

Dedicated to the increase and diffusion of knowledge about how the nation's lands are apportioned, utilized, and perceived.

# The Lay of the Land

The Center for Land Use Interpretation



WINTER 2019

All unmanned interpretive devices are essentially self-guiding. These include exhibits of all types, regardless of location. They may be along roads, trails, at historic buildings, various types of structures, or even in museums.

- from *The Interpreter's Handbook*, by Russell K. Grater

## LIGHTER THAN AIR EXPLORING THE LANDSCAPE OF HELIUM



The Helium Time Columns Monument in Amarillo, Texas is an evocative expression of the purity and complexity of helium. The sculpture was erected in 1968 to commemorate the 100th anniversary of the discovery of helium. Each of its four arms holds a helium-filled time capsule, containing books, documents, and artifacts, to be opened 25, 50, 100, and 1,000 years from its construction (the second chamber was opened and repacked late in 2018).

CLUI photo

THE LAND USE OF HELIUM may seem like a strange thing to consider, initially at least, because helium is invisible and is always trying to escape into space. Revealing the materiality of this immaterial element is a forensic process, as helium leaves its mark on the earth indirectly, through the industries of its extraction, processing, distribution, and consumption. Exploring the landscape of helium makes for a curious and revealing journey through the past century of American technology.

Helium is increasingly critical, and retrograde. It is one of the most abundant elements in the universe, but in usable form is a limited, non-renewable resource, extracted from natural gas. Helium gives rise to low tech, like blimps and party balloons, as well as high tech, like cryogenics, semiconductors, and nuclear bombs. Hoarded by the US government since the 1920s, the federal reserve has recently been sold off, and the industry of helium is now private, and global.

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## NPK: INDUSTRIAL FERTILIZER IN THE USA THE GROUND OUR FOOD EATS



Most of the phosphate fertilizer (the P in NPK) mined in the USA comes from strip mines in the Bone Valley of central Florida.

CLUI photo

PLANTS GET CARBON, HYDROGEN, AND OXYGEN from air and water, but the rest of what they need to grow comes from the ground, often from a nearly inert soil that is reconstructed and recharged with fertilizers between each planting.

As most gardeners know, the three basic elements of fertilizer required for plant growth are nitrogen, phosphorus, and potassium, often represented by their symbol on the periodic table of elements: N, P, K. In addition are other macronutrients and micronutrients like sulfur, calcium, magnesium, iron, zinc, and copper. In industrial agriculture, which provides more than 90% of the food Americans eat, these inorganic elements are mined, rather than grown — extracted using open pits and underground mines, and from fossil fuels pulled out of the earth.

Our collective appetite, therefore, extends through the plants and animals we eat, and even beyond the fields from which these staples are formed, for these fields are just a medium — an outdoor factory floor. The ultimate source of our food, you could say, are the places where the nutrients that make our food come from. In this way we are not herbivores and carnivores, but geophagists — people who eat the earth.

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### Editor's Note

Welcome to the 42nd newsletter of the CLUI. This issue is elemental, looking at things like helium and nitrogen — elements that are invisible, but which make up much of the universe, and form the core of physical existence. In this elemental way, we are closest to each other, as well as the material world we create and inhabit, since we and it are all made of this same stuff. We may come from different places, yet we all cast our eyes on these words as part of a contiguous maelstrom of interconnected matter. Glad you are *out/in t/here!*

## LANDSCAPE OF HELIUM

Helium has the atomic number 2, and is the second lightest chemical element, after hydrogen (atomic number 1). It is a noble gas, meaning it does not react chemically with other elements or compounds, making it useful as an inert gas in micro-electronics and vacuums (the original Declaration of Independence and Constitution are stored in a transparent helium-filled chamber.) Helium also has one of the lowest boiling points of any element, making it useful for cryogenics, and for chilling electronic imaging systems.

Helium was first discovered by astronomers making spectrographs during a solar eclipse in 1868, and is named after helios, the sun. It is the product of the nuclear fusion of hydrogen, which occurs on the sun (as well as in hydrogen bombs). Though helium is one of the most abundant chemicals in the universe, it is scarce in the atmosphere, as it is always escaping into space. The gas was not discovered on earth until 1895, when it was detected as a product of radioactive decay.



The atomic structure of helium, as depicted at the apex of the Helium Time Columns Monument. CLUI photo

Terrestrial helium is a product of earth's rot: the radioactive decay of uranium and thorium. For the most part, the gas remains stuck in the ground. In a struggle to rise above the heavier elements, following the path of least resistance within the ground, it joins other components of geologic rot, like the methane produced by the decay of carbon-based lifeforms (the primary component of natural gas). When we find sufficiently rich gas fields to tap, holes are drilled deep in the earth to let the gas out. In some of these fields, there is enough helium — even just three to five percent of the gas is enough — so that it, too, is captured, separated from the gas, and further refined.



The original Amarillo Helium Plant, the sole source of helium in the world from 1929 to 1943, was auctioned off by the federal government in 2007, and remains in private hands, abandoned and awaiting redevelopment. CLUI photo

### *Amarillo: The Helium Capital of the World*

The Texas Panhandle town of Amarillo has been the helium capital of the world for nearly a century, when natural gas in the region was discovered to have helium in high enough concentration to be extracted, and the federal government started work on the Amarillo Helium Plant, the nation's first major helium production operation.

The plant opened in 1929, following the Federal Helium Act of 1925, which authorized the Bureau of Mines to construct and operate helium purification facilities to supply Army and Navy blimps. It was the nation's sole helium plant until 1943, when the government opened a few more during WWII. It was also the site of the Helium Research Center, which explored new uses and markets for helium over many decades. The plant has been unused since the 1990s, after the federal government ordered the privatization of the helium industry, and federal plants were shut down.

With the creation of the Federal Helium Reserve in 1962, a few miles north of town, Amarillo became the storehouse for just about all the usable helium in the world. The reserve is a former gas field, with 23 wells drilled into it, originally used to extract helium-rich gas occurring naturally in the field, until it was depleted. The reserve was established there to inject helium-rich gas, extracted and refined elsewhere, into the ground for storage and use by the government.



The Federal Helium Reserve is located in the Cliffside Gas Field, 3,000 feet below ground, in a geologic structure known as the Bush Dome. Helium is extracted through former gas wells, and enriched at a plant on the surface. CLUI photo

The refined helium gas, generally referred to as crude helium, is around 75% helium, and came from around a dozen gas plants and helium refineries located in the helium-rich gas fields between Amarillo and central Kansas, connected by the 425-mile-long Federal Helium Pipeline. Starting in 1963, 40 billion cubic feet of crude helium flowed through the pipe, filling the reserve.

Some of the plants along the pipeline also produced refined helium from the crude helium they made, or that was piped to them from gas plants. Refined helium, above 99.5% pure, is often compressed and chilled to the point where it becomes liquid, making its volume 750 times smaller. Whether in gas or liquid form, refined helium is transported to distribution points and end users in specialized tank containers, mostly on trucks, though sometimes by rail, and

## LANDSCAPE OF HELIUM

in ISO containers by ship overseas. Generally transporters have 40 days or less to get the helium to end users before too much of it escapes through the walls of metal tanks.

In 1996 the Helium Privatization Act mandated that the government begin selling off its plants and stockpile of helium, in order to pay the cost of constructing the system, but also because strategic military uses, like blimps and nuclear bombs, no longer required so much of the material to be held by the government.

Now the pipeline runs in reverse: the crude helium is extracted from the reservoir and purified at the now privately owned and operated helium processing plants located up the pipeline, with the last one 425 miles away, at Bushton, Kansas.



The Federal Helium Pipeline emerges from the ground and terminates at the Federal Helium Reserve, north of Amarillo. Since 1963 most of the world's helium has passed through this pipe, connecting gas fields and processing plants. The other end is at a national gas hub in Bushton, Kansas, 425 miles away. CLUI photo

In 2004 the Bureau of Land Management, which took over the operations from the Bureau of Mines, opened the \$30 million Crude Helium Enrichment Unit at the reserve, to purify the gas to a standard level of 78% helium, aiding the process of distribution to the private refineries up the pipeline.

The BLM held its last crude helium auction in August 2018. Now, as required by the Helium Stewardship Act of 2013, three billion cubic feet will remain in the stockpile for government use — as helium has, once again, been re-listed as a strategic material.

Another three billion cubic feet that remains in the reservoir (and in the pipeline itself), is now owned by private industrial gas companies like Praxair and Linde. Air Products Inc. bought all of the helium sold at the last auction (210 million cubic feet, for \$58 million) and they, like the others, now pay the government a fee to store it there. Under current law, the BLM is supposed to sell the reserve, including the helium, wells, and the pipeline itself, to private companies, at auction, by 2021, getting completely out of the helium business. The government will remain a consumer of helium, for defense projects, rocket launches, fuels, and blimps, but will do so as a customer of the companies that already control the industry.



Air Products plant in Liberal, Kansas, one of just a handful of helium production facilities in the USA that produce around a third of the world's helium. CLUI photo

### *Private Helium Companies*

The US government once controlled 95% of the helium production in the world. Now private companies processing helium in the USA, along with the BLM (for another year or two), produce around 40% of the helium produced globally, at less than 15 helium refineries in the country. Domestic production and distribution is dominated by three industrial gas companies, companies that also dominate internationally.

The German industrial gas company Linde operates one of the largest helium plants in the country in Otis, Kansas, on the Federal Helium Pipeline. The plant has been operating since 1965, and was the first liquid helium plant in the world. Linde just completed a \$90 billion merger (in October 2018) with one of its competitors, Praxair, and the combined company, still called Linde, is now the world's largest helium producer and supplier, as well as the largest industrial gas company, with approximately \$27 billion in annual revenue. Praxair also operates two helium plants along the pipeline, one in Ulysses, Kansas, and the other at Bushton, Kansas, at the end of the Federal Helium Pipeline.

Air Products Inc. is the other major industrial gas company that refines and distributes helium produced in the USA. It operates two refineries on the helium pipeline, one in Liberal, Kansas, and another in Sherhan, Texas. Both produce Grade A helium, which is 99.99% pure, and is pressurized, liquefied, and trucked offsite in specialized helium tanker trucks, as is the case at the four Linde/Praxair helium plants on the pipeline. These five refineries, and two small independent operations, constitute all the refined helium produced along the Federal Helium Pipeline, at the moment.

There are other natural gas fields in the West with high concentrations of helium as well, especially in Utah, Colorado, and Wyoming. A few production plants have been established in these areas, especially in recent years, as the Federal Helium Reserve is being phased out, and the helium gas fields connected to it have become depleted.

These "off the pipeline" plants include the Doe Canyon Plant, a unique helium facility in the southwestern corner of Colorado, opened by Air Products in 2016. It was the first plant to produce helium from the carbon dioxide stream of the natural gas industry.

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Though small, the plant can produce up to 230,000 cubic feet of helium per day, and around 84 million cubic feet per year, about 1.4% of the global demand for helium, of around six billion cubic feet per year. And in southwestern Wyoming, ExxonMobil operates the largest single helium plant in the nation, part of its Shute Creek Gas Plant, in the Labarge Gas Field. The plant is capable of producing as much as 1.4 billion cubic feet per year of Grade A (99.99% pure) liquefied helium from natural gas collected and processed at the site. This is close to a quarter of the six billion cubic feet per year consumed in the world annually. The plant opens and closes based on production problems and market demands. It closed in 2011, but was back online in 2017.

Though 35-40% of the helium produced and consumed annually in the world comes from plants in the USA, helium is becoming a globally sourced material, with US production sharing the market with places like Algeria, Qatar, and Russia. Less than two percent of the helium escaping from gas wells is captured and processed, as it is too expensive to produce in small quantities. But with a few giant centralized gas processing plants being built and expanded (especially at Ras Laffan in Qatar, and Gazprom's new plant in Amur, Russia, each of which may end up producing a third of the global demand in a few years), there will likely be enough helium to meet demand for a growing need for helium from high tech industries, at a cost the market can bear. Helium is an element that is here to stay. At least until it all has floated away.



Helium balloon refuse from a birthday party, landing next to Hangar 2 at Tustin, California. Escaped helium party balloons can travel hundreds of miles, and take years to disintegrate. CLUI photo

### *Helium Consumption*

Almost 40% of the two billion cubic feet per year of helium consumed in the USA is used for MRI machines, and other high tech imaging technology, where helium's properties as a cooling gas and inert vacuum gas make it useful. It is also used to make fiber optics and semiconductors, and used in rocket fuel and nuclear bombs. Around 13% is used for welding gas, and breathing gas for deep sea divers, where it replaces nitrogen in the air, preventing narcosis (and making for high-pitched voices).

The use of helium as a lifting gas requires less refining, using gas that can be as little as 90% helium, which makes it less expensive to produce. The party balloon market in the USA, by far the largest user of helium as a lifting gas, consumes around 250 million cubic

feet of helium, around 12% of the total helium consumed annually in the USA. That translates to around a billion balloons.

Though airships, including blimps and dirigibles, once consumed all the helium produced, and were the main reason for the government monopoly on helium production, airships now consume less than two percent of the helium produced in the USA. Their impact on the ground, however, and on our imagination, remains the largest part of the legacy of helium.

Airships have been around for centuries, as hot air balloons and later hydrogen blimps and dirigibles, but it was the use of helium that enabled airships to evolve into modern forms, with widespread use. Helium replaced explosive hydrogen in US airships in the mid 1920s, and the government took over its production, seeing the strategic importance for surveillance airships guarding ships at sea.

While rapidly developing helium production, the government also ramped up airship production, with most of the craft being built by Goodyear. After WWII, in the boom years of marketing and consumerism, Goodyear's blimps became a unique and familiar brand. Now other companies make and market advertising blimps, though a similar number of blimps exist to hold radar on tethered aerostats — modern surveillance blimps guarding the nation's southern perimeter.



Goodyear's latest airship, Wingfoot Three, at the company's blimp base at Wingfoot Lake, Ohio. CLUI photo

### *Goodyear*

Commercial and military airships in the USA have been produced primarily by the Goodyear Tire and Rubber Company of Ohio, and the Zeppelin Company of Germany, often as a partnership between the two, operating as the Goodyear-Zeppelin Company.

Goodyear Tire and Rubber was founded in Akron, Ohio in 1898, and became the largest rubber company in the world by 1926, after developing the tubeless tire, and supplying Ford's Model T. Goodyear was an innovative marketer of its brand, and has used blimps for this purpose for nearly a century.

In 1916 Goodyear bought 720 acres in the countryside a few miles southeast of Akron, surrounding an artificial lake it renamed Wingfoot Lake, to reference the corporate logo, Mercury's winged foot. This has been the company's primary airship production and testing site for most of the last 100 years, and is, in a sense, the "Kitty Hawk" of lighter-than-air flight.

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Goodyear started making blimps in 1910, though they were more like giant oblong rubber balloons, and were filled with hydrogen, not helium. The first series of airships ordered by the Navy, the B series, was made at Wingfoot Lake in 1917. Since then, Goodyear has erected around 350 airships over the past century, 239 of which were erected at Wingfoot Lake.

During WWI, the Navy took over Wingfoot Lake as its Naval Airship Training Station, while Goodyear produced more Navy airships, including the C series, which were deployed to coastal bases, like Rockaway Beach in New York City. By the time the war ended and the Navy left, Wingfoot Lake had 26 buildings.

Goodyear made the first commercially licensed and helium-filled airship in 1925, and began using blimps for promotional purposes. The conversion to helium, a much safer gas, increased production, in spite of its limited supply. Between the wars the company built dozens of blimps at Wingfoot, which grew in size from 86,000 cubic feet of helium, to 123,000 cubic feet. In 1930 it made its first blimp with an illuminated sign, which spelled out “Goodyear” in neon. In 1940 it flew blimps with megaphones that made live sonic “blimpcasts” to the crowds below.

Most of these blimps were transferred to the Navy either before, or during, WWII. During the war, more than 100 Navy airships were erected at Wingfoot. The hangar was extended to 800 feet, and many other buildings were constructed on the site.

By the mid-1950s, Wingfoot Lake had evolved into a diversified aviation and electromagnetic test site, and in 1962 was renamed Wingfoot Lake Test Operations. It tested helicopter armor, cryogenics systems, fuel tanks, underwater acoustics, amphibious aircraft, and Macy’s Thanksgiving Day Parade balloons, and with 17 ranges, was called the “most complete radar testing facility in the USA.”

