



GEOLOGY OF WYOMING (/)

NORTH PLATTE RIVER: ONE DAMMED THING AFTER ANOTHER

Wow Factor *(3 out of 5 stars):*



Geologist Factor *(2 out of 5 stars):*



Attraction

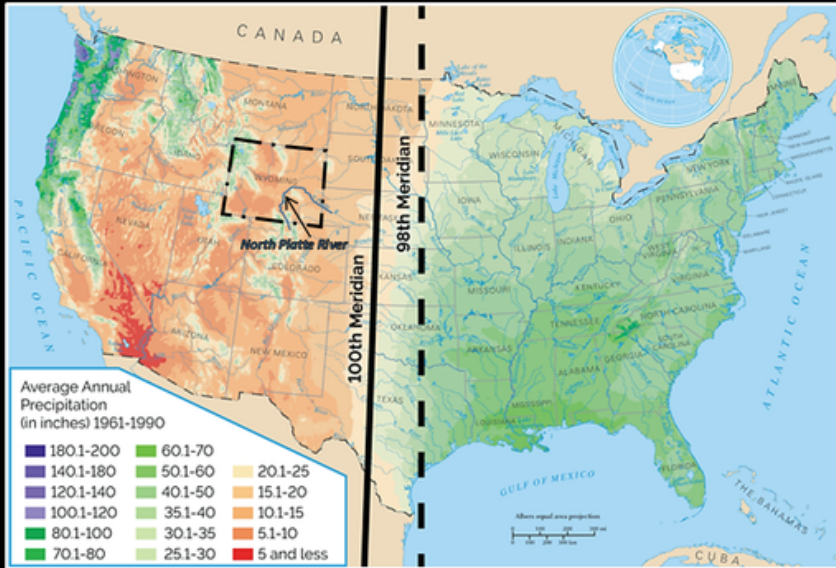
I don't know about you, but I love looking off dams. It is the combination of scenic canyons and geology, powerful water flows, scary heights, the engineering marvel of man harnessing nature, the production of clean power, the massive spring runoff captured for a thirsty state, and finally the significant investment made for the benefit of future generations. It just feels good!

North Platte River

The Rocky Mountain West is a dry place. Wyoming is a land of alpine mountains and semiarid to arid sage covered basins that historically served as a place "in between." It was not a destination but rather an area people passed through on their way to somewhere else. Passengers on the Transcontinental Railroad in 1900 thought the state was "... a barren wilderness of withered grass and stunted sage-brush, with an abundance of rugged mountain(s) ..." (Smith, W., 1900, *The Conquest of Arid America*, p. 207). Wyoming is the tenth largest state geographically but remains the least populated in the United States.

Geologist John Wesley Powell identified the 100th meridian (line of longitude) as the climate divide between the arid west and the humid east. Powell understood in his 1878 "*Report on the lands of the arid region of the United States*," that settlement west of the line would require the government to account for the regions aridity in development plans.

The 100th Meridian



Precipitation

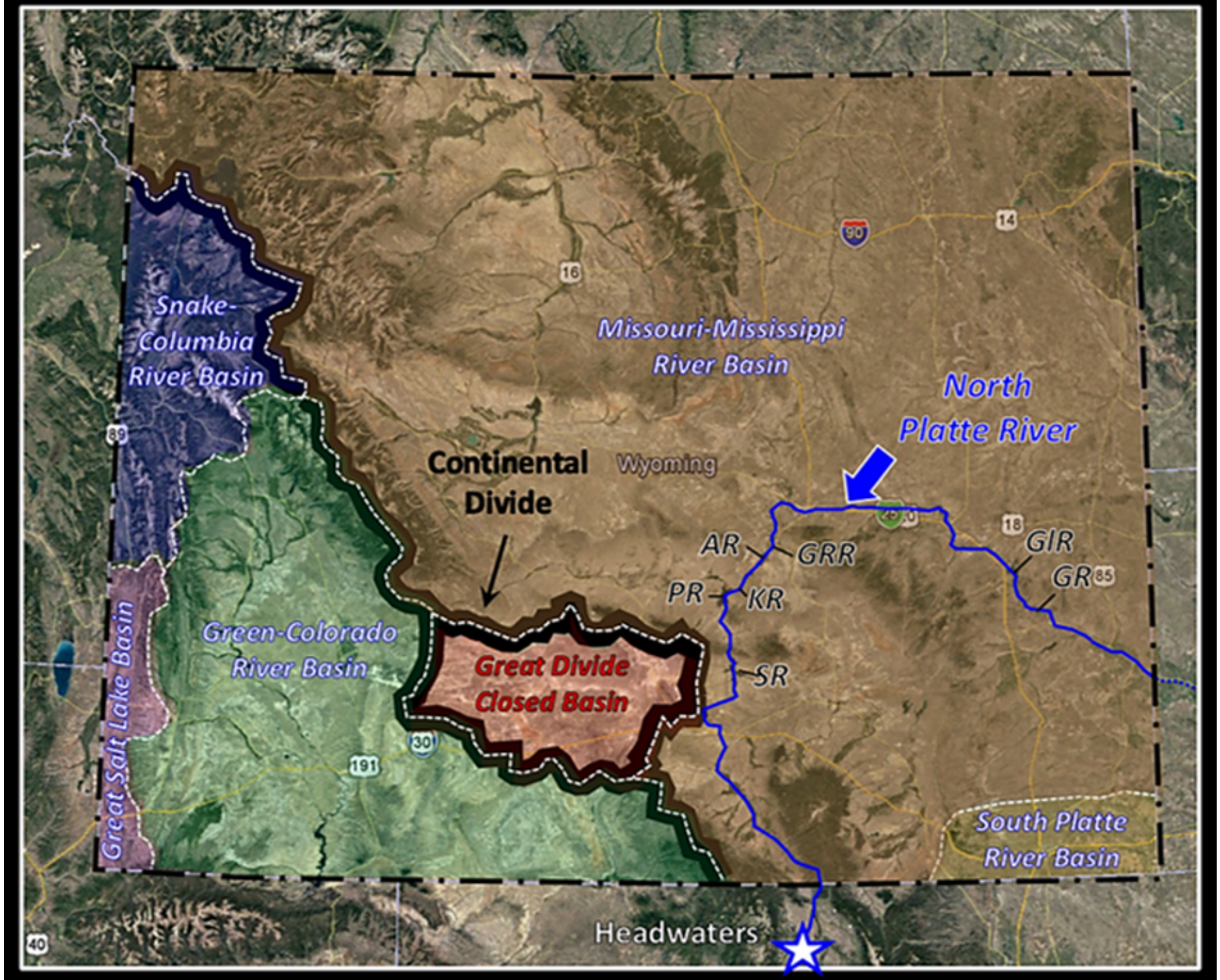


Population

The 100th Meridian division of precipitation (left) and population (right) of the United States with location of the North Platte in southeastern Wyoming displayed. The start of the arid zone has shifted 140 miles eastward to the 98th Meridian, based on temperature, wind and precipitation data measurements since 1980.

Image: Left: <https://www.earthmagazine.org/article/dividing-line-past-present-and-future-100th-meridian> (<https://www.earthmagazine.org/article/dividing-line-past-present-and-future-100th-meridian>); Right: http://www.dailygalaxy.com/my_weblog/2018/04/todays-top-science-headline-100th-meridian-arid-dry-climate-of-western-us-shifting-eastward.html (http://www.dailygalaxy.com/my_weblog/2018/04/todays-top-science-headline-100th-meridian-arid-dry-climate-of-western-us-shifting-eastward.html).

Water is arguably the state's most valuable resource because water is the main constituent of all organic life. It accounts for 60-90 percent by weight of living organisms. Wyoming is located over the continental divide and therefore is the headwaters region for four major river basins in the west: 1) Missouri-Mississippi, 2) Green-Colorado, 3) Snake-Columbia, and 4) Great Salt Lake. Where rivers flow there is a swath of green across the landscape (at least during the Spring runoff). Most of the water comes from the winter snowpack high in the ranges that surround the basins. The mountain sources are the birthplace of streams, that are the arteries of life for this arid land.



Major river basins draining Wyoming, percentage of land area drained, and final drainage location: 1) Missouri-Mississippi, 72%, Gulf of Mexico, 2) Green-Colorado, 17%, Gulf of California, 3) Snake-Columbia, 5%, Pacific Ocean, and 4) Great Salt Lake, 2%, closed basin. Four percent of Wyoming's land lies within the Great Divide Basin, a part of the Red Desert. This is an area of internal drainage that does not leave the basin. It is named Great Divide Basin because the continental divide (thick black and white dotted line) splits and surrounds the area. The South Platte River Basin is also part of the Missouri-Mississippi River Basin. North Platte reservoirs: AR: Alcova Reservoir, GR: Guernsey Reservoir, GIR: Glendo Reservoir, GRR: Gray Reef Reservoir, KR: Kortes Reservoir, PR: Pathfinder Reservoir, SR: Seminoe Reservoir.

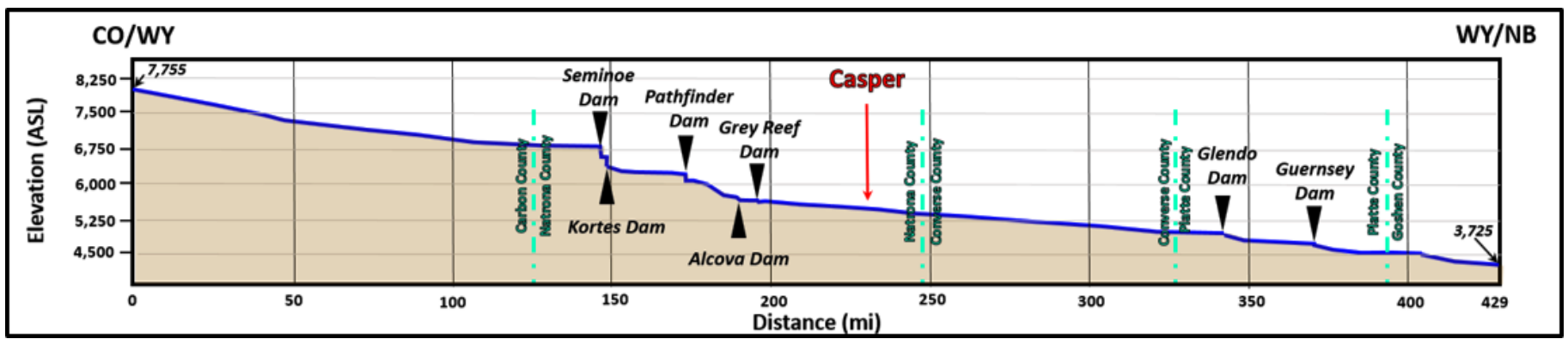
Image: Google Earth; Data: After Jacobs, J.J. and D.J. Brosz. 1993. Wyoming's Water Resources. Cooperative Extension Service, College of Agriculture and Wyoming Water Resources Center, University of Wyoming, Bulletin B-969, Fig. 2, p. 2

The headwaters of the North Platte River are at the confluence of Little Grizzly Creek and Grizzly Creek. These streams emerge from the snow fields on the eastern flank of the continental divide mountains surrounding North Park, Colorado. The North Platte enters Wyoming through Saratoga Valley between the Sierra Madre and Medicine Bow Mountains at 7,755-foot elevation. The stream flows northward across the Carbon-Hanna Basin, carves canyons through the Laramide mountain ranges at Seminoe and Granite Mountains and several anticlinal structures on the western side of the Laramie Range. It turns east in the Powder River Basin around the north flank of Casper Mountain, then flows southeast toward the Great Plains where it carves across the Hartville Uplift before exiting the Cowboy State into Nebraska at 3,725-foot elevation. The North Platte and South Platte merge to form the Platte River that drains into the Missouri-Mississippi system at the Iowa/Nebraska border. The 429-mile “big loop” water route through southeastern Wyoming crosses the Southern Rocky Mountain, Wyoming Basin, and Great Plains physiographic provinces of America.



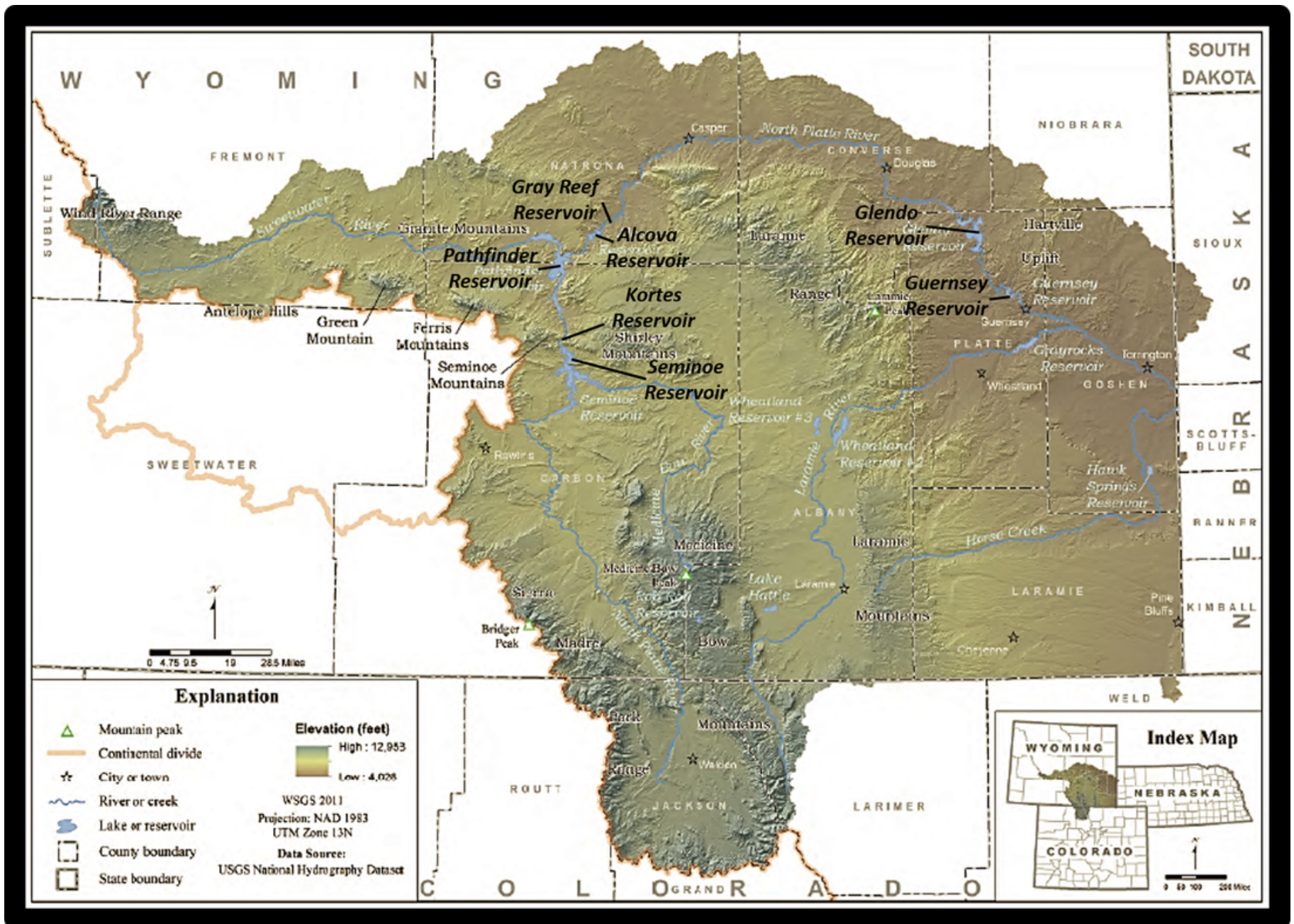
North aerial view of the North Platte River’s seven reservoirs area. Transcontinental railroad route across southern Platte River Basin shown by white track symbol. Emigrant Trail route shown by dashed white line. Dam abbreviations: SD: Seminoe Dam, KD: Kortes Dam, PD: Pathfinder Dam, Ad: Alcova Dam, GRD: Gray Reef Dam, GID: Glendo Dam, and GD: Guernsey Dam.

Image: Google Earth



North Platte River elevation profile across southeastern Wyoming.

Image: Data digitized from Google Earth.



Physiographic Map of the North Platte Basin and its seven dammed reservoirs.

