magazines were comparatively small and the exterior was thoroughly protected against sparks or fire (Reed 1995:40).

Class Four ammunition, high explosives, was consigned to magazines constructed with hollow tile walls and gypsum slab roofs. Typically measuring 26-by-42 feet, these magazines were designed with a capacity of 250,000 pounds of explosives. Complying with the American Table of Distances, high explosives magazines were spaced 800 feet apart. Class Four ammunition was comparatively sensitive. If ignited, it was likely that most of the explosives would detonate. Thus, the hollow tile and gypsum slab construction was necessary to prevent damage from heavy missiles (Reed 1995:40–41).

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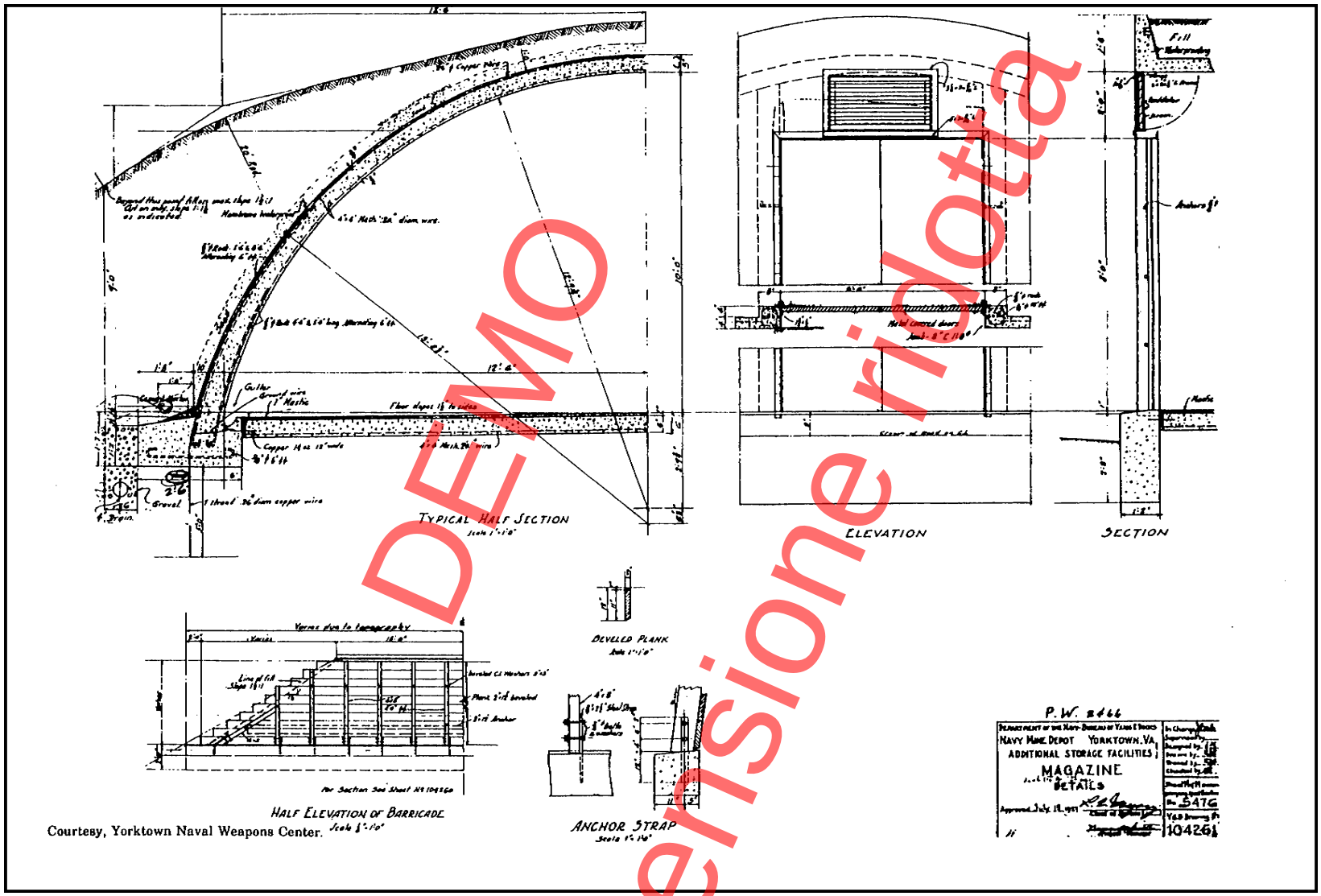

Courtesy, Yorktown Naval Weapons Center.