Meanwhile, Goodyear’s blimps continued to grow, from 132,000 cubic feet in 1959, to 202,000 cubic feet in 1969, with the introduction of the GZ-20 series, which became the mainstay of the Goodyear fleet for nearly 50 years. Signage was expanded with the introduction of the “Super Skytacular” system, with 3,780 lighted pixels on either side. Goodyear blimps became broadcast television platforms starting with the Rose Bowl in 1955, and the blimp’s association with large scale sporting events was tactically promoted during the events themselves, as well as in films, including *Black Sunday* in 1977, where a terrorist uses a Goodyear Blimp to attack a stadium filled for the Superbowl.

Goodyear restructured its aerospace business in the 1960s, and opened a blimp assembly and maintenance station in Spring, Texas. Wingfoot Lake was put into caretaker status in 1972, and many of the buildings, including three of the four hangars, were torn down.

Government and defense work continued at the site, however, including the use of the remaining hangar by the Department of Energy to develop centrifuges for uranium enrichment. Other electromagnetic test structures, including the Underwater Acoustics Test Facility, were used after Goodyear Aerospace was purchased by Loral Defense Systems and Lockheed.

In the 2000s, things at Wingfoot Lake again changed dramatically. The north part of the site, which had been used as a corporate retreat and recreation area for Goodyear, was sold to the state to become a wildlife area and public park. Goodyear kept the land on the southern shore of the lake, cleaning it up further, stripping away most of what remained of its industrial and military history, and turning it into a dedicated airship base, once again.

In 2011 Goodyear announced that its next generation of blimps would be designed by the Zeppelin Company of Germany (which resurfaced in 1993, after its disappearance in WWII) and assembled at Wingfoot Lake.

Since then, three of these 250-foot-long semi-rigid airships have been built. One is now based in California, and one in Florida. The third, named Wingfoot Three, was finished in June 2018, and is based in the revamped hangar at Wingfoot Lake.



The hangar at Akron Airport, in Ohio, also known as the Goodyear Airdock, was the second large airship hangar made in the USA. It was built in 1929, to construct the USS Akron and USS Macon. It is now owned by Lockheed, and is sealed up.

CLUI photo

Goodyear is the only private company to build and operate airship bases in the USA. Besides Wingfoot Lake, Goodyear built four other blimp bases for its airships, including one at Akron Airport, closer to its headquarters. Owned by several companies now, including Lockheed, the base is dominated by the Goodyear Airdock, built in 1929 to construct the largest airships ever made in the USA.

The airdock was designed by Karl Arnstein, from the Zeppelin Company in Germany, which partnered with Goodyear to become the Goodyear-Zeppelin Corporation in 1924. Arnstein also designed the first airships to be built inside the hangar, which resembled the hangars in structure and form.

The hangar is 325 feet wide, 211 feet tall, and 1,175 feet long, longer than the only other structure anything like it in the country at that time, Hangar 1 in Lakehurst, New Jersey, which was built in 1921 to construct the USS Shenandoah.

The first airship built inside the Goodyear Airdock was the USS Akron, in 1931, followed by the USS Macon, in 1933 — both around 785 feet long, the largest airships ever made in the USA. These were flown over the coasts and met their fate in the sea.

Smaller airships continued to be built in the hangar, especially during WWII. The last one built there was ZPG-3W, in 1960.

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After that the hangar housed other defense projects, mostly related to surveillance, including the photographic division of the Goodyear Aerospace Corporation.

In 1987 the Goodyear Aerospace Corporation was purchased by Loral, a space and surveillance company. Loral was purchased by Lockheed Martin in 1996, and the site became part of their Tactical Defense Systems branch, which built things like flight simulators for fighter jets, and their Naval Electronics and Surveillance Systems Division, which developed a high altitude surveillance blimp, to be stationed 70,000 feet above the ground (apparently it never went into production). Lockheed still owns the hangar, and uses it as an engineering and storage space.

Goodyear operated another blimp base in Spring, Texas, north of Houston, from 1969 to 1992, which took over maintenance and assembly activities from Wingfoot Lake in Ohio for that period, and served as the southeastern base for commercial blimp operations. The Spring facility closed after the company's base in Florida was expanded, and the site has been developed into a shopping center, though the footprint for the old hangar remains in the bushes on one corner of the property.



Goodyear's blimp base in Pompano Beach, Florida.

CLUI photo

Goodyear's Florida base is at the airport in Pompano Beach, Florida, on the coast between Miami and West Palm Beach. In 1986 it opened a new hangar, and an office building to serve the pilots, base administrators, and public relations specialists. The blimps based here are used for promoting the Goodyear brand over the crowded beaches of the Florida coast. They are also deployed to major outdoor sporting events in the southeastern USA, to shoot aerial video for broadcasts, and to be seen.

The hangar there is 275 by 150 feet, and was first occupied by the airship Enterprise, which operated until 1991, when it flew back to Akron to be deflated forever. It was replaced that year by the Spirit of Akron, which in 2006 was replaced by the Spirit of Innovation. In 2014 the Spirit of Innovation was retired, and replaced with Wingfoot One, the first of the latest generation of Goodyear blimps.

The fourth Goodyear blimp base is in Carson, California, visible next to the 405 freeway. It opened in January 1968, and covers 27 acres. It has been home to at least nine Goodyear blimps since then, but with just five different names: the Columbia, the Eagle, the Spirit of America, the Spirit of Innovation, and now, Wingfoot Two. Wingfoot Two is the second of this latest generation of Goodyear's blimps, and was delivered in 2017. Unlike all the previous models, the 250-foot-long Wingfoot series is a semi-rigid airship, and therefore, not a blimp, but a dirigible. Goodyear has decided not to challenge the popular, more general use of the word "blimp."



The industrial park with the offices and assembly building for the American Blimp Company, next to the airport at Hillsboro, Oregon. Besides Goodyear, all other advertising blimps are inflated at or near where they are being temporarily deployed, and are not kept inflated in dedicated blimp hangars. Google Earth image

### *Blimp Companies Besides Goodyear*

Goodyear is not the only company that made commercial blimps in the USA. The largest of the few independent blimp companies is the American Blimp Company. The company designs and builds commercial blimps for advertising companies out of its small fabrication plant and base of operations in an office park next to the airport in Hillsboro, Oregon. Starting in 1990, it built the first A-60 blimp model, a 68,000-cubic-foot manned blimp, which became popular for small advertising applications. Later, it made the larger A-150, originally commissioned by Sanyo, and capable of carrying nine passengers. In 2004 it built the even larger A-170, 178 feet long, with a 70-by-30-foot LED screen. These models, made by the American Blimp Company, constitute the majority of the 15 or so commercial blimps in the USA that are not owned by Goodyear.

Most modern blimps are shaped plastic skins filled with helium. While these independent companies may design and build the motors and pilot cars that attach to the inflated skin, a company called ILC Dover makes the plastic envelopes for just about all the small blimps and aerostats currently in use in the USA (with the exception of the three latest Zeppelin-made Goodyear Wingfoot blimps). ILC Dover is an aerospace engineering and materials company based out of a plant in Frederica, Delaware. It made most of the space suits used by NASA, and the Playtex brand of women's undergarments.

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Over the last year or two, the advertising company AirSign, which also does aerial sign towing and skywriting, bought all the small blimp companies doing advertising in the USA, including the Van Wagner company and the Lightship Group, which owned the American Blimp Company. AirSign seems to be consolidating all blimp advertising under its wing, and even has a contract now to operate blimps for Goodyear.

### *Military Airship Bases*

The vast majority of airships were developed and produced for military reasons, primarily as surveillance platforms to defend our naval fleet. They were often used as submarine spotters — large bulbous floating things in the sky looking for large bulbous sinking things in the sea. Though you can land and park a blimp in any large open space, airport, or even on a ship, leaving it outside exposes it to wind, which can have damaging effects on the craft.

Therefore, dedicated airship hangars and bases were built around the country, starting in the 1920s, but really taking off in WWII. The sites were at strategic locations along the nation's coastline. Though the military controls few of these sites today, these former blimp bases remain active, in one way or another. Their uses have evolved in interesting ways, reflecting prevailing conditions of their milieu.



Hangar 1, at the Naval Air Station in Lakehurst, New Jersey, was built in 1921, to construct the USS Shenandoah, the first of only three large rigid airships made in the USA. CLUI photo

### *Lakehurst New Jersey: The Main Base for Airships*

The Naval Air Station at Lakehurst, in the middle of New Jersey, was the historic center for lighter-than-air aircraft activity in the USA. It is now part of a combined Navy, Army, and Air Force base called Joint Base McGuire-Dix-Lakehurst, and is still a major testing and training center for aircraft carrier flight operations, such as catapult launching and landing arresting systems.

The Lakehurst portion, now a Naval Air Warfare Center, has six blimp hangars, the largest collection in the nation. Though the Navy officially ended its blimp activities in 1962, it has occasionally engaged in blimp programs since then. In 2006 it acquired a new blimp, the MZ-3, which it used for tests at Lakehurst, until it was sold to the aerial advertising company AirSign in 2017.

Lakehurst's Hangar 1 was the first large blimp hangar in the USA. It was built to construct the USS Shenandoah, the largest American-made airship at the time. The 680-foot-long rigid airship made its maiden flight in 1923, and was destroyed in a crash in Ohio two years later.

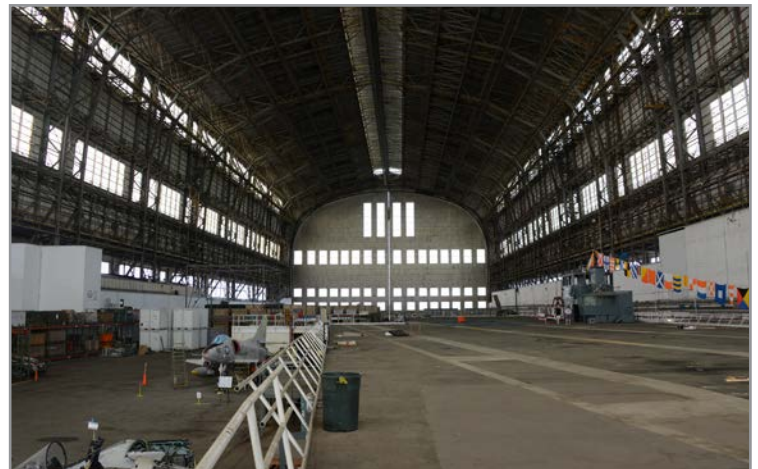
The hangar is a steel framed structure, 966 feet long, 350 feet wide, and 224 feet tall, and was by far the largest single-room, clear-spanned structure in the country when it was built in 1921. It was surpassed when Goodyear built an airdock in Akron in 1929 to construct the 785-foot-long USS Akron Airship.

Hangar 1 could hold two long rigid airships side by side. Other rigid airships that used it included the 685-foot-long USS Los Angeles, a German airship built by the Zeppelin Company in 1924 for the US Navy. The USS Los Angeles was based out of this hangar until 1939, when it was scrapped; it was the only one of the four US-based large rigid aircraft that was not destroyed in an accident.

Two German rigid airships used Lakehurst's Hangar 1 occasionally, too. The Graf Zeppelin, built in Germany in 1928, made its first transatlantic crossing that year by flying to Lakehurst. It later was the first commercial regularly scheduled transatlantic flight service in the world, flying between Germany and Brazil, before the airship was decommissioned in 1939 and scrapped in 1940.

The LZ 129 (the 129th airship of the Luftschiffbau Zeppelin company), otherwise known as the Hindenburg, was more than 800 feet long, and began flying commercially in 1936, when it made ten transatlantic trips between Europe and the USA in that year, making Lakehurst the first transatlantic airport in the USA. On its first transatlantic flight of the 1937 season, the Hindenburg crashed and burned on arrival at Lakehurst, with 97 people on board. 62 survived. A plaque marks the spot in an open field, a few hundred yards from Hangar 1.

In addition to the six large rigid airships that docked at Lakehurst in the 1920s and 1930s, hundreds of other non-rigid blimps of varying sizes have been housed here, in Hangar 1, and in the five other blimp hangars on base.



The view from the simulated aircraft carrier deck inside Hangar 1 in Lakehurst. Though built for training naval personnel, the carrier deck is also used by the East Coast Indoor Modelers club, a recreational model aircraft club that has been enjoying the calm air inside the hangar for decades. CLUI photo

## LANDSCAPE OF HELIUM

Hangar 2, located adjacent to Hangar 1, was the first WWII hangar to be constructed in the US, finished in 1942 to house blimp maintenance and refitting operations. Hangar 3, next to it, was a training blimp hangar, finished soon afterwards. Today they are used as machine shops and a gymnasium for the officers on base.

Hangar 4 was a WWI-era blimp and balloon hangar, originally located on a base in Norfolk, Virginia. It was moved to Lakehurst in 1931, to house blimps that couldn't fit in Hangar 1 when two large rigid airships were inside. Though it is called Hangar 4, it was the second blimp hangar on base. It is now cut off from the flight line, and is used for storage by FEMA and state emergency agencies.

Hangars 5 and 6 are adjacent to one another, across the airfield from Hangar 1. They were completed in 1943, and resemble the other fifteen or so new blimp hangars erected at blimp bases that were established quickly to defend naval and shipping fleets during WWII. Now these two are used for non-blimp-related engineering and storage.



A 1,133-foot-long steel-framed hangar still stands at Moffett Field, though it has been stripped down to its metal frame to address and dispose of toxic building materials and fireproofing as part of a slow moving restoration program.

CLUI photo

### *Moffett Field: The First Blimp Base on the West Coast*

Moffett Field, south of San Francisco, was established in 1931 as the West Coast base for the Navy's rigid airship program. It has three hangars on site, two from WWII, and the original Hangar 1 from the 1930s, one of the three that were built in the USA for this first phase of large rigid airships (the others being located where the ships were made, in Akron, and the east coast base at Lakehurst). Hangar 1 was built to house the USS Macon, the first airship on base and the third large rigid airship built by the US, which arrived from its trials at Lakehurst, New Jersey in 1933. Two years later the Macon was destroyed in a crash off Big Sur, California.

During and after WWII, the base grew dramatically and became a center for surveillance technology and aeronautic research, operated by the Navy, as well as NASA. NASA's Ames Research Lab still operates some of the largest wind tunnels in the world here.

Companies grew to surround the base, especially Lockheed, which built some of the most advanced surveillance satellites here, as well

as civilian earth imaging systems like Landsat. Lockheed still has a large presence, but most of the buildings around the base are owned by information and internet companies like Yahoo, Amazon, and Google, whose owners keep their private jets in former NASA hangars.

In 2014 most of Moffett Field, including the runways and hangars, was leased to a Google subsidiary, Planetary Ventures, LLC for 60 years, at a cost of \$1.16 billion. Though the agreement involved a plan for the restoration of Hangar 1, doing so has dropped down the priority list. There is even some talk now of demolishing it. Most of Google's current activity is taking place on the other side of the runway, around the other two blimp hangars on base. These were built during WWII to house surveillance and submarine-spotting blimps, and are similar to the 15 or so others that were built at ten sites around the country at that time.

Google is restoring these hangars, and using them to house a number of projects, some known, and some unknown. Google co-founder Sergey Brin is said to be developing a large airship inside one of the hangars, but so far no official statements about the project have been made.

This end of the airfield is also busy as the parking lot for Google's fleet of commuter buses, as well as a very active golf course, left over from the base, and now Google's.



The site of the WWII airship hangar at South Weymouth, Massachusetts. Less than half of the airship hangars built during WWII remain today.

CLUI photo

### *The Eight Other Naval Blimp Bases in the USA*

Lakehurst, on the east coast, and Moffett on the west coast were already established by the time WWII started, though each was expanded considerably at that time, including the addition of two large wooden blimp hangars at Moffett, and four at Lakehurst.

Eight other blimp bases were constructed during the war as well, covering the nation's coastlines from Massachusetts to Oregon. None of them remain active as naval aviation sites, but their current conditions serve as interesting models of redevelopment, reflecting local characteristic conditions and national trends.

In September 1941, work started on what was to become the Naval Air Station South Weymouth, south of Boston, Massachusetts. This

## LANDSCAPE OF HELIUM

was the first of the eight blimp bases built during WWII. Though blimp operations stopped in the 1950s, the base continued to be developed and used by the Navy until 1997.

In 1944, the South Weymouth Naval Station was the starting point for early transatlantic crossings of non-rigid airships. In March 1957, the *Snow Bird* took off from South Weymouth on a record-breaking journey, crossing the Atlantic twice, and landing in Key West, after 11 days aloft, covering 9,500 miles without refueling. It marked the pinnacle of a blimp's capabilities.

After the base closed, the Navy transferred its land to the surrounding towns in pieces, over the following 20 years, as there was considerable contamination and environmental work to be performed. The first blocks of condominiums opened in 2011, and the site is now mostly in the changing hands of developers, who plan a major mixed use project, with retail, offices, and thousands of homes in a dense New Urbanist community, served by circulating driverless cars.