Image: Taucher, Paul, Bartos, T.T., Taboga, K.G., Hallberg, L.L., Clark, M.L., Stafford, James, Gracias, Tomas, Hinckley, Bern, Worman, Brett, Clarey, Kieth, Lindemann, Lisa, Quillinan, S.A., Copeland, Dave, Hays, Richard, and Thompson, Melissa, 2013, Platte River Basin water plan update, level I (2009–2013)—Available groundwater determination: Wyoming State Geological Survey Technical Memorandum 5, 584 p., 11 pls, <http://sales.wsgs.wyo.gov/platte-river-basin->

North Platte Historical Context

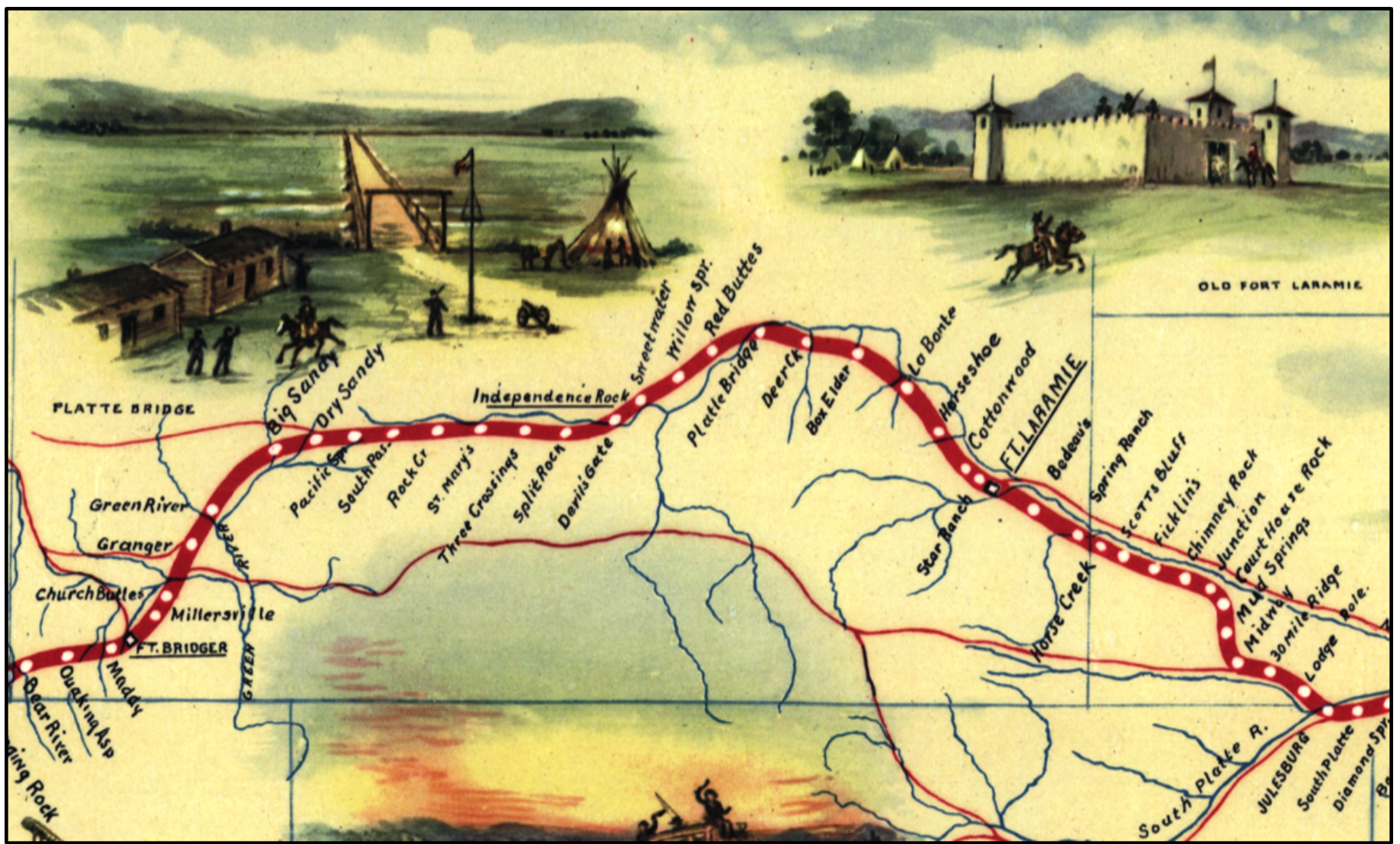
The population was about 8,000 citizens (non-native) when Wyoming became a territory of the United States in 1868. The Transcontinental Railroad construction had reached the town of Rawlins Springs. Traffic on the emigrant trails was dwindling. The population was concentrated along the path of the railroad in southeastern Wyoming. Army soldiers stationed at forts, cowboys working on open range cattle operations, miners seeking wealth in the mountains and valleys, and a few hardy homesteaders taking advantage of federal land disposal acts made up the rest of the Territory's population. All these individuals were located near the Territory's surface streams.

Manifest Destiny was a widely held concept in 19th century America. The term was first used by John L. O'Sullivan to support the annexation of Texas and Oregon. He believed America had a mission to spread democracy throughout America. John Gast's painting "American Progress" captured the mood of the country.



John Gast's "American Progress" (1872) is an allegorical representation of Manifest Destiny. Except for a lack of stock growers, it mirrors the Wyoming Territory's path to statehood. The United States (as Lady Columbia in the center) brings light to the West carrying a school book of knowledge and stringing telegraph wire for rapid communication (so long Pony Express). The dark savage West of bear, bison and Indians recedes on the left. Columbia is preceded by explorers, trappers and miners (lower center left), wagon trains and emigrants in a Prairie Schooner (center left). A Pony Express rider is just above her left knee. In her wake come farmers using the steel-point plow to farm the land (lower right), stage coach and railroads (right center). River navigation and bridge construction is represented on the far right with the rising sun.

Image: https://commons.wikimedia.org/wiki/File:American_progress.JPG
 (https://commons.wikimedia.org/wiki/File:American_progress.JPG)



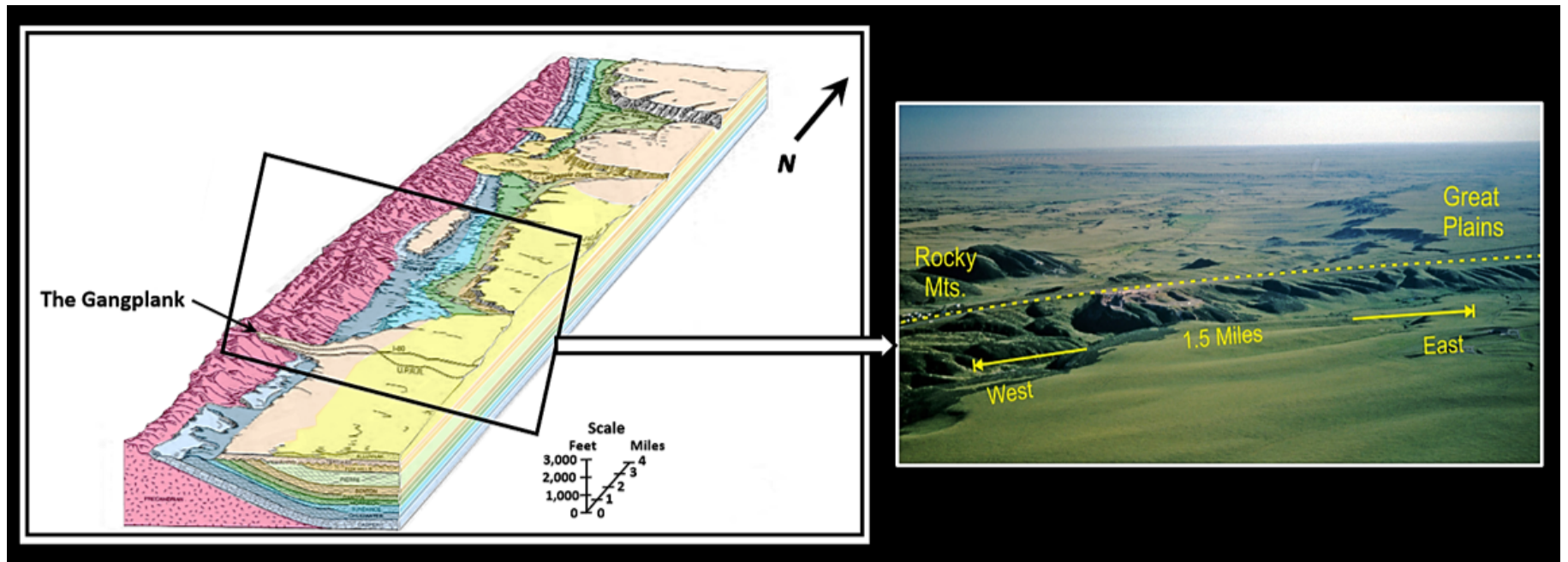
The Wyoming portion of William Henry Jackson's pictographic map "The Pony Express" The route of the Pony Express closely followed the North Platte-Sweetwater Rivers Emigrant trail across the North Platte River Basin. The short-lived (April 3, 1860 – October 24, 1861) mail route was made obsolete by the telegraph.

Image: Library of Congress, <https://www.loc.gov/resource/g4051p.tr000221/?r=0.406,0.024,0.294,0.172,0> (<https://www.loc.gov/resource/g4051p.tr000221/?r=0.406,0.024,0.294,0.172,0>).

was either *"The Garden of the World"* (C.W. Dana, 1856) or *"The Great American Desert"* (Zebulon Pike, 1810). The path of the North Platte River and its tributary the Sweetwater River was the route west for up to half million emigrants in the 19th Century. They did not think the area was suitable for settlement or dryland farming due to the climate (aridity and temperature extremes), isolation (Indians, distance to supplies and market), and topography (elevation and soil development). Countering this view was the theory that "the rain follows the plow." This view was supported by Ferdinand Hayden (explorer), William Gilpin (first territorial Governor of Colorado), and Samuel Aughey (minister, scientist, professor of natural science). The latter also served as Wyoming's first territorial geologist. But the hard truth of arid land experience showed rain is not influenced by the plow.

The Transcontinental Railroad required not only abundant water for the steam powered locomotor, but also coal for fuel and a gentle topographic grade. The surveyors discovered a

suitable passage in southeastern Wyoming that became known as The Gangplank. Here a natural ramp sloped upward from the plains to the crest of the mountains.



The Gangplank on east side of Laramie Range. Here preserved Tertiary fill laps onto the crest of the mountains creating a relatively smooth topographic slope that the trains can climb.

The Cheyenne tablelands are shown in yellow.

Image: Left: After Blackstone, D.L., Jr., 1996, Structural geology of the Laramie Mountains, southeastern Wyoming and northeastern Colorado: Wyoming State Geological Survey Report of Investigations 51, 28 p., 3 pls., scale 1:500,000, <http://www.wsgs.wyo.gov/products/wsgs-1996-ri-51.pdf> (<http://www.wsgs.wyo.gov/products/wsgs-1996-ri-51.pdf>);

Right: <https://visitolaramie.org/railroads-of-albany-county-tracking-the-past-brochure> (<https://visitolaramie.org/railroads-of-albany-county-tracking-the-past-brochure>).

The winter 1886-1887 is noted for its severity and cattle mortality in the Rocky Mountains. The cattle barons lost up to 25 percent of their livestock (some exaggerated claims report 90 percent loss). Stockmen began to rethink open range grazing. They began to employ better range management by reducing herd population and fencing grazing area, and water irrigation that provide stock water and winter feed.



Charles Russell's "Waiting for a Chinook: the last of 5,000" captured the brutal winter where thousands of open range cattle died from exposure, dehydration and starvation.

Image: Charles Marion Russell [Public domain], via Wikimedia

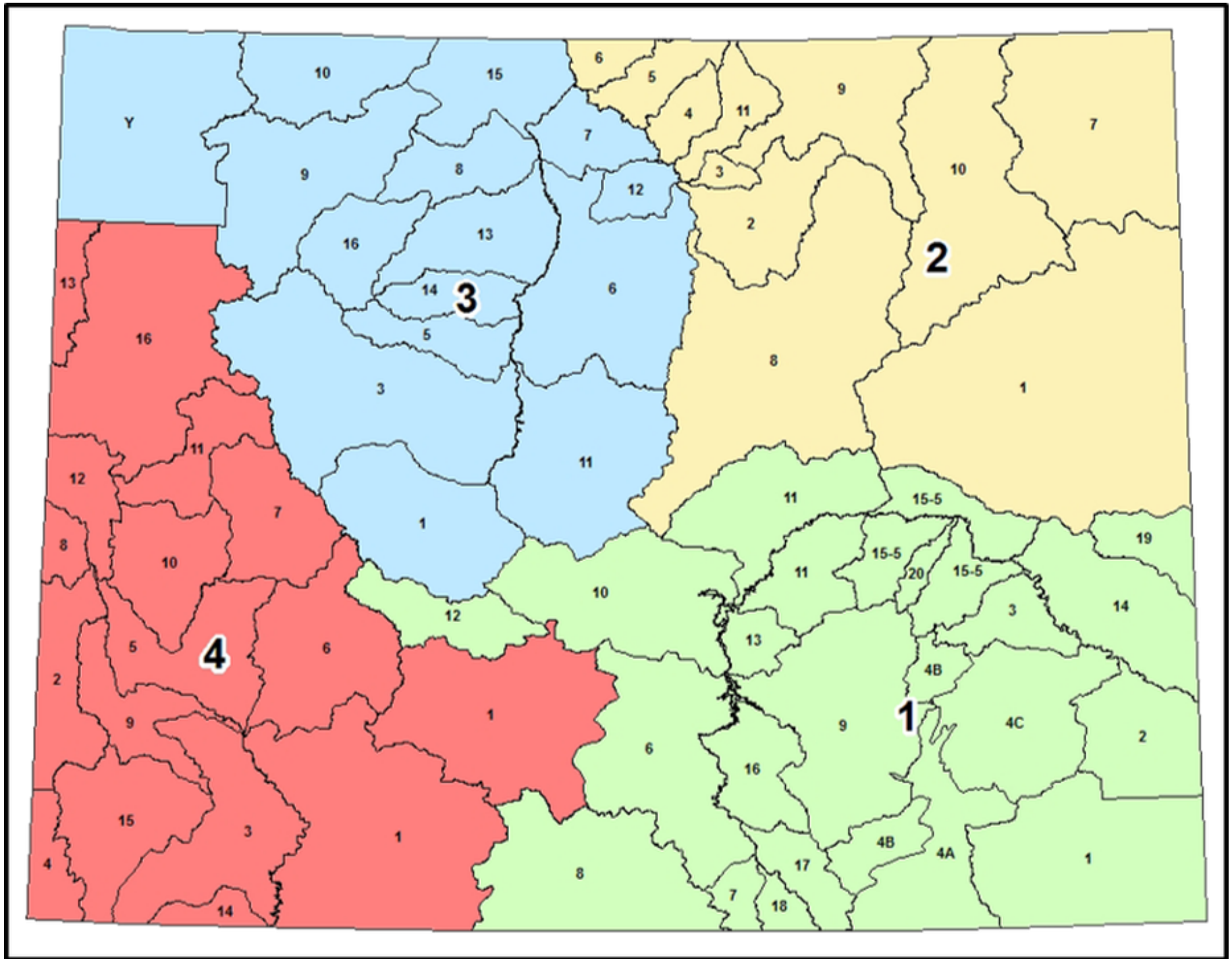
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(<https://upload.wikimedia.org/wikipedia/commons/9/99/Chinook2.gif>)

The first known irrigation in the North Platte basin occurred at Fort Laramie where the post surgeon managed a 5-acre garden. Vitamin-rich vegetable crops were grown to prevent disease and maintain a healthy diet for the soldiers. The War Department General Order 1 directed all posts to maintain "kitchen gardens" in 1851. This order was rescinded in 1854 and made all future gardening voluntary and at the discretion of the commanding officer. At Fort Laramie in 1868 the garden included strawberries, raspberries and blackberries. (Tate, M.L., 2001, *The Frontier Army in the Settlement of the West*, p. 162). Until 1888, the territorial legislature loosely regulated water diversions by the old common law doctrine of "prior appropriation." This doctrine held that the "first in use was the first in right." In practice, drainage ditches or canals were dug from the river with only a paper claim attached to a tree. Battles over water priority commonly erupted on the range and in court. The strong sentiments held by combatants over water rights is captured by an anonymous remark, often attributed to Mark Twain: "Whiskey is for drinking; Water is for fighting over."

