

TRONA TRAIL

Historic Mine Byway

INTERPRETIVE PLAN



Trona mining (Wyoming Mining Association)



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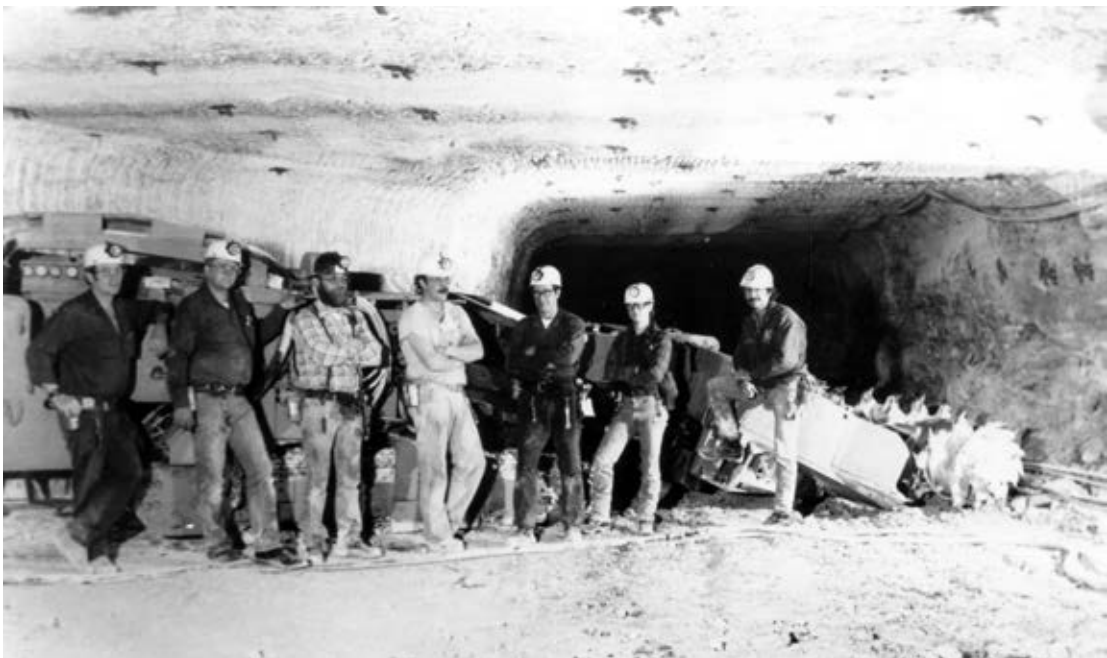
Crossing trona country on I-80 and approaching the City of Green River, Wyoming (Toxey/McMillan Design Associates)

INTRODUCTION TO THE PROJECT

The Historic Mine Trails and Byways Program was established by the Wyoming State Legislature in 2005. It is managed by the State Historic Preservation Office (SHPO) as part of the Monuments and Markers Program. The mission of the Historic Mine Trail and Byway Program is to identify historic mine locations within the state and to designate trails through them. To date, the program has developed three byways: *Gold Flakes to Yellowcake Historic Mine Trail*, which interprets the gold mines and uranium mines in the Sweetwater Mining District and the Gas Hills Uranium Mining District, *Black Gold Byway*, which interprets the Salt Creek Oilfield north of Casper, and *Black Diamond Trail*, which interprets the coal-mining district north of Sheridan. This interpretive plan is the first step in developing a new trail through Sweetwater County's trona-mining area west of Green River: *Trona Trail Historic Mine Byway*. The nomination for this byway was made to the Wyoming Monuments and Markers Advisory Committee in 2012 by the Sweetwater County Historical Museum, the sponsoring group.

Governing *Trona Trail* are the Historic Mine Trail and Byway Program objectives:

- 1) to provide a precise history of mineral development in Wyoming;
- 2) to interpret the role of mining and minerals in the development of Wyoming's economy;
- 3) to identify and describe Wyoming's mining and mineral development heritage.



Trona mine interior (Sweetwater County Historical Museum)

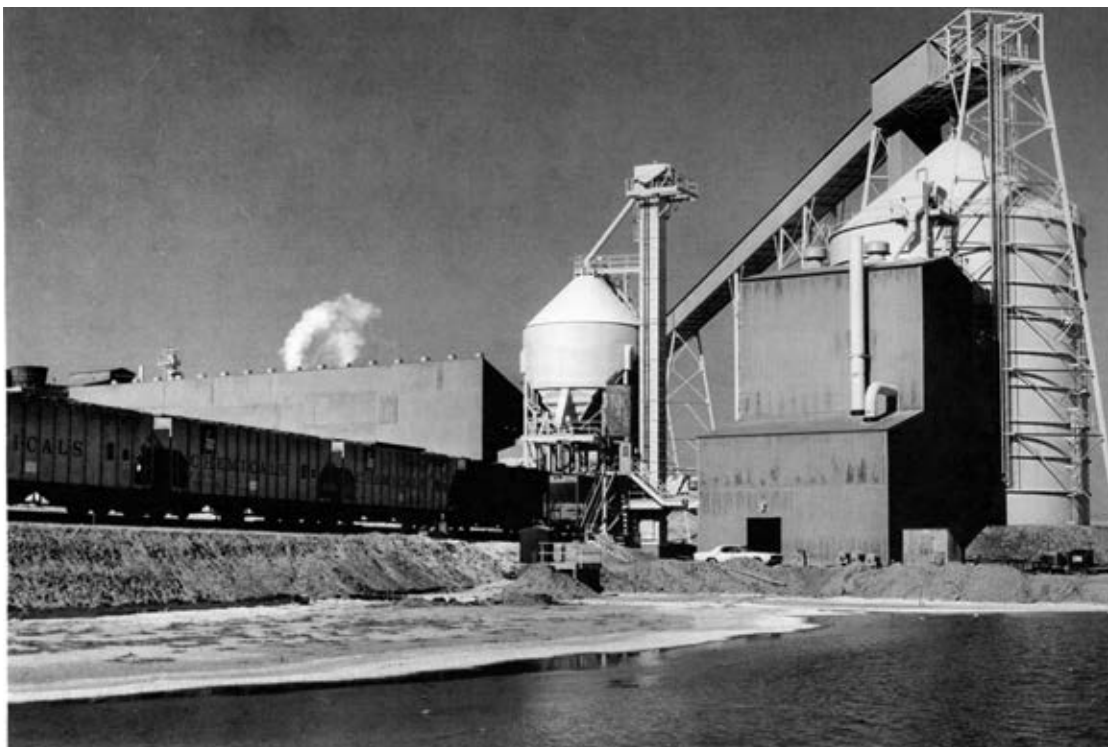
INTERPRETIVE SIGNIFICANCE

Driving across the scrubby, wind-swept, seemingly empty Green River Basin as it extends west of the town of Green River, few people are aware of the extensive roadways and bustling activity taking place 800–1600 feet below them in the trona mines. Fewer still know that this deposit of trona (also known as sodium sesquicarbonate) is by far the largest and purest deposit in the world and that it supplies nearly all the United States' (and some other countries') soda ash needs. And fewer still understand the significance of this fact: the ore mined here is used to produce nearly every commodity in their lives as well as to control pollution in air that they breath.

Considering the infinite ways in which this ancient rock touches modern American lives, it is surprising that outside of Sweetwater County and the fields of geology and chemistry, few people have ever heard of trona. Prior to the early 1950s, few people in Sweetwater County had heard of it either. Since that time, however, it has been sustaining the economy of this region.



Green River Basin (Toxey/McMillan Design Associates)



Historic image of FMC's trona mining and processing plant (Wyoming State Archives, Department of State Parks and Cultural Resources)

Buried hundreds to thousands of feet underground, more than 40 beds (layers) of trona have lain undisturbed for the past 50 million years. They are associated with an immense body of water, the now extinct Lake Gosiute, that covered most of southwest Wyoming and adjacent parts of Utah and Colorado for millions of years. During dry periods influenced by climate change, the lake would retract and become saline, depositing layers of trona and other minerals.

Although mining trona is fairly recent, Wyoming's trona did—from its deep slumber—influence an early 20th century attempt to produce soda ash in Green River using well water steeped in the ore's two salts (sodium carbonate and sodium bicarbonate). The region's other historical and current chemical industries—namely potash, natural gas, and oil shale—also derive from the lake and other surrounding geologic features and events.

The influence that the mining and processing of this ore has had on the city and surroundings of Green River is incalculable. Beyond providing a solid economic base, it has increased the population of the county, altered the local demographics with recruits from other countries, and dramatically expanded the footprint of the city of Green River with the construction of company-owned homes—to name a few impacts. It has also brought considerable revenue to the state and added another moniker to Wyoming's list of greats: "Trona Capital of the World."

PROJECT GOAL

The goal of *Trona Trail Historic Mine Byway* is to define and develop a driving circuit through the city of Green River and the trona-mining district west of town. A variety of media – including but not limited to roadside signs and a take-away brochure – will interpret the influence of Lake Gosiute on the geology, history, and modern culture and the extractive industries that Lake Gosiute sediments have engendered. The intended result is to create public understanding and appreciation of this unique story, which continues to unfold and to impact the everyday lives of all Americans.



Vicinity of Green River, Wyoming (Toxey/McMillan Design Associates)

INTENT OF THE INTERPRETIVE PLAN

The goal of this interpretive plan is to recommend a byway route and to guide the content development of signs, exhibits, and other interpretive media. To accomplish this, the plan:

- Synthesizes available visitor information to understand the project's audience,
- Defines learning, behavioral, and emotional objectives for the byway and its media and exhibit components,
- Establishes an interpretive theme for the project,
- Develops storylines,
- Identifies landscape features for interpretation (including subterranean features that cannot be seen as well as historical features that are no longer visible),
- Defines a driving route that ties together these features in a cohesive experience,
- Outlines other media for further development and interpretation of the byway.

METHODOLOGY & DEVELOPMENT PROCESS

The interpretation developed here results from a combination of meetings, interviews, field research, and bibliographic and archival research. Included among these was an Interested Parties Public Meeting in Green River on August 23, 2012. In attendance were members of the State Historic Preservation Office, Sweetwater County Historical Museum, Wyoming Department of Transportation (WYDOT), Bureau of Land Management (BLM), the four trona mine operators, City of Green River, other interested parties in the region, and the selected exhibit developer (Toxey/McMillan Design Associates – TMDA). In addition, representatives from these groups (Ruth Lauritzen, Terry Leigh, and John Dunivin) have led TMDA on three field trips through the city of Green River and trona-mining district west of town, including a tour of the mine that is owned and operated by Solvay Chemicals, Inc. The Sweetwater County Historical Museum also made its exhibits and extensive archives available to this project, as did the Sweetwater County Library. A list of bibliographic sources that were consulted in the development of this plan can be found at the end of this document.

AUDIENCE PROFILE

Components of Wyoming's economy differ significantly from those of many other states. The resource extraction industry and the travel-and-tourism sector are the main drivers behind Wyoming's economy. In support of both tourism and the mining industry, the *2010 Wyoming Tourism Industry Master Plan* makes recommendations to "develop an interpretive program around the energy and extraction industries." *Trona Trail* will do exactly this: link tourism to mining, converging these two economic engines.

Green River offers several advantages for tourism to Wyoming that relate to its location. It is situated on the main thoroughfare of Interstate Highway 80. Each year, millions of vehicles travel across this heavily used, transcontinental corridor. In southwest Wyoming alone, 23,000 vehicles per day drive by on I-80. Of these, approximately 60% are trucks and 40% are regular traffic.¹ This portion of I-80 incorporates the Lincoln Highway (U.S. Route 30), which also drives tourism to the region. Finally, U.S. Route 191, which extends from Canada to Mexico, passes only 16 miles east of the city.

The city's location on the Green River – near Flaming Gorge National Recreation Area and Expedition Island (from which John Wesley Powell embarked on his expeditions of the Green and Colorado rivers) – also situates it well for both cultural and recreational tourism. And its location in a geologically rich area – which has led to its mining and chemical industries – with dramatic scenery attracts rock hounds and geotourists.

Based on Green River's location, we anticipate three main audiences for *Trona Trail*: local and regional residents (including schoolchildren), out-of-town tourists traveling to the state or region, and the general traveling public along I-80.

AUDIENCE #1: LOCAL & REGIONAL RESIDENTS

Given that the mining and extraction industry is a major part of the state's economy, many people in Wyoming are employed in this sector and are therefore attracted to this topic. In Green River, for example, 2,000 of the 12,515 residents work in the mining industry.² *Trona Trail* will be of interest to these people and the greater community that benefits directly from this activity. The byway will also serve as a resource for local and regional school groups.

The demographics of the local population are as follows:

¹ Dave Hanks, Rock Springs Chamber of Commerce, personal communication, May, 29, 2013.

² Green River (City of), "City Data."



Green River Chamber of Commerce exhibits, Wyoming (Toxey/McMillan Design Associates)

1. The median age of residents of Green River is 33.9 years, which is significantly younger than the Wyoming median age of 41.7 years.
2. The median household income is \$71,643, which is significantly greater than Wyoming's median income of \$52,664.
3. The vast majority of Green River residents identifies as being White (83.8%). At 13.4%, Hispanics compromise the second largest category.
4. 59.4% are married.
5. The average household size is 2.68.³

AUDIENCE #2: TOURISTS

Tourism to Wyoming is increasing. As reported in the *2012 Visitor Profile Study*, new visitors (defined as those who have not visited Wyoming before or whose most recent visit was more than 5 years ago) saw a sizeable gain in 2012. Other data indicate that:

1. Overnight trips in 2012 rose to 49% compared to 36% in 2011.
2. Marketable trips rose to 55% compared to 39% the previous year.
3. New visitors from neighboring states rose to 34%, while new visitors from more distant states away rose to 59%.⁴

³ United States Census, 2010 .

⁴ Wyoming Office of Tourism, *2012 Visitor Profile Research*. Dave Hanks, Director of the Rock Springs Chamber of Commerce, states that the tourist demographics for Sweetwater County reflect those of Wyoming as a whole (personal communication, May 29, 2013).

Travelers include Wyomingites, Utahans (significant in Green River, which is located 44 miles north and 90 miles east of Utah borders), and long-distance travelers. The top three states for generating visitation to and within the state are Colorado, California, and Wyoming. Many visitors fly into Denver or Salt Lake City and drive to Wyoming, frequently passing through Green River. Sixty percent of visitors to Wyoming come from the surrounding states, the Midwest, New York, and Florida.⁵ The largest markets for tourism to the Green River/Rock Springs area are the Midwest, California, Texas, and Washington/Oregon.⁶

Visitor studies in 2012 also show small families or groups of adults as being the greatest sector of visitors to the state. Adults are aged ca. 40 years, with 62.9% being married and 93.3% having some college or tech school training or more extensive education. The average traveling party size of 2.7 was primarily composed of all adults. The average household income (increased from 2011) was \$77,154. Approximately 78% of the visitors in this survey used the Internet to plan or source information for their trips to Wyoming.

We can therefore assume that most visitors to *Trona Trail* will be educated and computer-literate. Providing a technical interface for exhibits, therefore, would not be inappropriate, and giving the trail a presence online would reach a large potential audience. Development of high-tech exhibits would also be suitable for this profile.

Of the visitors who came to Wyoming in 2012, 79% drove (2% of the 79% drove RVs). Having their own mode of transportation provides visitors with flexibility to visit a variety of sites—in particular mining and scenic byways—and to include initially unplanned destinations in the state. Moreover, flying to the state is at a 6-year high, with 23% of arriving in Wyoming via air.

In addition, 89% came to Wyoming specifically for leisure. While the top two trip destinations were national parks (1. Yellowstone, 2. Grand Teton), Green River ranked 14th. In fact in 2011, 11% of Wyoming tourists visited the Rock Springs/Green River area (up from 7% in 2010).

The 2012 *Visitor Profile Report* further reveals that the most significant trip motivators were (in the order of importance): visiting state and national parks, hiking or backpacking, scenic drives, wildlife watching, camping, snow skiing or snowboarding, visiting historical sites, visiting museums, fishing, sightseeing tours, visiting hot springs, attending a rodeo, horseback riding, biking, river rafting, attending art performances, and hunting. *Trona Trail* will provide opportunities for many of these activities: scenic drives,

⁵ Wyoming Office of Tourism, 2012 *Overnight Visitor Profile Research*.

⁶ Dave Hanks, Rock Springs Chamber of Commerce, personal communication, May 29, 2013.

visiting historical sites, and visiting museums.