New Urbanist redevelopment at the former blimp base in South Weymouth, Massachusetts. CLUI photo

At the moment, though, much of the site is still dominated by the fading remnants of the air base, including hundreds of acres of former runways, and a large circular paved blimp landing area, now used as a logistics site for new vehicles being imported into the Boston region.

The main blimp hangar was commissioned and designed in 1941, before Pearl Harbor and steel rations, so it has a design similar to other steel hangars built for earlier rigid airships, like the Goodyear Airdock at Akron, Ohio, and Hangar 1 at Moffett Field, California, with clamshell doors that opened on curved tracks around the end of the building. It was demolished in 1966, but its oblong outline with curved ends is still visible, though partially consumed by new roads. Part of the old track, which clamshell doors rolled on at either end, is still there, for the time being.

A second blimp hangar on base was similar to the 1,000-foot-long wooden types built around 1943, when steel was being rationed. It was torn down in the 1950s to make room for airbase runways; however, much of its floor remains visible in the grass, with rail tracks down the middle, as was common with these hangars.



A portion of Boston's Boylston Street, constructed on the runways at the former blimp base in South Weymouth, Massachusetts. CLUI photo

In 2016 a portion of Boston's Boylston Street was built on the old runways, for filming the explosion scenes for the movie *Patriots Day*, about the 2013 Boston marathon bombing. Just a few facades of the set remain there today. Another set was constructed nearby as a replica of the residential street in Watertown where the police hunted for and found the surviving bomber, Dzhokhar Tsarnaev (who is now on Death Row at the Supermax prison in Florence, Colorado).

The second of the eight WWII blimp bases to get started was at Weeksville, North Carolina, 40 miles south of Norfolk, Virginia, and near the large Coast Guard air station at Elizabeth City. Construction started on the first hangar at Weeksville in 1941, before the US officially entered the war. Like the first hangar at South Weymouth, it was made of steel. The second hangar at the base was built after Pearl Harbor, and was made of wood, to conserve steel for the war effort.

After the war, with the Navy phasing out blimps in the 1950s, Weeksville Naval Air Station was decommissioned in 1957. After that it was used for aerospace research by NASA and others, including testing of one of the first communications satellites, NASA's Project Echo, a reflective metallic sphere, 100 feet in diameter, which was inflated in the hangar in 1959, and in space in 1960.

In 1995, with the site used primarily by Westinghouse, a welder's torch started a fire in the wooden hangar, burning it to the ground, and destroying the Sentinel 1000, a Westinghouse airship, and other surveillance blimps that were stored inside the hangar. All that remained standing were the two pairs of concrete columns that once supported the doors at either end.

After the fire, Westinghouse sold its airship and surveillance divisions. In 1996, the aerospace contractor TCOM moved into the remaining steel hangar on-site, to develop small blimps and aerostats for the government, used primarily as radar platforms. Today TCOM still operates the site as a manufacturing, production, and testing location for airborne persistent surveillance solutions, including the tethered aerostats flown along the US/Mexico border. This is one of the few places left in the nation dedicated to blimp R&D work.

## LANDSCAPE OF HELIUM

The next of the eight WWII blimp bases built for the war was located near the coast in southern Georgia, near Glynnco. Like most of the others, it had two 1,000-foot-long wooden hangars, one to house a squadron of blimps, and the other to house additional and transient blimps. Blimp operations continued there until 1959, and the hangars were torn down in 1971. But the layout of the blimp base set the pattern for the future development of the site, and a few circular blimp parking pads are still visible on-site, though used for other things now.

After the base closed in 1974, it was redeveloped into a Federal Law Enforcement Training Center, with a variety of vehicular training tracks, mock towns, and even a mock international border port of entry facility. It is now one of four of these FLETCs, and is the headquarters for the federal program (now part of the Department of Homeland Security).



An old Bureau of Mines helium tanker car, part of the collection of the railway museum at Richmond, sits on the pad that used to be the floor of a 1,000-foot-long blimp hangar, one of three on the former Air Station, which burned down in WWII. The tower in the distance is one of the supports for the 150-foot-tall hangar doors.

CLUI photo

Richmond Naval Air Station, near Miami, was the largest of the eight new blimp bases built in WWII. It covered 2,100 acres, and had three 1,000-foot-long blimp hangars, instead of the usual two. It also had the shortest life of all of them. In late 1945, a hurricane swept through the area, starting a fire in one of the hangars, which spread to the others, burning them all down, and destroying all 25 of the blimps here, along with 368 military and civilian aircraft that were also on-site. Its life as a blimp base ended, though several other users developed a presence here.

At the center of the base was a large blimp landing and mooring area. It is now the parking lot for the Miami Zoo, which occupies the southern part of the former base. Next to the zoo is the Gold Coast Railroad Museum, which makes use of the tracks that originally served the naval air station, and continued inside the hangars. The museum built sheds on top of part of the original footprint of one of the blimp hangars, and some concrete portions of the hangar survived the fire and demolition crews, and are now used by the railroad museum for storage and display.

Among the many interesting specimens of rolling stock is a US Bureau of Mines helium transportation car, of the type that supplied helium for blimps from the Bureau's Federal Helium Stockpile in Amarillo, Texas. The railway museum has a display

hall about the Richmond Naval Air Station itself, located inside a converted railroad car.

Looming above the railroad museum is a concrete tower topped by antennas. This is the only remaining column of four that once held 150-foot-tall doors — one on either end of the hangar. Other tenants of the former air station installed the antennas, taking advantage of the boost the tower provides, as one of the tallest objects around.

Partially because of this tower, the air station became a significant regional federal communications complex, with several different agencies operating on-site, including the FAA, Coast Guard, Air Force, Army, and the CIA, which used facilities here to spy on the Cubans for many years, and to direct attempts to overthrow Fidel Castro's regime in the 1960s.

The CIA continued to operate its Foreign Broadcast Information Service here until just a few years ago, transmitting programming directed at Cuba. Other federal operations continue inside a substantial restricted area covering the north end of the former air station.



Portions of the old hangar at Houma, Louisiana remain, used for storage by offshore oil production, supply, and engineering companies that have taken over the former blimp base.

CLUI photo

Houma Naval Air Station, near the city of Houma, Louisiana, was another of the eight blimp bases built during WWII. It operated until 1947, when it was transferred to the city, which has since operated the runways as a municipal airport, and the hangar area as an industrial park. The outlines of a few circular blimp mooring pads are still visible within the industrial park.

Houma is located southwest of New Orleans, in a town dominated by the oil and gas operations in the Gulf of Mexico, and the industrial park is full of oil field service companies. The airport is a busy place for helicopters ferrying workers to and from offshore platforms.

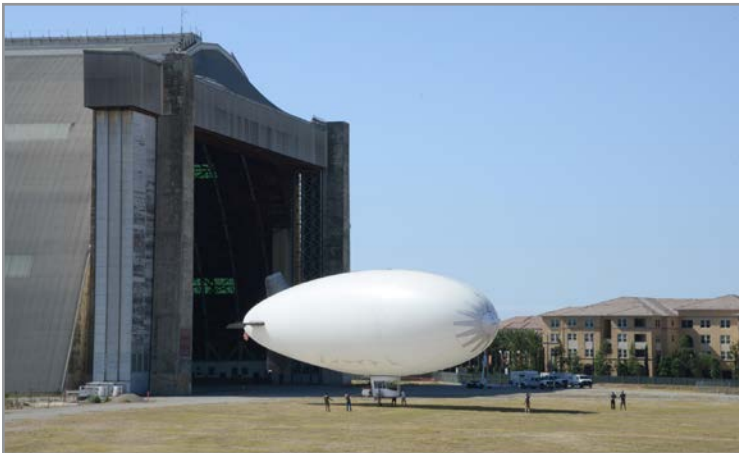
There was only one blimp hangar built here, and most of it disappeared ages ago. Its floor is used as a storage site and as a truck training site. The concrete beams that ran along the sides of the 1,000-foot-long hangar are still there, and have been partially filled in to make warehouses. Though it was a wooden hangar, like most of them built at that time, to conserve steel, the soft ground

## LANDSCAPE OF HELIUM

of southern Louisiana would not support the massive concrete towers that held sliding doors that were typically used on this type of hangar. Instead, doors at either end of the hangar were half domes, which moved aside on steel tracks.

The WWII blimp base at Hitchcock, Texas, near Galveston, like the other one guarding the Gulf of Mexico, at Houma, Louisiana, had only one hangar, and did not continue to be a military base for long after the war. It was sold as surplus in 1949, and purchased by a well-known Houston oilman, John Whitfield Mecom, who used the hangar and other buildings to service half-track vehicles used in the Korean War. In 1961 a hurricane damaged the wooden hangar, and it was demolished in 1962. Only the concrete portions of the hangar remain, including two pairs of towers that used to hold the 150-foot-tall doors. The site now operates as the Blimp Base Storage Company. Much of the site is used for open-air industrial and equipment storage, including things like electrical wind farm blades and parts, on their way to the interior of Texas. Another part of the base is an auto racetrack. The old headquarters building, identical to those at some other blimp bases, has been converted into a private home, with a swimming pool in the backyard.

Two blimp bases were constructed on the west coast during WWII, joining the pre-war base at Moffett Field, near San Francisco, in the defense of ships in the Pacific. In the south, the Santa Ana Naval Air Station, in Orange County, south of Los Angeles, was commissioned in 1942, and had the usual pair of 1,000-foot-long wooden hangars housing squadrons of blimps.



A small blimp being inflated and flown out of one of the two old WWII hangars at Tustin, California, in late 2018. The base, once known as Santa Ana Naval Air Station, is now surrounded by housing developments. CLUI photo

In 1949, the base was taken over by the Marine Corps, which operated the El Toro Marine Corps Base nearby. They used Tustin as a helicopter training base, until it was closed in 1999. Most of the property has been conveyed to the City of Tustin, and private developers. Housing has already been built, and much of the property's grounds have been graded. The fate of the blimp hangars themselves is still uncertain, and they are still owned, reluctantly, by the Navy. It seems unclear if they are an asset or a liability. Like many large buildings in limbo in Southern California, the hangars have been used by the entertainment industry, for advertising and films, including the 2001 film *Pearl Harbor*, and for other events, including an *X-Files* convention.

In 2013 the North Hangar was being used to build and test a massive airship prototype, being developed for the government by the Worldwide Aeros Corporation. In a windstorm, part of the roof fell in and damaged the craft. The company filed a \$65 million suit against the Navy for damages. Meanwhile, the roof has been stabilized by erecting two towers with cables strung between them, holding up the damaged part of the roof, for now. The south hangar is proving more stable, and can be rented out for \$9,000 a day, while its fate is being considered.



An inflated-looking cargo airplane, outside the WWII hangar at the former blimp base at Tillamook, Oregon, is part of the collection of an air museum that occupies most of the hangar. CLUI photo

The other west coast WWII blimp base was the Tillamook Naval Air Station, west of Portland, Oregon. Like most of the others, the station had two 1,000-foot-long blimp hangars, built out of wood in 1943, which housed eight blimps known as K-ships, the standard complement for blimp squadrons at that time. The base was decommissioned in 1948, and eventually became property of the Port of Tillamook Bay.

The Port of Tillamook Bay rented the hangars to a variety of tenants over the years, who used it primarily for storage. In 1992 the hangar known as Hangar A had several tenants, including one who stored 135,000 bales of straw there. A fire started in the straw, and the hangar burned to the ground. The concrete portions of the hangar remain, including two pairs of columns that held up doors at either end of the structure. The site has been leased to a composting operation associated with the local dairy industry.

Hangar B, undamaged by the fire, has been an air museum since 1991. The museum lost much of its collection in 2014, when the owner of most of the museum's WWII aircraft opened his own museum in Madras, Oregon. The condition of the hangar, including a leaky roof, was one of his reasons for removing his collection. The roof already has two layers of corrugated metal sheathing on it, and cannot bear the weight of another layer of material, so the owners, the Port of Tillamook Bay, patch what they can. Estimates to redo the roof run as high as \$15 million. It's a big roof.

The south end of the building is used for storage by a number of companies and individuals. The building is also used by the Stimson Lumber Company, which operates a lumber yard just outside the door. This is Oregon, after all.

## LANDSCAPE OF HELIUM



A 200-foot-long tethered aerostat blimp containing more than 2,000 pounds of radar gear, used by Customs and Border Protection at eight sites along the US/Mexico border. CLUI photo

### *TARS: Currently the Largest Use of Blimps*

Currently the largest use of helium-filled aircraft by the government, or anyone else in the USA, is for the Tethered Aerostat Radar System, or TARS. Like the blimp bases of WWII, TARS stations exist on the periphery of the nation — though in this case, focused on the southern border, not the east and west coasts.

There are currently eight active and three closed TARS stations in the continental USA, and one in Puerto Rico. They are part of a system watching for low-flying small aircraft that might be sneaking across the border, though they are also capable of seeing small boats and cars.

The unmanned blimps are held aloft, two miles up, with a nylon cord, spooled on a winch. Most of the sites use the TCOM/Lockheed blimp model known as the 420K, which hold 420,000 cubic feet of helium and are 208 feet long. Some facilities have used the smaller 275K model blimps, which hold 275,000 cubic feet of helium and are 186 feet long.

Both models are self-contained, with around 2,100 pounds of radar equipment powered by an on-board diesel generator. The blimps are winched down every few days to be refueled, or in heavy winds.

Radar data is transmitted wirelessly, and uploaded to a Defense Department data cloud. It is processed and analyzed in real time at the Air and Marine Operations Center (AMOC) at March Air Reserve Base, in Riverside, California.

The TARS site at Cudjoe Key, Florida, not too far from the naval station in Key West, was the first TARS site developed by the government. It opened in 1980, operated initially by the Air Force, which managed all TARS sites until July 2013, when the program was transferred to the US Customs and Border Protection division of the Department of Homeland Security.

Unlike the single aerostat at other TARS locations, Cudjoe Key operates two TARS blimps, out of adjacent facilities. One blimp has the usual radar platform. The other has transmission gear, used to broadcast US government radio and television programs aimed at Cuba.



Three of the TARS sites along the Gulf have been converted to other uses, such as the site at Morgan City, Louisiana, which is now a private helicopter base. CLUI photo

The Cudjoe Key and the Puerto Rico stations are the only TARS sites focused on the skies and waters of the Caribbean and the Gulf of Mexico. There were three other TARS stations along the Gulf Coast, but they have been closed, as there are other assets more effective at scanning the water for low-flying planes and boat traffic, including radar on board Coast Guard vessels and other shoreline radar. The three closed TARS sites on the gulf are abandoned, or repurposed. (The site at Horseshoe Cove, near the Florida Panhandle, now has a warehouse and factory for a metal roofing and metal building company on it. The one near Morgan City, Louisiana, is now used as a heliport by a local company, and the one at Matagorda, Texas, on the coast southwest of Houston, has not been reused by anyone yet.)

Six operational TARS locations are spread out along the terrestrial border between the USA and Mexico. Their effective range is around 200 miles, so they are less than 300 miles apart. Three are along the Texas part of the border (at Rio Grand City, Eagle Pass, and Marfa), and one, at Deming, covers the New Mexico part. In Arizona, there is one at Fort Huachuca, an Army communications and surveillance base, which was the second location to have an operational TARS blimp, in 1983 (after Cudjoe Key, Florida), and another at Yuma Proving Ground, which is the westernmost TARS, and covers the border along California to the Pacific Ocean.