Figure 8. Magazine details for Drawing 104261.

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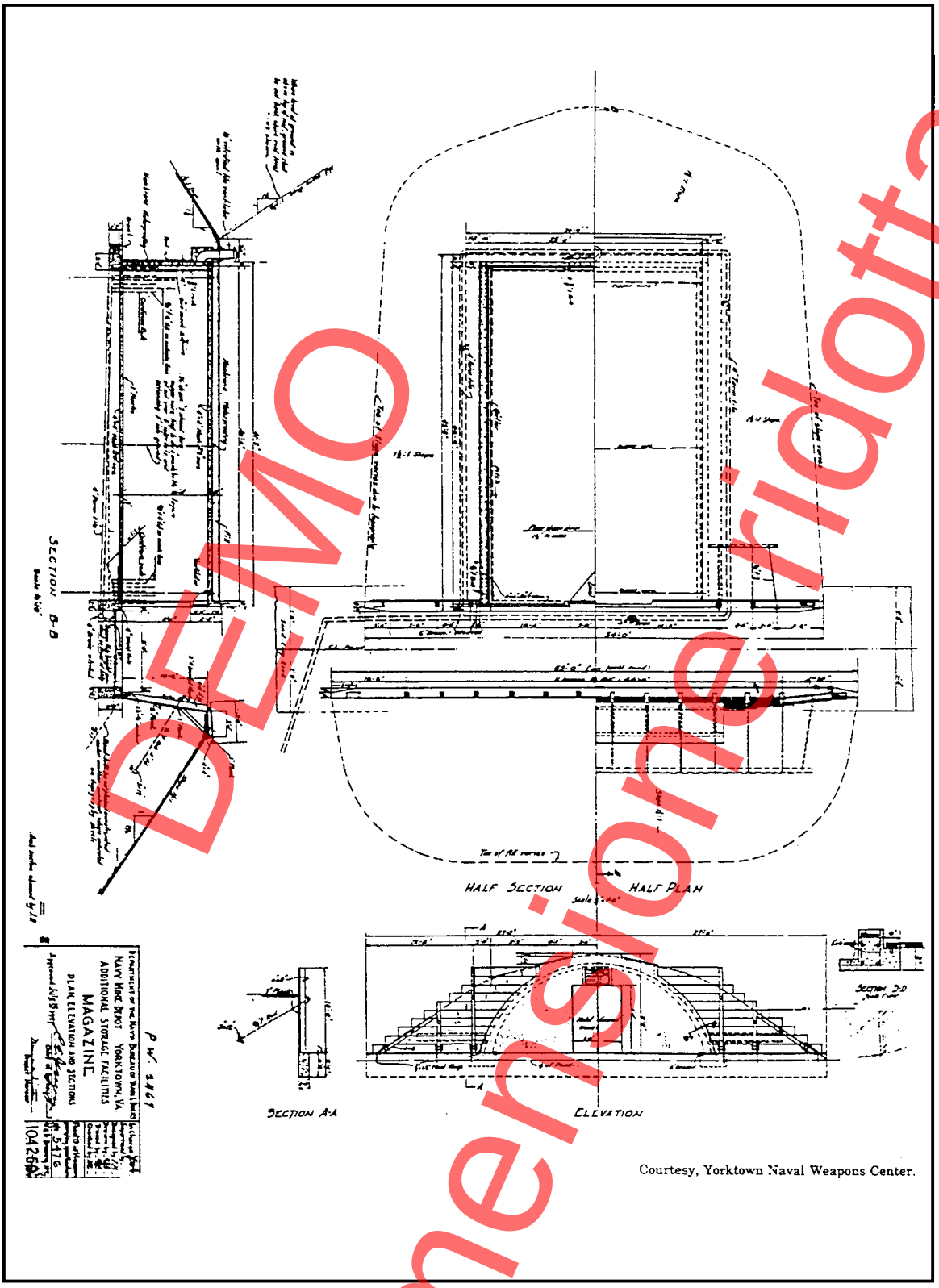

Figure 9. Magazine plan, elevations, and sections for Drawing 104260.