Flanking Green River on I-80 are two state Welcome Centers (one west at Bear River near Evanston and one east at Summit near Laramie), which provide the following visitor statistics. From May to December 2012, 106,143 visitors stopped at the Bear River Welcome Center, while from January to December 2012, Summit had 24,000 visitors.⁷



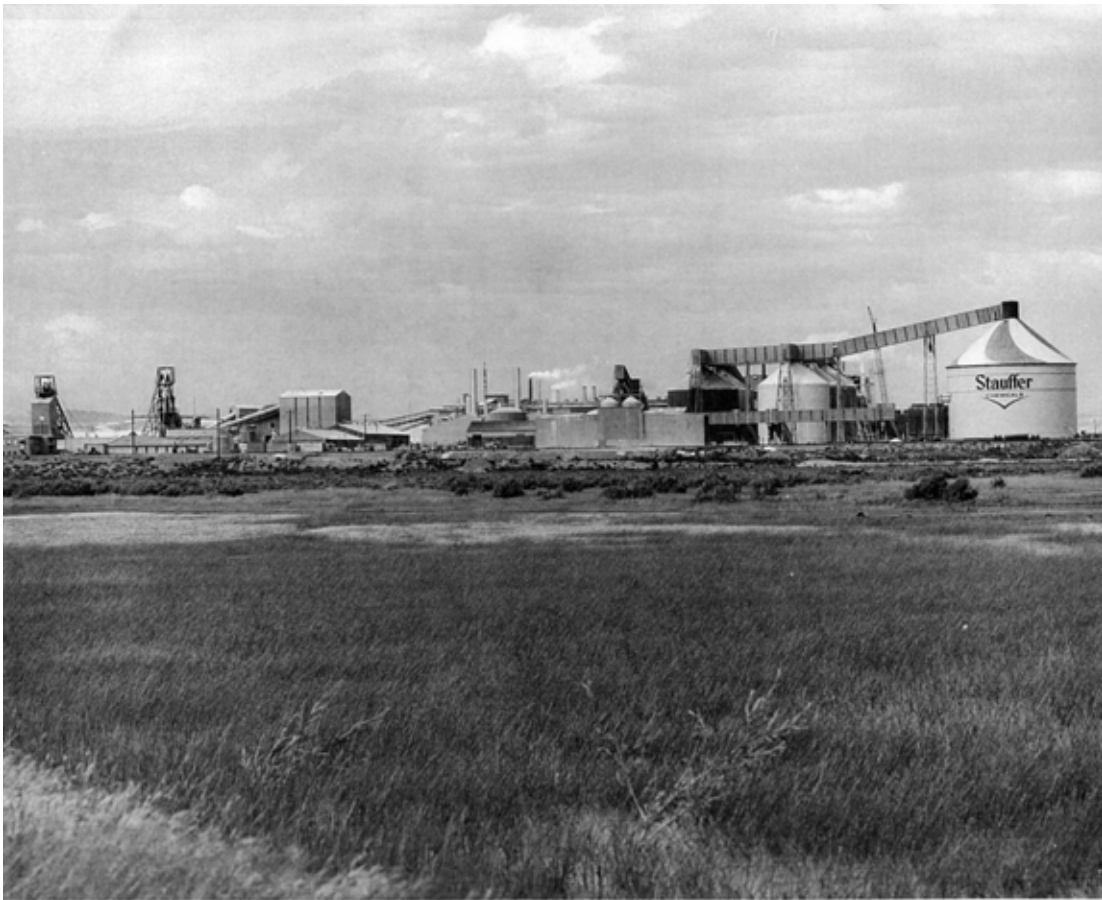
Traversing the Green River, Expedition Island, Green River, Wyoming (Toxey/McMillan Design Associates)

⁷ Data compiled and provided by Wyoming Office of Tourism.

AUDIENCE #3: TRAVELING PUBLIC

While there are no statistics on the last group of potential *Trona Trail* visitors whizzing by on I-80, we anticipate that the byway signs located at pullouts will attract a few passers-by. As shown in the data above, scenic drives are one of the top three activities in which tourists engage. Itineraries that did not originally plan to include scenic drives often change to include this activity once the travelers enter the state.

With 23,000 vehicles per day crossing the city of Green River on I-80 and with two other significant corridors nearby, the location has a lot of exposure to drive-by traffic. Trona Trail could attract some of these and could generate additional tourism to the region.



Stauffer Chemical Plant, near Green River, 1964 (Wyoming State Archives, Department of State Parks and Cultural Resources)

VISITOR NEEDS

To address a variety of ages and learning types and in order to meet the broadest spectrum of visitors, we propose interpretation that includes graphics, text, sound, and tactile as well as interactive components.

PROJECT OBJECTIVES

The objectives listed below were voiced and discussed at the Interested Parties Public Meeting in Green River on August 23, 2012.

LEARNING OBJECTIVES:

After experiencing *Trona Trail*, visitors will:

- know from where glass and baking soda come,
- understand how important trona mines are in their everyday lives,
- be aware of many of the different uses of soda ash and understand how far it goes,
- be aware of the fact that there are “fierce enclaves” of miners making their lives underground,
- understand the difference between “natural” and “synthetic” soda ash production,
- understand how changes in technology have impacted trona-mining methods,
- understand the size and extent of the trona patch: from Green River to Granger, and from the Uinta Mountains to 20 miles north of I-80,
- recognize how trona mining differs from other extractive industries in that it brings both economic and social stability to the surrounding community by being less susceptible to booms and busts and by hiring generations of miners from the same families,
- understand the physical impact on the City of Green River of the potash, sal soda, oil shale, natural gas, and trona/soda ash industries,
- understand the cultural impact on Green River of the trona/soda ash industry,
- understand that many of Wyoming’s landscapes have histories to tell of events taking place underground,
- recognize the significance that Green River trona/soda ash production has had on the nation’s soda ash industry and the economy of the state.



Trona mining near Green River, Stauffer Chemical Co., 1962 (Sweetwater County Historical Museum)



Green River Formation (Terry Leigh, Leigh Geological Services Inc.)

BEHAVIORAL OBJECTIVES:

After experiencing *Trona Trail*, visitors will:

- buy things made of glass,
- stop saying “There’s nothing out there” when looking at the Green River landscape,
- leave money in the city of Green River,
- visit the Sweetwater County Historical Museum,
- explore more of the historic sites and cultural offerings of Green River.

EMOTIONAL OBJECTIVES:

After experiencing *Trona Trail*, visitors will:

- Be overwhelmed by the size of the trona mining operations: trucks driving underground, underground cities, huge pockets of space underground, and separate medical facilities, water systems, and power production for each mine,
- be amazed at the number of uses there are for this mineral that they have never heard of,
- feel appreciation for the quality of life and economic stability that trona mining has brought to the region,
- feel respect for the land as a resource ,
- appreciate Wyoming’s diversity of landscapes, industries, and peoples.

UNDERLYING THEME:

An interpretive project has a central theme, which ties together the information presented. It defines what the content covers and does not cover. It establishes the main idea, like the moral of a story.

TRONA TRAIL THEME:

Buried hundreds and thousands of feet underground, ancient Lake Gosiute has been sustaining the town of Green River and surroundings for over a century through its extractive resources, most significantly trona.



Trona miners (Sweetwater County Historical Museum)

INTERPRETATION TOPICS & SUBTOPICS:

TOPIC 1: GEOLOGIC HISTORY

- 1a. History of Lake Gosiute
- 1b. Geology of the region
- 1c. Formation of trona

TOPIC 2: MINING & PROCESSING TRONA

- 2a. Methods of mining trona
- 2b. Methods of processing trona into soda ash
- 2c. Comparison to synthetic methods of producing soda ash: LeBlanc and Solvay methods

TOPIC 3: CURRENT & HISTORICAL USES OF TRONA

- 3a. Contemporary uses of soda ash and other chemicals derived from trona
- 3b. Ancient uses of trona and methods of deriving it

TOPIC 4: HISTORICAL CHEMICAL & ENERGY INDUSTRIES

- 4a. Sal soda plant and power plant in Green River
- 4b. Potash plant in Green River
- 4c. Oil shale endeavor near Green River
- 4d. Discovery of trona with the John Hay, Jr. Well No. 1

TOPIC 5: SOCIAL & URBAN HISTORY

- 5a. Local and regional immigration due to railroad, coal, and trona industries
- 5b. Green River Ordinance
- 5c. Urban history of Green River: expansion in response to railroad and chemical industry growth
- 5d. Mining culture: 24-hour town, shared lifestyles



Green River, Wyoming (Toxey/McMillan Design Associates)

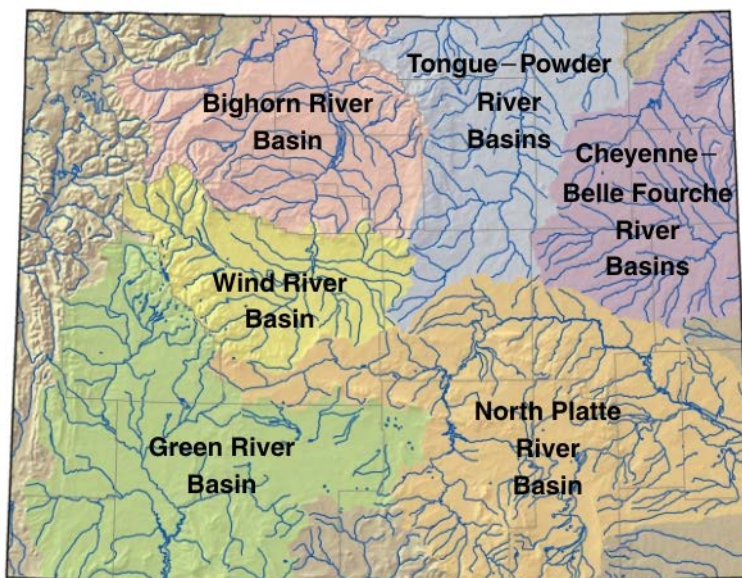
STORYLINE DEVELOPMENT

TOPIC 1: GEOLOGIC HISTORY

- 1a. History of Lake Gosiute
- 1b. Geology of the region
- 1c. Formation of trona

For about four million years during the early-to-middle Eocene Epoch, roughly 45–55 million years ago, an immense though shallow body of water called Lake Gosiute covered much of what is now southwestern Wyoming as well as portions of northern Utah and Colorado. It was bounded by the Uinta Mountains on the south (one of only a few east-west mountain chains in the U.S.), the Wyoming Range on the west, the Wind River Range on the north, and the Rawlins Uplift on the east. Ironically, the footprint of the lake generally conforms to what is now a desert region: the Greater Green River Basin (including the Great Divide/Red River Basin, Washakie Basin, and Bridger Basin—as well as Sand Wash Basin in northern Colorado).

During the Eocene, the climate of this region was generally warmer and wetter than it is today. Described by scientists as moist-temperate to subtropical, the climatic conditions supported a large variety of plants and animals, including warm-climate animals such as crocodiles. The Green River Formation, which refers to the series of rock strata that formed at this time from lake sediments, is well known for its abundant, varied, well-preserved plant and animal fossils, which shed light on the Eocene Epoch. Being largely covered by a lake, it is no surprise that millions of fossilized fish have been found here. However, primates, turtles, horses, birds, reptiles, and plants are also preserved in its strata.



Map of Wyoming basins (United States Geological Service, 2004)



Green River Basin geology (Toxey/McMillan Design Associates)

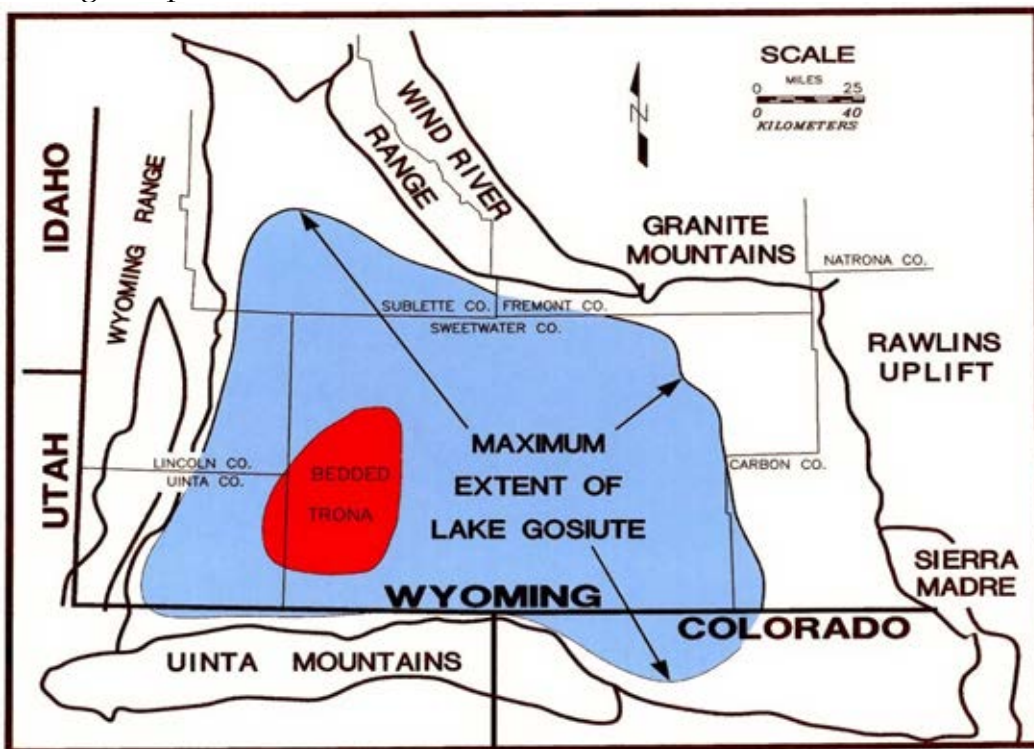
Decomposition of copious aquatic organisms (including algae) and plant debris resulted in the formation of hydrocarbons that are extracted today as natural gas, oil, coal, and soon to be joined by oil shale. Ironically, carbon from these organisms is also thought to have influenced the formation of the inorganic mineral trona, whose thick, “pure” (i.e., containing few impurities) beds in the Green River Formation are unique in the known world.

A spectacular cross-section of the Green River Formation can be seen in the sheer cliffs lining the north side of I-80 as it crosses the city of Green River. These colorful and much admired outcrops are known by name—for example, Palisades, Castle Rock, Tollgate Rock, and Giant’s Thumb. Thomas Moran immortalized them in 1871 in his canvas, “Cliffs of Green River,” painted during the Ferdinand Hayden expedition. The vista he portrayed can be seen through the picture window of the Green River Chamber of Commerce.

Over the course of its lifetime, Lake Gosiute was impacted by tectonic changes and volcanism, which altered the lake’s chemistry and character. It also experienced periods of climate change from wetter to drier to wetter to drier, causing the size of the lake to oscillate. At its maximum extent, the lake is estimated to have covered 15,500 square miles (that’s about 13 times the

size of Rhode Island), and at its smallest extent, it is estimated to have covered 4,000 square miles (roughly 3 times the size of Rhode Island).⁸

Geologists have identified three major phases of the lake's life, although the lake and the climatic conditions were constantly in flux. In the first major phase, which lasted roughly 1,000,000 years, the lake was freshwater. It had abundant water entering and overflowing from it. The warm, wet climate resembled that of the Gulf Coast. In the second phase, which also lasted about 1,000,000 years, the climate became more arid—like that of Salt Lake City but with warmer winters. The lake shrank in size, stopped overflowing, and became saline. It was during this time that the trona deposits were created, in a portion of the Green River Formation called the Wilkins Peak member—which is the only saline member (series of strata) out of the Green River Formation's five members. In the third major phase of Lake Gosiute, which lasted about 2,000,000 years, the climate became moister again and the lake became freshwater and overflowing, again. It expanded to its greatest extent during this period.⁹



Map of Wyoming showing maximum extent of Lake Gosiute and location of trona beds (Terry Leigh, Leigh Geological Services Inc.)

During the life of the lake, the mountains surrounding it were actively rising, creating a deeper basin. However, at the same time, sediments eroding off these mountains were filling the basin with silt and soil deposited by rivers

⁸ Bradley and Eugster, p. 1.

⁹ Bradley and Eugster, p. 1; Carl Hayden, p. C15.

and streams.¹⁰ Also filling the lake and blanketing most of Wyoming during this period were large volumes of volcanic ash produced in northwest Wyoming and locations farther west.¹¹

The result of these events, especially during the second phase of the lake, was the transformation of fresh water into a concentrated, mineral-rich, saltwater brine, from which trona formed on the lake bottom, largely due to the introduction of carbon dioxide and to surface evaporation of the brine. Exactly how it formed and what were the sources of carbon dioxide and of the high concentration of sodium in the brine – both of which were necessary to create this volume of almost pure sodium carbonate – continues to baffle scientists.

Other dry lakebed deposits of trona exist around the world (in China, Turkey, Kenya, Tanzania, Egypt, South Africa, Chile, Mexico, and California); however, none have the massive volume and purity of the Green River trona. Making the puzzle more challenging is the fact that the different beds of trona found in Green River have different crystal sizes and characteristics, leading to the conclusion that they were formed in different ways at different times.



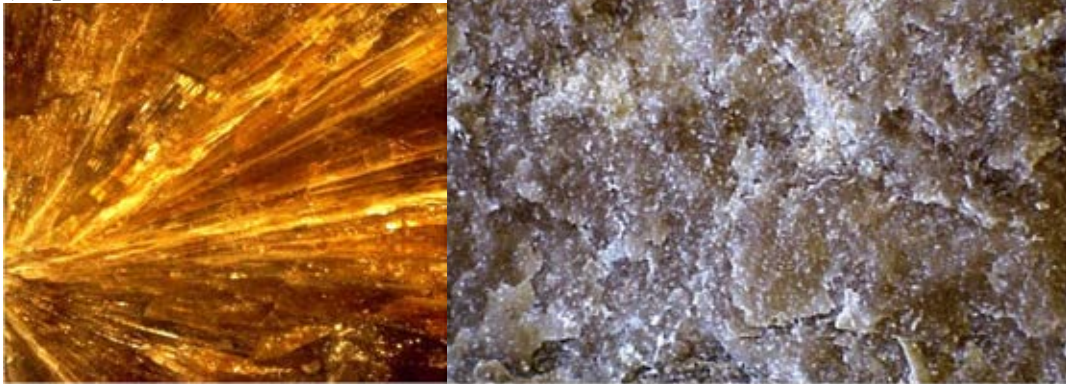
Spar trona (R. Terry Leigh)

Crystals range from fine-grained “maple sugar” texture in the lower, older beds (which are located southwest of the city of Green River) to larger coarser crystals in the upper, younger beds (which are located northwest of Green River, toward Granger). “Pure” trona is white or colorless. It is a double salt (sodium carbonate + sodium bicarbonate), and it is symbolically represented as: $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$. It breaks down to: 47.3% Na_2CO_3 , 37.5%

¹⁰ Leigh in Dyni and Jones, eds.