The two circular TARS pads at the Cudjoe Key base in Florida. Google Earth image

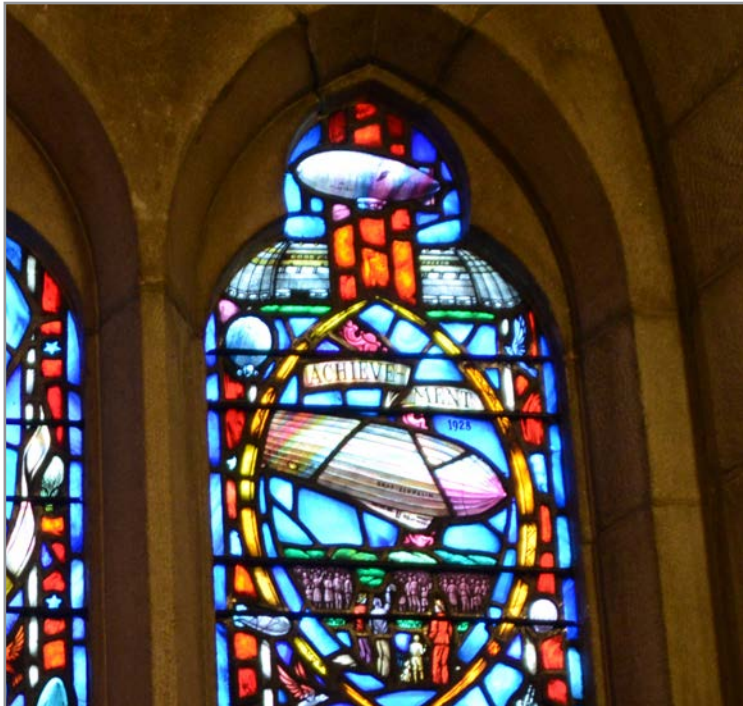


The Cathedral of the Air, built in 1933, between the crashes of the Akron and the Macon, is located at Lakehurst, New Jersey, the main base for much of the nation's airship history, and serves as a memorial for the hundreds of lives lost in airships over the years.  
CLUI photo

### *Back Down to Earth: Airship Crashes*

While helium strives relentlessly upwards, everything else falls away, back to the ground — often in bad ways. The three big American-made rigid airships — the Akron, Shenandoah, and Macon — all crashed within two years of being deployed (one in the Pacific, one in the Atlantic, and one in the middle, in Ohio). Our idea of airships is blighted with their failures.

Over the past 110 years, there have been dozens of crashes of airships in the USA, with more than 250 people killed. Some of these early crashes involved hydrogen, not helium airships, as hydrogen is easier to produce, and is even lighter than helium, but is flammable. It was the Roma crash in 1922 that compelled the US Navy to switch to helium, and by 1925, most US-based airships were converted to the safer gas. But the airships continued to fall.



The stained glass windows inside the Cathedral of the Air depict the history of human flight, including the airships that once flew outside this very window.  
CLUI photo

Goodyear's first airship, the hydrogen-filled blimp called the Akron (not to be confused with the later and much larger USS Akron), crashed. It was built for the photographer and explorer Melvin Vaniman in 1912. Vaniman was attempting to fly across the Atlantic Ocean (something he tried and failed to do the year before, in the French-built blimp America). The Akron was a rubber bladder more than 100 feet long, suspending a long gondola. Minutes after starting on its historic journey at Atlantic City, New Jersey, the Akron exploded, killing all five people on board. Parts, including the lifeboat, were recovered at sea.

Another early airship disaster in the US was in 1919, when Goodyear's Wingfoot Air Express, a hydrogen-filled blimp, ignited in mid-air over the Loop in downtown Chicago. Pieces of flaming debris fell through the skylight of the Illinois Trust and Savings Bank, killing ten employees and injuring 27 more. Three people on the ship were killed as well.

In 1922, the US Army airship Roma hit power lines at a base in Hampton Roads, Virginia and caught fire, killing 34 of the 45 crew on board. Later that year the Army and Navy announced that they would be moving away from flammable hydrogen as the lifting gas for airships, and moving to more inert helium, as soon as possible.



The site at the Gamary farm where the control car from the USS Shenandoah, breaking apart in the skies above, fell to the ground, killing its captain and some of the others on board.  
CLUI photo

The USS Shenandoah was the first of the four large rigid airships operated by the US, and was the first large airship ever built to use helium. It was assembled in 1923, in Hangar 1, at Lakehurst New Jersey, from parts manufactured at the Naval Aircraft Factory in Philadelphia. The airship was 680 feet long, and held 2.1 million cubic feet of helium, nearly all that existed in the US at that time. It had a range of 5,000 miles, and could travel at 70 miles per hour. In 1924 it was the first rigid airship to travel across the country.

In September 1925, two years after its first flight, the Shenandoah was on a promotional tour, visiting state fairs and such in the Midwest, when it broke up in a squall over southern Ohio. The ship fell slowly, blown around by the storm in pieces, sustained aloft because the helium was contained inside in individual cells.

The control car fell on the Gamary farm, where there is a memorial at the site, known as Crash Site 1. Four people landed with parts of the central section here, and survived. Others died in the control

## LANDSCAPE OF HELIUM

car, or by falling from the sky, including the commander, Zachary Landsdowne. The stern section fell about a mile west, at a site now next to Interstate 77. The spot has been marked with a large sign, visible to motorists on the highway. 18 people rode the stern section to the ground and survived. The bow section floated for a while longer, landing several miles away at the Nichols farm, where Ernest Nichols tied its dangling ropes to a tree. Seven people crawled out of the wreckage here. Of the 43 on board the USS Shenandoah, 14 perished, and 29 survived by riding the pieces to the ground.

In the hours and days following the crash, thousands of people flocked to the crash sites, taking parts of the wreckage as souvenirs. Some thousands still come to the small town of Ava today to visit the crash sites, especially around September 3, the anniversary of the crash.



The USS Shenandoah is memorialized in a mobile museum kept inside a garage in Ava, Ohio, a situation that resembles a blimp in a hangar. CLUI photo

The owners of the garage in town, Theresa and Bryan Rayner, became the chief local historians of the crash, directing people to the crash sites, and arranging memorials and displays. They made a museum about the crash inside a camper trailer they had towed away from a wreck on the highway.

The USS Akron was the first of two similar rigid airships made in the early 1930s, in Goodyear's giant hangar in Akron, Ohio. It was 785 feet long, the largest flying craft ever made in the USA. It flew for the first time in 1931, and was deployed to Hangar 1, in Lakehurst, New Jersey. It was destroyed in 1933, when it crashed into the ocean off the coast of New Jersey, killing 73 of the 76 crewmen on board.

As soon as the USS Akron was completed and left for Lakehurst in 1931, work began on the nearly identical USS Macon, in the vacated hangar in Akron, Ohio. When it was finished, two years later, the Macon was deployed to Moffett Field, California, to guard the west coast.

The Akron and the Macon were flying aircraft carriers, capable of holding five Sparrowhawk biplanes inside their belly, which flew ahead to search for enemy vessels. The Sparrowhawks were launched and captured with a trapeze system hanging under the access portal, snared by hooks on top of each plane. When the

airships were deployed over the ocean, the Sparrowhawks had their wheels removed, to save space and weight. The only place to land was back aboard the airship.

In 1935, two years after it was built, the Macon crashed into the Pacific Ocean, off the Point Sur Lighthouse, witnessed by lighthouse operators, who helped coordinate the rescue. The ship fell slowly, allowing time to put lifejackets on. 74 of the 76 crew on board survived.

The loss of the Macon put an end to the rigid airship program in the US. All future airships would be much smaller, and would be blimps, without a frame. The wreckage of the Macon still lies on the bottom of the ocean, more than 1,400 feet down, and has been documented by robotic submarines.



Window at the Point Sur Lighthouse, overlooking the area where the USS Macon crashed into the ocean. The wreckage rots away 1,400 feet below the waves. CLUI photo

The most famous airship crash, of course, is the Hindenburg, as it crashed over land and was witnessed by people amassed for its arrival, including film crews and radio broadcasters. The 800-foot-long vessel was one of two German-made and operated rigid airships that made transatlantic flights between Germany and Lakehurst, New Jersey. It was designed to be filled with helium, but it burned in this fiery way because it was filled with hydrogen. The US controlled the world's supply of helium, and banned its export, in part due to limited supply. The US stopped the use of hydrogen in airships by 1925, 12 years before the Hindenburg disaster. Amazingly, 62 of the 97 people on board survived.

After the end of the rigid airships of the 1920s and 1930s, blimps continued to crash, though in less dramatic and disastrous ways. In WWII, there were at least ten major blimp accidents in the US, resulting in a total of more than 50 deaths. Since the end of the naval blimp program in the early 1960s, there have been more than a dozen airship crashes in the USA, though only one with a fatality (when an experimental Forest Service blimp fell apart on a test at Lakehurst in 1986). One of the more unusual modern crashes occurred when a tethered JLENS aerostat became untethered in 2015.

Designed by Raytheon and TCOM in the late 1990s, the blimp was part of an experimental surveillance system, called the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System,

## LANDSCAPE OF HELIUM

JLENS, that had been developed and tested in several forms and at several places around the country. In 2015 it was at Aberdeen Proving Grounds in Maryland, when one of the two unmanned blimps in the system broke free and went on an uncontrolled trip into the sky, and down wind.

The 240-foot-long blimp had 6,000 feet of broken tether dangling underneath it, which when it descended, was dragged through fields and across power lines, knocking out power for more than 20,000 people. The blimp eventually was snagged by some trees near Clarkstown, Pennsylvania, more than 100 miles from where it broke free four hours earlier. Before it could get away again in the breeze, state police arrived on the scene and used shotguns to shoot it full of holes, to allow more of the helium to escape. Once sufficiently deflated, military personnel arrived to remove the sensitive equipment, and clean up. The JLENS program was later scrapped by the Pentagon, though other tethered aerostat programs continue to be developed. ♦

*Helium was the subject of an exhibition called Lighter than Air: The Rise (and Fall) of American Helium, which opened December 28, 2018 at CLUI Los Angeles.*

### CLUI DROPS IN ON BOMBING RANGES WITH LITTLE IMPACT

PHOTOGRAPHY, INTERPRETATION, AND BOMBING RANGES was the subject of an exhibit shown in the CLUI space in Los Angeles, March 30-August 5, 2018. Called *On Targets: Dropping in on American Bombing Ranges*, it was a research project first and foremost; an inventory of training ranges around the country, presented as a photographic installation, that looked at the act of looking, and the ways of seeing.

The show featured 14 framed images of circular targets at 14 different impact ranges, from coast to coast. The images, though, were not really photographs, but were high resolution screen grabs from Google Earth, selected for their aesthetic as well as graphic and contextual qualities from among hundreds of targets at dozens of locations, discovered by research and searching, scanning the online grounds of suspect areas, for bullseye targets to zoom in on.

The process of searching for targets, by scrolling over the online digiscape, finding them, evaluating them, and then isolating them as an image, printing, mounting, and framing, seemed to parallel the act of flying over the actual ground, looking for targets in space. And the act of looking at them on the wall, isolated, singled out, a frame around a mat, around an image of concentric circles within circles, shrinking to a central point, a crosshair marking a middle, like a gunsight, like a lat/long, coordinates on a digital or cartographic grid, marking a spot, exactly there, but also not there at all, instead in the analog of digital space.

But more there, too, as this thing, this target, would not even be discoverable, or at least visible, without this new digitized globe, that reveals all, in its limited way, making things that were there, but not there, too — but either way, in every way, On Target. ♦

## BOMBING RANGES



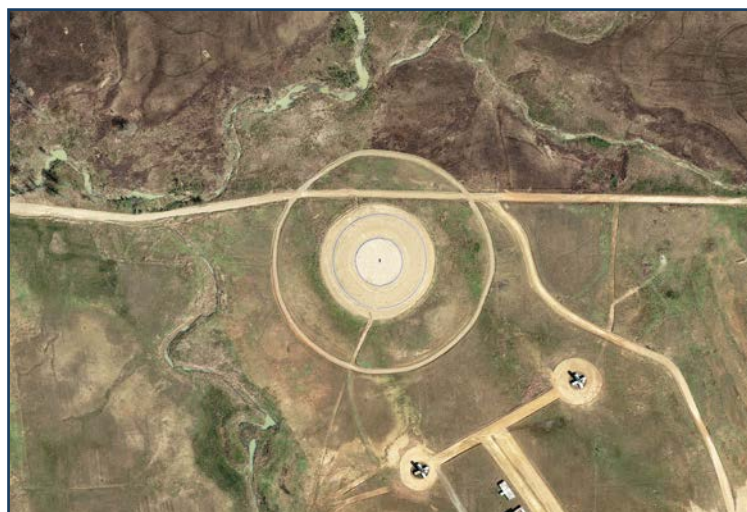
Zooming in from the CLUI *On Targets* exhibit . . .

CLUI photo



. . . to the photographs of the targets . . .

CLUI photo/Google Earth image

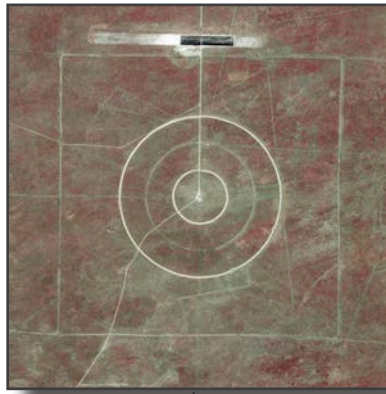


. . . to the image of the targets on the land.

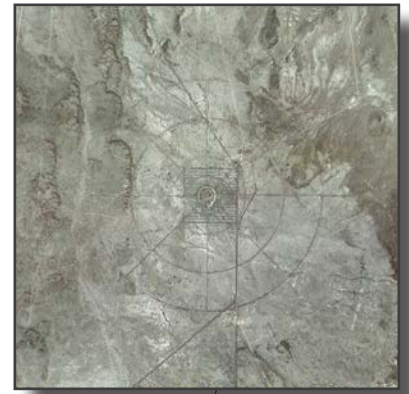
Google Earth image



Superior Valley Range  
California



Boardman Bombing Range  
Oregon



Dugway Proving Ground  
Utah

## ON TARGETS

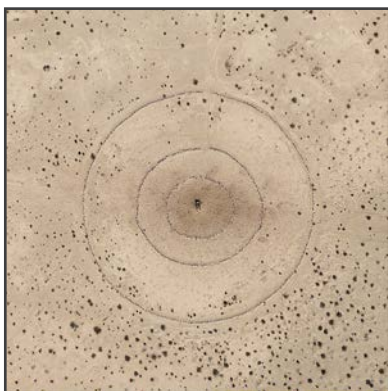
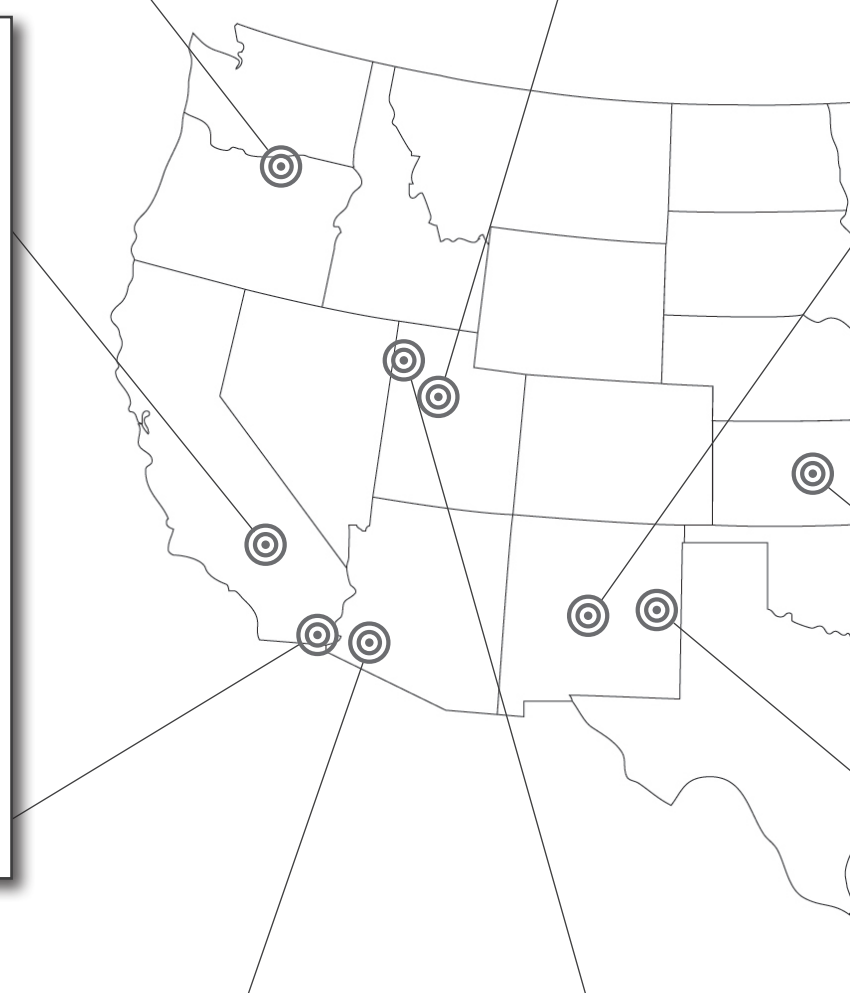
### Circular Samples from the Dozens of Impact Ranges Across America

There are all kinds of targets out there across the American land. They are square, triangular, rectangular, circular, and linear. Some are in the shapes of other things, like airbases, villages, convoys, industrial areas, surface-to-air missile sites. Old airplanes, trucks, tanks, cars, buses, boats, tires, mounds of earth, and empty shipping containers are used. Some targets are meant to be physically bombed or strafed, others electronically.