Elwood Mead, formerly Professor of Irrigation Engineering at Colorado State Agricultural

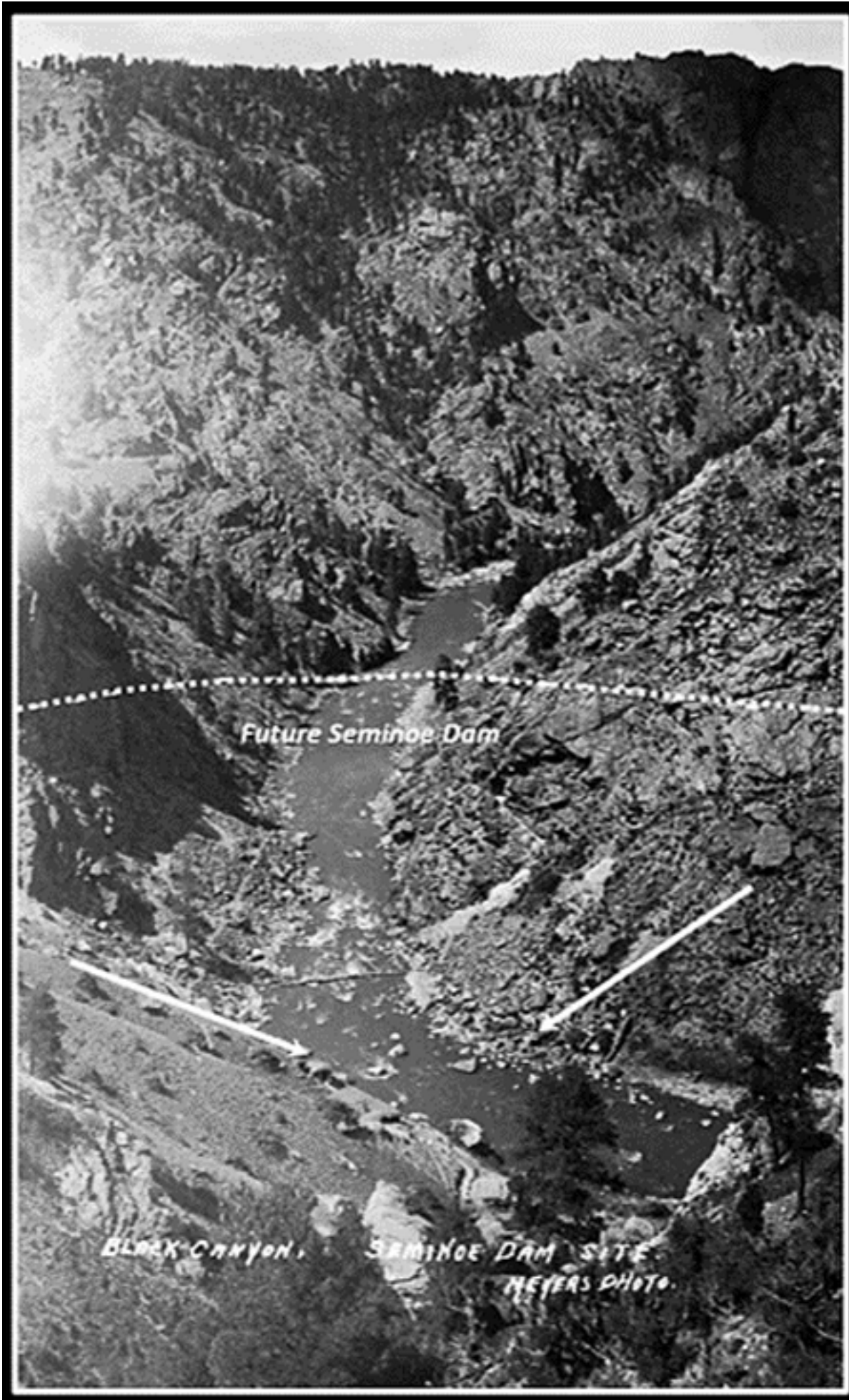
College (now Colorado State University), is the person most responsible for organizing Wyoming's water laws. He served as the first Territorial and State Engineer (1888-1899). He drafted the Wyoming's Constitution section on water law that included state ownership of water, established a board of control to administer four water divisions and the concept of "beneficial use" as the basis and limit to priority appropriations. Wyoming's water law became a model for other western states. "Wyoming's place as the [water] lawgiver of the arid region is due neither to geographical location or to superior natural resources; certainly, it is not due to large population. It owes its commanding position solely to the character and ability of a few public men who happen to have found in this line of work their best opportunity for usefulness." (Smith, W., 1900, *The Conquest of Arid America*, p. 221).



Water divisions of Wyoming's Board of Control. The North Platte River system is in Division 1 (green area).

Image: <http://seo.wyo.gov/agency-divisions/board-of-control> (<http://seo.wyo.gov/agency-divisions/board-of-control>)

The U.S. Reclamation Service established in 1902 (U.S. Bureau of Reclamation since 1923), was the agency tasked with the federal commitment to design and construct water development projects in 16 western states with federal lands (a concept first promoted by Powell, 1878). Beneficiaries would repay the government with annual installments over a ten-year period. All seven dams along the North Platte River were constructed as part of a reclamation project. In selecting dam locations, the bureau considered the type and cost of construction at each site. Several geologic factors affected the decision, including topography, rock type of foundation, earthquake hazard and volume of water available. The North Platte basin consists of narrow V-shaped canyons in basement rock suitable for arch type dams and hilly, plains conducive to earth-filled dams. Both dam types were constructed along the river's course.



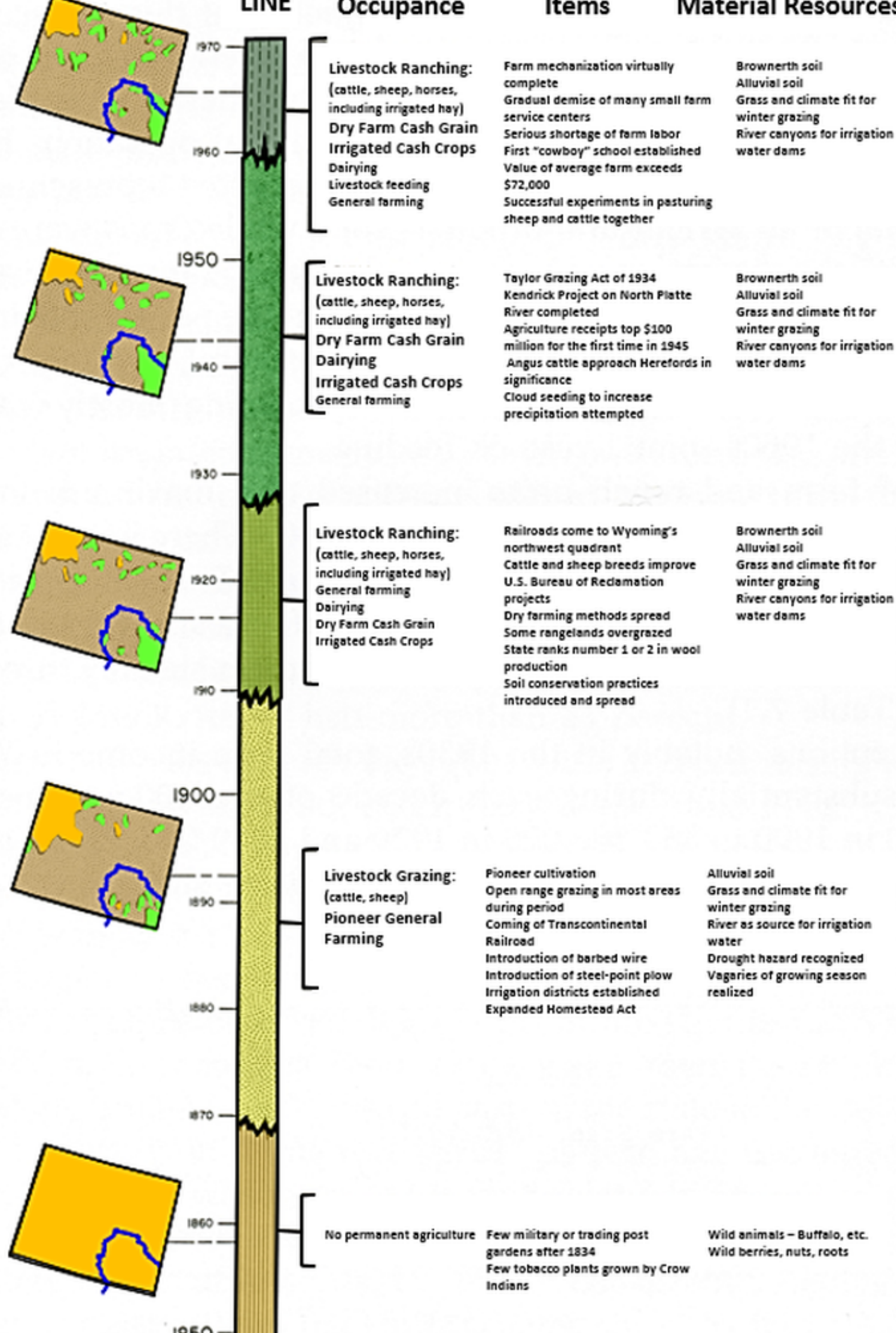


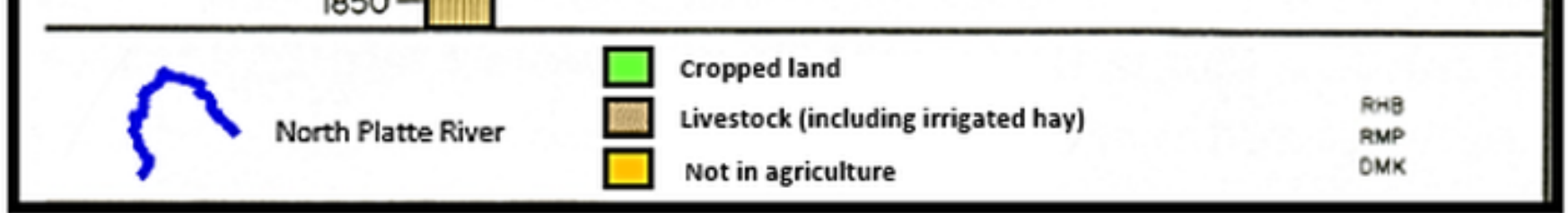
(https://www.researchgate.net/profile/Paul_Buchheim2/publication/275564804_Paleoenvironments_lithofacies_and_varves_of_the_Fossil_Butte_Member_of_the_Eocene_Green_River_Formation_southwestern_Wyoming/links/5698028808aea2d74375db4f/Paleoenvironments-lithofacies-and-varves-of-the-Fossil-Butte-Member-of-the-Eocene-Green-River-Formation-southwestern-Wyoming.pdf) **North Platte Landforms - Top: V-shaped valley in Black Canyon at Seminoe Dam site in 1935: The arrows represent the direction of water runoff. Water flows downhill into the stream and erodes the valley into its V shape. Bottom: hilly plains in Glendo area.**
Image: Top: <https://www.wyohistory.org/encyclopedia/history-seminoe-and-kortes-dams> (<https://www.wyohistory.org/encyclopedia/history-seminoe-and-kortes-dams>); Bottom: Clark and Associates photo of Meadowdale Ranch Property, <http://clarklandbrokers.com/ranches-for-sale-in-wyoming/> (<http://clarklandbrokers.com/ranches-for-sale-in-wyoming/>).

Sequential Development of Agriculture

TIME LINE	Type of	Some Cultural	Some Perceived
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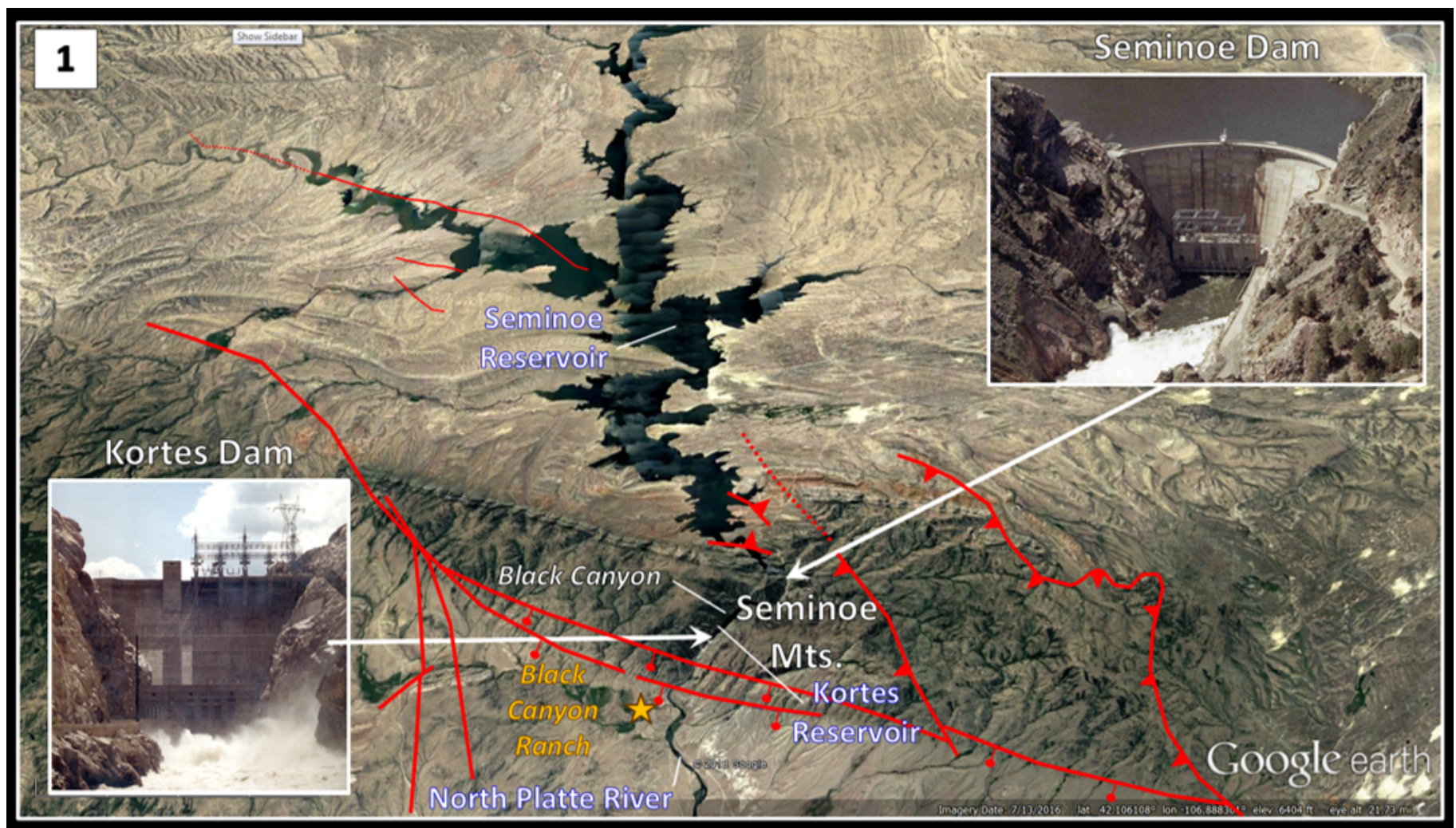
LINE Occupation Items Material Resources