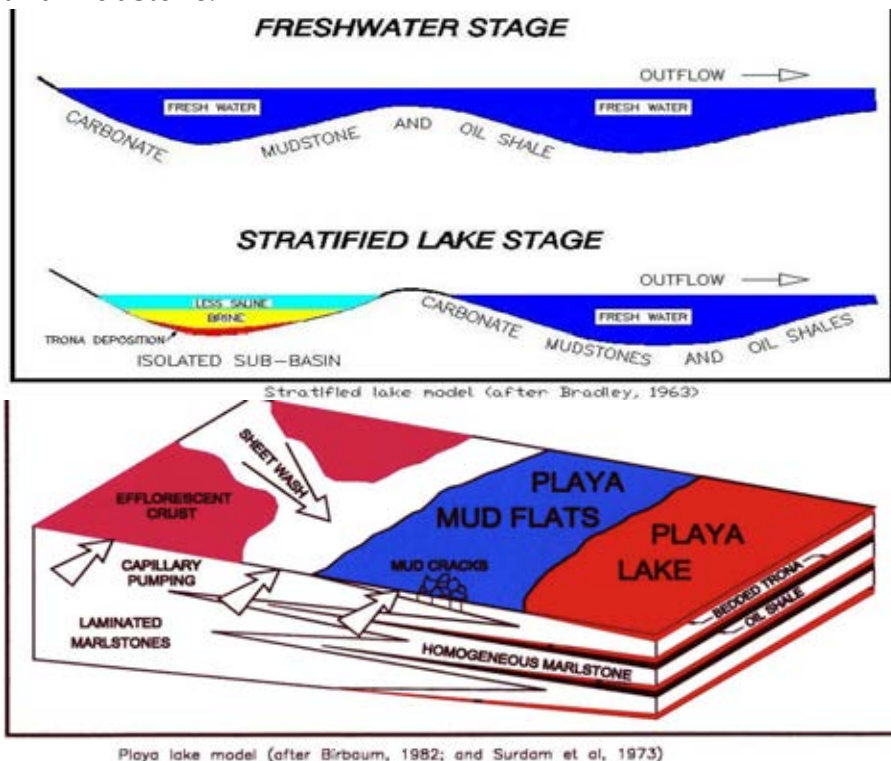
¹¹ Knight, p. 12.

NaHCO_3 , and 15.2% H_2O .¹² While some of the beds of trona found here are colorless and almost pure sodium carbonate, many range in hue from amber to gray due to the inclusion of silt, other sediments, and other salts (impurities) when the trona formed.



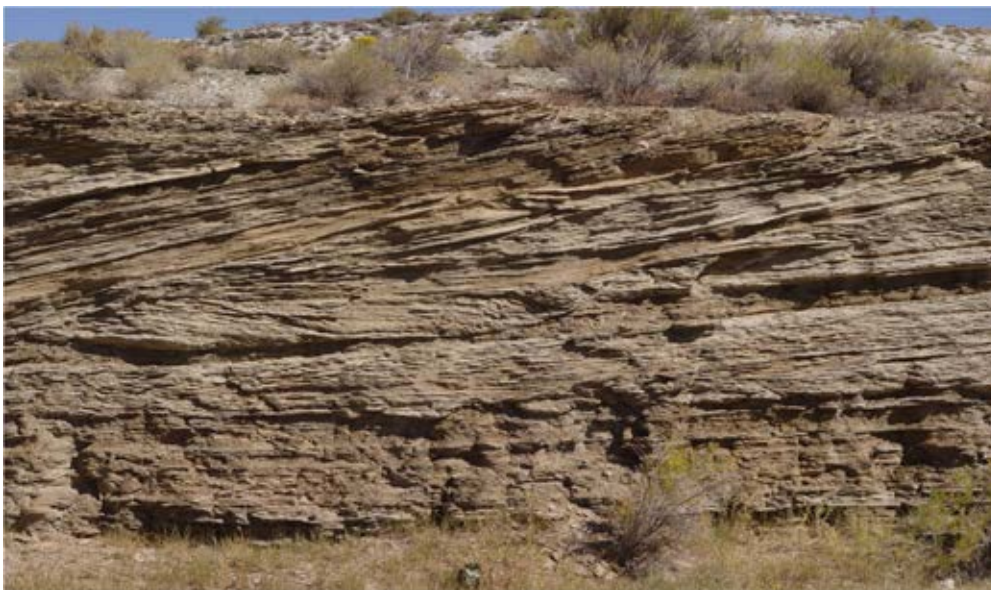
Large crystalline texture of upper trona beds (left) and “maple sugar” texture of lower beds (R. Terry Leigh)

Theories have been advanced for the source of carbon dioxide needed to turn brine into trona and for the ways in which crystallization took place. These include, for example, the *stratified lake model* (in which freshwater floated above saltwater, supporting different life and chemical conditions) and the *playa model*. Other scientists suggest that a combination of these two models best explains what happened, which seems most likely due to the different crystalline characters of the trona beds that formed between layers of oil shale and mudstone.



Diagrams of *stratified lake model* (above) and *playa lake model* (below) (R. Terry Leigh)

¹² Mannion, p. 199.



Green River sedimentary formation (R. Terry Leigh)

When not depositing trona, the lake was expanding with fresh water and depositing layers of mud and organic materials that became mudstone and oil shale. Not only did Lake Gosiute give us the largest trona deposit in the world, but also the largest oil shale deposit in the world – and significant natural gas reserves.

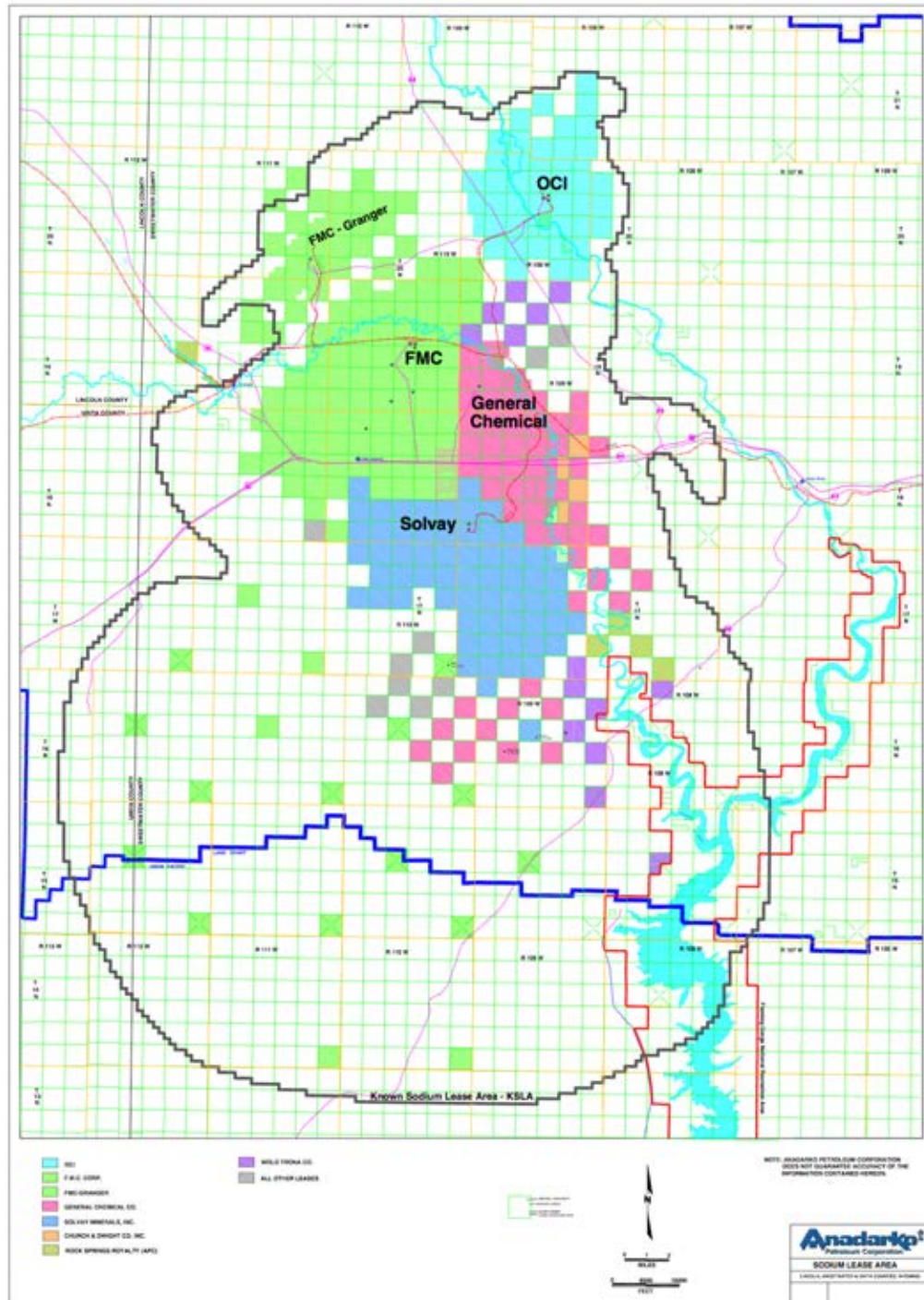
In the last 2,000,000 years of the lake's life and during millions of years that followed, the beds of trona were buried deeper and deeper underground by new layers of sediment, eventually reaching a mile in depth. Due to later events of uplift and erosion, however, the trona beds are now located closer to the earth's surface (440–3,500 feet underground) and within economic reach.¹³

The trona beds cover 1,000 square miles of land west of the city of Green River, flanking I-80 between Peru Cutoff and Granger. Within a snowman-shaped area called the Known Sodium Leasing Area (see KSLA map) are located the 22 beds of trona 4–15 feet thick that are considered to be mineable – based upon current mining methods. The uppermost of these is located 800 feet below ground. Twenty or more thinner beds ranging from 0.5–4 feet thick are located between and above these. New technologies, such as solution mining and directional drilling, may some day make even the thin beds commercially viable.

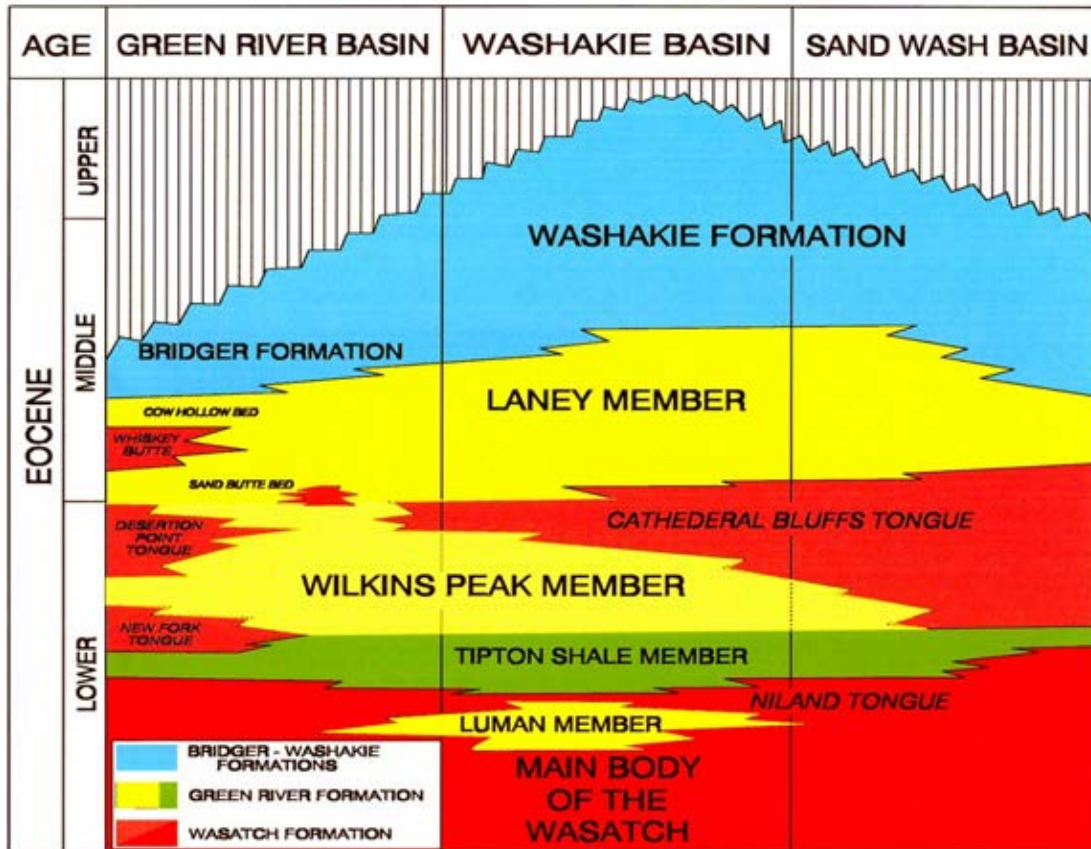
The amount of trona located in the 22 mineable beds is estimated at 100 billion tons. This translates to about 60 billion tons of soda ash, which at current consumption levels would keep the U.S. supplied for millennia.

¹³ Hayden, p. C15.

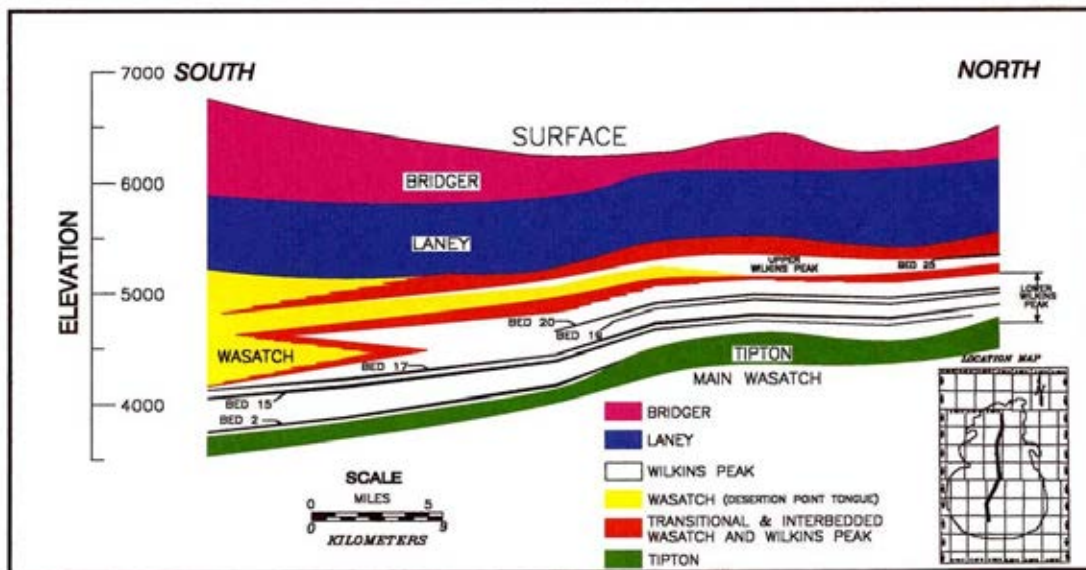
Trona mining and processing contributes significantly to Wyoming's coffers. It is the state's fourth largest revenue-generating mineral, after oil, natural gas (much of which is extracted in the Green River Basin), and coal (which is also abundant in the mineral- and energy-rich Green River Basin).



Map of Known Sodium Leasing Area (KSLA), prior to Tata's purchase of General Chemical (U.S. Bureau of Land Management, 2005)



Section of Eocene Epoch formations (R. Terry Leigh)



Section of Green River Formation (trona located in Wilkins Peak member) (R. Terry Leigh)

TOPIC 2: MINING & PROCESSING TRONA

- 2a. Methods of mining trona
- 2b. Methods of processing trona into soda ash
- 2c. Comparison to synthetic methods of producing soda ash: LeBlanc and Solvay methods

The discovery of a massive trona deposit 1,800 feet underground in the Green River Basin took the U.S. mining industry by surprise. “No solid body of trona had ever been found before.”¹⁴ Obviously, therefore, trona had never been mined before, at least not commercially mined in the U.S. There was no precedent for extracting it from the ground.

There was, however, experience collecting soda brine (sodium-laced water) from artesian wells and drying it to produce sal soda (aka washing soda), which is an impure form of soda ash. A version of this method was tried in the 1940s on the trona discovery bed by Westvaco (West Virginia Chlorine Products Company), who pioneered trona mining and processing in Green River.

Reluctance to attempt underground “dry mining” stemmed from fears that the cost would outweigh the profit and the fact that no one had ever attempted to mine underground trona – much less 1,800 feet underground. Lack of success with the brine method, however, pushed Westvaco to take this bold step into the unknown. This time they succeeded, and the first load of mined trona in history was brought to the surface in 1947, after spending 50 million years underground.



Trona mine (Wyoming Mining Association)

¹⁴ FMC brochure, "The Needle-Shaped Crystals"

Despite this success, a considerable amount of experimentation was required before the new industry had developed a system for extracting this new ore. Large-scale production was finally achieved about 1961; however, the experimentation did not end there. For the past 66 years, the companies mining trona – led by FMC, which Westvaco later became – have continued to develop more efficient, safer, and more environmentally sensitive procedures for extracting and processing trona.

Recognizing the mineral as being fairly soft, the company applied coal mining techniques and technologies to its vanguard efforts, nicknaming trona, “white coal.” Unlike coal, however, trona is non-toxic and non-combustible, so the risks of mining it are fewer.

The closure of coal mines in the vicinity of Green River in the early 1950s meant that trained coal miners (500 of them!) and mining equipment were available to launch the new industry. The mining method that they brought to trona is called “conventional” or “room-and-pillar.” The coal equipment had to be revamped for the harder trona ore, but the technology remained the same.

The room-and-pillar mine is laid out in a grid of streets flanked with “rooms” much like house lots. “Rooms” of ore are removed leaving generous “pillars” of ore behind to support the mine roof. With this method, about 50% of the ore is extracted. However, secondary recovery is practiced in the form of “pillar robbing” (when pillars are removed and the roof is allowed to cave) and “solution mining” (in which an old mine is flooded with a solvent, which dissolves the remaining trona and is then extracted and piped to a processing plant).