The most focused type of target, the classic target you might say, is circular, like a bullseye. It's simple geometric embrace of space defines a periphery, and center. Though largely two-dimensional when seen from above, shown as a gallery they have an cosmological air, whether a planetary hard mass pulled in by gravity, or a solar gas in a sustained continuous explosion. The tension between being drawn inwards toward the ground and exploding outwards is in equilibrium.

Some people say that these days everything is a target. These, however, undoubtedly are, and they are out there for the world to see, on internet-based satellite imagery providers, like Google Earth.

Google Earth images



Navy Target 68  
California



Barry M. Goldwater Range  
Arizona



Utah Test and Training Range  
Utah



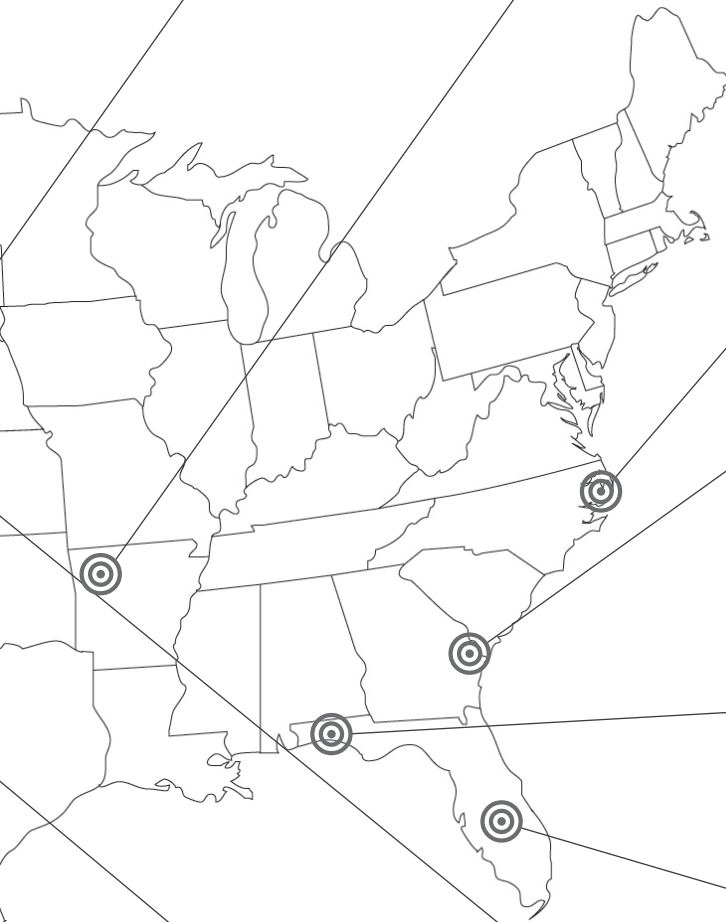
Oscura Range  
New Mexico



Razorback Range  
Arkansas



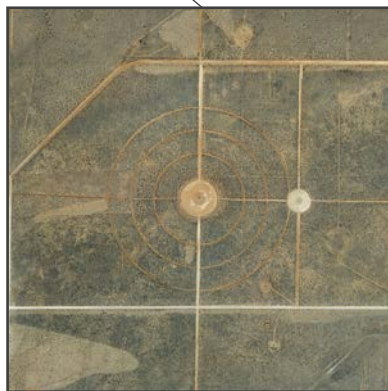
Dare County Range  
North Carolina



Townsend Bombing Range  
Georgia



Eglin Air Force Range  
Florida



Melrose Air Force Range  
New Mexico



Smoky Hill Air National Guard Range  
Kansas



Avon Park Air Force Range  
Florida



The CF Industries plant in Donaldsonville, Louisiana is the largest single source of nitrogen fertilizer in the nation, by far. Unlike potassium and phosphorus, which are mined from solids in the earth, nitrogen fertilizer is made into a solid (and liquid) out of natural gas, extracted from the earth. CLUI photo

*continued from first page*

## THE BASIC ELEMENTS OF FERTILIZER: NPK

### Nitrogen (N)

Nitrogen is prevalent in the earth's atmosphere, but in order for it to be absorbed into plants, it has to be fixed in the soil. This limitation on agricultural production was overcome by technology in the early 1900s with the Haber process, which uses gas to make ammonia, a highly reactive form of nitrogen. The Haber process created the synthetic fertilizer industry, and a global boom in agricultural productivity, dependent on fossil fuels extracted from the earth.

In the USA, dozens of companies produce nitrogen-rich fertilizer components at refineries that are fed by the nation's network of natural gas pipelines. A few companies dominate the industry, but none more than CF Industries. CF stands for Central Farmers, and the company was established as a distribution network for a federation of agricultural cooperatives in 1946, when the post-war synthetic fertilizer industry expanded.

In the 1950s, CF began to produce fertilizer components (in addition to distributing them) with a nitrogen production plant in 1954, a phosphate complex in Idaho in 1955, and potash mining in 1958. By the late 1960s, CF was on its way to being one of the largest distributors and producers of nitrogen, phosphate, and potash products in the USA. In 2005 it ceased to be a cooperative, and became a publicly traded corporation. Since then it has sold its potash and phosphate operations, focusing on nitrogen production.

Though the company has several plants around the country, CF's Nitrogen Production Complex in Donaldsonville, Louisiana, is by far the largest nitrogen plant in the country. The plant is located on the Mississippi River, in the nation's principal petrochemical production area, a 100-mile-long stretch of river lined with industrial facilities between Baton Rouge and New Orleans.

Gas lines feed the plant, and nitrogen products, in fluid and solid forms, are shipped out by railcars, trucks, and ships. The plant is connected to the Gulf Central Pipeline, an ammonia pipeline built in the late 1960s, that connects plants and terminals in agricultural areas as far away as Nebraska and Indiana.

CF began nitrogen production at the big plant in Donaldsonville in 1966, expanding it in the 1990s, and again in 2016, when more than two billion dollars was spent on increasing its capacity. It now covers 1,400 acres and produces five million tons of nitrogen products for agricultural and industrial use. The plant produces ammonia and UAN (urea-ammonium nitrate), the most common forms of nitrogen fertilizer feedstocks, as well as granular urea, a solid form of fixed nitrogen. CF Industries operates several other significant nitrogen production facilities in the USA, including two in Oklahoma, one in Iowa, and another in Mississippi.

Nutrien is the second largest nitrogen fertilizer producer in the USA. It was formed in 2018, with the merger of two Canadian companies, the Potash Corporation, and Agrium, both of which were already among the largest NPK fertilizer companies in the world.

Nutrien operates a nitrogen plant in Geismar, Louisiana, on the Mississippi River, a few miles upstream from the big CF facility at Donaldsonville. The company operates other plants in Lima, Ohio; Augusta, Georgia; Kennewick, Washington; and Borger, Texas. Borger is a convergence point for many petrochemical products pipelines, including the Mid-America pipeline, that carries ammonia from the Nutrien plant to the Upper Midwest, and connects to other nitrogen plants in Oklahoma, Nebraska, and Iowa.

Koch Fertilizer, LLC is the third largest producer of nitrogen fertilizers in the USA, and is part of Koch Industries, the multi-national energy and chemical company owned by the notorious Koch brothers, and often ranked as the second largest privately held company in the USA (after Cargill). Koch got into nitrogen in 1988, when it purchased ammonia pipelines that connect many of the plants in the USA with distribution terminals, such as the nitrogen fertilizer plant in Beatrice, Nebraska, which is located on the Mid-America Pipeline, a six-to-eight-inch-wide ammonia pipeline that runs from Borger, Texas to Mankato, Minnesota, more than 1,000 miles away.

Koch also operates a nitrogen plant near Fort Dodge, Iowa, located on the Gulf Central Pipeline, one of the longest pipelines of any kind in the USA, which runs for 1,900 miles, connecting nitrogen plants along the lower Mississippi to terminals in cropland as far away as central Nebraska and Indiana.

Though nitrogen fertilizer production in the USA is dominated by big companies like CF Industries, Nutrien, and Koch, dozens of other companies also produce the material in varying amounts. Trammo, for example, is a privately held international fertilizer commodities marketer, based in Manhattan, that operates terminals, train cars, and barges for ammonia, as well as a few plants. Another, Cherokee Nitrogen, operates a 160-acre plant on the Tennessee River, in Cherokee, Alabama, a few miles downstream from the former federal fertilizer research facility at Muscle Shoals.

The government's plant at Muscle Shoals was the American center for industrializing the Haber process for fertilizer, and explosives, another important use of ammonium nitrate. In WWI,

## INDUSTRIAL FERTILIZER

Muscle Shoals was likely the largest explosives production plant in the nation. After the war, with the coming of the Tennessee Valley Authority, the site was expanded into the Muscle Shoals Reservation, a diversified fertilizer and chemical production center, where more than 4,000 people worked at the peak of WWII. After that war, its phosphate production plants continued to make fertilizers, and chemical weapons. The innovations in industrial fertilizer production at Muscle Shoals were instrumental in creating the modern industrial agricultural revolution worldwide.

The chemical connection between nitrates for fertilizers and explosives are close, and several companies produce both, while others focus on one or the other. Apache Nitrogen, for example, was formerly known as the Apache Powder Company, and now produces ammonium nitrate for use as mining explosives, as well as for fertilizer at a plant located in a remote desert region of southern Arizona. Another company, the privately held Trademark Nitrogen Corporation, operates a nitrogen plant in an industrial park in Tampa, Florida, which supplies highly concentrated ammonium nitrate to explosives companies like Dyno Nobel.

Dyno Nobel — its corporate roots are with the Swedish inventor of dynamite, Alfred Nobel — is likely the largest explosives company in the USA. It operates two large ammonium nitrate plants in the country, one in Missouri, serving primarily the mining and quarrying industries in the south and eastern USA, and the other, in Wyoming, serving the larger-scale excavations of the west, including the coal mines of Wyoming's Powder River Basin.



The Dyno Nobel nitrate plant in the town of Louisiana, Missouri, is located on the Mississippi River, and supplies explosives to coal mines in Appalachia, and to quarries in Texas and Florida, as well as locally (including one of the largest cement mines in the nation, just up the river in Hannibal, Mark Twain's hometown). It also makes some fertilizer. CLUI photo

It is common for nitrogen plants to be sited within larger chemical production complexes, as they can symbiotically share feedstocks and byproducts. CVR Energy's nitrogen plant in Coffeyville, Kansas, for example, is next to its oil refinery. This plant is unique because it uses petroleum coke, a byproduct from the oil refinery, to make the hydrogen component of ammonia (instead of natural gas, which is typically used to do this).

Another example is AdvanSix's chemical plant in Hopewell, Virginia. The plant is one of the largest producers of caprolactam,

a feedstock for nylon. The creation of nylon (invented by the explosives and chemical company DuPont), involves a lot of nitrogen-related material, including ammonia, so the site is also a major producer of ammonium sulfates used for fertilizer.

In 2018, BASF and Yara opened their jointly owned \$600 million ammonia plant at BASF's chemical complex in Freeport, Texas. The plant uses hydrogen (produced at the massive Dow Chemical plant next door) to make ammonia, instead of using natural gas. BASF, a German company that is often ranked as the largest chemical producer in the world, was the company behind the Haber process, initiating the large-scale production of synthetic nitrate fertilizers in the first place.



Nitrogen and phosphate production (the N and P of NPK) are chemically closely related, and sometimes share facilities. The Mosaic Company's Faustina Plant in Donaldsonville, Louisiana, next to CF's Nitrogen Complex, is one of the largest ammonia plants in the country. Rather than producing ammonium nitrates (the N of NPK) it produces ammonia for ammonium phosphate fertilizers (the P of NPK). It is fed by a stream of phosphoric acid, which comes to it via pipeline from another Mosaic plant across the river. This is just one of several major plants operated by Mosaic, a company that dominates phosphate production even more than CF dominates nitrogen. CLUI photo

### THE BASIC ELEMENTS OF FERTILIZER: NPK

#### *Phosphorus (P)*

Phosphorus is essential to root growth and other plant functions. It is naturally found in most soils, but in limited amounts. Therefore, soil is commonly enhanced with fertilizers, including phosphorus (the P in NPK). Phosphorus can be found in things like bone meal, but the largest source is from phosphate rock deposits, associated with ancient sea beds.

The United States was the world's largest producer of phosphate rock from the end of the 19th century until 2006, when US production was exceeded by China. Today the US still supplies more than 20% of the world's phosphates, and 75% of that comes from one region in central Florida called the Bone Valley. The Bone Valley phosphate formation underlies hundreds of square miles in central Florida, a region that has been transformed by a hundred years of phosphate mining.

Dozens of companies have been active here in that time. Engaged in strip mining, draglines (giant shovels on cranes) are used to uncover the layer of phosphorus rock that lies ten to 50 feet below the surface, to dig it out for further processing into fertilizer. This

being Florida, groundwater is just a few feet below the surface, and the process of extracting the rock is a wet one. Puddles, pools, and ponds of curious shapes are created, making a complex landscape.

Increasingly, reclamation has gotten more organized, and the land is often leveled and reengineered for reuse, as tomato fields, golf courses, wildlife areas, recreational parks, and other developments. Much, however, remains off limits, as the residual effects of phosphate processing leaves chemical remains, which have to be contained almost perpetually.

Companies that have operated here over the years include ARCO, Agri-Chemicals, Beatrice, Cargill, Conoco, Conserv, Estech, Kaiser, Kerr-McGee, IMC, PPG Industries, the Williams Companies, and CF. After decades of mergers and acquisitions, today the Bone Valley is basically owned and operated by one company, Mosaic.



The historic center of phosphate mining in the Bone Valley is the town of Mulberry, 30 miles east of Tampa, where mining companies have supported the creation of a phosphate mining museum. The galleries are inside old railroad cars, and have colorful displays about the industry. A more conventional museum display is located in an adjacent building, which showcases the fossils that have been uncovered in the process of unearthing so much earth. The chemistry of the phosphate deposit, created by ancient seas, preserves fossils well, which explains the region's name, Bone Valley. CLUI photo

Mosaic is a new company made up of old companies, formed in 2004 by merging Cargill's crop nutrition division and IMC Global, both of which were already among the largest fertilizer companies in the nation. Headquarters are in Plymouth, Minnesota, just a couple miles up the road from the headquarters of Cargill, which remains the nation's largest privately held company. The merger instantly created the largest US-based producer of potash and phosphate fertilizer.

Mosaic owns almost 300,000 acres in the Bone Valley, and leases the rest of what it needs, with expansion plans for two more mines in the southern end of a mined and potentially mineable area of 40 by 80 miles. Mosaic operations officially list two active production plants in the Bone Valley, fed by four active mines; however, the company keeps busy throughout the region, managing dozens of former mines, ponds, tailings piles, plants, and waste sites, covering hundreds of square miles.



Mosaic's Four Corners Mine is currently the largest of its active mines, producing 6.4 million tons of phosphate rock in 2017 (out of a total of 15 million tons produced by the company globally). The mine covers 12,000 acres, and employs around 500 people. Another, Mosaic's South Pasture Mine, is one of a few phosphate mines and plants that Mosaic acquired from CF Industries in 2014, when CF sold its phosphate and potash facilities, to focus on nitrogen. CLUI photo

Each mine is really a network of surface excavation areas, overburden storage, water retention ponds, berms, ditches, pipelines, pumping facilities, and preliminary processing plants.

The first step in the mining process is to dig trenches and berms around the immediate area to be mined, so that some of the groundwater drains into the perimeter ditch, keeping the mining area from becoming more of a mud puddle than it already is.

Then draglines remove the sandy soil that covers the ore body, some ten to 50 feet below. Mosaic has around 20 draglines in the area. The company says they are the largest earth-moving machines on the planet. They run on 72,000 volts of electricity, and have two operators.

After the outer layer of overburden is moved to the side, draglines extract the ore body, known as the matrix, which is around 1/3 clay, 1/3 sand, and 1/3 phosphate rock. Each scoop of matrix is dumped in a pool, where high-powered steerable water-jets break down the material into a slurry. The slurry goes in a 20-inch pipeline to the beneficiation plant.

Each mine site has a beneficiation plant, a large facility, which, by washing, screening, flotation, and other means, separates the sand, clay, and ore. The sand is stored until it is used for filling in mine pits, and the clay goes to clay ponds, as a slurry.

The clay ponds are generally around a square mile in size, and grow to be 40 to 50 feet tall, as more and more clay is deposited. The water leaches out of the clay into pipes controlled by a valve at the bottom of the pond. The clay ponds are also used to store water, which helps keep dust down.