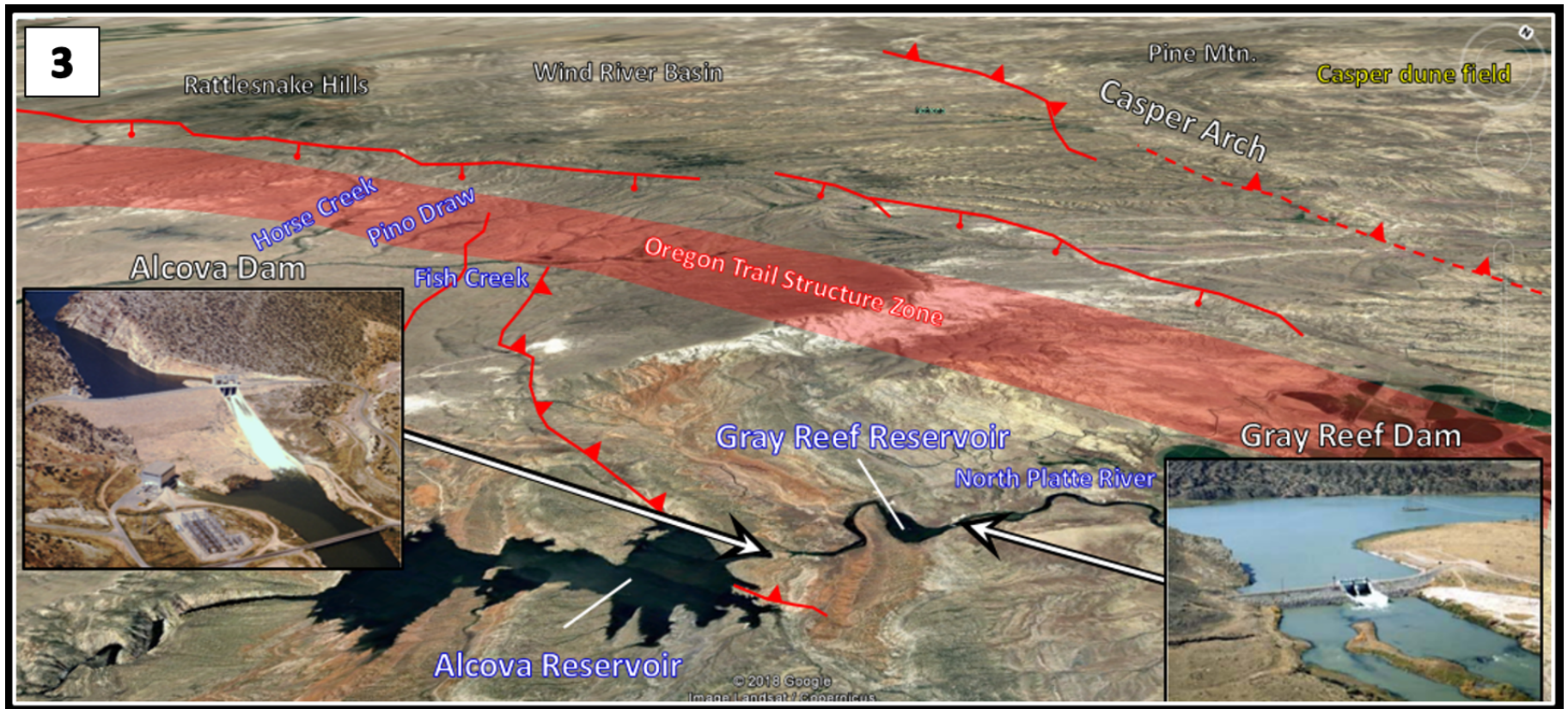
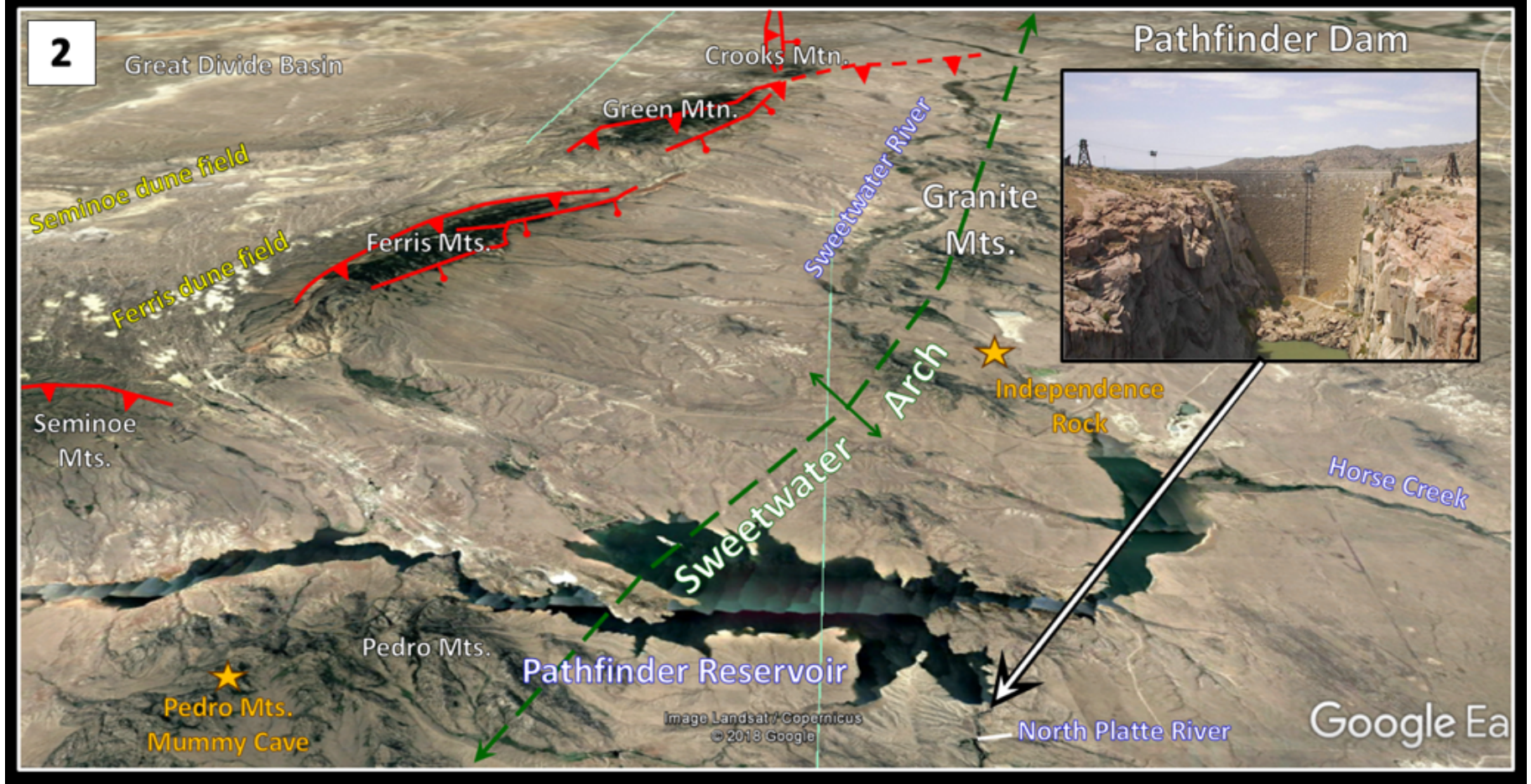


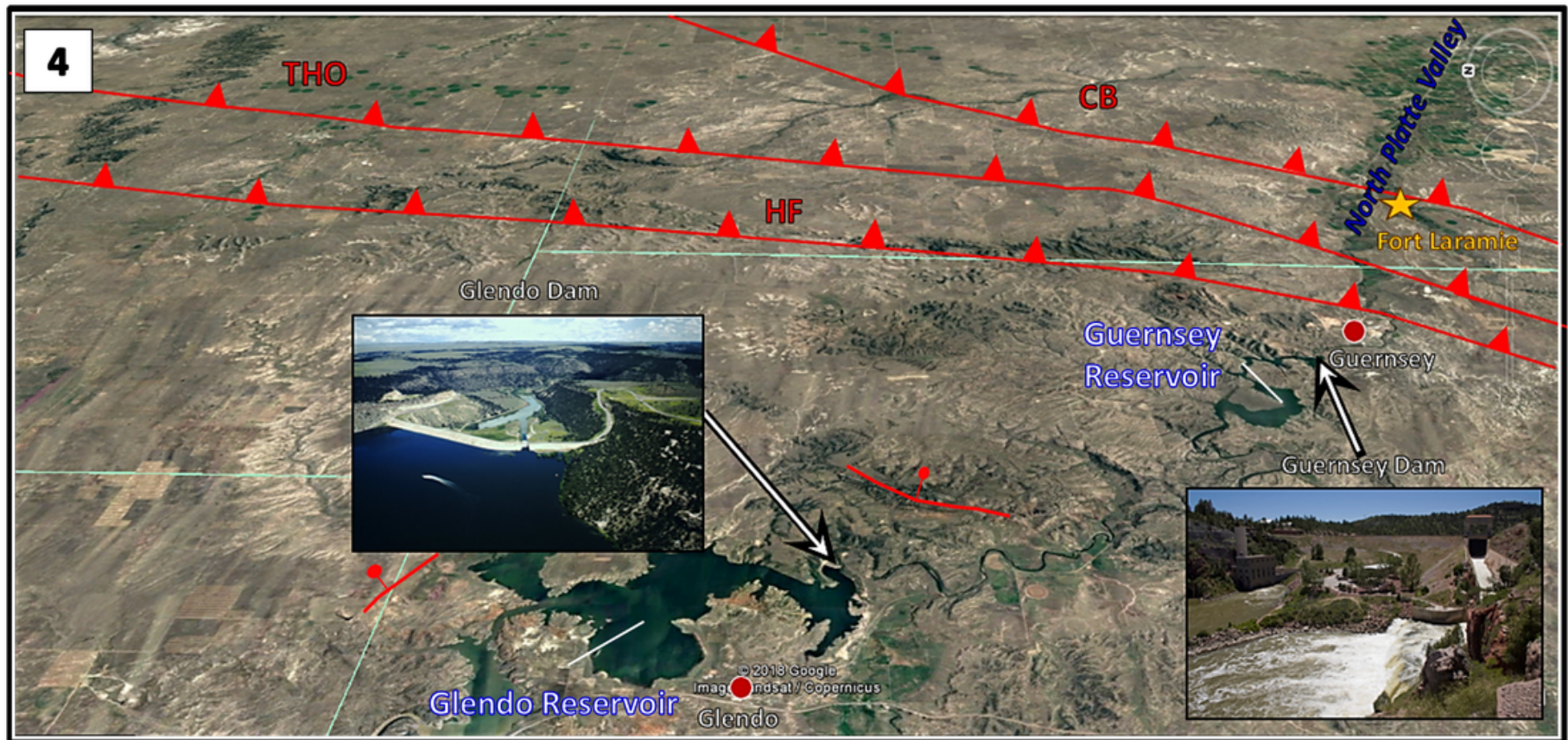


Timeline of Wyoming's agricultural development and water use. The North Platte River Basin has the largest volume of irrigated land.

Image: After Brown, R.H., 1980, Wyoming: Westview Geographies of the United States, Fig. 7.2, p. 155.







Dams along the North Platte River: 1. South view of Seminole and Kortes Dams, 2. Southwest view of Pathfinder Dam, 3. West View of Alcova and Gray Reef Dams, and 4. Southeast view of Glendo and Guernsey Dams. Faults shown by red lines: reverse faults: Sawteeth on upthrown block with teeth pointed in the direction of fault surface dip; normal faults have line and ball symbol on downthrown block. Notation: CB: Cheyenne Belt, THO: Trans-Hudson Orogen, HF: Hartville Fault.

Images: U.S. Bureau of

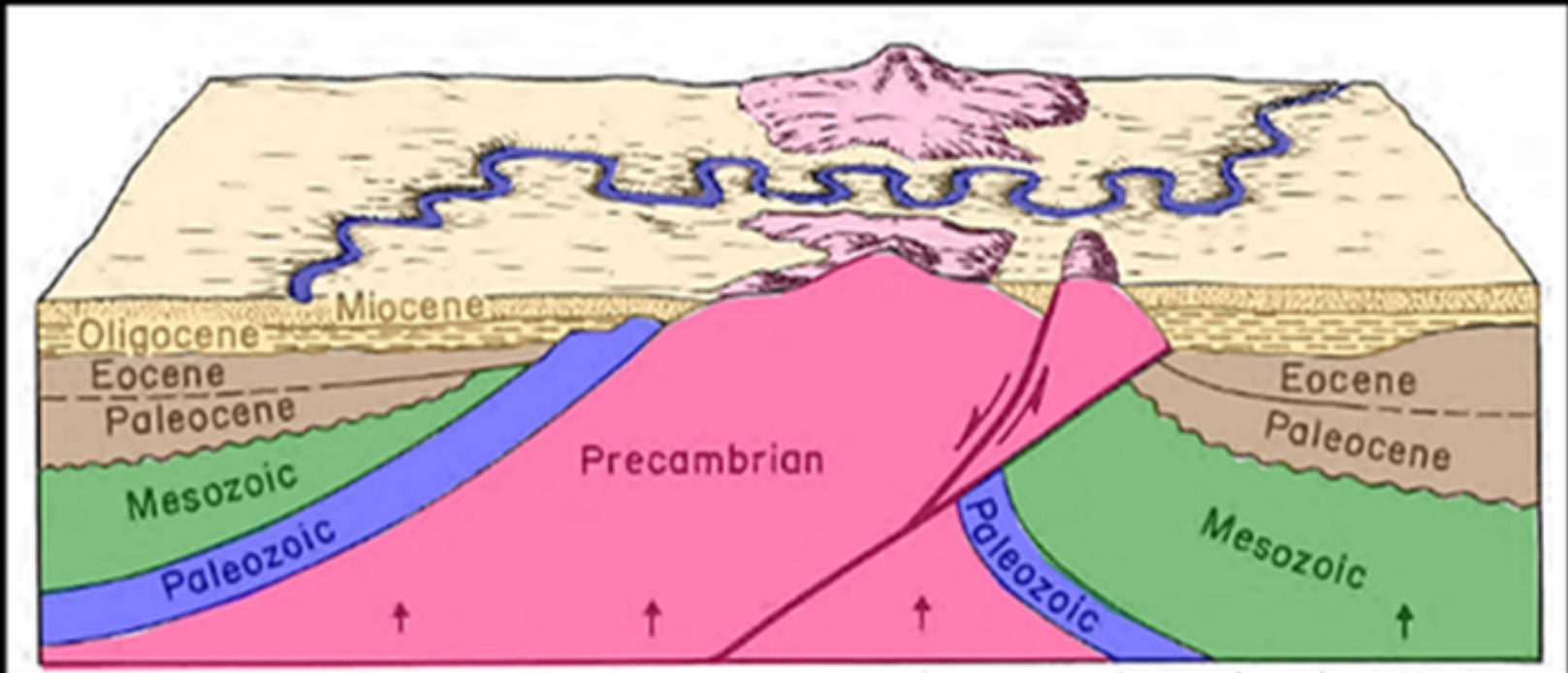
Reclamation, http://waterplan.state.wy.us/plan/platte/2006/techmemos/TechMemo_2-6_FINAL.pdf (http://waterplan.state.wy.us/plan/platte/2006/techmemos/TechMemo_2-6_FINAL.pdf); Guernsey Dam: <https://www.usbr.gov/gp/wyao/spill/guernsey.jpg> (<https://www.usbr.gov/gp/wyao/spill/guernsey.jpg>).

Dam	USBR Project	Purpose	Constuction Dates					Reservoir				Power Station			
			Start	Competition	Type	Height (ft)	Length (ft)	Elevation (ft AGL)	Maximum Depth (ft)	Surface Area (ac)	Volume (ac-ft)	Date	Head (ft)	Capacity (MW)	Annual Output (KWh)
Pathfinder	North Platte (formerly Sweetwater)	water storage, power generation	1905	1909	masonry arch	214	432	5,846	192	49,000	1,016,500	1960	300	6.7	172,606,300
Alcova	Kendrick (formerly Casper-Alcova)	water storage, power generation	1935	1938	zoned earthfill	265	763	5,500	172	2,470	184	1955	180	3.6	92,408,000
Seminole	Kendrick (formerly Casper-Alcova)	water storage, power generation	1936	1939	concrete gavity-arch	295	530	6,357	206	20,291	1,017,279	1939, uprated in mid-1970s	166	4.5	96,406,970
Kortes*	Pick-Sloan Missouri Basin-Kortes Unit (dropped from Kendrick)	power generation, control water elevation at base of Seminole powerplant	1946	1951	concrete gravity	244	440	6,160	224	83	4,765	1951	200	3.6	124,685,820
Gray Reef	Pick-Sloan Missouri Basin-Glendo Unit	reregulating reservoir (moderates flow fluctuations from Alcova dam)	1959	1961	zoned rock and earthfill	36	650	5,332	25	182	1,798	NA	NA	NA	NA
Glendo	Pick-Sloan Missouri Basin-Kortes Unit (dropped from Kendrick)	power generation, control water elevation at base of Seminole powerplant	1946	1951	concrete gravity	244	440	95	224	83	4,765	1951	200	3.6	124,685,820
Guernsey	North Platte (formerly Sweetwater)	water storage, power generation	1925	1927	diaphragm-type embankment of sluiced clay, sand and gravel	135	560	4,420	82	2,382	71,040 (reduced to 46,000 due to silting)	1928, uprated in 1992 & 1994	92	6.4	12,108,622
* Location selected to provide additional water depth between upstream Seminole Powerplant water discharge and the downstream Pathfinder Reservoir water elevation															

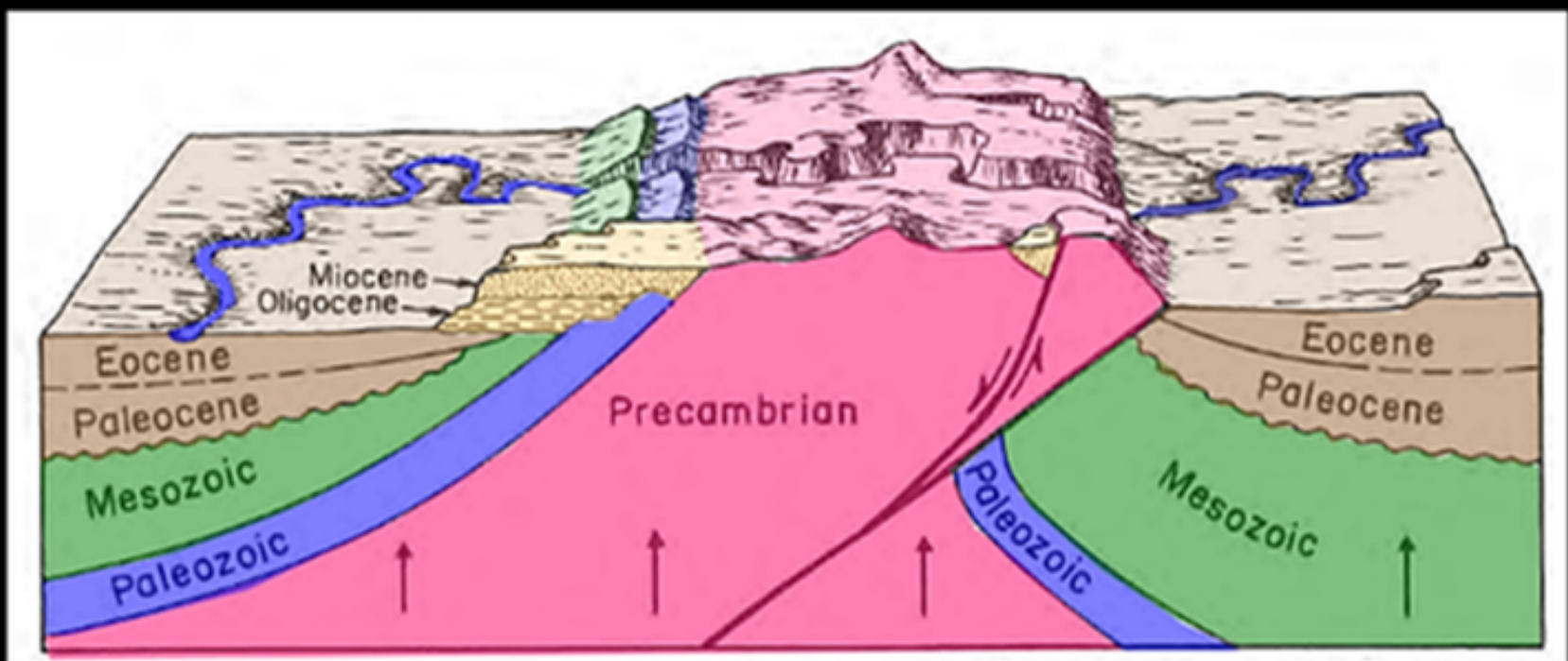
Key details on the North Platte River basin dams.
 Image: U.S. Bureau of Reclamation Data, <https://www.usbr.gov/projects/index.php?id=363>
 (<https://www.usbr.gov/projects/index.php?id=363>)

Dam Geology

The geologic structure of Wyoming was created 75 to 50 million years ago during the Laramide Orogeny. The fabric of the Precambrian basement influenced the location and orientations of the Laramide structures. Sediment eroded from the uplifts filled the basins, topped the mountains and extended eastward onto the Great Plains. Ancestral streams flowed across this high-level surface stripping away the Tertiary fill and carving canyons through the mountains and structures.