Inside a room-and-pillar trona mine with RTVs, Solvay Chemicals (Toxey/McMillan Design Associates)



Miners build cribbing to support ceiling in an early southwest Wyoming coal mine (Sweetwater County Historical Museum)

The procedure for creating rooms and recovering trona in the conventional coal-mining method is to undercut the ore face with a narrow, horizontal, 10-foot deep slice. This is done with a giant chain saw called a “cutter.” Second, 10-foot-deep holes are drilled into the face. Then, blasting caps are inserted into the holes. These are then ignited, and 100 tons of trona fall to the ground. Loading machines sweep up the fallen rock and load it onto shuttle cars that transport it to a ceiling-mounted conveyor belt, up to 10 miles in length. This brings it to the mine shaft where it is hauled to the surface.

The conventional method of mining continues to be practiced in the Green River trona mines; however, it has been joined by new methods. All of them function essentially the same way: breaking the solid rock into small chunks, which are then lifted to the surface for processing.

Originally, wooden cribbing (bracing) was added to provide additional support for the mine roof. This, too, was borrowed from coal mining (see image). In 1949, however, a more efficient system developed for trona mines, through much experimentation. With the aid of a roof-bolting machine, 5-foot long bolts made of thick rebar pierce the ceiling and are “laminated” into place using resin, which bonds the strata of rock overhead – saving countless trees and leaving the mine spaces uncluttered.

Beginning in the late 1970s, a new method of extracting ore was introduced, called continuous mining, which avoids the need of explosives and facilitates haulage. This, too, was adapted from coal mining and continues the room-and-pillar layout. Here, a continuous mining machine cuts straight into the strata of ore. The ore falls onto a mobile conveyor belt incorporated into the machine, which loads the shuttle cars. A variation of the continuous miner's barrel-shaped cutting wheel is the boring machine, whose spinning teeth bore worm-like rounded tunnels into the solid rock.



Continuous miner mining trona (Wyoming Mining Association)

Longwall mining, shortwall mining, and solution mining (also known as liquid feed and considered to be a secondary extraction method) were introduced to Wyoming trona mines in the 1980s. These methods extract nearly all of the ore in the strata. In longwall mining, a long line of self-advancing, hydraulic roof supports are computer-coordinated with a cutting wheel. While it chews into the 750-foot-long mining face, removing the entire seam, rocks drop onto a conveyor belt that whisks them away. As the digging



Boring machine (left) and longwall mining machine (right) working trona mines (Wyoming Mining Association)

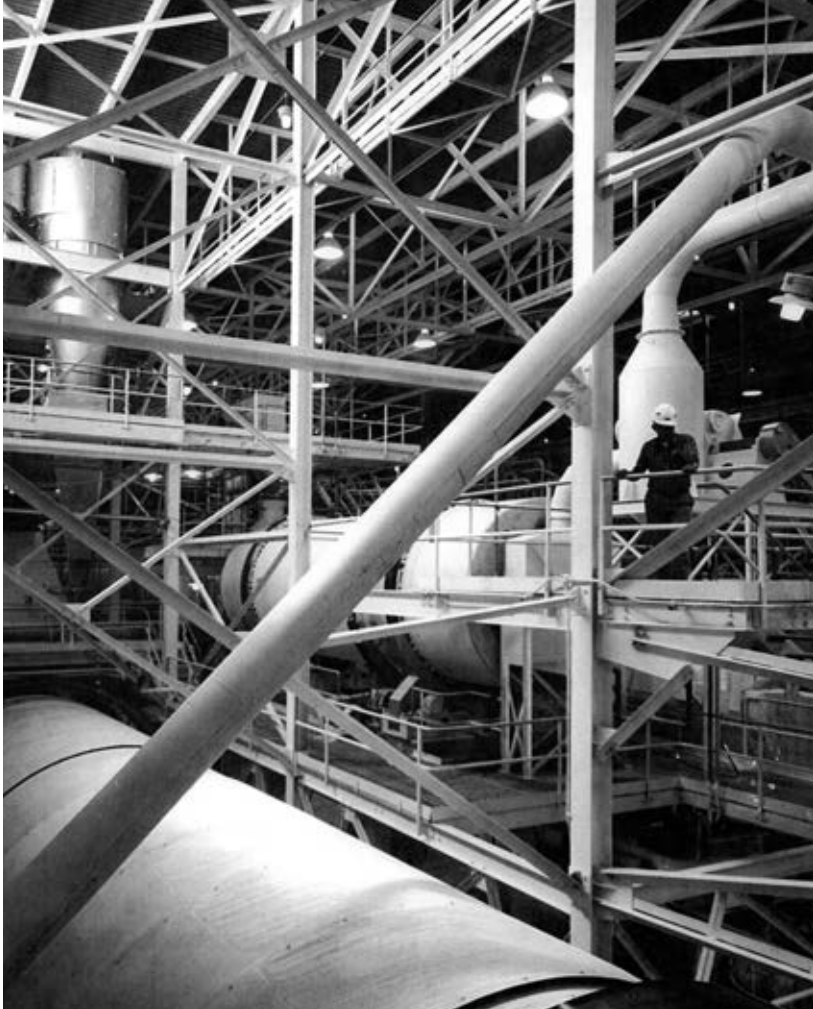
progresses, the equipment supporting the roof moves forward, allowing the roof to collapse behind it—resulting in a 6-inch depression on the earth's surface. Shortwall mining is a hybrid of the longwall and borer methods. Finally in 1985 another kind of secondary extraction was introduced: dredging sodium carbonate minerals from tailings ponds.

To carry out all of the dry-mining methods, two vertical shafts are drilled to the level of the ore: one is a service shaft for people and equipment. The other is a production shaft, half of which hoists ore up and admits clean air down and the other half of which vents return air. Every piece of equipment in the mines has been lowered through one of these shafts. Since much of the equipment is too large to fit on skips (elevators)—although they hold 50 passengers at a time—it is transported in pieces and assembled underground.

To accomplish this, to support the work and workers, and to optimize efficiency and safety, many services are provided underground: offices, warehouses, parts and repair shops (staffed with construction and maintenance crews), medical facilities, water systems, power systems, break rooms, restrooms, armies of diesel-powered trucks and RTVs, huge pockets of space, and thousands of miles of roads and tunnels. Among the active mines, which operate 24-hours per day, there are always about 150–300 staff members working underground.



Underground break room at the Solvay trona mine (Toxey/McMillan Design Associates)



Stauffer Chemical Co., plant and mill, 1962 (Wyoming State Archives, Department of State Parks and Cultural Resources)

Likewise, day and night there are about 200–350 people working “topside” (above ground) in the processing plants associated with each mine. Instead of shipping raw ore to customers, the trona operations process this into a more usable form—that of soda ash—which, being reduced in bulk by about 35%, is cheaper to ship. In addition to soda ash (sodium bicarbonate), some of the Green River trona processing plants produce sodium bicarbonate, sodium tripolyphosphate, and high-purity sodium sesquicarbonate.

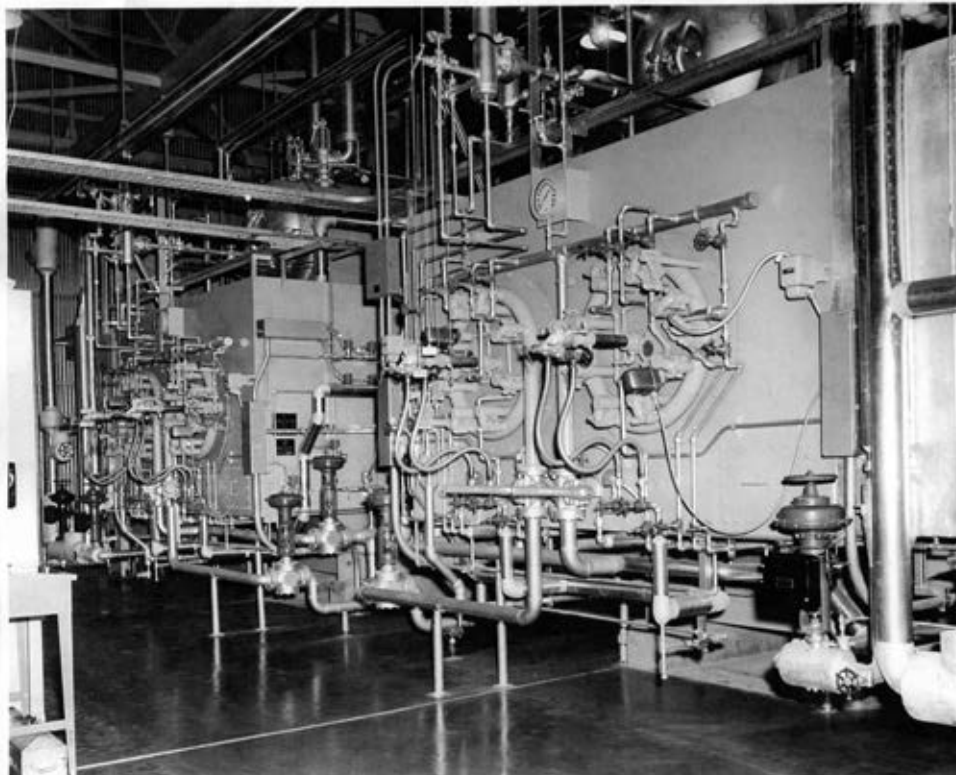
Soda ash, a basic chemical used in many industries, is composed of 99% sodium carbonate (Na_2CO_3). Green River trona ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$) contains 65% sodium carbonate.¹⁵ The remaining 35% is composed of water, carbon dioxide, and impurities or “insolubles,” which are traces of mud, shale, and other lake sediments. To convert trona into high-quality soda ash, these impurities need to be removed along with excess water and carbon dioxide.

¹⁵ Texasgulf, “Soda Ash Fact Sheet.”

The trona mining and processing companies have developed two methods for doing this: 1) the *sesquicarbonate soda ash process*, placed in operation in the 1950s, and 2) the *monohydrate soda ash process*, placed in operation in the 1970s. Being less caustic and less costly, the newer process is generally practiced today.

In the older method, the ore is first crushed and then dissolved in hot water. The solution is filtered for impurities, crystallized, and finally calcined (heated) to drive off carbon dioxide and water. In this process, the substance remains a sesquicarbonate until the end. The newer method involves the same steps but calcines the trona ore immediately after crushing. This turns it into a monohydrate *before* carrying out the rest of the steps: dissolving it in water, filtering out insolubles, centrifuging it, and finally piping the pure soda ash solution into evaporators where it is crystallized. With the newer method, what you see coming out of the plant stacks is just water vapor from the evaporation process, since the carbon dioxide was driven off earlier.

Both methods face the same challenges regarding environmental protection. In both methods, carbon dioxide is driven out of the sesquicarbonate to form a monocarbonate. This means that carbon is released into the atmosphere. The soda ash companies are currently working on methods of carbon capture.



Stauffer Chemical Plant: trona ore and soda ash production (Wyoming State Archives, Department of State Parks and Cultural Resources)

Another problem is what to do with the wastewater from processing. Charged with excess chemicals and impurities, the soda ash companies have been discarding this liquid in tailings (waste) ponds. Although designed not to enter groundwater supplies, the immense ponds (each one being hundreds of acres in size) can cause problems for wildlife and in general are unsustainable. Though not chemically toxic, sodium carbonate crystals present in the waste water coat the feathers of visiting ducks and prevent them from flying, potentially killing them. Fans, airboats, and air guns are used to discourage ducks and other fowl from alighting and to rescue those that do. Patrolling these immense ponds is a fulltime job, especially in the fall when the problem intensifies due to evaporation and dropping temperatures.



Airboat crossing Stauffer Chemical Co.'s 400-acre tailings pond, scaring away ducks and rescuing those that land (*Green River STAR*, November 5, 1975, p. 15)

An environmental protection measure required of the trona mining and processing operations is the collection of "fugitive dust" (sodium carbonate powder) during transportation of ore and as it blows off the tailings ponds, which can be seen as white dust clouds from a distance. Fines are in place for those operations that do not control the dust.

Another environmental concern is that for the safety of miners, the mines vent toxic gases (carbon monoxide, methane, and ammonia) that occur deep underground (associated especially with the strata of oil shale) into the atmosphere. However, this is not good for the atmosphere and those that live nearby. Changes of procedure are currently in the works for capturing methane and using it (burning it for energy) in the processing plants.



Fugitive dust (soda ash) blowing off Green River soda ash plants and tailings ponds (Toxey/McMillan Design Associates)

Though troublesome, the environmental concerns faced by trona mining and “natural” soda ash production are small compared with those faced by the synthetic soda ash industry, whose product is costlier in terms of material costs, labor costs, energy costs, and environmental costs (described as being “heavy pollution”) and produces large amounts of problematic chemical waste-products. It is tempting to believe that this last observation – voiced in Wyoming newspapers from the 1970s¹⁶ – is the empty boast of local boosters. However, in that Green River soda ash went from having a zero (domestic) market share in 1954 to having a majority market share in 1974 and a 90% market share for the past few decades, it appears that the assertions of Green River soda ash being higher quality and lower price are true.

In addition to being 99.8% pure sodium carbonate (which is touted as being “unprecedented purity” and the “highest grade possible”), Green River soda ash has a different crystal form from synthetic soda ash. Green River soda ash’s needle-shaped crystals, which form during processing, have many advantages. They allow the substance to flow more freely, mix better with other ingredients, and produce less dust.¹⁷ These traits have helped Green River win and control this market.

¹⁶ See, for example, *Wyoming State Tribune-Eagle*, “Wyoming Trona Industry in ‘Back to Nature’ Movement,” p. 3.

¹⁷ FMC brochure, “The Needle-Shaped Crystals ...”.

The remaining synthetic soda ash production in the U.S. and the method used throughout most of the rest of the world is known as the Solvay or ammonia process. It was developed in Belgium in 1861 by Ernest Solvay. Here, carbon dioxide is bubbled through an ammonia-saturated solution of salt (NaCl) to produce calcium carbonate with calcium chloride and sodium chloride as waste products. Disposing of the chloride has posed a problem for producers, who have flushed it into ponds, rivers, and oceans, creating serious environmental problems.

When introduced in 1861, the Solvay method (which produced fluffy white powder) displaced the LeBlanc method, which had been used throughout Europe since its introduction in 1791 by Nicholas LeBlanc. Darkened by one of its ingredients, coal, this method produced a dark version of soda ash called “black ash” through a combination of limestone, coal, and globbersalt (sodium sulfate). LeBlanc’s method was the first synthetic recipe for soda ash, which had previously been produced by leaching ashes from burned seaweed and other alkaline plants—hence the name: soda ash. It led to the first large-scale chemical industry, which developed to satisfy the growing soda ash needs of the Industrial Revolution for the production of soaps, glues, textiles, and glass. It took the great mineral deposits of the American West to turn this highly synthetic product of the Industrial Revolution into a simpler, more natural substance.



Continuous haulage trona mining equipment (Wyoming Mining Association)

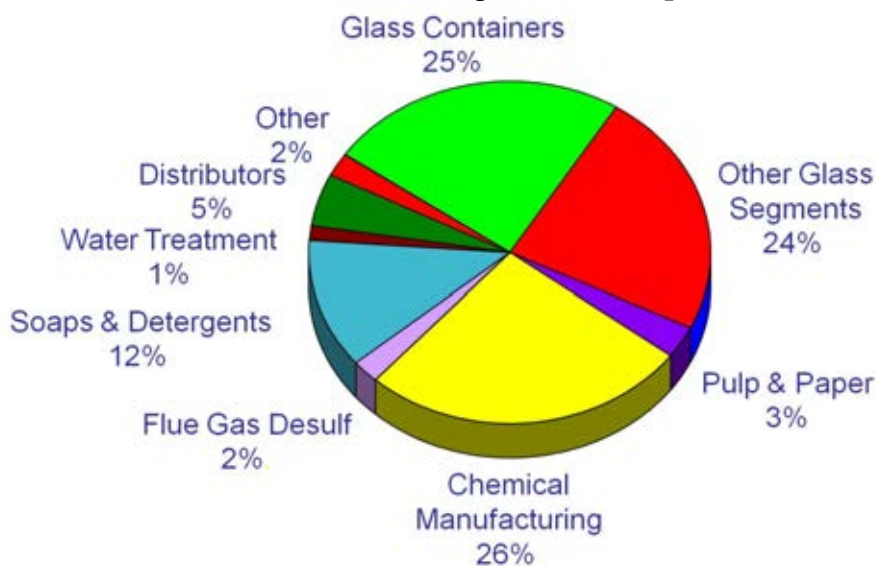
TOPIC 3: CURRENT & HISTORICAL USES OF TRONA

- 3a. Contemporary uses of soda ash and other chemicals derived from trona
- 3b. Ancient uses of trona and methods of deriving it

Soda ash is one of the oldest chemicals to be used by human beings and one of the oldest chemicals to be industrially produced. It is also one of the most produced chemicals in the U.S. and is an important global commodity. Ninety percent of U.S. production of soda ash happens *here* with the mining and processing of Green River trona. An extremely versatile chemical, soda ash is used in most industries today at some point during assembly or production. It is astounding to see the number of ways in which trona ore, unearthed from deep underground, touches our lives everyday. Although many people have never heard of trona, every household in America has a bit of this Green River rock in it—including food in the pantry!¹⁸

Exact numbers always change, but what remains constant are the four main products that use soda ash.

- 1) **Glass** (both containers and flat glass—as well as eye glasses, drinking glasses, dishes, instruments): consumes close to 50% of all soda ash produced
- 2) **Other chemicals:** soda ash (aka sodium carbonate) is basic chemical that is used in the manufacture of other chemicals
- 3) **Soaps and detergents:** soda ash (which is an alkali) forms soap when combined with a fatty acid
- 4) **Pulps and papers:** soda ash helps the sodium sulfite-soda ash solution remain alkaline for the softening of wood chips



U.S. Soda ash demand profile (R. Terry Leigh)

¹⁸ "OK...So What's a Trona?" (unpublished article).