The phosphorus rock material, separated and dried at the beneficiation plant and in granular form, is shipped by train to processing plants, to be turned into fertilizer products. Other source material is moved by slurry pipeline, where it is dried out at the processing plant.

## INDUSTRIAL FERTILIZER



Mosaic has a few processing plants in the Bone Valley, one of which is the Bartow Facility. The Bartow Facility produced more than two million tons of processed phosphates in 2017, out of a company-wide total of nine million tons. Over that time it also produced a million tons of phosphoric acid, out of a company-wide total of five million tons, which is about 10% of world production, and 60% of North American production. CLUI photo

The initial material produced at Mosaic's processing plants is phosphoric acid, which is created by combining processed phosphate rock with sulfuric acid. Sulfur for creating sulfuric acid comes to the plants by rail or truck from oil refineries, where it is an abundant byproduct. Mosaic owns a sulfur terminal in Houston (for shipping sulfur) and another in Tampa (for receiving it).

The principal finished product produced at these plants is diammonium phosphate (DAP), which is made by combining phosphoric acid with anhydrous ammonia. This combination produces slurry, which is pumped into a granulation plant and mixed with more ammonia to produce DAP, a solid granular product that is applied directly or blended with other solid plant nutrient products such as urea (N) and potash (K). It takes more than 1.5 tons of phosphate rock to make one ton of DAP. Most Mosaic plants also produce monammonium phosphate (MAP), which is similar to DAP, but has more phosphorus. The plants also produce a bulk fertilizer product called MicroEssentials, an ammonium phosphate product with additional micronutrients, like sulfur and zinc.

When phosphate rich ore is mixed with sulfuric acid to make phosphoric acid, it produces phosphogypsum as a byproduct,



In 2016, a sinkhole formed under one of the two cells in the active gypstack at the New Wales Plant, causing process water to drain into the sinkhole. Close to \$100 million has been spent to fix the problem. Together Mosaic's gypstacks in Florida and Louisiana contain an estimated 60 billion pounds of hazardous waste, along with billions of gallons of acidic wastewater. With pressure from lawsuits, the EPA, and state governments, the company has recently agreed to develop a two-billion-dollar fund to address the problem. CLUI photo

which is piled high at these plants in a waste mound known as a gypstack. The material arrives as a slurry, and a liquid pond is usually present at the top of an active gypstack.

Mosaic has two currently active processing plants in the Bone Valley (the Bartow Facility, and the New Wales Plant), as well as some plants on standby. It also has major production plants outside of the Bone Valley, including the Riverview Plant, on Tampa Bay. Because of Mosaic's operations inland and on the shore, Tampa Bay is the largest port for phosphates and nitrates (ammonia) in the nation. Mosaic's Tampa Marine Terminal is a storage and shipping facility, used for the export of DAP and MAP, the two primary phosphate fertilizers it produces at its three active central Florida plants. From here the material is shipped by barge around the Gulf Coast, and up the Mississippi to the corn belt and other agricultural areas.

Mosaic uses facilities at the port to receive and store the large amounts of anhydrous ammonia it needs to make phosphoric acid and other products at the plants. One of these is the Hookers Point Terminal, acquired from CF Industries, with a 38,500-ton ammonia storage tank and a deep water dock. The terminal is connected to a 75-mile underground pipeline system that delivers ammonia to the Riverside Plant, and to the other plants in the Bone Valley. Ammonia is normally a gas, so it is kept pressurized in order to condense into liquid form for storage and transport. Around two million tons of ammonia comes into the Port of Tampa in this form every year, to feed Mosaic's production. The ammonia comes by tanker ship from Mosaic's ammonia production facility at Donaldsonville, Louisiana, and from other nitrate companies, like CF Industries.



Entrance to the "largest integrated phosphate mining and chemical plant in the nation," Nutrien's phosphate mine and processing plant in Aurora, North Carolina. CLUI photo

Mosaic is not the only phosphate fertilizer company working in Florida and Louisiana. Though it is more prolific in its production of nitrogen and potash fertilizer products, Nutrien is the second largest phosphate fertilizer production company in the USA. It operates two mining areas, one in Florida, and the other in North Carolina, as well as one in Canada, where the company is based. These facilities were previously operated by the Potash Corporation until 2018, when Nutrien was formed by the merger of that company and Agrium, its chief competitor.

## INDUSTRIAL FERTILIZER

Nutrien's Florida operations are in the northern part of the state, near the border with Georgia, and cover a ten by ten square mile region around White Springs, most of which has literally been turned over by years of strip mining phosphates, with two separate production plants. Nutrien is also the new owner of PotashCorp's phosphate mine and plant in Aurora, North Carolina. Not as vast as the northern Florida site, the Aurora operation, measuring six miles by six miles, is large enough to be called the largest integrated phosphate mining and chemical plant in the nation, since it has just one plant, surrounded by its mines and waste ponds and piles. The mine produces around five million tons of phosphate ore a year, which the plant turns into around one million tons of phosphoric acid.



Monsanto's plant in Soda Springs, Idaho, one of three major phosphate plants in southeastern Idaho. CLUI photo

There is another cluster of phosphate mining and fertilizer production in the western United States, centered around a remote corner of southeastern Idaho, where a Permian-age sea bed deposit known as the Phosphoria Formation is mined. More than 30 mines have operated there over the last century. Today there are a half dozen or so active mines, operated by a few different companies, and they are small and scattered compared to the operations in Florida and North Carolina.

Three large processing plants process the phosphates produced by these mines. One of them is the Conda Phosphate Operation, near Soda Springs, which produces approximately 540,000 tons per year of mono-ammonium phosphate, super phosphoric acid, merchant-grade phosphoric acid, and other specialty phosphate products. It is owned by Itafos, a Canadian phosphate fertilizer company, based in the Cayman Islands. Itafos recently acquired the operation, including some of the mines in the area, from Agrium, after regulators required Agrium to divest itself of some phosphate assets in order to join with the PotashCorp to become Nutrien.

Nearby is Monsanto's Soda Springs Phosphate Plant, which has been operating since the 1950s. It is currently supplied mostly by the Blackfoot Bridge Mine, the latest of several mines that have supplied the plant over the years.

Monsanto, based in St. Louis, is one of the largest and longest lasting agrochemical companies in the USA, notorious in more

recent times for genetically engineering crops controlled by its branded herbicides. In June 2018, the company was officially sold to Bayer, the German life sciences corporation, which announced that it would be discontinuing the use of the Monsanto name.

Despite the end of "Monsanto," it is expected that the plant will continue to operate, as its capacities are unique, producing elemental phosphates used for foods, chemicals, fertilizers, and the company's signature herbicide, Roundup. As a functioning superfund site, it will have to be maintained as an environmental management site for a while to come. Over the years its gypstack has been a local attraction, as cauldrons of glowing molten slag can sometimes be seen being dumped over the edge of the continuously growing mound, and flowing down like lava.

The third big phosphate plant in the region is the Don Plant, in Pocatello, operated by Simplot, with a growing black gypstack behind it, too. The plant has been operating since 1944, when it was the first fertilizer production facility built by the J.R. Simplot company. It produces more than a million tons a year of phosphate fertilizers, feed phosphates, and industrial products from around 1.7 million tons of phosphate ore annually, which comes from its Smoky Canyon Mine, in southeast Idaho, next to the border of Wyoming.

Simplot's Smoky Canyon Mine was developed in the mid-1980s and has a beneficiation plant on site, which refines and grinds the ore into a powder. It is then mixed with water and moved via an eight-inch-diameter pipeline to the Don Plant, 86 miles away.

The Don Plant is the largest of four fertilizer plants operated by J. R. Simplot. Another is an isolated facility outside of Rock Springs, Wyoming, where the company makes monoammonium phosphate (MAP), as well as phosphoric acid. The Rock Springs plant was built by Chevron in the mid-1980s, and was taken over by Simplot in 2003. The company recently built a \$300 million ammonia plant at the site, which supplies the Don Plant with ammonia too. The phosphate ore for the Rock Springs Plant comes from a mine north of Vernal, Utah, and is conveyed to the plant through a pressurized slurry pipeline 96 miles long.



Idaho-based Simplot, famous for its potatoes (the company is credited for inventing the modern French fry), is a major phosphate producer, operating the Don Plant in Pocatello and the Rock Springs plant in Wyoming. CLUI photo

## INDUSTRIAL FERTILIZER

### THE BASIC ELEMENTS OF FERTILIZER: NPK

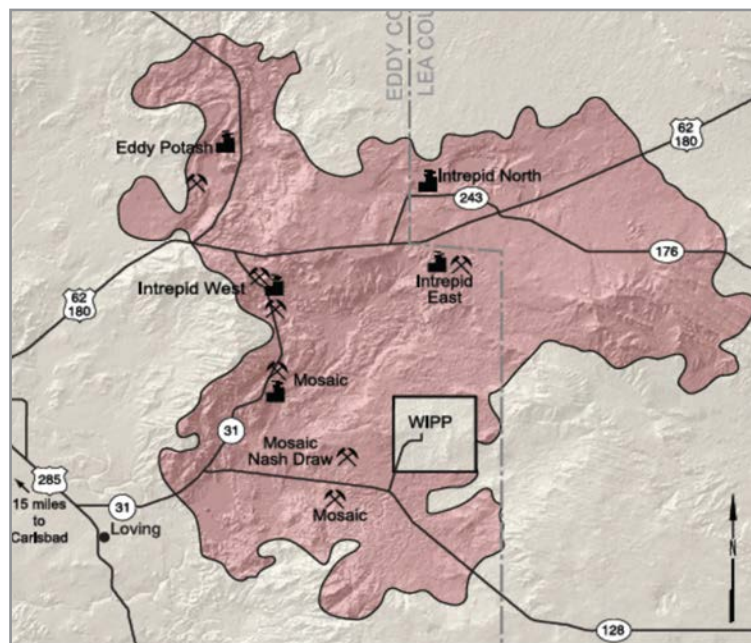
#### Potassium (K)

Potassium facilitates growth, photosynthesis, and other critical functions in plants. For fertilizer, it is mostly extracted from potash, which is found in salt deposits underground and on the surface (potassium's elemental symbol K is derived from kalium, Latin for alkali).

Of the millions of tons of potash fertilizer used in the USA annually, most comes from other countries, especially Canada. 15% or so comes from domestic mines, and nearly all of that from three underground mines in southeastern New Mexico, with a little more from around the Great Salt Lake in Utah.

Three mines, producing 80% of the potash in the USA, are in the Carlsbad Basin, in the southeast corner of New Mexico. Potash was discovered here in the 1920s, and underground mining was underway substantially by the late 1930s, when the federal government set aside 43,000 acres to encourage potash mining over other uses. After a boom in production spurred by demand for explosives in WWII, the federal Designated Potash Area was expanded to cover nearly 500,000 acres. Oil and gas production, active in the region, has noticeably fewer wells inside the Potash Area.

Over the years mines and processing plants have opened and closed in the area, and mining companies have changed names and ownership. Today two companies own and operate the mines, which have left an interconnected complex of rooms and pillars a thousand feet below the surface, under an area that is around 20 by 25 miles in size.



Map showing principal current mines and approximate boundary of the federal Designated Potash Area of southeastern New Mexico, half a million acres, where drilling for oil and mining other minerals is restricted, in the interest of maintaining a potash industry. (In 1973, 16 square miles were removed to accommodate the nation's federal nuclear waste facility, WIPP.)

Map after Bajer and Gundilier, via the BLM

The largest of these operations is the potash mine and plant at Laguna del Sol. This plant and mine complex was operated for decades by IMC Global, which is now owned by Mosaic. Based in suburban Minneapolis, Mosaic, the largest US-based producer of phosphates, is also the largest US-based producer of potash. This, though, is the only potash mine owned by the company in the USA (most of its potash comes from mines in Saskatchewan).

The mine has been operating since 1940. It extends horizontally underground more than 12 miles from the plant, which sits on top of the main shafts. 700 people work at the plant and underground, running ten continuous mining machines, cutting out langbeinite and sylvite ore from two separate mine layers, around a thousand feet below the surface. This is turned into more than a million tons of potassium fertilizer products annually.

Mosaic's operation is one of the largest underground mines in the nation, but it is smaller than the other network of mines in the area. This other network, under the northern part of the Designated Potash Area, has a number of connected mines, most of which are now owned by another company, Intrepid Potash. Intrepid, based in Denver, is the only US company dedicated solely to producing potash in the USA, and produces more than anyone else, from these two mines in New Mexico and two in Utah.

Located a few miles up the road from Mosaic's plant is Intrepid's West Mine facility, with two shafts connecting to a mining area with around 13 square miles of underground rooms and pillars. Above ground is a plant and a tailings pile covering a square mile. Opened in 1931 by the American Potash Company, this was the first potash mine in the region. Later it was owned by the Mississippi Chemical Company, until 2004, when it was purchased by Intrepid.

Over a period of more than 80 years, the West Mine extracted and crushed sylvite rock, which was turned into muriate of potash (the most common form of potash fertilizer) at the West Plant, and shipped by truck to the nearby North Plant for final processing and storage. In 2016, Intrepid placed the facility on care and maintenance status, idling mining there indefinitely, focusing its operations on other mines in the area.

Near the West Mine is a set of evaporation ponds covering a square mile. Intrepid built them a few years ago as part of a new potash mining operation known as the HB Solar Solution Mine, a hydraulic mining operation. The evaporation ponds hold water that has been pumped through flooded underground mines, dissolving ore from the walls and pillars, to settle and dry out here. After a year or so the dried residue is scraped up and processed into potash fertilizer.

Construction on the HB solution mine project began in 2012, and is costing up to \$300 million, as it involves miles of pipelines and other infrastructure, including six injection wells that pump salt water into disused underground mines, and five extraction wells that pump it out and convey it to the ponds.

## INDUSTRIAL FERTILIZER



The ruins of the former Eddy Potash Plant, bought by Intrepid Potash in 2004, sit on top of the underground mine workings, a thousand feet below, being flooded with the HB Solution Mining operation. CLUI photo

Four disused underground mines, including the Eddy Mine, connect underground, in a complex that covers nearly 50 square miles of room and pillar space. The solution mine flushes water through the rooms, creating underground leach lakes that dissolve pillars that were left to hold up the ceiling, but which are no longer needed. Up to 200,000 tons of potash a year is expected to be generated from the HB Solar Solution mining operation, for a run of 28 years. The company may expand the solution mining operations to cover more of the abandoned mine workings in the region, if all goes well.

Intrepid's East Mine is an underground potash mine started by Kerr McGee in 1965. It was part of Mississippi Chemical's operations when it was purchased by Intrepid in 2004. The East Mine is the largest of the underground mines in the area now owned by Intrepid. Around 25 square miles of room and pillar space has been excavated, and connect both the North and the West Mines. The working mine walls can be six miles from the shaft sites, making for long underground commutes for workers.

Still a dry mine, a few hundred people work in the East Mine, and mill. It stopped producing muriate of potash in 2016, and now focuses on mining the langbeinite ore body layer, which produces a more valuable form of potash with a lower chloride content, favored by higher value crops like citrus, vegetables, and sugarcane.



Intrepid Potash's Cane Creek Mine, near Moab, Utah, an underground solution mine where the company first developed its solution mining expertise. CLUI photo

Intrepid learned about in-situ solution mining, which it applied in the HB Solution Mine project in New Mexico, at its mining complex outside of Moab, Utah, the Cane Creek Mine. In 1963 the TexasGulf Company opened Cane Creek as an underground potash mine, seeking to diversify from its increasingly obsolete sulfur operations in Texas and Louisiana. Soon after the mine opened, 18 people died in an explosion 3,000 feet below the surface.

It was converted into a solution mine in 1970, using water from the adjacent Colorado River to flush out the potash, no longer requiring people to work underground. Intrepid (Intrepid Oil and Gas Company at the time) bought the mine in 2000, and changed its name to Intrepid Potash. The mine can produce between 75,000 and 120,000 tons of potash annually, depending on evaporation rates, which vary widely, depending on temperature and rainfall.

After purchasing the Cane Creek Mine, Intrepid went deeper, and shallower, into potash, acquiring underground mines in New Mexico, and a surface mining operation in Wendover, Utah.



Intrepid Potash's Wendover plant. Potash has been mined from the Bonneville Salt Flats for more than 100 years. With potash's chemical connection to salt beds, it makes sense that the Bonneville Flats, the largest saltiest salt flat in the nation, was among the first places to be commercially mined for potash. CLUI photo

Wendover's potash production dates back to WWI, when the Utah Salduro Company extracted potash here from 1917-1921. After that, operations ceased until WWII. In 1939 operations began again, expanded into almost 100 square miles of ponds and canals. Kaiser Aluminum and Chemical Corporation took over operations in 1964. When Intrepid took over in 2004, the mine was owned by Reilly Industries, one of the few remaining family-run chemical companies, which dissolved the following year.