Latest Eocene through mid-Miocene
(37-12 million before present)

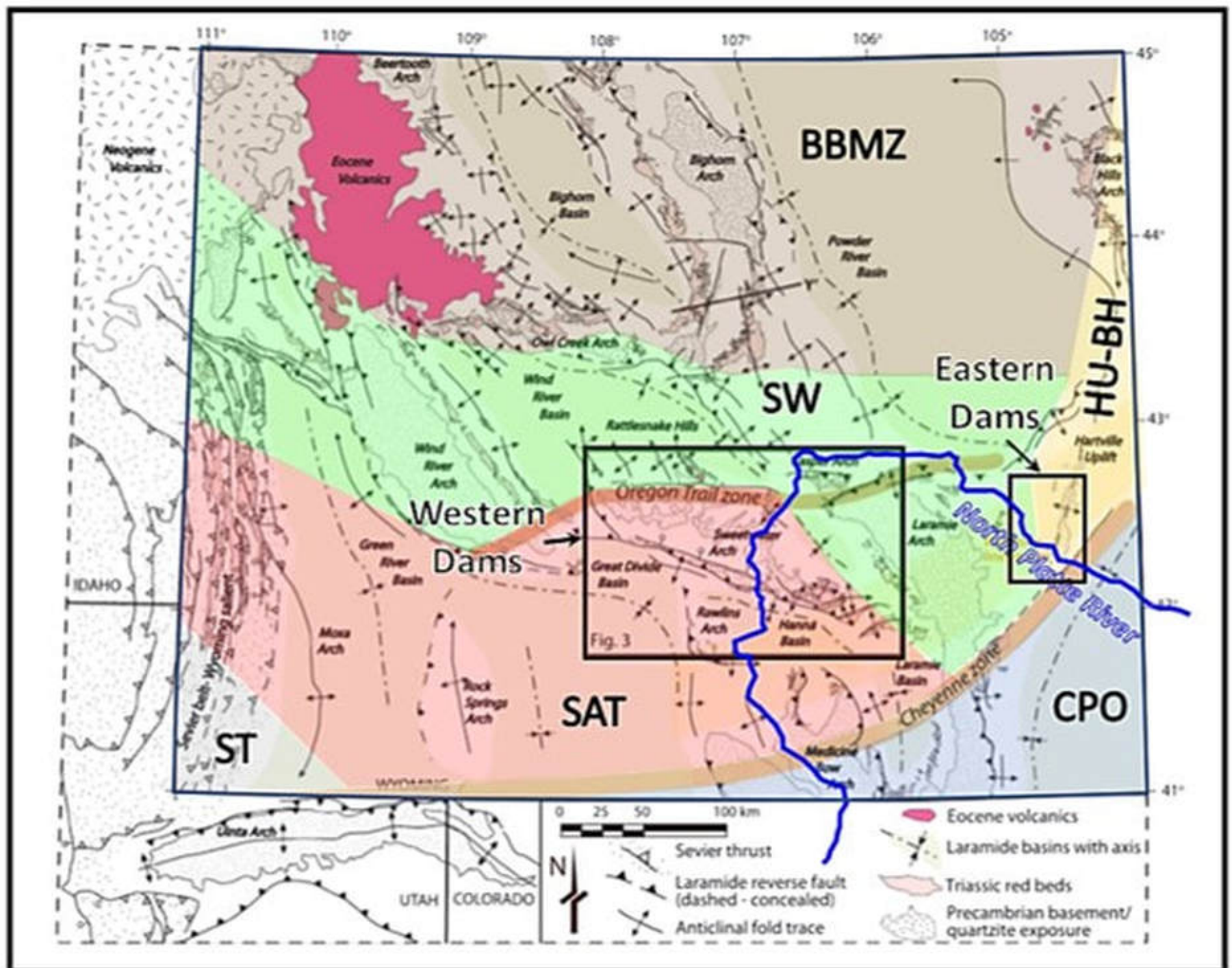


Late Miocene through Holocene
(12 million before present to 10,000 years ago)

Stream superposition across a Laramide structure. Top: Latest Eocene through mid-Miocene time: Progressive filling of basins with ash from remote eruptions; onset of regional uplift and normal faulting; meandering streams crossing buried parts of mountains; Bottom: Late Miocene through Holocene time: Excavation of basins-fill sediments and superposition of stream accompanying uplift.

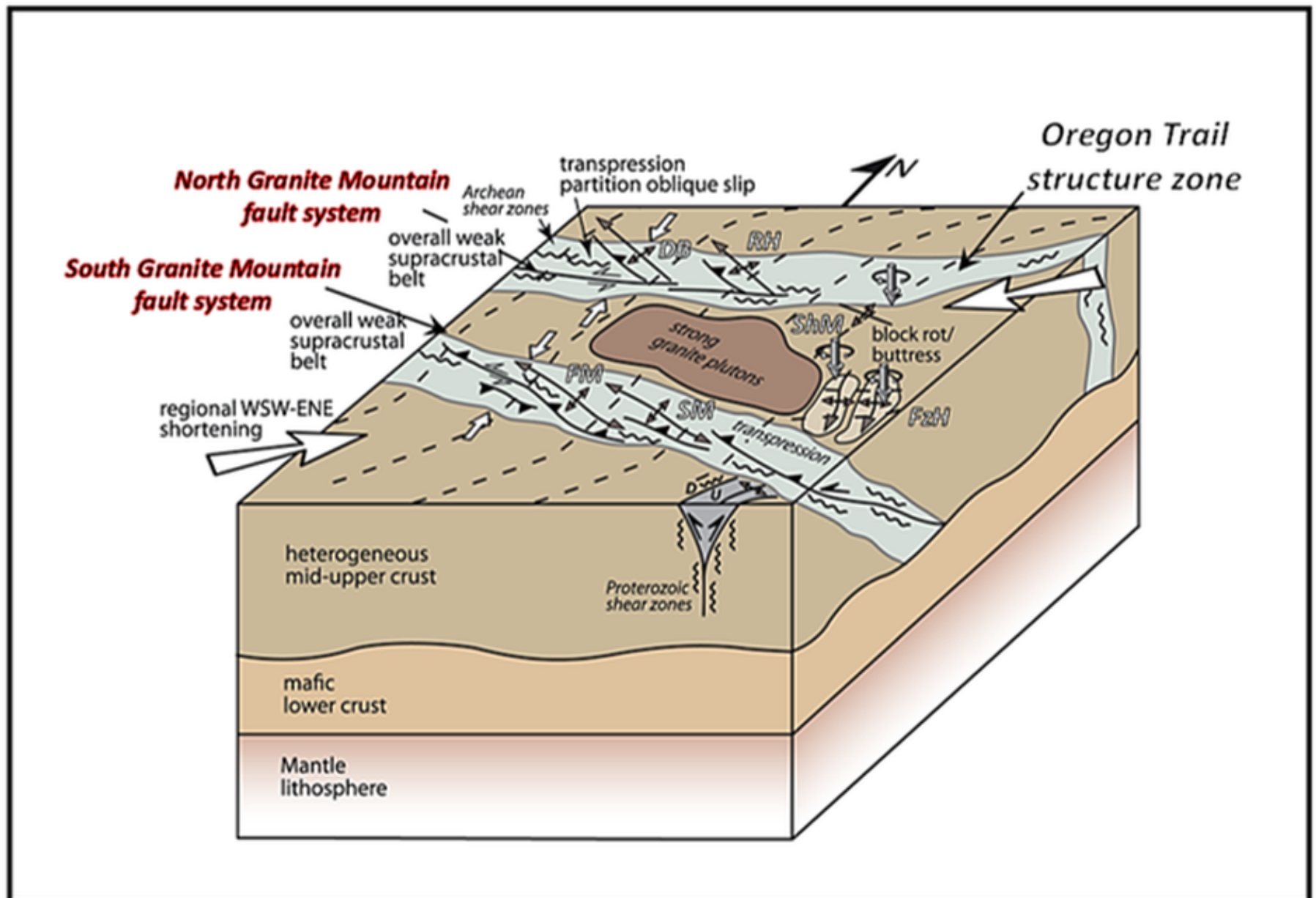
Image: After Mears, B., Jr., 1993, *Geomorphic history of Wyoming and high-level erosion surfaces*; in Snoke, A.W., Steidtmann, J.R., and Roberts, S.M., eds., 1993, *Geology of Wyoming*:

The dominant Precambrian structure in central Wyoming is the Sweetwater Arch trending east-west at the southern margin of the Wind River Basin. This feature formed by the intrusion of granite plutons 2.62 billion years ago, over a 125-mile area. The consistency of lithology and age range has given rise to the term Wyoming Batholith applied to the region (Bagdonas et al., 2016). The batholith is the exposed core of an ancient silicic magma chamber. Other basement rocks on the flanks of the arch include a 3.3-3.0 billion year gneiss (developed along the Oregon Trail accretion belt) and 2.7-2.6 billion year old greenstone/granitic terranes on the north (Rattle snake Hills) and south (South Pass, Seminoe Mountains) margins. The U.S. Bureau of Reclamation projects west of the Laramie Range are all located in the Southern Accreted Terrane of the Wyoming Craton. The projects on the east side are in the Sweetwater subprovince (Glendo) and the Hartville Uplift-Black Hills subprovince (Guernsey).



Tectonic map showing major structures of the Sevier and Laramide orogenies, the subprovinces boundaries of the Wyoming Craton and the location of the North Platte River drainage. Subprovince codes: BBMZ: Bighorn-Beartooth Magmatic Zone, SW: Sweetwater terrane, SAT: Southern Accreted Terrane, HU-BH: Hartville Uplift-Black Hills terrane, ST: Selway Terrane, CPO: Central Plains Orogen. Black rectangles indicate, Left: the western area of the Sweetwater Arch with surrounding greenstone belts, Laramide age structures and dammed reservoirs; Right the eastern area of Glendo and Guernsey dams and the southern portion of the Hartville Uplift.

Image: After Weil, A.B., Yonkee, A., and Schultz, M., 2016, Tectonic evolution of a Laramide transverse structural zone: Sweetwater Arch, south central Wyoming: Tectonics, 35, Fig. 8B, p. 1091, <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2016TC004122> (<https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2016TC004122>).



Block diagram showing Laramide forces that created the structures in the Granite Mountains area of central Wyoming. Abbreviations: DB: Dutton Basin, FM: Ferris Mountains, FzH: Freezeout Hills, RH: Rattlesnake Hills, ShM: Shirley Mountains, SM: Seminoe Mountains

Image: After Weil, A.B., Yonkee, A., and Schultz, M., 2016, Tectonic evolution of a Laramide transverse structural zone: Sweetwater Arch, south central Wyoming: Tectonics, 35, Fig. 18B, p.