Water softeners and other water treatments provide another fairly large market for soda ash, which is particularly useful in an industrial setting to keep scale from building up in boilers.



Other products that use soda ash in some way include (to name a few):

- Baking soda (bicarbonate of soda)
- Baking powder
- Processed foods (such as ramen noodles and Twinkies)
- Cellulose
- Metals (both non-ferrous and ferrous (as a flux during refining))
 - Iron
 - Steel
 - Uranium
 - Aluminum
 - Aluminum foil
- Textiles
 - Wool (scouring to remove impurities such as salt, oils, and acids)
 - Rayon
- Textile dyes
- Cellophane
- Plastics (some)
- Film
- Vegetable oils
- Animal feeds (as nutritional supplement and antacid)
 - Cattle feeds
 - Swine feeds
- Petroleum refining (as an acid neutralizer)
- Petroleum products



Rubber reclaiming
 Drugs / pharmaceuticals
 Antacids
 Fire extinguishers
 Fire retardants
 Cleaning compounds
 -Metal cleaners
 -Neutralizers for acid wastes in industrial production
 Dental cleansers
 Leather tanning
 Paints and varnishes
 Glues
 Crop treatment: mildew retardant in vineyards
 Bauxite refining
 Ceramics clay (to fluidize certain mineral suspensions)
 Stack scrubbers (to prevent industrial pollution)
 Concrete (to accelerate cure times)



Other chemicals made from soda ash:

Caustic soda

Sodium sulfite (used in photography)

Sodium bisulfite (used in photography)

Sodium carbonate peroxide (used as a dental cleanser)

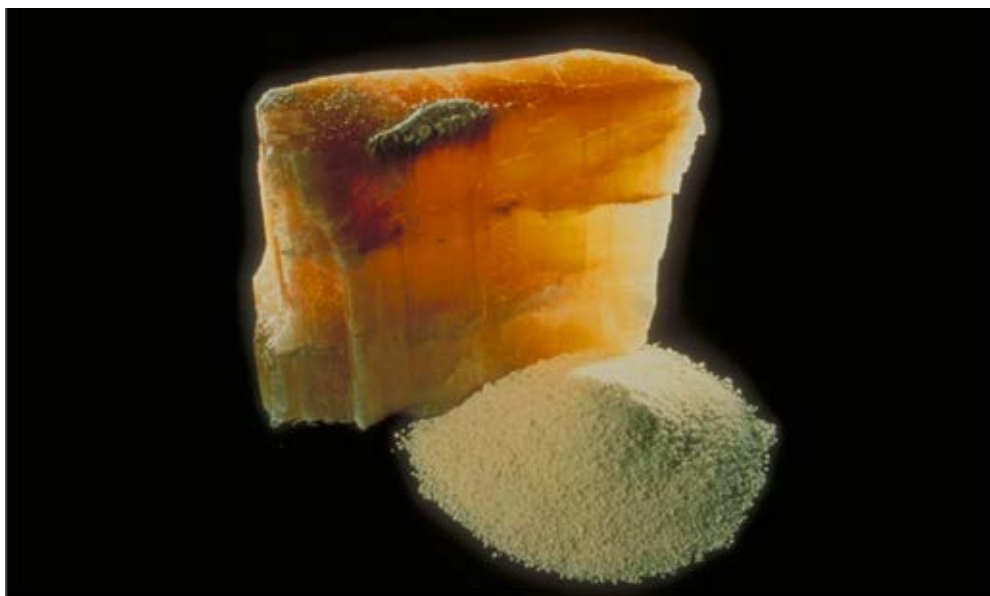
Sodium ferrocyanide (used in tanning leather)

Sodium linoleate (used in paint and varnish driers)

Sodium naphthalene sulfonate (used to liquefy animal glue)

Sodium carboxymethylcellulose (used as an anti-soil redeposition agent in detergents to help keep white cotton shirts from turning gray)

Phosphates (used in detergents and soaps; with evidence that phosphates may contribute to the eutrophication of lakes, detergents are replacing them with soda ash or silicates made with soda ash)



Soda ash (R. Terry Leigh)

Historic uses of soda ash:

Very early glass production was carried out in the ancient Near East and Egypt, where glass ornaments date to several millennia BCE. These have been found alongside comparably dated mummies, embalmed with soda.¹⁹ There is also evidence of Egyptian soap manufacture with soda.²⁰ Expanding on the technology, as documented in the first century CE by the historian Pliny, Romans used soda ash in glass manufacture, too, as well as in bread making and medicinally for colic pain and skin eruptions.²¹

These examples demonstrate ancient knowledge of soda and the ability to use

¹⁹ "The Soda in Your Glass" (unpublished article).

²⁰ Romano, pp. 34–38.

²¹ FMC brochure, "The Needle-Shaped Crystals ...".

it for many of the same products that we make today – except for the mummies.



Ancient Roman glass jug

Still today we follow the basic recipe for glass discovered by the ancients: soda ash, silica (sand), lime, and heat. Use of soda ash substantially lowers the melting point of the sand, meaning that less heat (therefore less fuel) is needed to make glass – plus the cooler molten substance is easier to handle.

Relationship of trona, sodium (Na), and Natrona County

The common denominator linking trona, the symbol for sodium (Na), and Wyoming's Natrona County is the naturally occurring substance known as "natron." It is this substance that the ancients discovered in shallow deposits next to evaporating lakes, such as Lake Natron in Tanzania.

Natron (*ntry* in ancient Egyptian) is a double salt, closely related to trona (both chemically and etymologically). It is 83% sodium carbonate decahydrate (a form of soda ash) and 17% sodium bicarbonate (baking soda). The ancients used it in its raw form; however, limited supplies of this naturally formed substance and growing uses as a cleansing agent, drying agent (for preserving bodies), glass ingredient, mortar ingredient, and so on led to efforts to manufacture it. It was discovered that the ashes of burned seaweed, for example, could be leached with water, which, when dried, produced sodium (aka soda ash). This is how sodium got its symbol, Na, from natron.

Surface deposits of natron found in the vicinity of Natrona County led to its name – suggested, no doubt, by hopeful boosters. It is ironic that 60 years later nearby Sweetwater County realized this dream of a naturally occurring soda ash resource for the state.

TOPIC 4: HISTORIC CHEMICAL & ENERGY INDUSTRIES

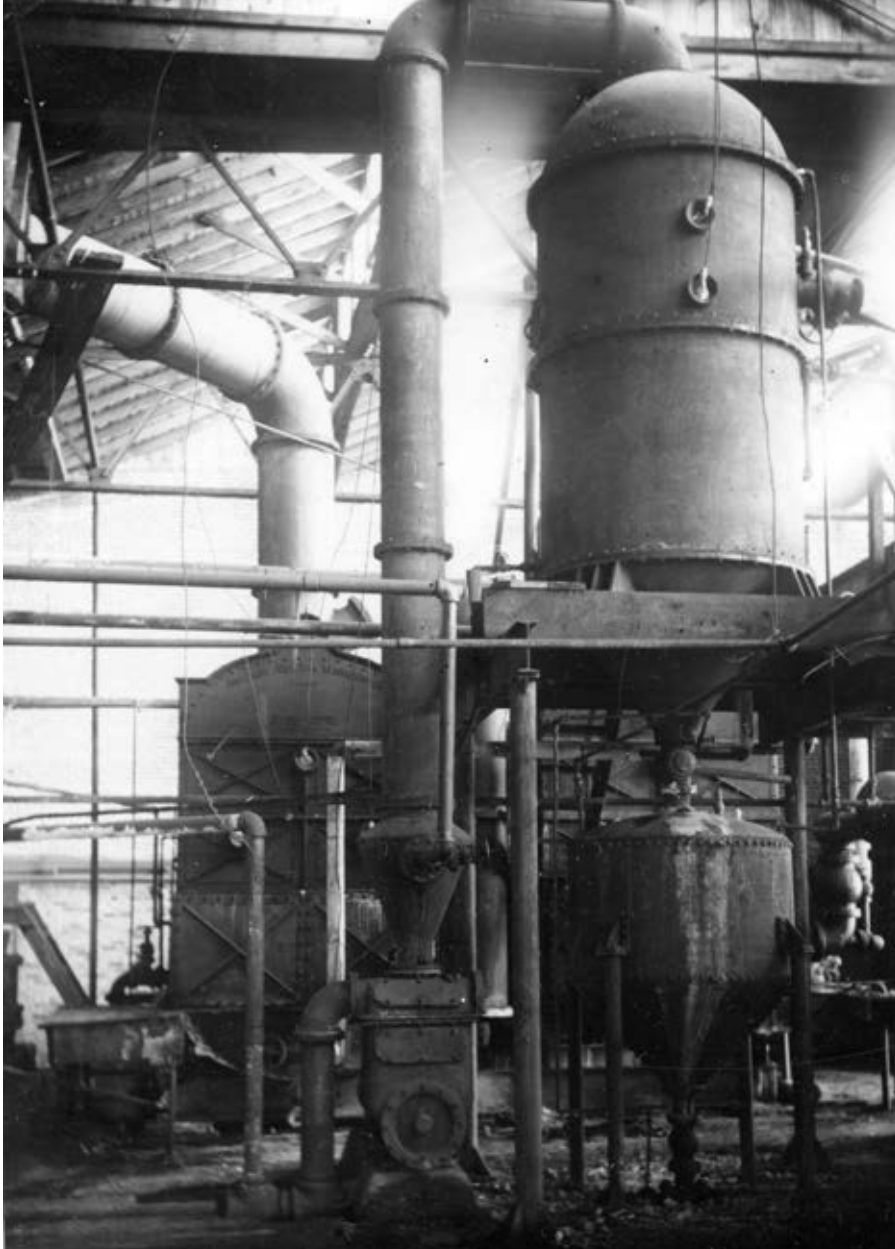
- 4a. Sal soda plant and power plant in Green River
- 4b. Potash plant in Green River
- 4c. Oil shale endeavor near Green River
- 4d. Discovery of trona with the John Hay, Jr. Well No. 1

Southwest Wyoming's chemical and energy industries owe their existence to Lake Gosiute's deep sediments of minerals and organic matter (now hydrocarbons) and to volcanic and tectonic activities that shaped the area and left a rich mineral legacy. Before Green River's success with inventing and developing a trona industry, several endeavors were made to establish resource extraction industries here. Despite available funding, raw materials, and infrastructure, these attempts failed.

Hopeful that the surrounding geology had oil potential, a group of Green River citizens, known as the Green River Fuel and Oil Company, drilled a well next to the river in 1896. This is the first known well sunk at Green River. Now capped and protected by a chain-link fence, it is located in the Sweetwater County service yard on Uinta Drive at the T-intersection with E 4th S St. Instead of oil, however, they found saline water, which they sent to the "State University at Laramie" for testing. Professors W.C. Knight and Slosson identified the brine as very pure, high-quality sal soda and valued it greater than oil.



Green River soda plant (Stimson Collection, Wyoming State Archives, Department of State Parks and Cultural Resources)



Green River soda plant (Sweetwater County Historical Museum)

The soda brine that the well discovered is essentially ground water steeped in sodium carbonate probably derived from trona beds below. Between 1896 and the early 1920s, a series of additional wells were dug, and a succession of owners and lessees attempted to produce saleable quantities of sal soda by pumping the brine into pans and evaporating it to harvest sal soda crystals. They even expanded their offerings to include caustic soda, by heating the brine with lime. Their efforts met with occasional success, which was never long lived. One reason for failure was due to fire, which destroyed the original plant.

Reports state that the plant's products were sold to Union Pacific as a water softener, local laundries, and soap manufacturers in several states. Some sources state that operations ceased in 1908 when the wells were capped, while another recounts that they continued off-and-on through World War I (at which time Green River sal soda was reputedly sold to Japan).²² The most credible source states that operations continued sporadically at least through the late 1920s and that some experimentation even took place during World War II. The wells were capped or pulled and a one-time industry in Green River ceased to be."²³

One of this endeavor's side benefits was the development of a power plant to run the evaporator. This private utility furnished the city's first electricity power and also supplied the railroad.

Mystery shrouds Green River's second and shortest attempt to develop natural resource extraction here: an oil shale refinery located just west of town. In that the Green River Formation is believed to be the largest oil shale deposit in the world, the site selection for this early refinery was a reasonable one. The venture was tied to the great, early 20th century inventor, Milton J. Trumble, who invented the retort used at the Green River oil shale plant. However, after a huge outlay of capital, the operation closed in less than a year, leading local residents to question the intentions of the business promoters, who may have wanted to dupe investors.²⁴

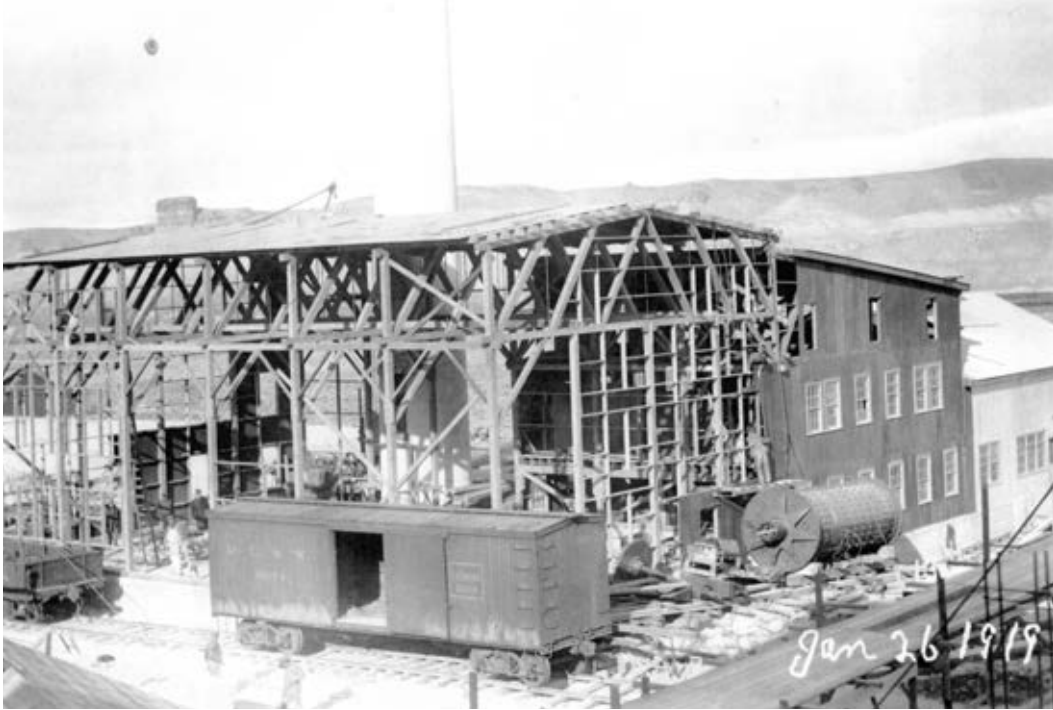


Green River oil shale plant (Sweetwater County Historical Museum)

²² Waggener, p. 13; *The Green River Star*, "Old Timer Recalls Start of Green River Industry;" "NA2 CO3. NAHCO3. 2H2O" (unpublished article).

²³ Mrs. J.H. Jacobucci.

²⁴ Lauritzen, Green River/Trona nomination: "The Wyoming Historic Mine Trail and Byway System Nomination Packet," 2012, p. 3.



Liberty Potash Company (Sweetwater County Historical Museum)

Green River's third attempt to establish an extractive industry was its potash venture. Leading up to World War II, the U.S. was importing most of her potash supplies from Germany, a source that evaporated during the war. Potash is a chemical composed of potassium and lime. It is used for fertilizers and for gunpowder, neither of which Germany wanted to supply her adversary. At the advent of war, U.S. chemists rushed to develop a potash processing method. Green River was selected as the production site. Local boosters hoped that the production of potash would continue after the war. In fact, much discussion surrounded the founding of this plant as being the first step toward developing a large chemical industry here. This industry would include trona whose existence had recently been proven by the Union Pacific with core drilling.

The city of Green River was chosen by the potash developers for its access to coal for fuel and to the three necessary ingredients: Wyomingite (a potassium-rich lava formation found in abundance at the coal-mining town of Superior, north of Rock Springs in the Leucite Hills); limestone (from Sage); and salt (from Salt Lake City). Liberty Potash Company was formed for this purpose. It built a plant on Shoshone Avenue, a mile south of town. The railroad spur leading to it can be seen on the bluff south of Expedition Island.

Despite newspaper reports of the company's success in producing and shipping potash, the plant folded when the war ended. This was at least in part the fault of the U.S. government. The War Trade Board disregarded pleas from the American Potash Producers' Association to protect this rapidly

developing industry by maintaining the embargo on German potash for a while longer as they became more competitive.²⁵ New Mexico is now home to the “Potash Capital of the World.”

The most significant event in Green River’s economic history was in 1938 when Mountain Fuel Supply Company drilled a dry hole 20 miles west of Green River. The company was wildcatting for oil and natural gas. The well is known as the John W. Hay, Jr. Well No. 1. Studying the well’s drill core for mineral content, the company’s chief geologist, William T. Nightingale, was curious about a 10-foot section of salts located 1,500 feet below grade. He sent a sample of this to the Mining Division of the United States Geological Service, where chemists J. J. Fahey and Roger C. Wells identified it as trona.²⁶

In the years immediately following, additional cores were drilled, including several by the Union Pacific railroad, whose extensive property crossed the trona patch. The studies combined to prove the existence of an immense body of trona unlike anything known on earth. Publication of the discovery in *Science News Series*, 140, in an article entitled, “Occurrence of a Deposit of Trona” caught the attention and the imagination of chemical engineer Robert Pike. He recognized the potential bonanza that this discovery represented, and he became a booster for the idea of establishing a chemical industry in Green River. He pitched it to the U.S. Senate, the Union Pacific, and others. Despite Pike’s observations that this industry (expanded to include potash production) would help the war effort, World War II was diverting many people’s attention. In addition, the concept of a chemical industry based on a deep underground source of trona seemed far-fetched when soda ash could be made synthetically without needing to mine ore and without needing to transport it from Wyoming all the way to East Coast markets.