The process involves around 100 miles of ditches, 20 feet deep, dug into the salt flats. With the water table just a few feet below the salty and muddy surface, the ditches immediately fill with water containing the dissolved minerals of the region held in solution. The ditches lead into a central canal — the mother canal — which ends at a pumping station.

The water is pumped into a network of evaporation ponds, first dropping out salt, which is scraped off and sold or dumped. The water moves on to a harvest pond, where it dries into a briny potash slurry, and then is scraped up and taken to the plant where it is crushed, flotated, and dried to become muriate of potash.

## INDUSTRIAL FERTILIZER

For more than 50 years, the plant has produced between 65,000 and 100,000 tons of potash a year, depending on the weather (especially rain, which dilutes the ponds).



The beginning of the Behrens Trench, where concentrated brine from the impoundments at Clyman Bay travels in an inclined subaqueous trench across the bottom of the Great Salt Lake, to a potash plant on the other side. CLUI photo

The nearby Great Salt Lake, at the bottom of the Bonneville Basin, is a terminal lake, with no drainage to the ocean. All the minerals from the surrounding mountains fall into it, layering onto its bottom, or dissolving in its water, which becomes fully saturated with minerals by the relentless evaporation from the sun and dry air. And so, the waters of the lake itself are a mineral resource, mined by a few companies, including one that extracts potash in an elaborate, vast, and flat mining process.

On the northwest end of the lake, where the water is made even saltier by the railroad causeway that divides the lake in half, the Compass Minerals Company pumps water from the lake into evaporation ponds next to the lake, in an area known as Clyman Bay. After the heat and dry air of the region further concentrates the water in this pond, it is released into a canal heading east into the lake.

The canal continues across the lake, underwater, cut into the bottom, and continuously sloping downwards, as it heads eastward. Because brine released from the pond is denser and heavier with salts, it stays inside the canal, flowing slowly — water within water. The canal, called the Behrens Trench, was built in 1991 by the Great Salt Lake Minerals and Chemicals Company, which operated the salt and potash plant on the lake at that time. It is unique in the nation, if not the world. Dredges keep it maintained.

Taking a week or so to ooze its way to the other side (a distance of 21 miles) the brine is pumped out of the east end of the trench and over the railroad tracks of the causeway, into a more normal canal heading east along the shore of Promontory Point. The canal system ends at the older and larger pond complex at Bear River Bay, next to a potash plant that has been operating here since the late 1960s.

Here the lake brine, with additions from the more immediate waters of the lake, is slowly cooked, taking up to two years to reach the right concentration. The pregnant brine then enters the plant, where it is processed into sulfate of potash, a form of potash fertilizer that is used on high value crops, like fruits and nuts. Much of it is purchased by citrus growers in Florida.

Compass Minerals, based near Kansas City, took over the operation in 2003, and makes around 350,000 tons of sulfate of potash fertilizer here annually. They also produce a couple of million tons of salt, used on roads and in industry.

The two antithetical products, salt and fertilizer, one which helps plants grow, the other which kills them, come from the same salty place, and are separated from one another to perform disparate functions. Eventually, of course, they merge again, as nearly everything does, in the oceans that cover the planet. ♦

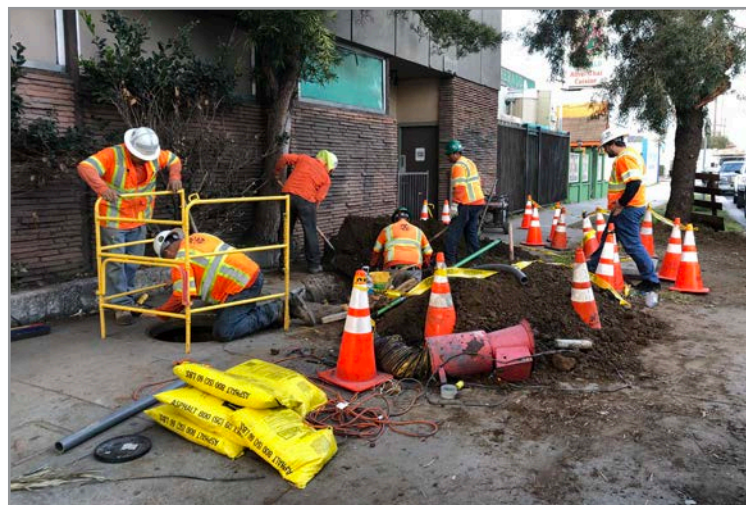
*Industrial fertilizer in America was the subject of an exhibition at the CLUI in Los Angeles from August 10-December 23, 2018, called The Ground Our Food Eats: Industrial Fertilizer Production in the USA.*

### CLUI VISITORS AND VISITATIONS CLUI ON THE ROAD OR AS A STOP ON THE ROAD

CLUI PROGRAMS FOUND THEIR WAY into several exhibitions at other institutions throughout the year, including an exhibit called *Environment(al)*, at the Southern California Institute of Architecture, and another, called *The Expanded Field*, organized by Askeaton Contemporary Arts and Lismore Castle Arts, in Ireland.

CLUI representatives presented lectures at colleges and universities throughout the Los Angeles area, as well as in New York (at the Swiss Institute) and in Europe, including at the University of Exeter in Cornwall, UK; the Institute of Design and Technology in Dublin, Ireland; and a convening on creative interventions in post-mining landscapes at the Wheal Martyn Museum in Cornwall.

Classes and school groups came by the CLUI HQ in Los Angeles for talks and presentations, too, including from the New York Institute of Technology, University of Southern California, Albuquerque Academy, Washington University, University of Michigan, Claremont College, Boston University, and the University of Nebraska. ♦



Some people really dig the CLUI! Like this crew working outside our front door in December, 2018, tapping into a fiber optic line under a manhole cover in the sidewalk. Bandwidth is expanding around us, with Amazon and Apple moving into new buildings a block or two away. CLUI photo

## CLUI WALLOWS IN WEST TEXAS

GENERATES HYPEROBJECTIVE OVERVIEW OF BIG PLACE

IN A CONTINUOUS SEARCH FOR the sizable, the CLUI zeroed in on West Texas in 2018, and created an exhibit called *50 Big Things in West Texas*, which was on display in the West Texas town of Marfa.

50 sites were selected to characterize the place, and were presented through images and text in an interactive “overlook.” Sites were selected because they were big, or because they expressed components of the bigness that exists out there in West Texas like nowhere else. West Texas is where things have room, so big things come here, as well as come from here.

First thing to do, though, is define our boundary — where exactly is West Texas? We know that West Texas funnels westward to a point at El Paso. But where it begins, in the east, is a matter of opinion. We can probably all agree that it begins somewhere further west than just the “west half” of Texas. It is also somewhat determined by a change in moisture level, and topography. It is also different things to different people, depending on where they are. Since we had to draw a line, somewhere, we put it from the eastern edge of the Panhandle, through Abilene, to Del Rio, on the Rio Grande. This, we figure, is about as big as West Texas can be.



Once we had the area of study established, we went to work searching for big things, starting in the CLUI Land Use Database, and then to Center’s library, as well as online sources, to learn everything we could about the region’s major land uses. Then, of course, we headed to GoogleEarth, conducting an exhaustive overview, identifying and flagging features and sites. Then we went to ground, visiting the places, especially those that were new to us, filling in the gaps in our database with more ground-based imagery and site visits.

Some of our findings were obvious, but overwhelming just the same, like: The Panhandle has a heck of a lot of cattle feedyards (dozens, including six owned by Friona Industries), several large meatpacking plants (like the JBS meatplant at Cactus, the Cargill plant at Friona, and the Tyson plant at Amarillo), and some of the biggest dairies and industrial cheese production plants in the land (like the Hilmar Cheese Plant in Dalhart).

It seems we just can’t say enough about the Panhandle capital of Amarillo, with its curious big industries, like the Federal Helium Reserve, Asarco Copper Refinery, Bell Helicopter Plant, and Pantex, the nation’s only nuclear weapons assembly plant; and its big art, mostly commissioned by Stanley Marsh III, like *Cadillac Ranch*, *Amarillo Ramp*, *Ozymandias*, and *Floating Mesa*.

Lower down the Panhandle, south of Amarillo, is the bigger West Texas city of Lubbock. Lubbock’s sense of play comes more from the music side of the arts, from Buddy Holly, through Joe Ely and Terry Allan, and notable creative landmarks like the Stubbs BBQ joint memorial, and Robert Bruno’s steel house in Ransom Canyon. The formal purity and integrity of Lubbock’s functional modernist architecture dominates the expansive commercial parts of town, and culminates in the cotton sheds and seed refineries, massive sheet metal sheds, veritable cathedrals of cotton.

Surrounding nearly everything, from the Panhandle on down, and westward over the Permian Basin, is oil and gas production, coalescing into likely the largest contiguous gas extraction space in the whole of the USA (covering Denver City, Andrews, Midland, Odessa, and beyond), with gas gathering and processing plants all over, including big ones like Kinder Morgan’s CO2 plant in Snyder, and Occidental’s gas plant in Seminole, and refineries at Sunray, Big Spring, and Borger, towns that also have those oh so dark and dusty carbon black plants, which used to abound in Texas. And funnily enough, since carbon black is still used to make tires dark, West Texas also has some of the biggest tire company proving grounds in the country, like Bridgestone’s Texas Proving Ground, the former BF Goodrich track at Pecos (now the Pecos Research and Testing Center), and Goodyear’s proving ground at San Angelo.

West Texas’s open space also contains large-scale remnants of previous industries, like the old Celanese acetate plant at Pampa, and the sulfur operations in Culberson County, whose plants and pits are now open and exposed in piles and ruins.

There are the big men, the oil men, the big ranchers, and the big ranches, like the Mesa Vista Ranch, along the Canadian River, east of Borger, where famous Texas oil man T. Boone Pickens has lived since 1971. He has developed it in dramatic ways, with more than a dozen lakes and lodges for his extended family, guests, and staff. The biggest of the homes is 33,000 square feet, and has a golf course. There is also an airport with accommodations for the pilots, a stable, kennels, pub, and chapel. The ranch covers 65,000 acres, and was on the market recently for \$250 million.

Or Van Horn Amazonian Jeff Bezos, the richest man in the world, who owns around 400,000 acres of ranchland in Hudspeth and Culberson Counties, including the Figure 2 Ranch, a famous West Texas ranch established by James Monroe Daugherty, known as the site of one of the last battles between the Texas Rangers and the Apache Indians, and later owned by James Marion West, the flamboyant Texas oil man from the famous West family based in Dallas. Bezos maintains a large domestic compound here, across the highway from his rocket test site.

Up the hill behind his house, the first full-scale version of the Clock of the Long Now is being built inside a hollowed out mountain. The project, to make a clock that can run for at least 10,000 years (as long as civilization has existed) was conceived by the technologist Danny Hillis, who founded the Long Now Foundation with Stewart Brand and others, to promote long term thinking and strategy, as an antidote to the short-sightedness of our times. Thinking big.

Such visionary and utopian ideals are part of what the expansiveness of West Texas engenders, and permits, up to a point, as evident in other places, too, like the Yearning for Zion Ranch, an intentionally built community, south of San Angelo, that was home to a few hundred members of the Fundamentalist Church of Jesus Christ of Latter-day Saints, that was raided by law enforcement in 2008, a few years after it was built, and taken over by the State of Texas.

A more successful utopian project can be found in the West Texas town of Marfa, where the post-minimalist dreamer Donald Judd made an empire of art over his lifetime, which lives on through the Chinati Foundation, the Judd Foundation, and the dozens of other entities that have come to enhance and soak in the atmosphere. It was inside one such place, known as Ballroom Marfa, where the Center's electronic interpretive overlook of West Texas was installed.

*50 Big Things in West Texas* was part of a group exhibition *Hyperobjects*, on view April-November 2018, a show based on the writings of Timothy Morton, especially his 2013 book, *Hyperobjects: Philosophy and Ecology After the End of the World*. It was the first deployment of a new kind of overlook system used by the CLUI, where one screen, mounted on a post, has locational and text information, and interacts with a larger overview screen, mounted on the wall above it. In this way, the small screen acts like a canted descriptive plaque, describing the window-like view on the larger screen, an electronic interpretive overlook. This technology enables a nearly limitless amount of sites to be selected, located, viewed and described, in a manner normally experienced at outdoor sites in the field, but in this case brought indoors, with an infinitely expanded view. ♦



Pivoting points of view: the Center's West Texas Interactive Interpretive Overlook, in Marfa, Texas. Photo by Alex Marks

### TEN BIG THINGS IN WEST TEXAS from the CLUI Land Use Database



CLUI photo

#### Cactus Meat Plant

Texas is still the capital of cattle country, with nearly half the 100 million beef cattle in the nation, and this plant, near the top of the Panhandle, currently owned by JBS, is massive, and typical. JBS, the world's largest meat company, is based in Brazil. It bought the Swift Company, one of the original large American beef packers, based in Greeley, Colorado, in 2007. Though totals are dropping, Americans still eat around 60 pounds of beef per person per year, from 30 million cows, and only four companies provide 80% of it: Tyson, Cargill, JBS, and National Beef, from a few dozen large packing plants around the country, like this one. The Cactus Feedyard, near the plant, is one of dozens of feedyards in the northern Panhandle that are around a square mile in size.



CLUI photo

#### Hilmar Cheese Plant

The Hilmar Cheese Company operates this massive industrial cheese plant in the Panhandle. The plant opened in 2007, and produces cheese, as well as whey protein concentrates, whey protein hydrolysates, whey protein isolate, refined and ultra-refined lactose, and skim milk powders, which are used in a wide range of processed foods. Hilmar is one of dozens of large cheese and whey companies, but operates out of only two large facilities, this one, and the company's original plant in Hilmar, California.



CLUI photo

### 50th Street Cottonseed Plant

Lubbock is the capitol of cottonseed oil production in the nation, and there are several large-scale plants and storage sites associated with the industry, like this cottonseed oil mill operated by PYCO Industries. PYCO is likely the largest cottonseed cooperative in the nation, with more than 60 member gins. Cottonseed oil produced here is used for cooking, and the byproducts — cottonseed meal, hulls, and linters — are used for nutritional ingredients by the livestock industry, and also for manufacturing products such as mattresses, upholstery, paper, and plastics.



CLUI photo

### Pecos Research and Testing Center

One of a few large automotive testing facilities in West Texas, this 5,800-acre site opened in the early 1960s, and was the primary testing grounds for BF Goodrich. In 2005 it was taken over by a consortium of private and state organizations, including Texas A&M, and is now called the Pecos Research and Testing Center. Onsite are nine separate test tracks, including a circular track that is nine miles in circumference, making it one of the largest in the country. Activities now seem to be related mostly to security testing and training, and the site's primary asset seems to be its remoteness. Recent tests have involved large-scale explosive-related testing conducted by the Rocky Mountain Scientific Lab and Applied Research Associates.



CLUI photo

### Borger Carbon Black Plants

Two of the five remaining carbon black plants in Texas are next to each other here — one operated by the Sid Richardson Carbon Company, and the other by Orion Engineered Carbons. Carbon black is a powdery black carbon material resulting from the incomplete combustion of a heavy hydrocarbon (tar, fuel oil, etc.), in a combustion zone fueled by air and natural gas. It is used primarily in synthetic rubber, where it acts as a pigment, as well as a heat dissipator and strengthener. Texas once produced 75% of the nation's carbon black, with large plants at Big Spring, Borger, Seagraves, Skellytown, Baytown, and Aransas Pass. Plants at Big Spring, Borger, Sunray, and Pampa remain active.



CLUI photo

### Culberson Sulfur Mine Site

This remote mining site was once a major source of sulfur, but has been abandoned since the early 2000s. Sulfur, also known by its more biblical name, brimstone, is used to make sulfuric acid, used in great quantity in chemical industries, oil refining, and to make fertilizer, and gunpowder. It used to be mined, often hydraulically, from surface and underground deposits, and Texas was the primary producer of mined sulfur. Sulfur is now extracted from natural gas and as part of the petrochemical refining process. This is one of three major abandoned sulfur plants and mine sites in West Texas.



CLUI photo

## Million Barrel Museum

Located in Monahans, Texas, this five-acre concrete bowl, 35 feet deep, used to have a roof, and was built in the late 1920s to store crude oil — around a million barrels worth — during the early boom years of the region. The oil leaked out through cracks, into the ground, and the tank was soon abandoned. In the 1950s it was filled with water and turned into a recreational lake, which also leaked, and was abandoned. In 1987 it was opened as part of a museum site, operated by the local country historical commission.