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Pathfinder
Dam

Pathfinder

Reservoir

Tm

Qt

Qs

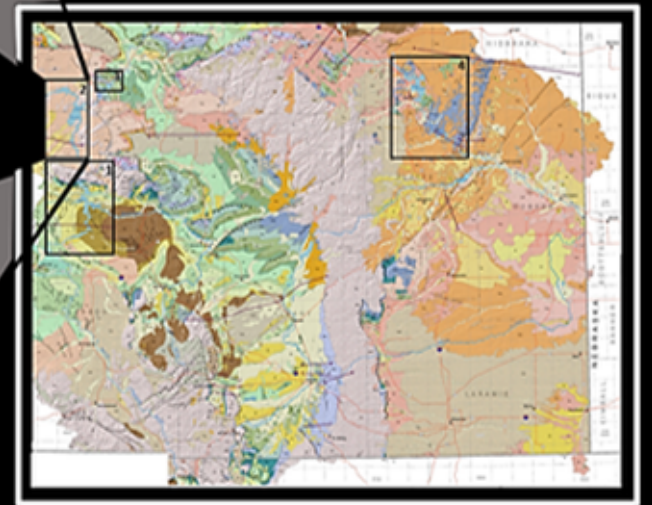
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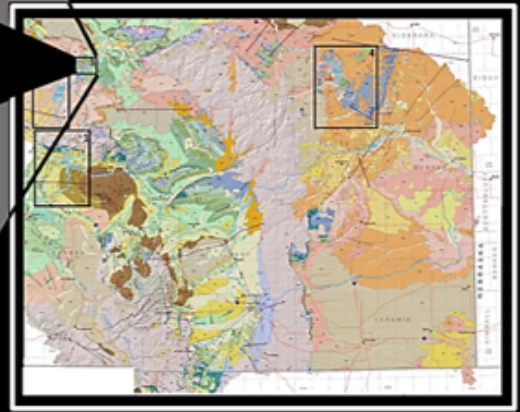
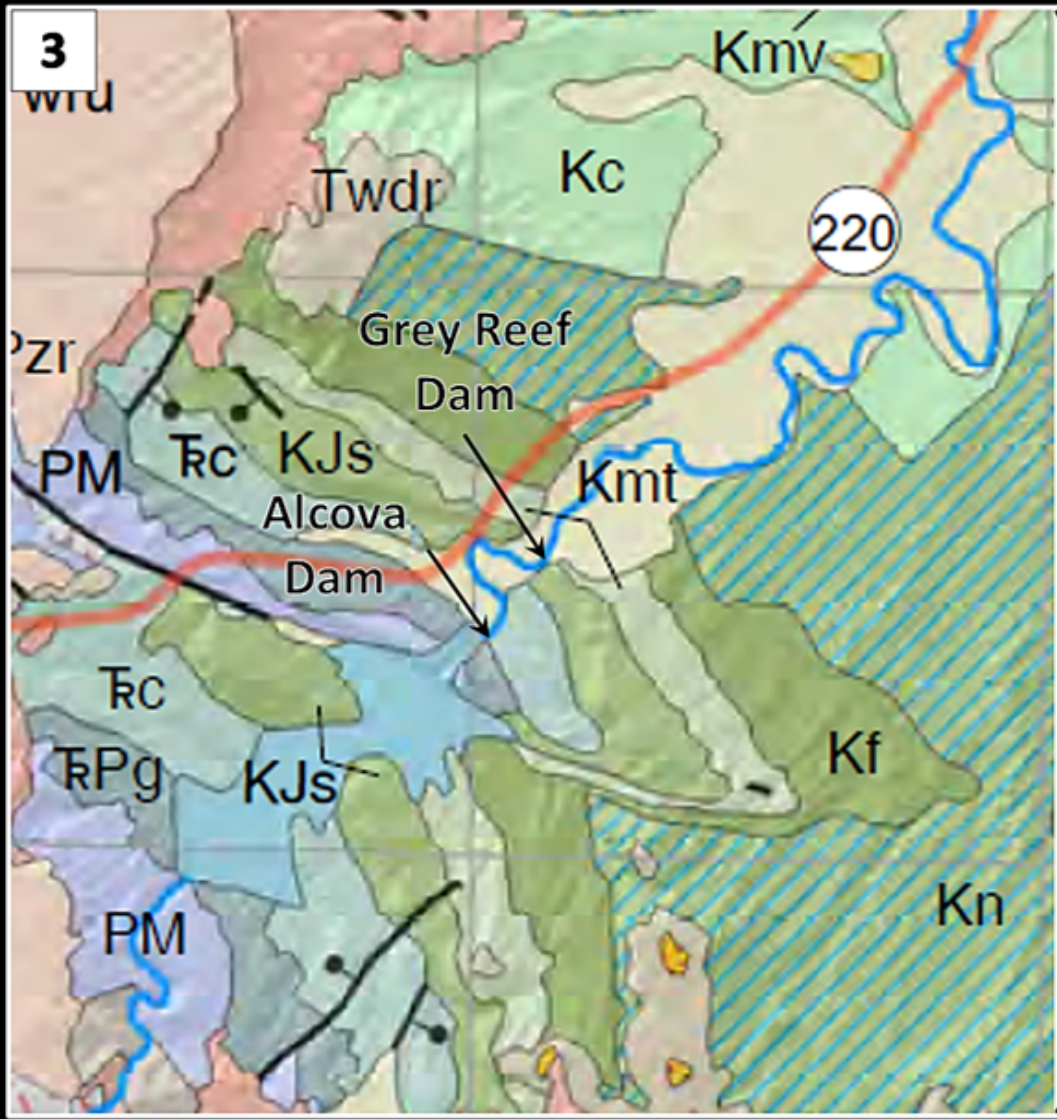
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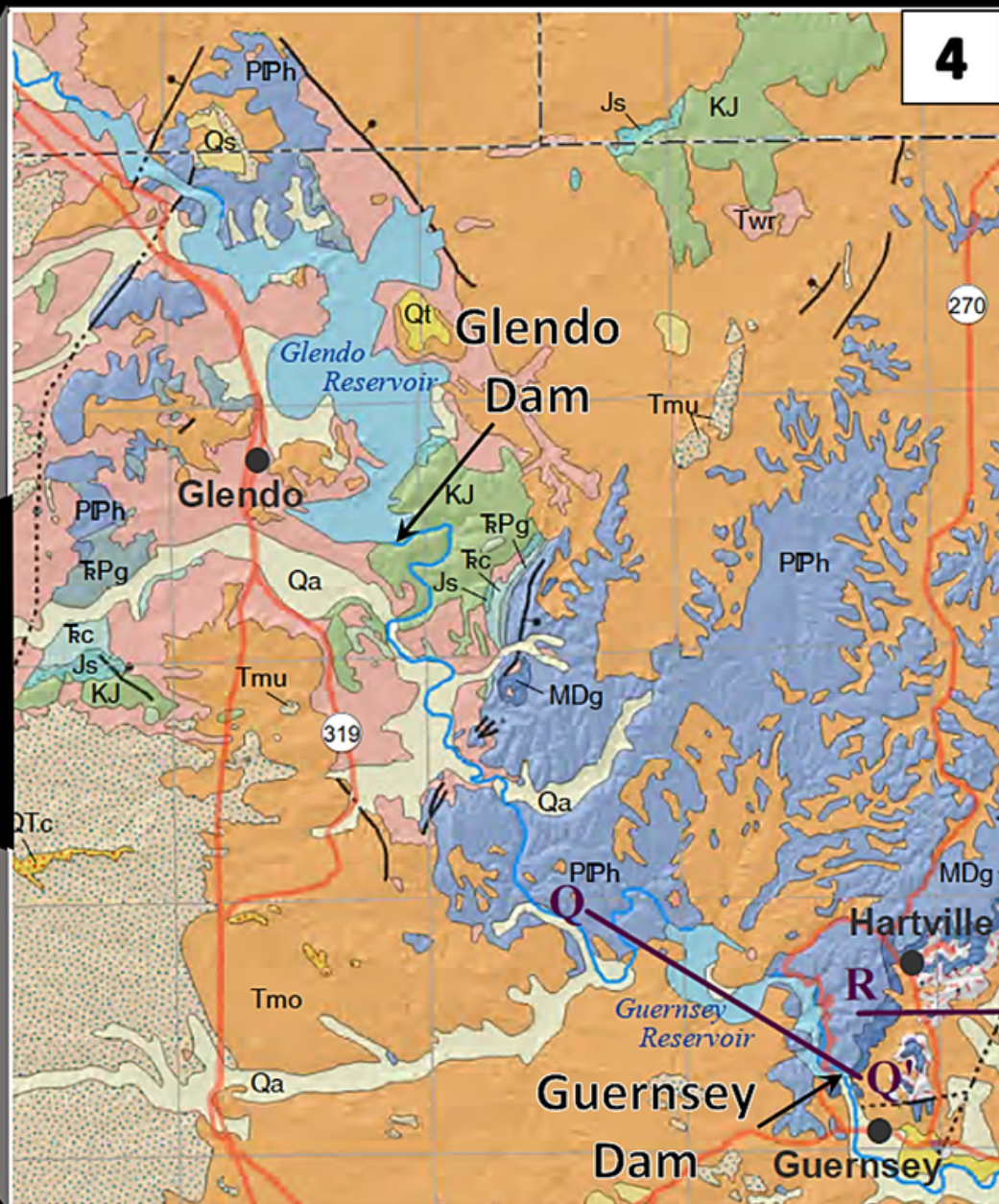
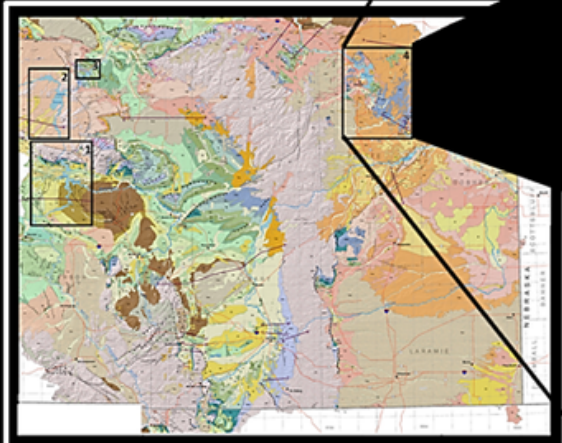
Tu

Qa

Kcf







Wyoming Geologic Units

CENOZOIC

Quaternary

Qa	Alluvium & colluvium
Qg	Gravel, pediment, & fan deposits
Qgl	Glacial deposits
Qli	Landslide deposits
Qs	Dune sand & loess deposits
Qm	Playa lake or marine deposits
Qa	Undivided surficial deposits

Quaternary and Tertiary

QTg	Terrace gravels
QTc	Conglomerate
QTb	Bug Formation

Tertiary

Tm	Miocene rocks (undivided)
Tmu	Upper Miocene rocks (North Park Formation in Saratoga Valley & Ogallala Formation in Denver-Julesburg Basin)
Tml	Lower Miocene rocks (undivided)
Tmo	Lower Miocene & upper Oligocene rocks (Arikaree Formation in Denver Basin)
Tu	Post-Eocene Sandstone & conglomerate
Twr	White River Formation
Twrw	Upper conglomerate member of White River Formation
Twrw	Brule Formation of White River Group
Twrw	Chadron Formation of White River Group
Too	Oligocene &/or upper & middle Eocene rocks
Tid	Dacite and quartz latite intrusive & extrusive rocks
Tip	Ice Point Conglomerate
Twb	Wagon Bed Formation
Tb	Bridger Formation

Tb	Bridger Formation
Tcg	Crooks Gap Conglomerate
Tai	Alkaline intrusive & extrusive rocks
Tgl	Laney Member of Green River Formation
Tgr	Tipton Shale Member or Tongue of Green River Formation
Tw	Wasatch Formation
Twc	Cathedral Bluffs Tongue of Wasatch Formation
Twm	Main body of Wasatch Formation
Tbw	Transitional unit between Battle Spring & Wasatch Formations
Tbs	Battle Spring Formation
Twdr	Wind River Formation
Tim	Indian Meadows Formation
Tco	Coalmont Formation
Tha	Hanna Formation
Tfu	Fort Union Formation
Tl	Lebo Member of Fort Union Formation
Tlh	Tullock Member of Fort Union Formation

CENOZOIC AND MESOZOIC

Tertiary and Cretaceous

TKf	Ferris Formation
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MESOZOIC

Cretaceous

Kl	Lance Formation
Klm	Lance Formation & Lewis Shale
Kmb	Medicine Bow Formation
Klh	Fox Hills Sandstone

Kll	Fox Hills Sandstone & Lewis Shale
Kml	Meeteetse Formation & Lewis Shale
Kle	Lewis Shale
Km	Mesaverde Formation or Group
Kp	Pierre Shale
Kc	Cody Shale
Kcf	Cody Shale & Frontier Formation
Kf	Frontier Formation
Ks	Steele Shale
Ksn	Steele Shale & Niobrara Formation
Kn	Niobrara Formation
Knf	Niobrara & Frontier Formations, & Mowry & Thermopolis Shales
Kf	Frontier Formation, & Mowry & Thermopolis Shales
Knt	Mowry & Thermopolis Shales

Cretaceous and Jurassic

KJ	Cloverly & Morrison Formations
KJs	Cloverly, Morrison, & Sundance Formations

Jurassic

Js	Sundance Formation
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Jurassic and Triassic

Jtn	Nugget Sandstone
-----	------------------

Triassic

Tc	Chugwater Formation
Tcd	Chugwater & Dinwoody Formations

MESOZOIC AND PALEOZOIC

Mz	Mesozoic & Paleozoic rocks (undivided)
----	----------------------------------------

Triassic and Permian

TPcg	Chugwater & Goose Egg Formations
TPg	Goose Egg Formation
TPjs	Jelm & Chugwater Formations, Forelle Limestone, & Satanka Shale

PALEOZOIC

Pz	Paleozoic rocks (undivided)
Pp	Phosphoria Formation & related rocks
Pfs	Forelle Limestone & Satanka Shale
PPc	Casper Formation
PPcf	Casper & Fountain Formations
PPh	Hartville Formation
PPM	Casper Formation & Madison Limestone
PM	Tensleep Sandstone & Arnsden Formation
Mm	Madison Limestone or Group
MDg	Guernsey Formation
OC	Bighorn Dolomite, Gallatin Limestone, Gros Ventre Formation & Flathead Sandstone
Cr	Cambrian rocks (undivided)

PRECAMBRIAN

pCr	Precambrian rocks
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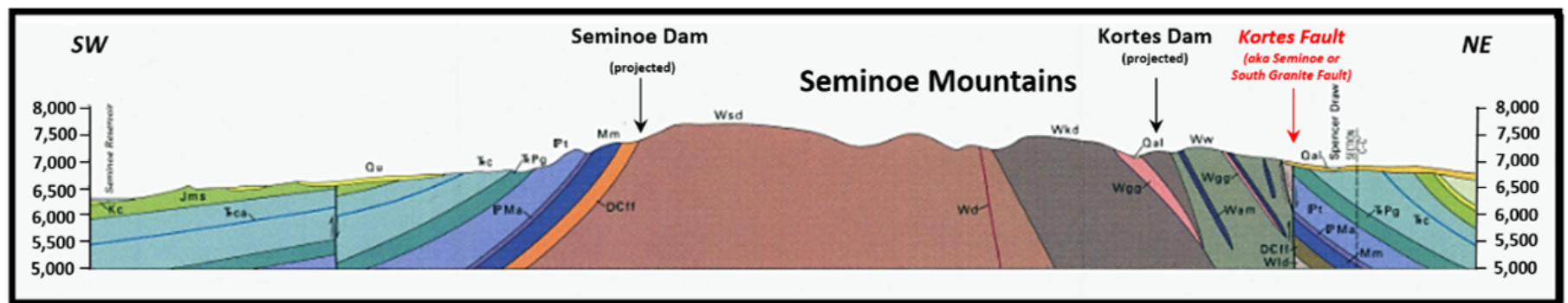
Explanation

	Interstate highway		City or town
	U.S. highway		Township boundary
	State highway		County boundary
	Line of cross section		State boundary
	Normal fault - dotted where concealed; ball & bar on downthrown block		Lake or reservoir
	Thrust fault - dotted where concealed; sawteeth on upper (tectonically higher) plate		River or creek

Geologic maps of the four areas of the seven reservoirs with explanation. Western area: 1: Seminoe and Kortes Dams, Area 2: Pathfinder Dam, Area 3: Alcova and Gray Reef Dams, and Eastern area: 4: Glendo and Guernsey Dams. Formation index displayed below

Image: After Platte River Basin Water Plan Update Groundwater Study Level I (2009-2013): Wyoming State Water Plan, http://waterplan.state.wy.us/plan/platte/2013/gw-finalrept/plate_1.pdf (http://waterplan.state.wy.us/plan/platte/2013/gw-finalrept/plate_1.pdf).

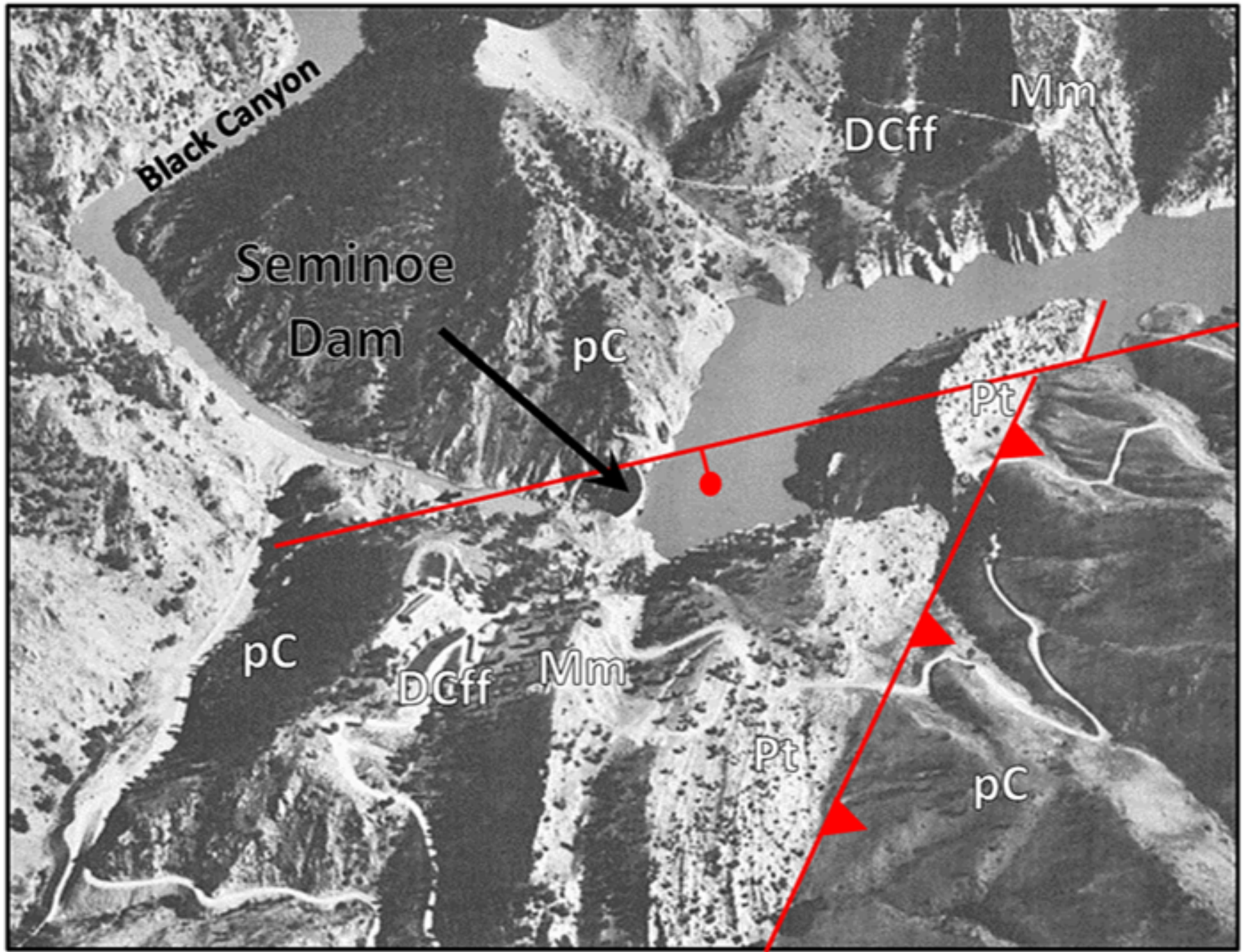
Seminoe Dam Area (Geologic Map 1 above)



Seminoe Mountains structural cross section B-B'. The line of section is about two miles southeast of the dams. Section does not show the Laramide-age, south-directed reverse fault that elevated the mountains. The down to the north fault on the northeastern margin has many names. Geologic code: Qal: Quaternary alluvium, Qu: Quaternary undifferentiated deposits, Qtr: Quaternary terrace gravel, Kc: Cretaceous Cloverly Formation, Jms: Jurassic Morrison and Sundance Formations, Trc: Triassic Chugwater Group, Trca: Triassic Alcova Limestone, TrPg: Triassic and Permian Goose Egg Formation, Pt: Pennsylvanian Tensleep Sandstone, PMa: Pennsylvanian and Mississippian Amsden Formation, Mm: Mississippian Madison Limestone, DCff: Devonian Fremont Canyon Quartzite and Cambrian Flathead Quartzite, Wd: Archean diabase, Ww: Archean white granite, Wkd: Archean granite of Kortes Dam, Wsd: Archean granite of Seminoe Dam, Wld: Archean granite of Larkin Dome (Wyoming Batholith), Wgg: Archean granite gneiss, Wam: Archean amphibolite.