Through Pike’s efforts, as well as those of Senator Joseph C. O’Mahoney and the Green River Chamber of Commerce, interest in trona was finally kindled. West Virginia Chlorine Products Company (Westvaco), who was seeking a source of sodium carbonate for its chemical products, initiated commercial mining of the trona. Arriving in 1944, they first attempted to recover trona from brine, but in 1947 the company sank a 12-foot wide shaft 1,550 feet deep to a level below the ore in order to attempt direct, dry mining.²⁷ At the same time, it built a pilot plant for processing ore as natural soda ash. The first few years were spent in development of methods and procedures; however, in 1954, regular extraction and processing of ore began.²⁸

²⁵ *Rock Springs Rocket*. “Potash Men Ask That Embargo Not Be Lifted.”

²⁶ Dyni and Jones. According to Ramon Frint, the only reason that a core was taken during the drilling of this well was because geologist Charlie Love from the USGS office in Laramie asked Mountain Fuel to do so as a professional favor; see Ramon Frint, Oral History.

²⁷ Hand. Other accounts say that this well was sunk in 1946, e.g., FMC brochure, “The Needle-Shaped Crystals....”

²⁸ Romano, pp. 34–38.

Green River credits its prosperity today to the success of these two pioneering efforts: the mining and processing of trona. Successful beyond anyone's dreams, the legacy of these events has placed Green River in control of the nation's soda ash supply (furnishing 90% of U.S. needs), while also providing a significant share of the nation's baking soda products.



Views of Green River soda plant (Sweetwater County Historical Museum)

TOPIC 5: SOCIAL & URBAN HISTORY

- 5a. Local and regional immigration due to railroad, coal, and trona industries
- 5b. Green River Ordinance
- 5c. Urban history of Green River: expansion in response to railroad and chemical industry growth
- 5d. Mining culture: 24-hour town, shared lifestyles

The city of Green River has been tied to cross-country trade and traffic from fur trappers working and traveling the river, to the Pony Express, to Ben Holladay's stagecoach station and repair shops along the Overland Trail south of town, to the location of a Union Pacific division point here, and finally to the Lincoln Highway followed by I-80 crossing the north side of town.

Being located on a transcontinental corridor keeps Green River in a constant flow of new people and ideas, giving the place a remarkably cosmopolitan feel for a town of 12,500 residents. In the past six months, the Chamber of Commerce has registered visitors from 49 states and more than 18 foreign countries.²⁹



Green River (Sweetwater County Historical Museum)

²⁹ Green River Chamber of Commerce, "2011–2012 Tourism data."

Part of the reason for this has to do with demographics. Among the largely Caucasian population, ancestries cited are equally English and German, to a lesser degree Irish and American, as well as Danish and Swedish. Not only did the trona mines in the 1970s recruit coal miners from Canada, England, Wales, Finland, and other parts of Europe, but also in the early 20th century, the Union Pacific recruited coal miners to the Rock Springs mines from England, Scotland, Wales, and Ireland – not long after they had established a large Chinese population in Rock Springs for railroad construction. These nationalities spilled into Green River as well.³⁰

Another international influence in Green River is the trona mining and processing companies themselves. At present, three out of four of them are foreign (Belgian, Indian, and Korean – which purchased from a French corporation).



Downtown Green River, ca. 1950s, 24-hour town (Sweetwater County Historical Museum)

The two industries that have supported Green River's economy since the late 19th century – the railroad followed by the trona mines – have also given Green River an urban feel due to shift work. Instead of the town closing up at 9 PM like most rural towns this size, a number of establishments stay open all night, and people are out on the streets at all hours.³¹ This lifestyle is not new to Green River. It was the town's 24-hour schedule that led to its famous ordinance, passed in 1931, and copied by many cities. It prohibits door-to-door solicitation, which at the time was waking up night-shift railroad workers who slept during the day. It continues to be useful today for the trona shifts.

³⁰ Public meeting discussion August 23, 2012; Gardner and Flores, p. 19.

³¹ Public meeting discussion August 23, 2012.



Green River today has 24-hour restaurants to serve shift workers (Toxey/McMillan Design Associates)

For over 100 years—from the town’s birth in the 1860s until the early 1970s—Green River was a small town whose population hovered between 2,000 and 4,000. With a footprint about 25% its current size, the town was situated on the north side of the river, with the elite living north of the tracks and the non-elite south of them.



Green River 1924. Notice the grid street pattern and the concentration of the houses in the foreground, north of the railroad. The soda plant is in the mid-ground. (Sweetwater County Historical Museum)

In the late 1940s when nearby coal mines started to close due to the introduction of diesel and natural gas, and the Union Pacific began to scale back due to competition from automobiles and trucks, Green River's and Sweetwater County's future looked grim. But just as jobless residents began to leave, Westvaco's experimental trona mine began to produce ore and to hire former coal miners. Despite the overall county's loss of population, Green River's 1950 census shows a 17% population increase, which was met by construction of 100 new homes in a new neighborhood called Man's Face Addition.

The real boom hit in the 1970s, when several events coincided. 1) Five trona mines had been established and were doubling in size and in employment. 2) A major power plant was being built and operated nearby. 3) The local coal industry revived due to the OPEC embargo, which led to 1,000% growth in coal production.³² Green River's population tripled within less than a decade. Recognizing the acute housing shortage that the city faced, the trona companies stepped in to help.

As a temporary measure, mobile homes and tent villages were set up on the south side of the river. Over the course of the 1970s, however, permanent structures were built that pushed the city southward across the river, quadrupling the footprint of the city. Texasgulf led the effort, spending \$20 million on the construction of 235 houses and 142 apartments in Green River for its employees, as well as a playground, park, picnic area, little league baseball field, and lighted tennis courts. It also donated land to the city for a school. Five years later the company allowed employees and the general public to purchase the homes.³³ Company spokesperson explained: "It is not the desire of the company to create a 'company town' within Green River, however, after much study of the land situation, Texasgulf felt that by offering permanent housing they would have the best opportunity to create a stable work force."³⁴ Likewise, FMC spent \$12 million constructing single- and multi-family dwellings in south Green River for employees and established a park.³⁵ Growing to meet the new chemical industry's demands, the Union Pacific also revived at this time and is responsible for constructing a neighborhood in south Green River.

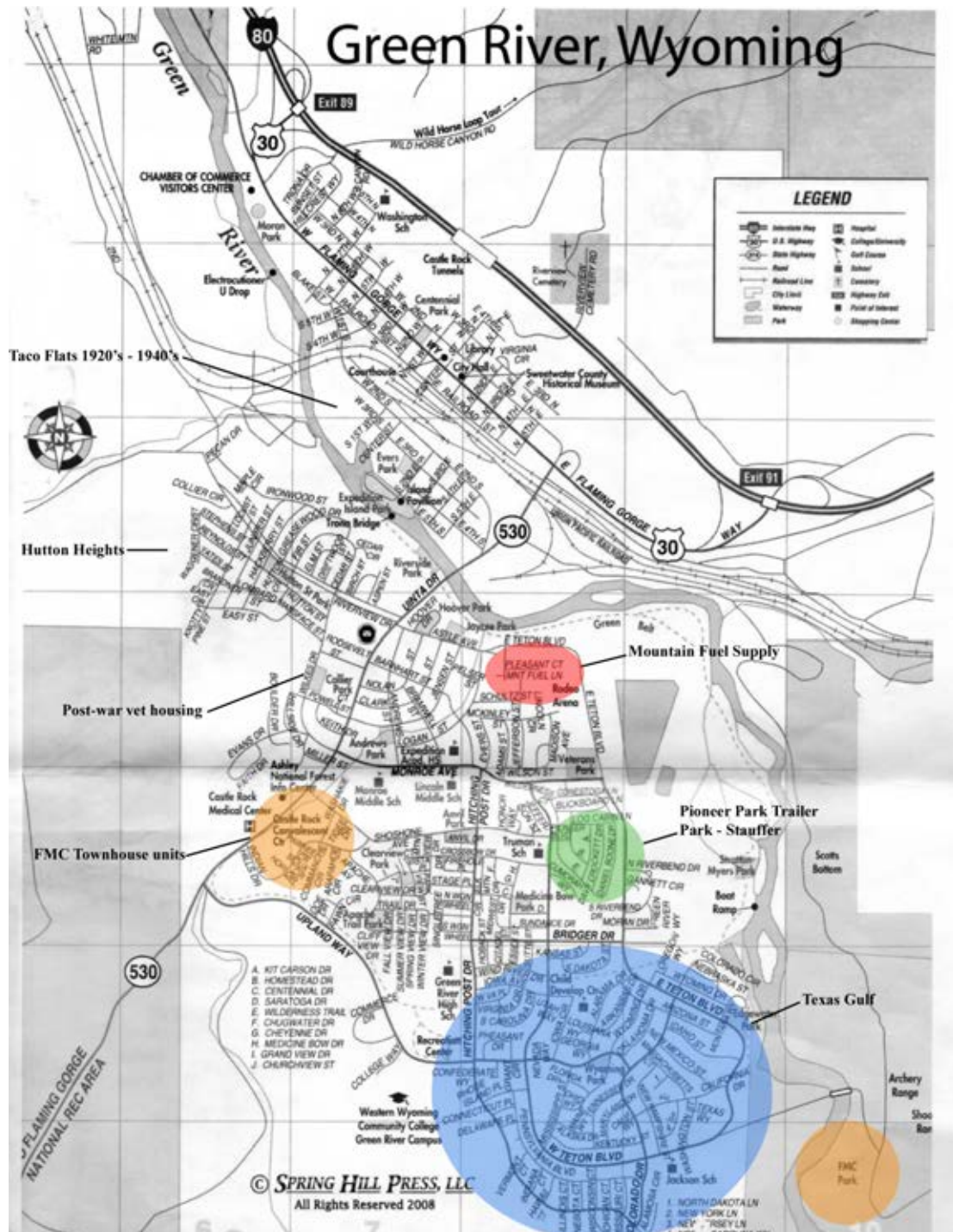
Looking at a city map, you can see these neighborhoods as well as the abrupt change in urban form from the gridiron old city north of the tracks and the curvilinear street plan of south Green River, which largely dates to the 1970s.

³² *The Green River Star*. "Trona Increase Is A Reason For Asking College to Establish Mine Work Plan."

³³ Texasgulf. "Industrial Awareness Week."

³⁴ *Star-Tribune*. "Homes for Many."

³⁵ *Star-Tribune*. "Homes for Many."



Map of Green River. The pre-1970 city is concentrated north of the river in a gridiron plan. The post-1970 town is located south of the river on curvilinear street plans, which include several company-built neighborhoods (colored zones) [FMC: tan, Texasgulf: blue, Stauffer: green, Mountain Fuel Supply: red]. Here, too, are located amenities developed and built by trona mine companies for workers and for the community.

In addition: "The five trona concerns have joined together in an organization called the SW Wyoming Industrial Association and contributed toward the recruitment of physicians and financing clinic facilities and equipment. Their history may be short, but they have provided help with civic problems due to impact and in their beginning saved workers, out of work, due to changing times, from disaster."³⁶

Efforts such as these to provide for their employees and to build stable communities have paid off. The mining community is tightly-knit—especially the crewmembers that work together. They share a culture: they have everything in common from wearing the same clothes (for example, steel-toed boots) to having the same stickers (reflectors) on their lunch buckets. There is also a feeling of camaraderie that develops on the buses (contracted through private companies). With 2,000 members of the community working for the mines, and only 4,441 households in the community, it means that almost half the households in Green River have a family member working for the mines (man or women, since many miners these days are female).

While strikes are rare, some tension exists between the unionized and non-unionized workers—FMC and Tata employees belong to United Steel Workers; while OCI and Solvay employees are not unionized. The pay, however, is very good, which makes most people content. The median household income of Green River is 32% higher than that of the state and 60% higher than the national average.



Trona mine and plant, Solvay Chemicals (Toxey/McMillan Design Associates)

³⁶ "NA₂CO₃. NAHCO₃. 2H₂O" (unpublished article).

MEDIA PLAN & RECOMMENDATIONS

This interpretive plan will be used to guide the development and design of the media suggested below.

Please note that cost estimates provided below are not based on defined scope and design and therefore are hypothetical. Depending upon scope, design, and available budget, these could change.

1. TRONA TRAIL ROUTE

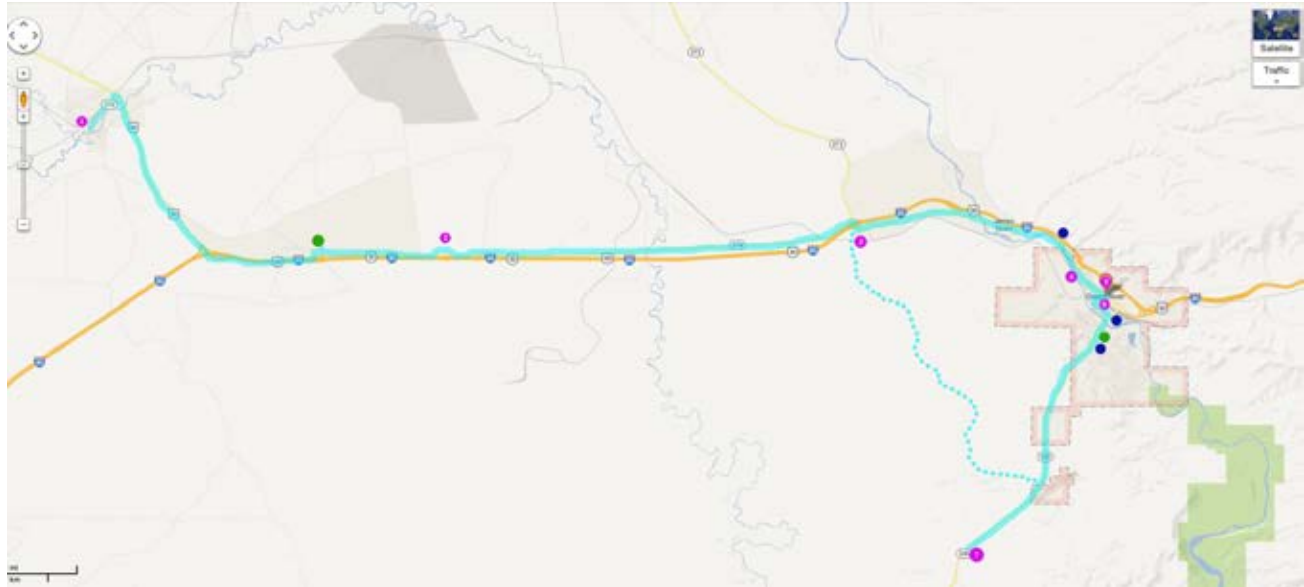
The maps below define the proposed byway route.

The proposed route is linear and can be approached from several different directions. Adventuresome visitors can complete the route as a loop by taking a graded county road (Peru Cutoff Road).

One terminus of the route is an existing pullout located ca. six miles south of Green River on U.S. Route 530, and the other terminus is an existing State Parks, Historic Sites & Trails feature (Granger Stage Station) located 30 miles west of Green River in the town of Granger.

In addition to passing trona and other resource extraction features along the way, the route winds through the city of Green River to see the urban, economic, and cultural features located here that relate to byway storylines. This excursion also provides visitors access to the Sweetwater County Historical Museum, tourist information and exhibits at the Green River Chamber of Commerce, parks, refreshments, restrooms, and other amenities and places of interest, such the historic downtown district, historic Union Pacific depot and viaduct, and Expedition Island.

Because visitors to the byway may be entering from three points (westbound Interstate Highway 80, eastbound I- 80, or northbound U.S. Route 530), the trail needs to accommodate motorists in all directions. It is recommended, therefore, that any interpretive panels placed on the route include a small trail map marking the route and the locations of other signs.