CLUI photo

## Village Farms Marfa Greenhouse

Village Farms operates some of the largest hydroponic greenhouse operations in the country at two nearby sites: at the Marfa Airport, and a few miles further up the road towards Fort Davis. These structures allow growers to grow tomatoes (and some cucumbers and peppers) in carefully managed conditions, without soil, by controlling temperature, irrigation, fertilizer, carbon dioxide levels, humidity, and light. Village Farms, the Canadian company that owns the operations here, has another set of hydroponic greenhouses near Vancouver. These structures are not immune to external conditions. A hail storm in 2012 severely damaged the structures, and closed operations for some time.



CLUI photo

## Andrews County Disposal Site

The Andrews County Disposal Site is a major commercial chemical and radioactive waste site, accepting waste from all over the nation. It has been a chemical waste disposal site since 1989, and is operated by the Waste Control Specialists Company, based in Dallas. It started accepting radioactive waste in 1998, with shipments from the cleanup of the DOE's Fernald site in Ohio, and later expanded to accept all three types of low-level radioactive waste: class A, B, and C. It was selected to be the disposal site for the PCBs dredged from the Hudson River, as part of General Electric's cleanup of the upper Hudson, after decades of dumping. The 14,000-acre facility is next to the New Mexico state line, and URENCO, the only uranium enrichment plant currently operating in the nation, which supplies fuel to most of the nuclear power plants in the USA.



CLUI photo

## Yearning for Zion Ranch

This intentionally built community, south of San Angelo, was constructed over just a few years, starting in 2003, and became home to a few hundred members of the Fundamental Church of Jesus Christ of Latter-day Saints, who moved there from their state line community at Hildale, Utah and Colorado City, Arizona. The 1,700-acre site is a self-contained village, with an amphitheater, meeting houses, school, power plant, sewage lagoons, houses, farm, and a temple. The polygamous sect soon attracted attention of child welfare agencies, and the site was first raided by law enforcement in 2008. After legal battles, the State of Texas took possession of the property in 2014, and its remaining residents were evicted. The site remains empty, awaiting its future.

### WENDOVER REPORT

FROM THE CLUI OUTPOST IN THE BONNEVILLE BASIN



Close call: wide (and tall) load, crossing the continent in April 2018, nearly gets stuck under casino sky bridge at the Nevada/Utah state line. Wendover is on the edge of many things, and while margins are extremely wide, tolerances can be exceedingly narrow. CLUI photo

THE CENTER'S BONNEVILLE BASIN OPERATIONS complex in Wendover, Utah, continues to serve as a base for regionally focused creative projects, and did so in a variety of ways over the 2018 season. CLUI facilities, on the edge of the old airbase, housed a number of creative researchers including Everest Pipkin and Alex Lucas, from Carnegie Mellon, who worked on a project documenting the rock art and graffiti along the Interstate through the flats. After a few weeks at the CLUI, they headed on to a residence program in Montello, Nevada, to continue their work.

Others using the CLUI facilities in Wendover in 2018 included Terry Ownby, a professor of communication at Idaho State University, who was working on a photographic project in the area, and a group of filmmakers from New York known as Thirteen Black Cats, who are working on a film addressing aspects of the atomic history of the region, and who will be returning in 2019.

The artist Lukas Marxt also spent some time in Wendover this year, working on the "loading pits" part of his larger project about the Manhattan Project-era nuclear bomb testing based out of Wendover.

Wendover recidivists such as the aerial photographer Michael Light and the artist William Lamson also used CLUI facilities to support their ongoing projects in the region. Lamson's salt encrustation installation, called *Mineralogy*, continues to evolve and draw people to it. Oswaldo Gonzalez visited in the fall to construct a new CLUI exhibit space which will open later in 2019.

Late in the year some of the contents of the CLUI exhibit hall were removed and shipped to the Center for Art + Environment, part of the Nevada Museum of Art in Reno, to join the rest of the Wendover Residence Program archives. The CLUI residence program officially ended in 2016, transitioning to a more informal program for the support of fewer and longer-term projects in the region.

Numerous groups and individuals visited the CLUI Exhibit Hall, Orientation Building, and other publicly accessible CLUI displays, some leaving their signatures in guest books, some not. Some were just witnessed poking around on CLUI security cameras. Some journalists even wrote about Wendover, like Sarah Urist Green, as part of a PBS project about art in Utah, called *Spiral Jetty, Sun Tunnels, and Salt* (viewable on YouTube).

The Land Arts of the American West class, based out of Texas Tech in Lubbock, stayed in Wendover for close to a week, as it has for more than ten years, as part of its annual semester in the field. Its leader, architect professor Chris Taylor, developed the Great Salt Lake Exploration Platform, with fellow Wendover recidivist Steve Badgett of Simparch. The GSLEP has been based out of Wendover since its maiden voyage on the Great Salt Lake in 2015. It is now headed to California's Salton Sea, to embark on its expanded role, as the Terminal Lake E/x Platform, the TLEP.

An informal gathering of educational field program facilitators was organized over Memorial Day weekend at Wendover by CLUI Program Manager Aurora Tang. Tang, who teaches a field program called *Wilderness as Myth and Metaphor* with collaborator Ian James at Otis College, convened this group to share strategies and experiences among practitioners of this method of teaching and learning about landscape in-situ. Attendees included Matthew Fluharty, of Art of the Rural; Mary Rothlisberger and Richard Saxton, of the Rural Environments Field School, at the University of Colorado, Boulder; Alexander Robinson, from the Landscape Architecture department at the University of Southern California; Jesse Vogler, of the Sam Fox School at Washington University; Chris Taylor, from Texas Tech's Land Arts of the American West program; and Kaitlin Pomerantz, of the University of Pennsylvania.

In 2018 CLUI Wendover became a local management partner for *Sun Tunnels*, an increasingly well known piece of land art located near Lucin, 40 miles north of Wendover. Earlier last year the work, completed by the artist Nancy Holt in 1976, was acquired by the New York-based Dia Art Foundation, following Ms. Holt's death in 2014. It makes a perfect complement to *Spiral Jetty*, her husband Robert Smithson's 1970 work, located on the other side of the Bonneville Basin, which she gave to Dia in 1999. ♦



Student group heading towards a bunker at the old Wendover airbase. photo by Chris Taylor

## BOOK REVIEWS

## BOOKS NEW TO THE SHELVES OF THE CLUI LIBRARY

**Great Walls and Linear Barriers**, by Peter Spring, 2015

Written before the current onslaught of wall talk, this book discusses large scale walls throughout history, all over the globe. Attempts to keep the heathens out have left their marks all over Asia and old Europe, though few of those walls have stood the test of time. Their ruins encourage us to consider Progress as occurring at a greater historical scale.

**The Swamp: The Everglades, Florida, and the Politics of Paradise**, by Michael Grunwald, 2008

Most of Florida is a surficial crust of land barely above water. Central to its transformation into a semi-habitable place is the restructuring of its pre-human drainage (AKA swamp) into a manageable, infrastructured hydrology. This is the story, mostly, of the Everglades, and it is compellingly told in this book.

**The Gulf: The Making of an American Sea**, by Jack E. Davis, 2017

Though initially a bit too heavy on the natural history side for us “land users,” this epic about the Gulf of Mexico region gets going by its second half, back on the land, with the transformative regional developments of the twentieth century.

**Last Train to Paradise: Henry Flagler and the Spectacular Rise and Fall of the Railroad that Crossed an Ocean**, by Les Standiford, 2002

Henry Flagler, Rockefeller's partner at Standard Oil, spent his fortune building the railway and hotel empire that created modern Florida, from north to south. But the last bit of it – from Miami to Key West, was over the top. This book is a riveting quixotic, all-true and tragic tale of the building of one of the last, most ambitious, and unnecessary rail lines in the nation.

**Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production**, by Vaclav Smil, 2001

On July 2, 1909, Fritz Haber, a chemistry professor in Karlsruhe, Germany, demonstrated his newly discovered process for creating synthetic nitrogen to chemists at the BASF company. Shortly afterwards, aided by Carl Bosch, the process was industrialized at BASF, allowing a nearly limitless supply of nitrate fertilizer to be manufactured and spread all over the land (as well as explosives and a host of other chemical compounds). This technical but accessible book maps out the process of synthesizing nitrogen, and its effects – including, the author claims, enabling the population of the world to grow from 1.6 billion to six billion in the twentieth century.

**Autophoto**, by the Cartier Foundation of Contemporary Art, 2017

This is the catalogue from a nearly impossibly ambitious exhibition of international photography about people and cars. Big and heavy like a school textbook, the catalogue ends up hitting most of the marks, and is a massive, thoughtful, and even, somehow, modest encyclopedia of the genre.

**Observation Points: The Visual Poetics of National Parks**, edited by Thomas Patin, 2012

An at times fun collection of scholarly essays regarding the visual rhetoric at National Parks. Though it includes discussions about things like display technologies and orientation films, the essays are mostly about the contexts and modes of “seeing” nature, more generally, in the USA. Full of interesting tidbits though.

**Energy: A Human History**, by Richard Rhodes, 2018

In 1986, Richard Rhodes published *the* book on the Big Bang of the modern era, *The Making of the Atomic Bomb*, followed, ten years later, by *Dark Sun: The Making of the Hydrogen Bomb*. If he did nothing else, this would have been more than enough. Everything after that, no matter how decent, is whistling in the ruins and shadows.

**A Higher Form of Killing: The Secret History of Chemical and Biological Warfare**, by Robert Harris and Jeremy Paxman, 1982

Published back in 1982, then republished with a new last chapter in 2002, this book remains one of the best histories of modern chemical and biological weapons, from their origins in the pre-WWI industrial conglomerates in Germany, through their use in WWII, and further postwar development in the USA, and elsewhere. The development of these weapons involved some surprisingly familiar companies and people, and remains one of the most latent tales of our times.

**Accessory to War: The Unspoken Alliance Between Astrophysics and the Military**, by Neil deGrasse Tyson and Avis Lang, 2018

It should not be a surprise that the populist scientist/educator Neil deGrasse Tyson, director of the Hayden Planetarium, would make such a light meal out of such a heavy topic (which begins with the telling quote from Abraham Lincoln, “Do I not destroy my enemies when I make them my friends?”). Nonetheless, there is some meat to be found among the fluffy banter, but hopefully someone will revisit the recipe, and boil this soup down to a more potent broth.

**Pinpoint: How GPS is Changing Technology, Culture, and our Minds**, by Greg Milner, 2016

GPS, by itself, is as earth-shattering a development as the invention of longitude, but comprehension about its effects will forever trail behind its continuously forming and transforming applications. This book is a good history of the technology, and a valiant attempt to understand what's going on with our increasingly located and disoriented selves at sea in a culture of technology.

**China Lake: A Journey into the Contradicted Heart of a Global Climate Catastrophe**, by Barret Baumgart, 2017

At times a uniquely evocative portrait of a compelling marginal space – the southern end of the Owens Valley and the fringes of the China Lake Naval Weapons station, and at other times literarily running amok, gonzo/Vice-style, through current events. It may add up to an important hill of beans if you are into writing, and/or writers, but there is enough going on in this book to amount to something more.

**A Girl's Guide to Missiles: Growing up in America's Secret Desert**, by Karen Piper, 2018

A lighthearted memoir of a childhood at China Lake, the primary naval weapons development and test station in the Southern California desert, in the 1970s. In some ways China Lake is the purest form of suburb, where surreal extremes of collective behavior are normalized into banality.

**Northland: A 4,000-Mile Journey Along America's Forgotten Border**, by Porter Fox, 2018

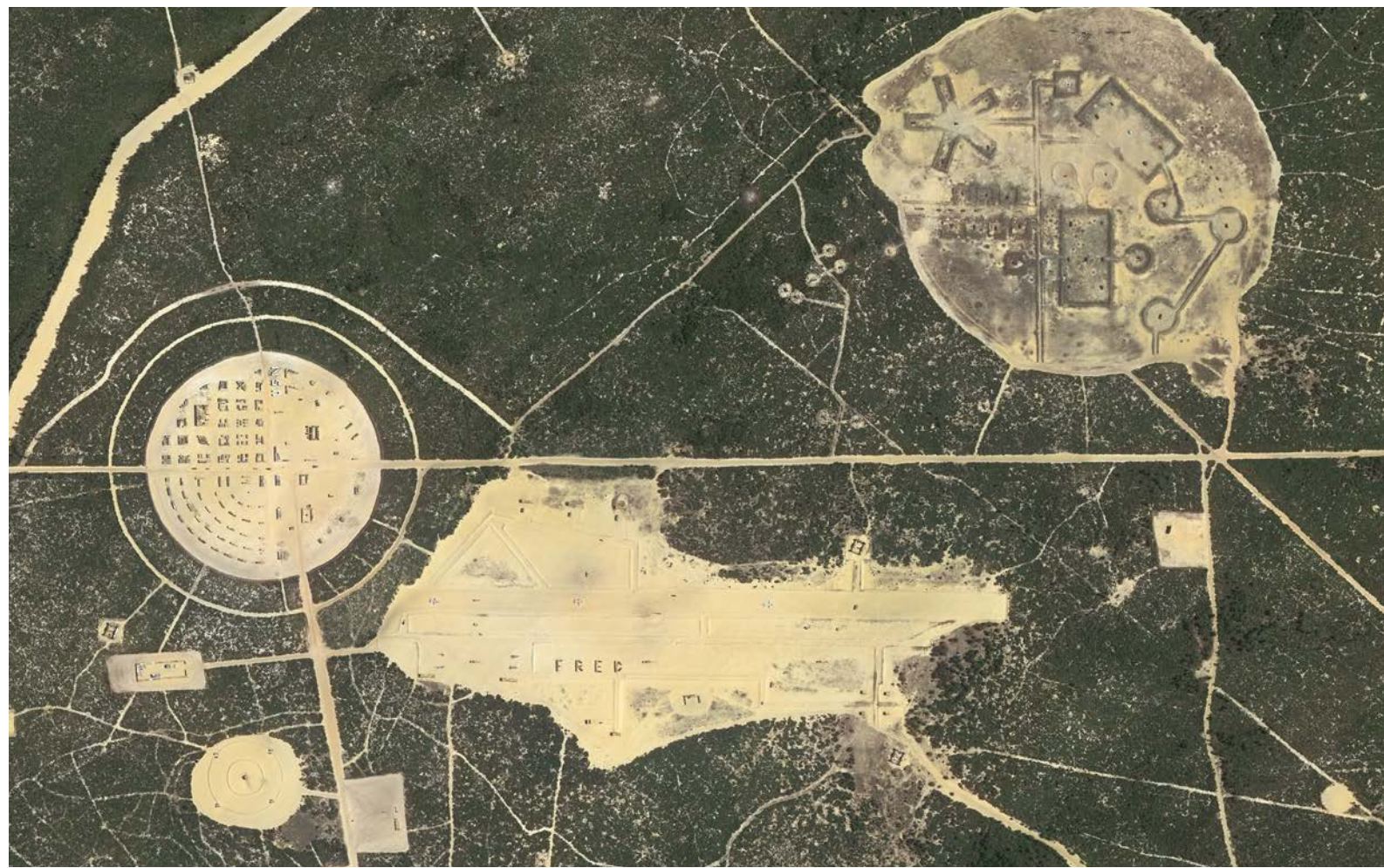
Though its title suggests some degree of linear thoroughness, this book is about the author's experiences and reflections on visits to five sampled sections of the border. It's more about the traveling, including canoe trips and a ride on a freighter in the Great Lakes, than the place, and it often strays from the line, talking about pipeline protests, Indian battles, and things not directly related to the border itself. It's about the author's trips, as these things most often tend to be.

**Man of the Hour: James B. Conant, Warrior Scientist**, by Jennet Conant, 2017

This is a biography of an important character in the development of modern America. Conant was a chemist who worked on chemical weapons in WWI, and became the president of Harvard for two decades, starting in 1933. In this role he was a central player in the development of the atomic bomb, connecting resources, politics, and research, and was one of the crew on site for the Trinity test in New Mexico. The author, Jennet Conant, is his granddaughter, and the author of *Tuxedo Park* and other interesting books about the academic scientists behind WWII technologies that set the nation on its current trajectory.

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CLUI Corps: Matthew Coolidge, Sarah Simons, Aurora Tang, Ben Loescher, George Budd, Steve Badgett, Oswaldo Gonzalez, Rob Ray, Tellef Tellefson, Igor Vamos.  
Newsletter Editors: Matthew Coolidge, Sarah Simons, Aurora Tang.



Part of Pinecastle Impact Range, a 6,000-acre naval training site in Florida. (And yes, "FRED" is spelled out in shipping containers.)

Google Earth image



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