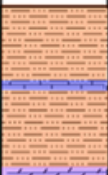


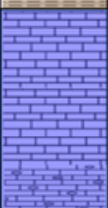



Image: After Dixon, H.R., 1990, Cross section BB', Geologic map of the Seminoe Dam NE quadrangle, Carbon County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-1673, 1:24,000, https://ngmdb.usgs.gov/Prodesc/proddesc_1187.htm (https://ngmdb.usgs.gov/Prodesc/proddesc_1187.htm)

Seminoe dam is the first dam encountered north of the Colorado/Wyoming Stateline. The river flows north from Saratoga Valley into the Hanna Basin and has carved a canyon through the mountains. The dam is located at the southern mouth of the canyon near the contact of lower Paleozoic and basement granitic rocks. The foundation is in Precambrian granite (Wsd) near the unconformable contact with lower Paleozoic quartzite. The dam is named for the mountains and canyon that were named for mountain man Charles Lajeunesse's nickname, "Cimineau or Simino."

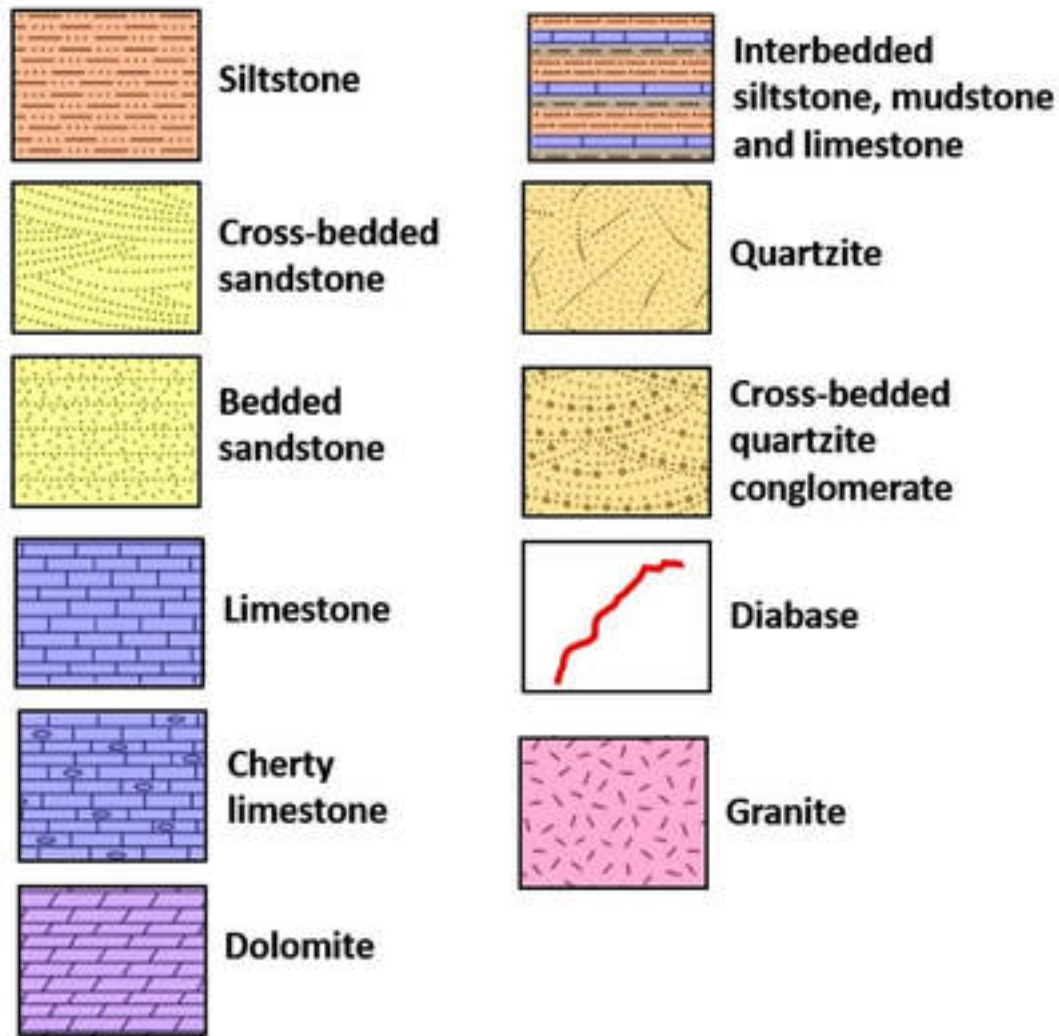


Aerial photo of Seminoe Dam site. Geologic codes: Pt: Pennsylvanian Tensleep Sandstone, Mm: Mississippian Madison Limestone, DCff: Devonian Fremont Canyon Quartzite and Cambrian Flathead Quartzite. Red lines show faults: thrust fault have sawteeth on upthrown block, normal fault has stick and ball on downthrown block.

Image: Love, J.D., 1970, *Cenozoic Geology of the Granite Mountains Area, Central Wyoming*: U.S. Geological Survey Professional Paper 495-C, Fig. 46, p. C104, <https://pubs.usgs.gov/pp/0495c/report.pdf> (<https://pubs.usgs.gov/pp/0495c/report.pdf>).

Eon		Era	Formation	Aproximate Thickness	Map Notation	Lithology	Description
Phanerozoic	Paleozoic	Lower Triassic and Permian	Goose Egg	280-295	TrPg		Pale-red to reddish brown siltone containing thin layers of light-gray limestone and dolomite
		Middle Pennsylvanian	Tensleep	738	Pt		Grayish-yellow, fine- to medium-grained, calcareous quartzite containing beds of light-gray dolomite near the base.
		Lower Pennsylvanian	Amsden	98	PMa		Pale-reddish-brown to grayish-red siltstone and mudstone interlayered with thin, grayish-pink limestone beds. Poorly exposed but forms a topographic low between the more resistant Tensleep Sandstone above and Madison Limestone below.
		Upper and Lower Mississippian	Madison	361	Mm		Light-gray, fine-to medium-grained limestone containing thin bed sand nodules of medium-gray chert.
		Upper Devonian and Middle Cambrian	Fremont Canyon and Flathead	279	DCff		Pale-red, grayish-red and grayish-orangs pink, medium- to coarse-grained quartzite. The basal part is commonly crossbedded conglomerate containing clasts as much as 3 cm long of quartz, quartzite, and dark-gray phyllite.
Precambrian		Late Archean	Diabase		Wd		Dark-gray, to dark-greenish-gray, fine-grained diabase. Occurs as dikes rarely more than 7 feet but traceable along strike for 1 to 2 miles.
			Granite		Wsd/kd		Grayish-orange-pink, , medium-grained, massive granite. Accessory minerals are apatite, opaque minerals, and locally zircon, secondary minerals are muscovite, chlorite, epidote and sphene. The granite typically feldspar megacrysts 0.2 to 0.4 inches. Foliation of biotite flakes is present locally.

Lithology Key



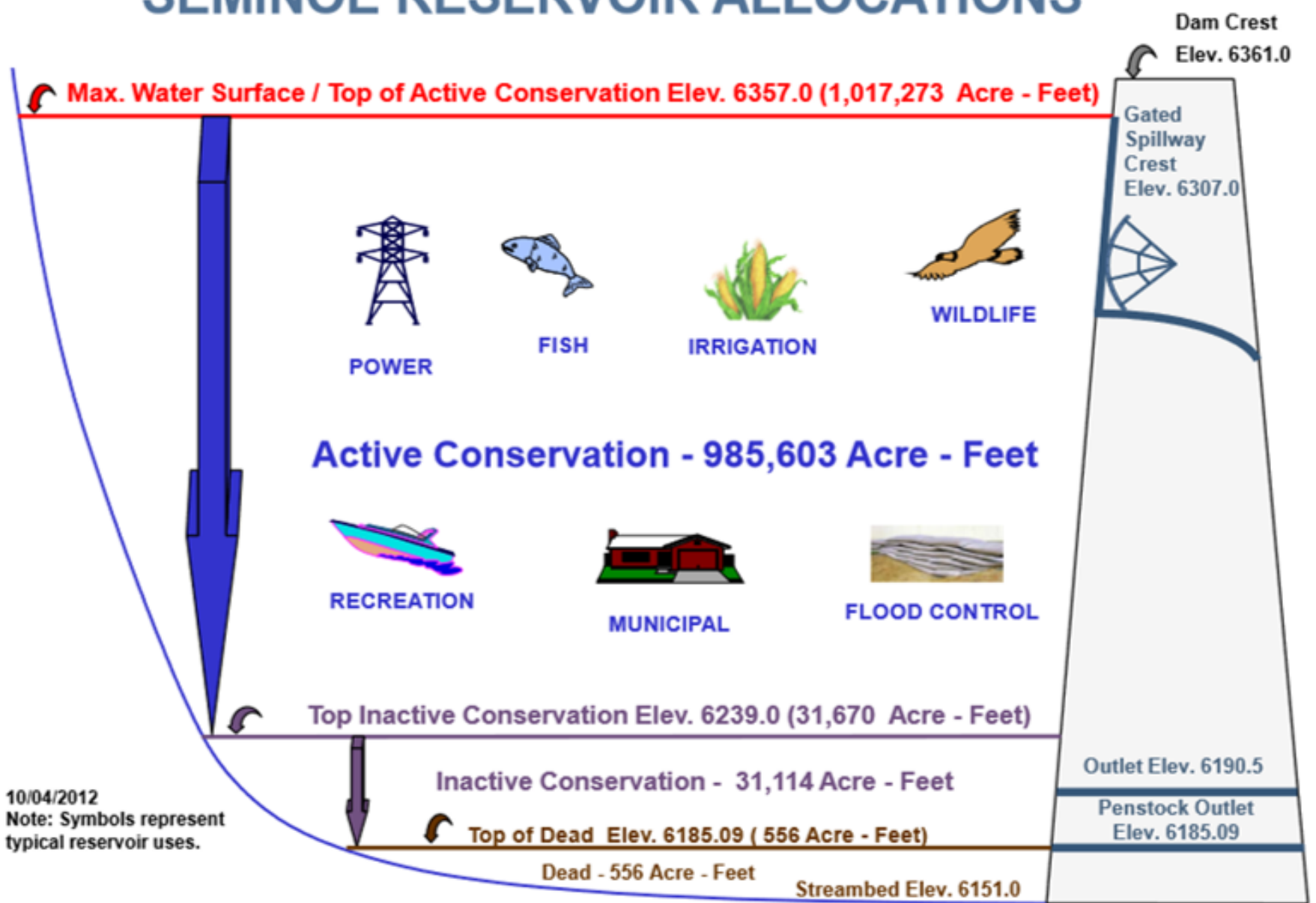
Stratigraphic column for Seminoe and Kortes dam sites.

Image: After Dixon, H.R., 1990, *Geologic Map of the Seminoe Dam NE Quadrangle, Carbon County, Wyoming*: USGS GQ-1673, Scale

1:24,000, https://ngmdb.usgs.gov/Prodesc/proddesc_1187.htm

(https://ngmdb.usgs.gov/Prodesc/proddesc_1187.htm)

SEMINOE RESERVOIR ALLOCATIONS



Water allocations for Seminole Reservoir.

Image: U.S. Bureau of

Reclamation, https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html

(https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html)

Kortes Dam is located two miles downstream of Seminole Dam entirely within the walls of Black Canyon (aka Seminole Canyon). The foundation lies on Archean granite (Wkd). The name comes from the Kortes Black Canyon Ranch about two and a half miles northeast of the dam. The Kortes Fault trace crosses the river at the northern margin of the canyon, near the ranch. The fault is one mile north of the dam and juxtaposes Precambrian granite (Wkd) and Miocene Split Rock Formation. The river below Kortes Dam is a world class fishery for large Rainbow trout known as the "Miracle Mile."



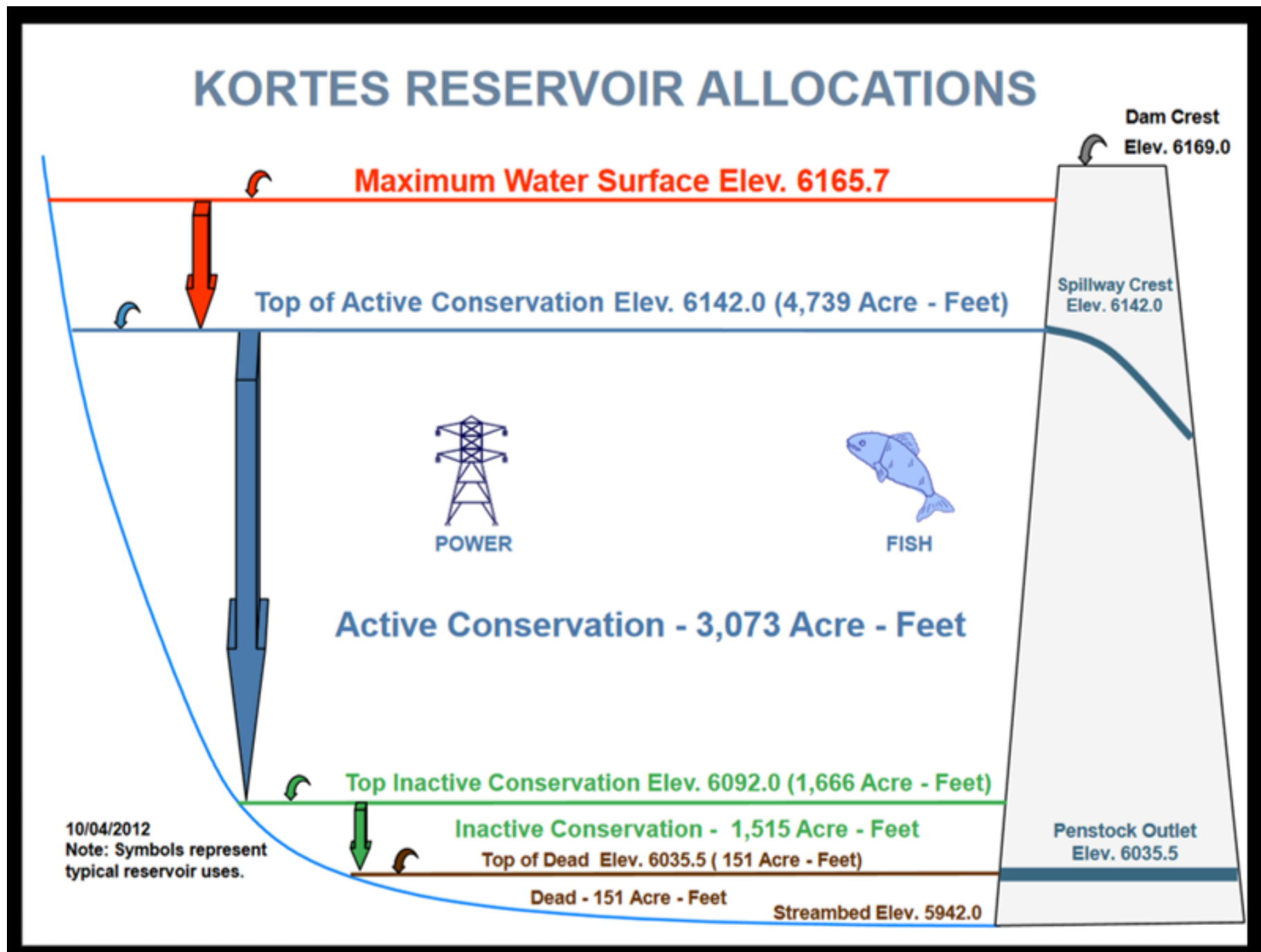
The Miracle Mile of the North Platte River.

Image: Reef Fly Shop photo, <https://www.northplatteflyfishing.com/fishing-guide/fishing-destinations/miracle-mile-fishing/> (<https://www.northplatteflyfishing.com/fishing-guide/fishing-destinations/miracle-mile-fishing/>).



South view of Kortes Dam.

Image: U.S. Bureau of Reclamation, 2004, Photo C545-600-2002 by Dave



Water allocations for Kortes Reservoir.