Overall view of Trona Trail route

Purple dot: Interpretive panels (7)

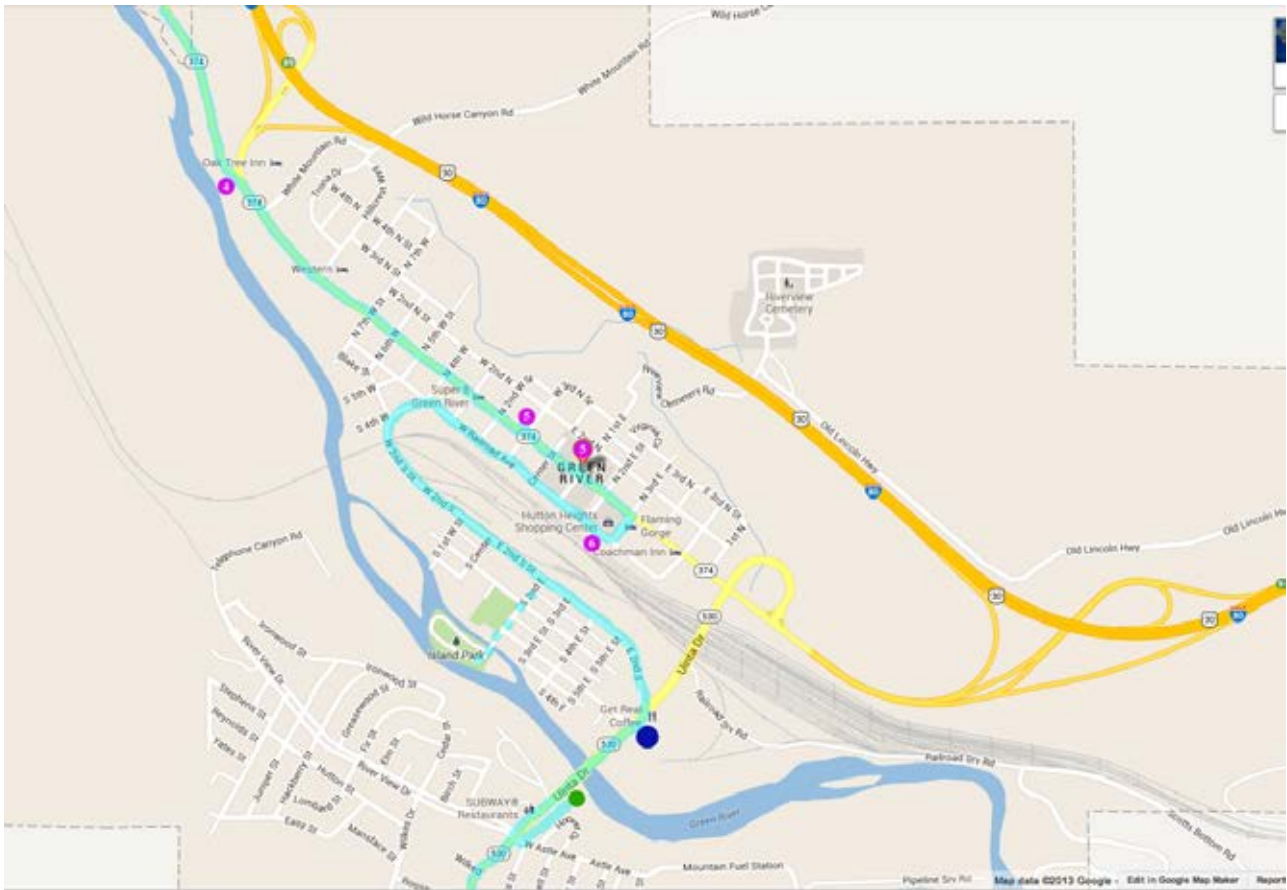
Green dot: Route map (2)

Blue dot: Point of interest (at least 3: potash plant, sal soda plant, oil shale plant)

DIRECTIONS

- Begin at the Granger Stage Station Historic Site in Granger. This is the location for *Trona Trail Sign 1*. This is the western edge of current trona mining activities.
- Follow road 375 to U.S. Route 30, and take this south five miles to Interstate Highway 80.
- Turn eastward on I-80. In two miles, exit the highway at Little America (exit 68). We propose to locate a *Trona Trail Route Map* (exterior cast aluminum sign) in the parking lot at Little America for the many travelers who stop here. This is also a good refreshment stop for any byway travelers.
- From Exit 68 (or if leaving Little America) take WYO 374 east for three miles (parallel to I-80) to the existing pullout, where a SHPO marker describes the former railroad town of Bryan. This is the location for *Trona Trail Sign 2*. Though not perceptible, the trona bed beneath the road from US 30 to a point approximately 8 miles farther east of this pullout has been extensively mined, and the land extending tens of miles on both sides of the highway is leased for mining.
- Continue traveling eastward on WYO 374. In about 10.5 miles, WYO 374 turns right and passes over I-80. It intersects at this point with the northern end of Peru Cutoff Road. This intersection is the location of *Trona Trail Sign 3*. Adventuresome travelers could take the Peru Cutoff Road across a

pasture/gas field to arrive at *Trona Trail's* southern terminus. The recommended path, however, is to continue traveling east on WYO 374 into the city of Green River.



Detail view of Trona Trail route through Green River

Purple dot: Interpretive panel
Green dot: Route map location
Blue dot: Point of interest

- At the entrance to Green River at the intersection of White Mountain Road with WYO 374 (aka Flaming Gorge Way) is the Green River Chamber of Commerce. This is the location for *Trona Trail Sign 4*. This stop also provides visitors with regional exhibits (including information about and samples of trona), tourist information, a nature walk, and restrooms. It will soon also exhibit donated trona mining equipment in exterior exhibits.

- Continue traveling east through downtown Green River on WYO 374/Flaming Gorge Way. *Trona Trail Sign 5* will be located at one of two city parks on this street. The first option is Centennial Park, located two blocks west of Sweetwater County Historical Museum. This established park has many amenities to welcome visitors. The alternate location is a pocket park that is currently being designed immediately east of the museum. Its

proximity to the museum, which offers interpretive exhibits about mining and the region, is advantageous.

- Continue traveling east on WYO 374/Flaming Gorge Way. Turn right (south) on N 3rd E Street and again turn right (west) onto E. Railroad Street. Pull into the parking lot of the historic Union Pacific railroad depot, the second largest UP depot in the state. This is the location for *Trona Trail Sign 6*. The city is in the process of planning the restoration of this stately structure and the inclusion of new civic functions as part of its Main Street Program, which will also provide visitor amenities. From here visitors can also walk across the historic viaduct over the rail yard (which was installed in 1937 as a safety feature for pedestrians). This is one of few remaining viaducts in the state.
- Continue westward six blocks on E. Railroad Street, and turn left onto S 4th W Street. You will be passing a neighborhood composed of UP company homes for former railroad workers as well as dispatcher offices.
- Veer left onto W 2nd S Street whose underpass crosses beneath the railroad. As you travel along W 2nd S Street you will be passing through distinctive South Side, which is where immigrants and people of color traditionally lived. You will also be passing within 2–3 blocks of Expedition Island, which is a well-interpreted park that visitors may wish to detour to see. If desired, a this detour could be worked into the byway, and an additional *Trona Trail Sign* could be located on the island. On the bluff visible to the south of the island is the railroad spur leading to the old potash plant, another topic of byway interpretation.
- Continue east on W 2nd S Street to its end at Uinta Drive (US Route 530) and turn right (south).
- In about 250 feet on your left is a county service yard. At the back of this yard is the old capped well (now surrounded by a chain link fence and a sign) that furnished soda water to the city's first chemical industry: a soda plant. This is a feature of the byway content; however, the access to it is limited and possibly problematic for county operations, making this a less-than-desirable place to locate a *Trona Trail Sign*. We propose covering this topic in a different sign and locating this site on the byway route map as a point of interest.



Soda plant well and sign, Green River (Toxe/McMillan Design Associates)

- Continue southward on Uinta Drive/ WYO 530, and turn left (east) at the top of the hill, onto W. Astle Avenue. Then turn immediately left again (north) onto a small, unmarked lane, which looks like a frontage road for Uinta Drive/ WYO 530. You will pass a state marker for an Overland Trail stagecoach station as you proceed to the end of the road. Overlooking the site of the old soda plant and providing a good overview of Green River (the town, the river, and the railroad), this scenic site has been considered for a *Trona Trail Sign*. However, the road leading to it does not appear to be a legitimate road, and large vehicles may not be able to negotiate the tight turns. We therefore propose to locate a *Trona Trail Route Map* (exterior cast aluminum sign) here to mark the trail but not include pertinent interpretive content that we fear many motorists would miss. This map would also be of service to visitors beginning the byway at its southern terminus.

- Turn around and retrace steps to W. Astle Avenue. Turn right (west) onto W. Astle Avenue and immediately turn left (south) onto Uinta Drive/ WYO 530.

- Continue south about 6.5 miles on Uinta Drive/ WYO 530 to a pullout on your left, which is the southern terminus of the byway route and the location of *Trona Trail Sign 7*. Along the drive, notice the good views to the west of the Tata, Church and Dwight, and Solvay processing plants. Straight ahead are the Uinta Mountains that define the southern end of Lake Gosiute. On your right about 2 miles before arriving at the pullout (and located directly across from the airport) is the southern end of Peru Cutoff Road, which some byway visitors may want to drive to loop back to the western portion of the route.

2. EXTERIOR INTERPRETIVE SIGN SERIES

We suggest that seven exterior interpretive roadside panels be located along the byway route. If additional (or fewer) funds are available and more (or fewer) panels desired, the interpretive content described below could be reorganized over more (or fewer) panels. The panels' content should develop the theme and topics described above. They should include text, photographs, diagrams, and maps. It is also recommended that each panel include a brief definition of trona for those people who happen onto the middle of the trail. Panels should be located along the trail at existing pullouts or appropriate places where cars can safely stop. Please see map and descriptions (above) for proposed route, points of interest, and sign locations. Proposed sign topics are outlined below.

To mark the trail, sign graphics should be distinctive, identifying the byway and reflecting the subject matter. For example, since glass is by far the largest use of refined trona, glass panels could be used. These could be fabricated many ways, such as laminating interpretive content between two sheets of glass or to the back of one sheet. These would elegantly illustrate the content and identify the trail in a distinctive way. An alternate idea would be to solicit large, defunct mining equipment from the active mines to use as supports for interpretive panels. These, too, would serve as icons for the byway. Panels affixed to the equipment could be made of high-pressure laminate, fiberglass, metal, or (again) glass, which would show the full range of activity from mining through final product.

The graphic template and style palette developed for these signs should also be used in developing other interpretive and marketing media, such as brochures.

Regarding the possible inclusion of QR codes on the panels, although this simple graphic is a popular medium for providing more content, it poses the following challenges and is therefore not recommended at this time: 1) it would require more development costs for content, programming, and websites, 2) it would require SHPO to place more resources than it currently has in website maintenance, 3) it can be easily hacked and lead trusting visitors to malware sites.

Cost estimate for seven signs of approximate size 3' x 5': \$35,000 for research, writing, graphic design, layout, image collection and licensing, review and correction process, fabrication of signs in high-pressure laminate, crating, and delivery. Mounts and installation not included.

HIGHWAY APPROACH SIGNS

It is recommended that WYDOT or other agency provide small signs indicating the path of the trail, at least at highway turn-off points along I-80.

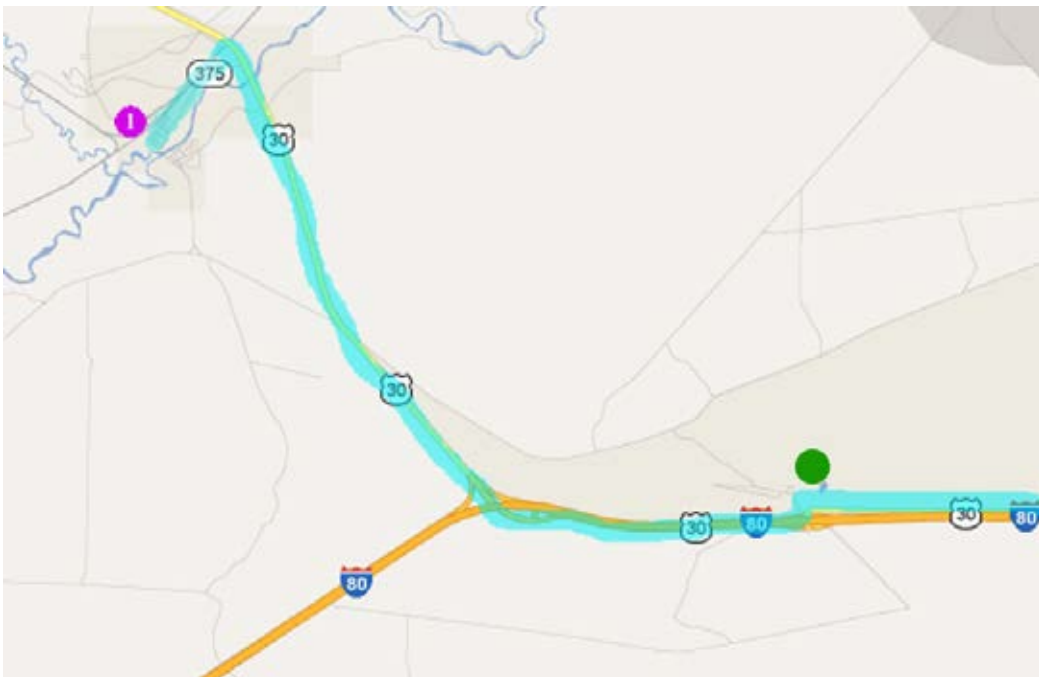
SEVEN SIGN TOPICS / LOCATIONS:

Sign location 1: Granger Stage Station (State Parks, Historic Sites & Trails feature)



Sign topic 1:

- Contemporary (and growing) uses of soda ash and other chemicals derived from trona
- Impact that trona (or naturally produced soda ash and sodium bicarbonate) has on modern, everyday life
- General statistics on amounts soda ash used in various industries and world and U.S. consumption rates

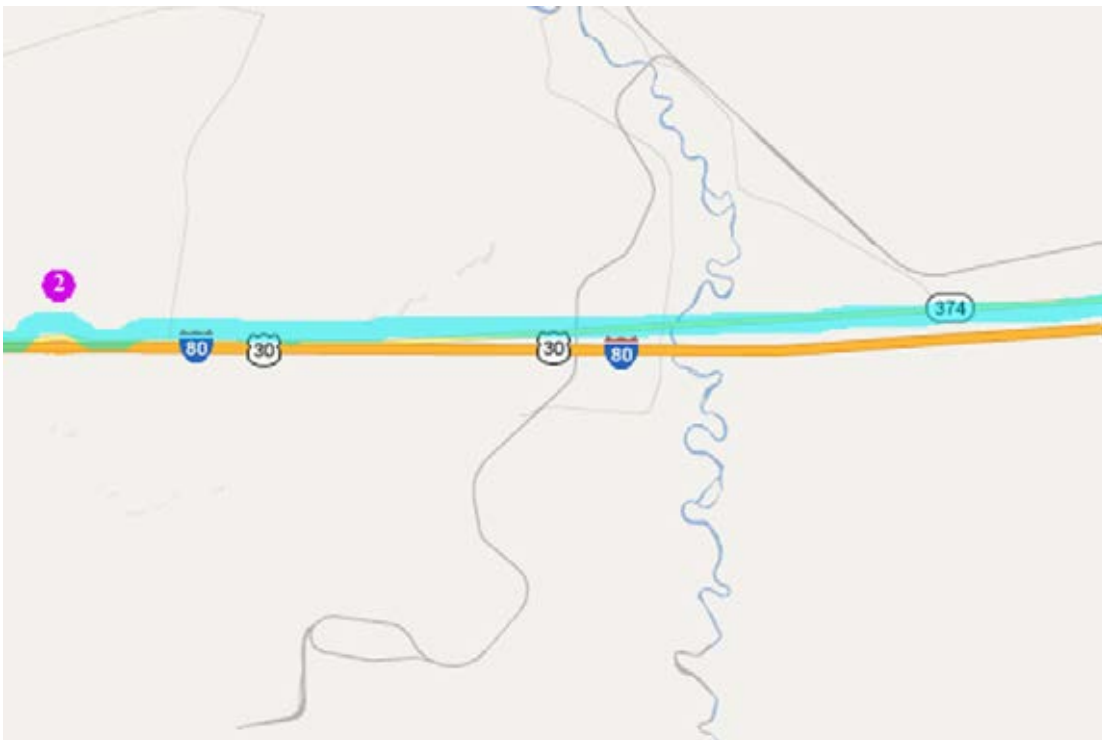


Trona Trail Sign 1 at Granger and Route Map at Little America

Sign location 2: Existing pullout along WYO 374 approximately three miles east of I-80 Exit 68 (and Little America). This is also the location of a SHPO marker describing the former railroad town of Bryan.

Sign topic 2:

- Extent of trona mines underfoot and amount of removed material
- Trona mining methods originally based on coal
- New mining methods developed here or adapted from elsewhere
- Environment of the mine: underground city



Trona Trail Sign 2 , existing pullout on I-80 located next to SHPO sign for Bryan

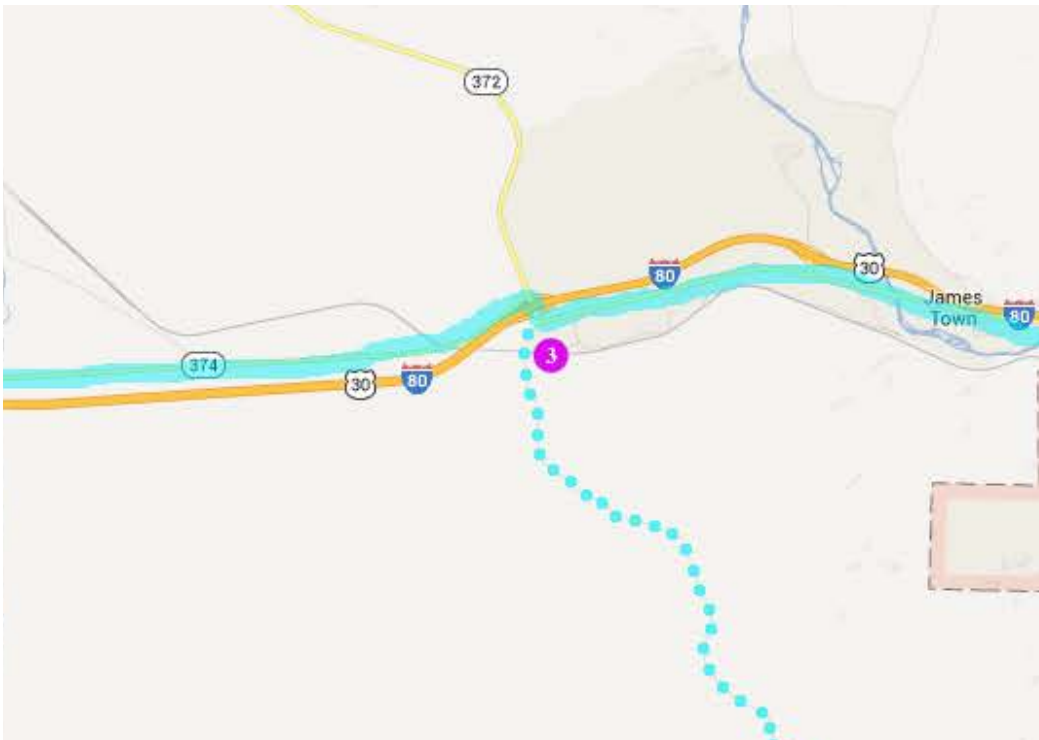
Sign location 3: Intersection of WYO 374 (after I-80 underpass) and Peru Cutoff Road.