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Figure 10. Magazine 56-AT-2 at Hawthorne Naval Ammunition Depot.

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Figure 11. Triple Arch Magazine at Hawthorne Naval Ammunition Depot.

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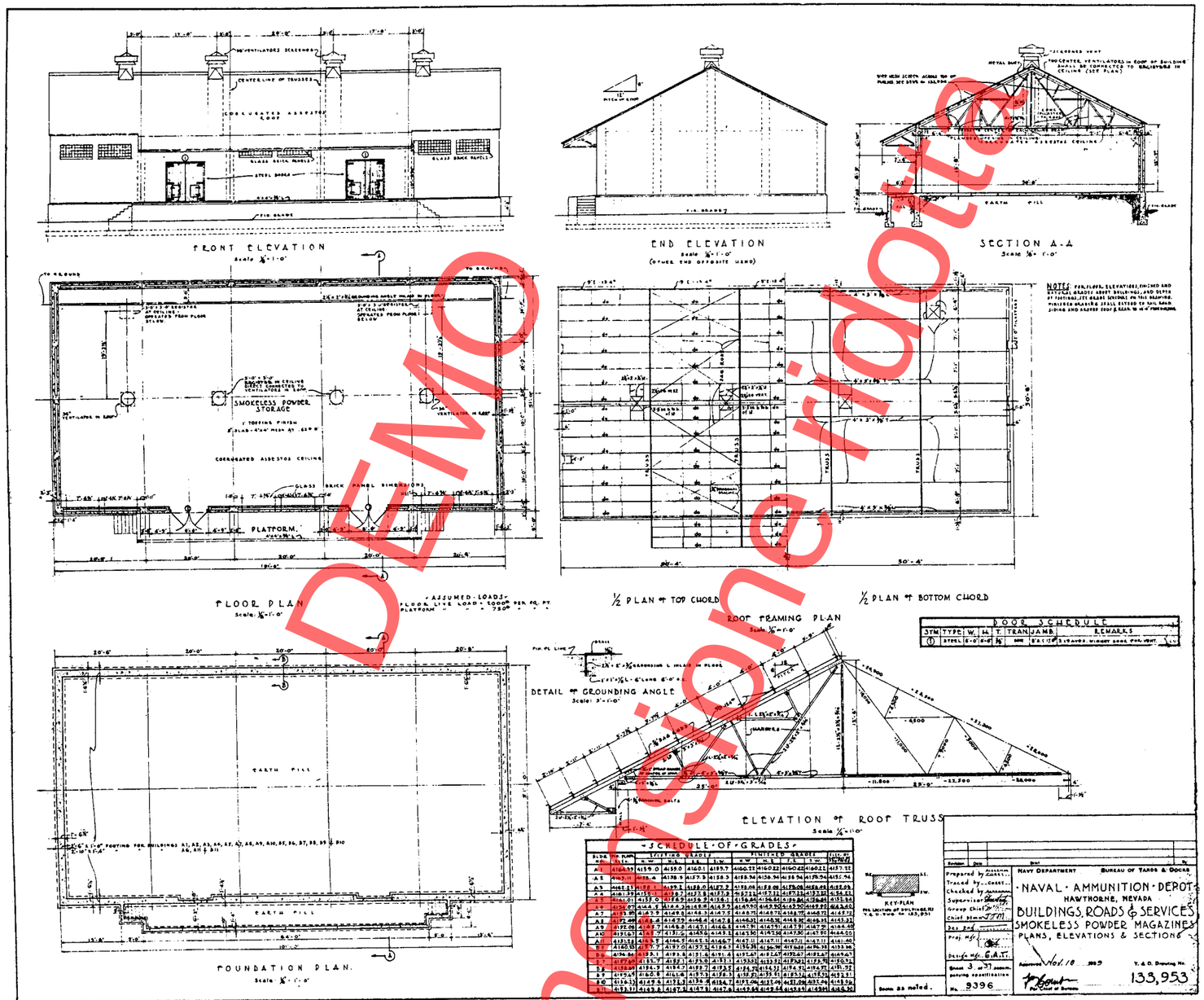

Figure 12. Plans, elevations, and sections for Smokeless Powder Magazine at Hawthorne Naval Ammunition Depot.

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