OPTION: Loop to other byway terminus via Peru Cutoff



Sign topic 3:

- Methods of processing trona into natural soda ash
- Synthetic soda ash processing methods (Solvay and LeBlanc)
- Historical uses of trona/soda ash and ever-growing demands
- Relationship of trona to natron and sodium (Na)



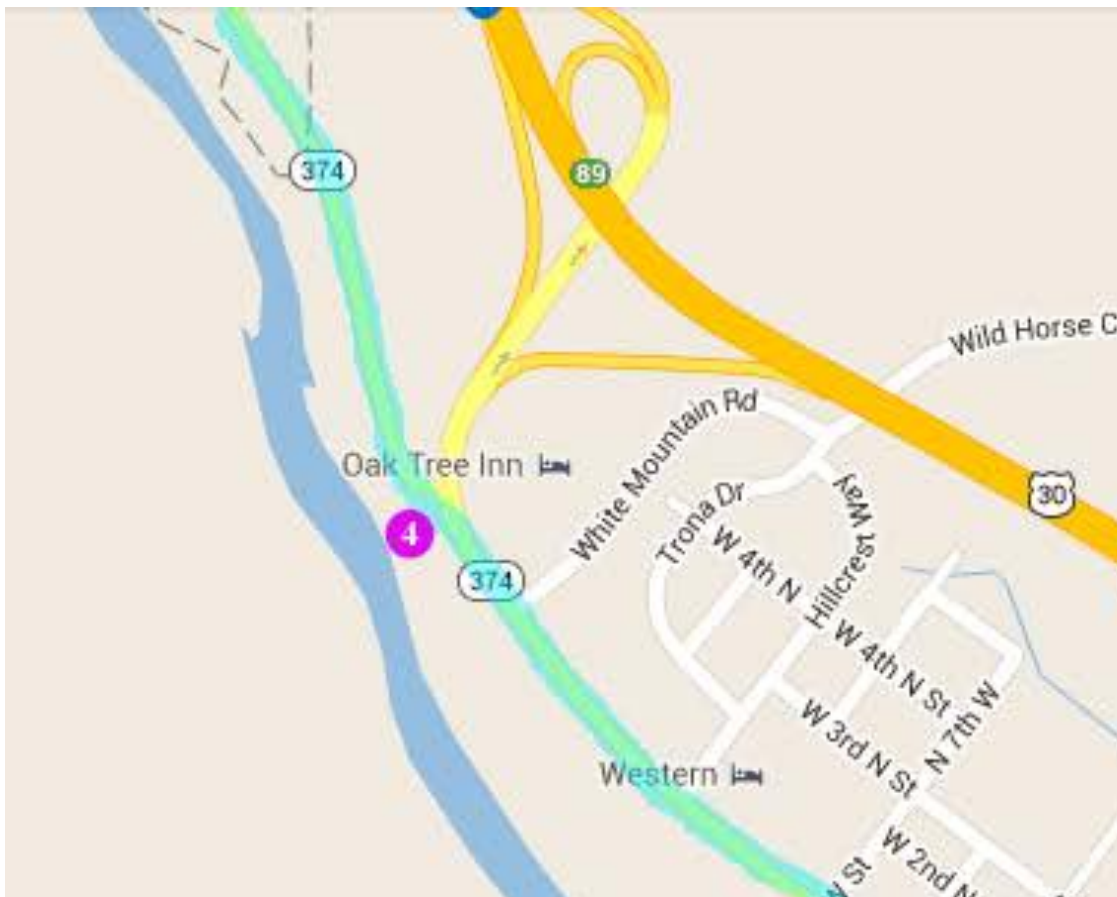
Trona Trail Sign 3: at intersection of WYO 374 and Peru Cutoff Road

Sign location 4: Green River Chamber of Commerce parking lot: intersection of WYO 374/Flaming Gorge Way with White Mountain Road.



Sign topic 4:

- Immigration history of the region due to railroad and trona industries
- Green River Ordinance
- Urban history of Green River: expansion in response to railroad and chemical industry growth
- Mining culture: 24-hour town, shared lifestyles, closely knit community



Trona Trail Sign 4: Green River Chamber of Commerce

Sign location 5: One of two city parks located in downtown Green River on WYO 374/Flaming Gorge Way: Centennial Park (two blocks west of Sweetwater County Historical Museum) or the pocket park being designed immediately east of the museum.

Sign topic 5:

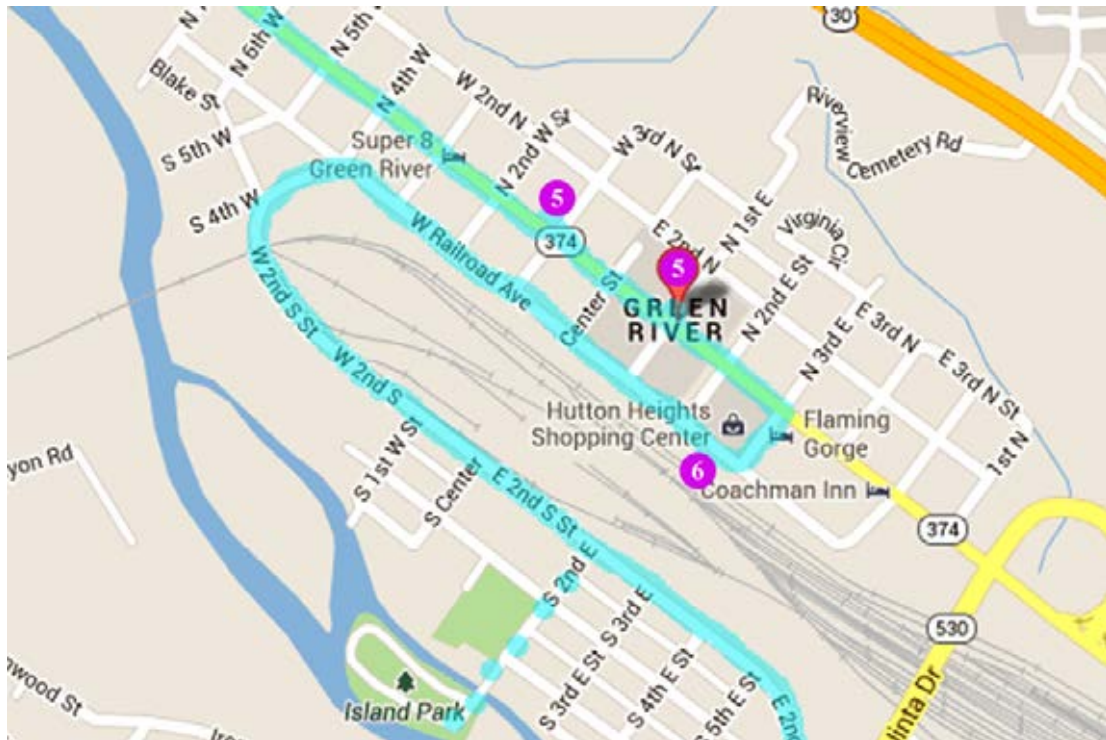
- History of the discovery of trona in the Green River Basin (John Hay, Jr. Well No. 1)
- History of development of trona mining (first ever) and processing industries

Sign location 6: Parking lot of the historic Union Pacific railroad depot, located on E. Railroad Street at the intersection of N 3rd E Street

OPTION: cross railroad pedestrian viaduct and visit Expedition Island

Sign topic 6:

- Economic history of the region: railroad, ranching, coal-mining, energy industries, and chemical industries
- History of the sal soda plant and power plant in Green River
- History of the potash plant in Green River
- History of oil shale endeavor near Green River



Trona Trail Sign 5 (two park options) & Sign 6 (Union Pacific depot)

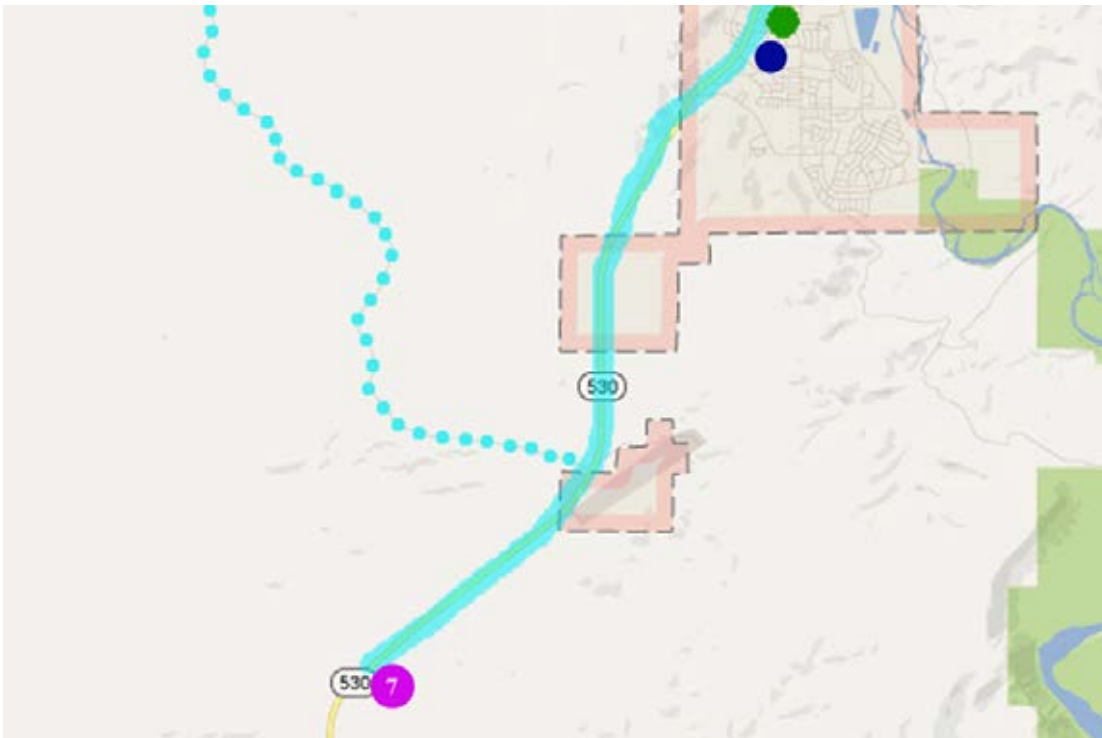
Sign location 7: Existing pullout on east side of Uinta Drive/ WYO 530, approximately 6.5 miles south of the city of Green River and about 2 miles south of Peru Cutoff Road.

OPTION: loop back to I-80 along Peru Cutoff



Sign topic 7:

- History of Lake Gosiute
- Geology of the region
- Formation of trona



Trona Trail Sign 7 and Route Map location (on bluff in Green River, overlooking river). Point of interest at old potash plant site.

3. BROCHURE

Following the precedent set by the previous three Wyoming Historic Mine Trails and Byways, we recommend developing a brochure for this trail. It should provide a clear map of the route of the *Trona Trail* with locations of interpretive panels and points of interest noted. It should also include photographs and text that provide an overview of the byway interpretation. This brochure can use existing marketing strategies and be distributed through state, regional, and local tourism channels in order to make travelers aware of the trail and to accompany them on the trail. It could also be made available for download on a website to facilitate trip planning.

Cost estimate: \$4000–5,000 for research, writing, graphic design, layout, development of maps, development of illustrations, image collection, image licensing, photographic enhancement, mockups, review process, and proofs. Printing and shipping cannot be estimated without parameters.

4. WEBSITE

With most travelers planning their trips using the Internet, a website is a strong method for building *Trona Trail* awareness. In addition to orienting visitors before they arrive, a website can furnish information to those unable to experience the byway in person.

The website should provide the *Trona Trail* route map and locations of interpretation. It is also a venue for unlimited additional information about the byway and the history of the region. For example, it could include:

- a virtual tour of the trail
- historic photographs
- video clips such as flyovers and interviews/oral histories
- off-byway and recreational opportunities
- links to related museums, chambers of commerce, Wyoming Office of Tourism, and other partner organizations in the region
- links to other Wyoming Historic Mine Trails and Byways

Cost estimate: \$8000– \$16,000, depending upon website complexity

5. AUDIO TOUR

In conjunction with the roadside interpretive panels, an interpretive audio component could provide an auditory dimension at each of the interpretive roadside signs. This is an opportunity to utilize edited clips of some of the oral histories that the Sweetwater County Historical Museum has collected.

While a text panel has only a few seconds to capture and keep readers' attention, audio tour listeners are captive for longer periods of time.

Therefore, if this component were developed as an audio driving tour to accompany drivers along the *Trona Trail*, the oral history clips could include narration, music, and the sounds of mining machinery.

Cost estimate: Approximately \$500–700/minute of audio. This includes development of storylines, scripting, narration, editing of oral histories, sound effects, and background music.

6. VIDEO TOUR

Many visitors would respond favorably to an interpretive video component. This could be a virtual tour of the *Trona Trail* viewed from a computer and located on the trail's website. Or, using portable digital devices, the audio tour could be illustrated with video and accompany visitors on the trail. The video component could even develop the *then-and-now* concept by presenting historic and contemporary images of locations, or even video tours through digital 3D reconstructions of mining sites.

Production costs of these ideas range considerably, depending upon whether existing historical images are used or 3D modeling is developed. If using historic imagery provided by the community to illustrate an existing audio tour, the cost would be ca. \$400–500 per minute. If a script and voice talent were additionally needed, the price would be closer to \$600–800 per minute.

7. EXHIBIT

Exhibits are a wonderful way to enrich the *Trona Trail* experience, especially since most visitors will not have the opportunity to enter a working trona mine. We recommend placing a walk-in mine diorama inside (space permitting) a city, state, or county building near one of the interpretive panel locations in Green River. It includes a tunnel sculpted to look and feel like a trona mine. The space is unlit, and visitors wear miners' helmets and lights in order to light the exhibit space and read the panels. The space is filled with sounds of miners and mining equipment. Since mines are loud, the auditory part of the exhibit might be carried out through earphones or small speakers built into the helmets. The sound track includes the voice of a miner, checking air quality, discussing the next drilling campaign, humming a tune. The visitor senses the high-tech quality that modern mining has achieved, while maintaining the camaraderie that has always bound miners. The diorama will be supplemented with interpretive panels and hands-on mining equipment. It could also include a display case of artifacts.

Cost estimate: \$30,000–\$60,000, for an interior, multimedia exhibit.



This photograph of miners at Stauffer Chemical Plant near Green River (1970s) has the feel that we are proposing for the museum-type walk-in exhibit (Wyoming State Archives, Department of State Parks and Cultural Resources)

8. OFFICIAL STATE HIGHWAY MAP OF WYOMING

We recommend approaching the Wyoming Department of Transportation to request placement of the *Trona Trail* on the state highway map.

9. DESIGN STANDARDS AND RECOMMENDATIONS

Include the Historic Mine Trail and Byway program logo and Wyoming State Historic Preservation Office logo on all signs and printed media. Once a template has been designed for one of these media, use it as the basis for other graphic and media design to provide a consistent image and identity for the *Trona Trail*.

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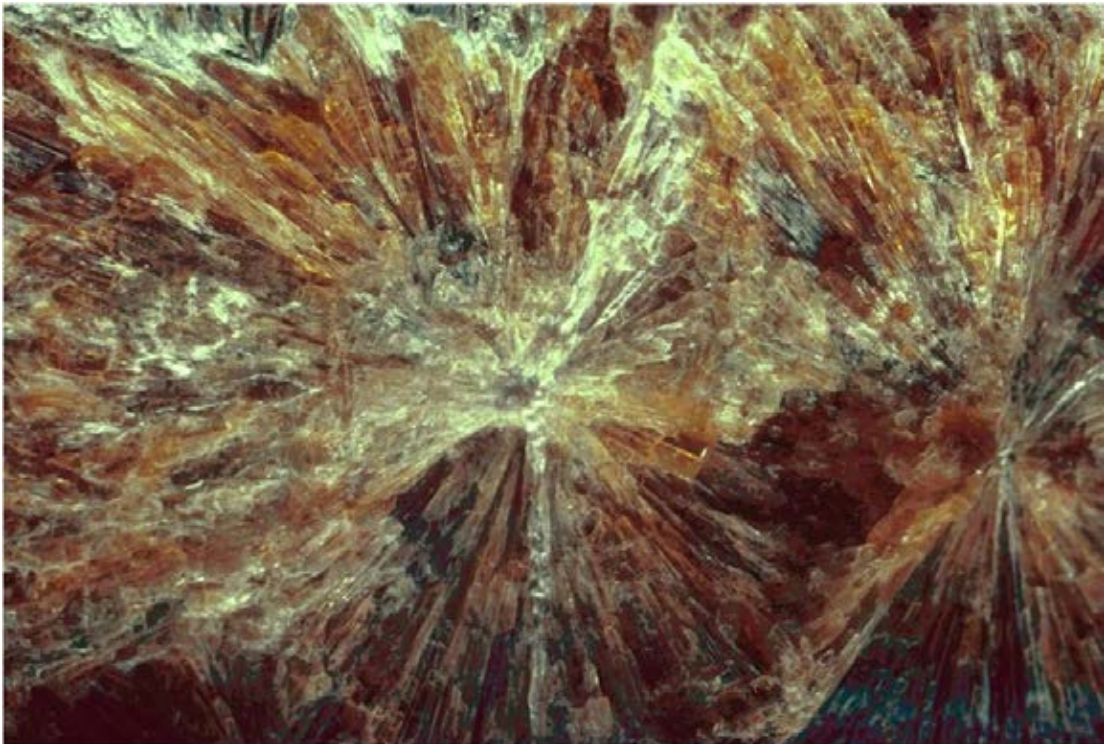
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Root-beer-type trona (R. Terry Leigh)

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FOR MORE INFORMATION

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