Image: U.S. Bureau of Reclamation, https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html
(https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html)

Pathfinder Dam Area (geologic map 2 above)

Pathfinder is the third dam located along the North Platte and the first to be constructed in the North Platte River Basin. The structure was named after the nickname of John C. Fremont (historical note: Kit Carson was the actual guiding "Pathfinder" in the party). Fremont records a description of the canyon and his harrowing water passage through it in his journal *The*

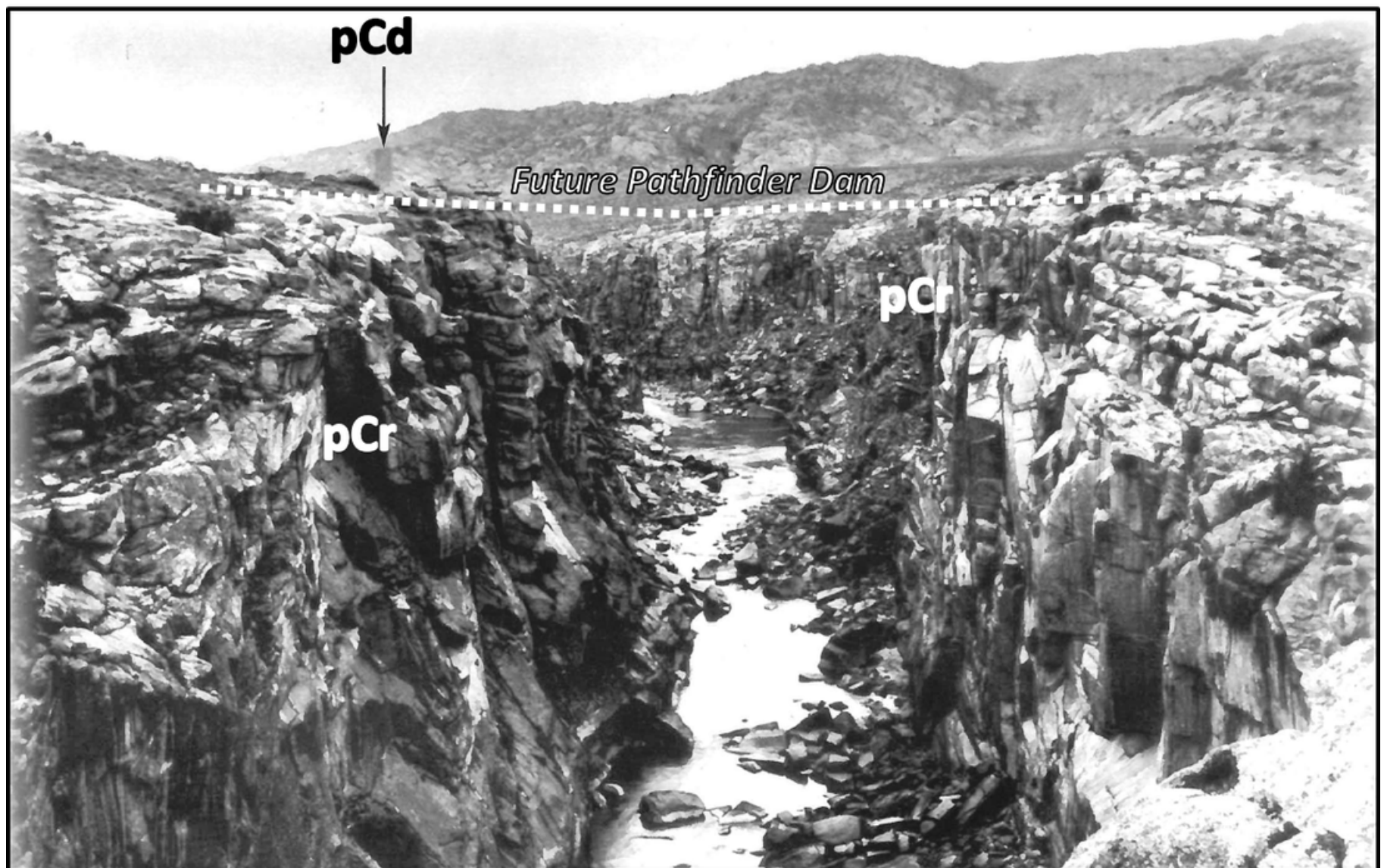
exploring expedition to the Rocky Mountains, Oregon and California”

(<https://babel.hathitrust.org/cgi/pt?id=aeu.ark:/13960/t4fn1zv6j;view=1up;seq=8>
(<https://babel.hathitrust.org/cgi/pt?id=aeu.ark:/13960/t4fn1zv6j;view=1up;seq=8>)).

The dam was constructed at the southern mouth of Fremont Canyon in the northeastern portion of the Granite Mountains. It is about three miles downstream from the confluence of the Sweetwater and North Platte Rivers and eight miles north of Seminole Dam. The foundation bedrock is an exposed portion of the Wyoming Batholith. The reservoir backfills portions of both streams above their confluence.

Spring runoff was heavy in 1909 and concerns were raised that the new dam might fail. As a precautionary measure 5 drill holes charged with dynamite were placed near the top of the dam. This would allow the engineers a failsafe to blow an opening in the dam to allow escape of water and prevent dam failure. As the flood waters receded, so did the memory of the dynamite charges. They remained in place until they were rediscovered in 1949 when the explosives were removed from the dam.


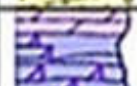

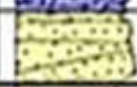








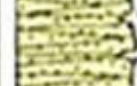

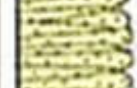

The eastern margin of the reservoir lies adjacent to the Pedro Mountains. This uplift is also part of the Wyoming Batholith. Here the mummified remains of a Native American infant were discovered by two prospectors in 1932. Their discovery gave rise to tales of a race of little people living in the area. The remains were lost in 1950, but that did not stop speculation that continues today.

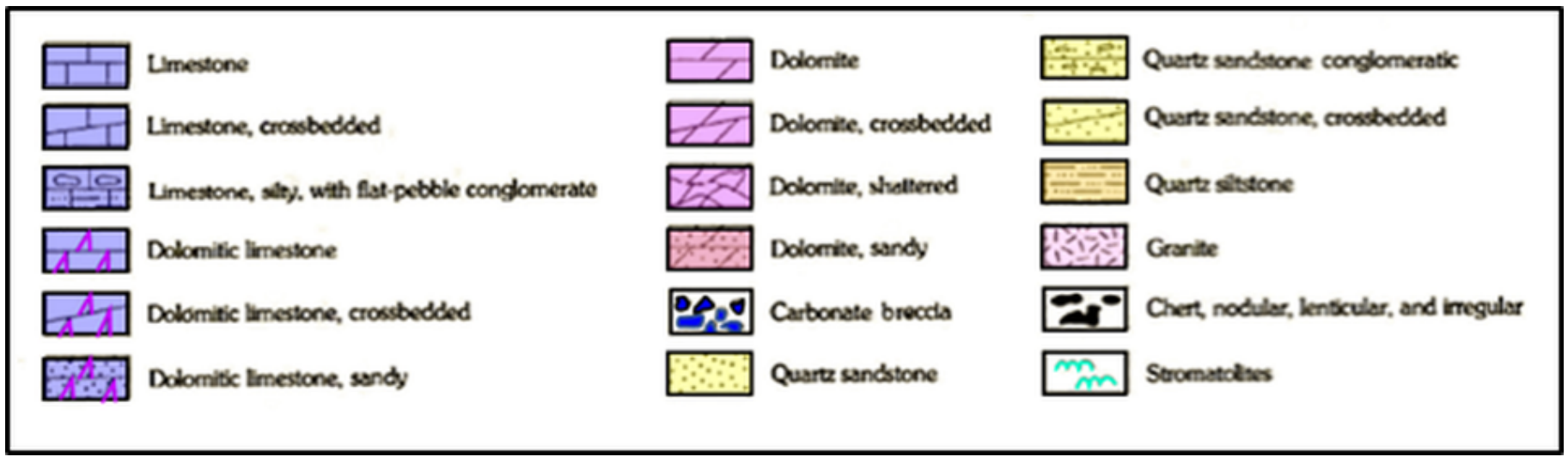


Late Archean granite of the Wyoming batholith exposed at Pathfinder Dam site in Fremont Canyon. Dam Location shown by white dashed line. Geologic codes: pCd: Precambrian

diabase (dike), pCr: Precambrian rock (granite).

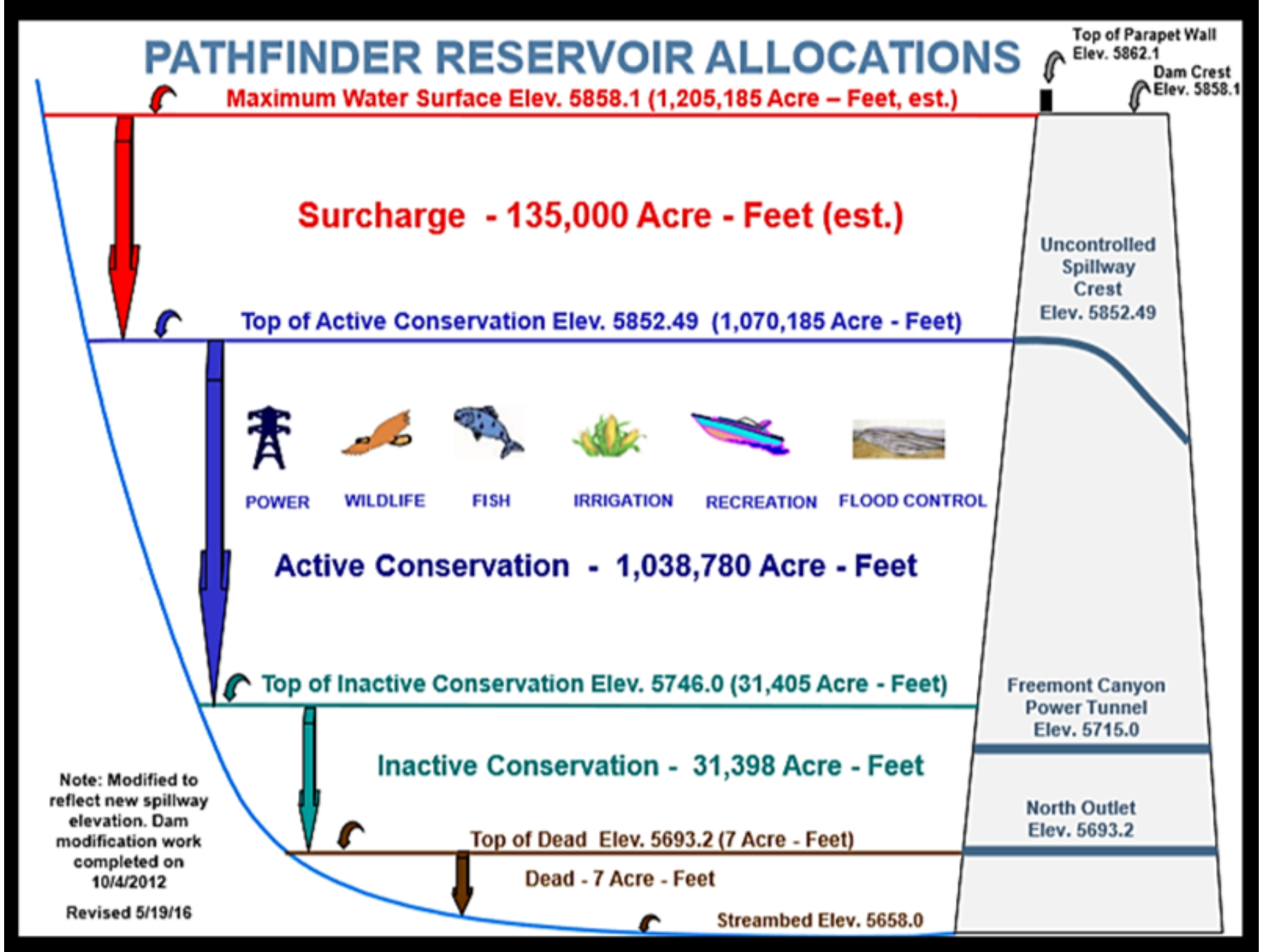
Image: After Knittel, Peggy, Van Burgh, D.P., Jr., Logue, T.J., Strube, B.E., and Jones, R.W., 2004, Field guide for the Alcova area, Natrona County, Wyoming: Wyoming State Geological Survey Educational Series 2, Fig. 58, p. 34, <http://sales.wsgs.wyo.gov/field-guide-for-the-alcova-area-natrona-county-wyoming-2004/> (<http://sales.wsgs.wyo.gov/field-guide-for-the-alcova-area-natrona-county-wyoming-2004/>)

Eon	Era	Formation	Aproximate Thickness	Map Notation	Lithology	Description
Phanerozoic	Paleozoic	Tensleep	600	Pt		Quartz sandstone, cross-bedded
		Amsden	150	Pa		Dolomite
		Darwin	500	Pd		Dolomitic limestone
		Madison	150	Mm		Dolomitic limestone, thin bedded, sandy
			400			Cross-bedded sandstone
			300			Siltstone (Upper solution zone)
			200			Cherty limestone (Little Tongue Member)
			100			Disrupted cherty limestone
			50			Carbonate breccia (Lower solution zone)
			0			Cherty limestone with Stromatolites
		Englewood	200	De		Shattered dolomitic limestone, with nodular chert (Big Goose Member)
		Fremont	100	Cfc		Dolomitic limestone, with nodular chert
Late Archean	Precambrian		0			Quartz siltstone
			0	pC		Quartz sandstone, cross-bedded
						Quartz sandstone, conglomeratic
						Granite, some diabase dike intrusions (Wyoming batholith)



Fremont Canyon stratigraphic column. Pathfinder Dam was constructed on the Precambrian granite.

Image: After Sando, W.J. and Sandberg, C.A., 1987, *New interpretations of Paleozoic stratigraphy and history in the northern Laramie Range and vicinity, Southeast Wyoming*: U.S. Geological Survey Professional Paper 1450, Plate 1, <https://pubs.er.usgs.gov/publication/pp1450>
 (<https://pubs.er.usgs.gov/publication/pp1450>)



Water allocations for Pathfinder Reservoir.

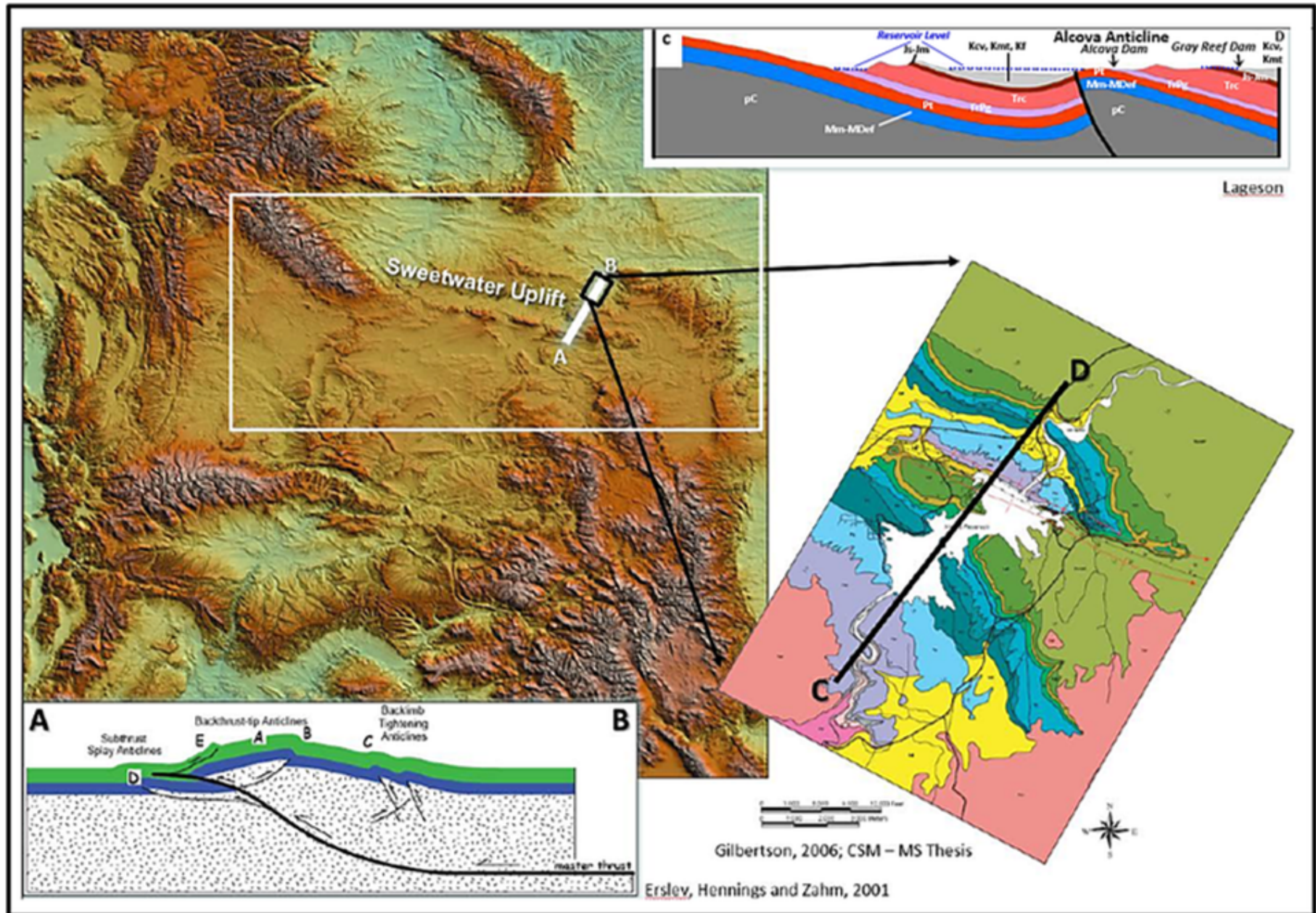
Image: U.S. Bureau of

Reclamation, https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html

(https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html)

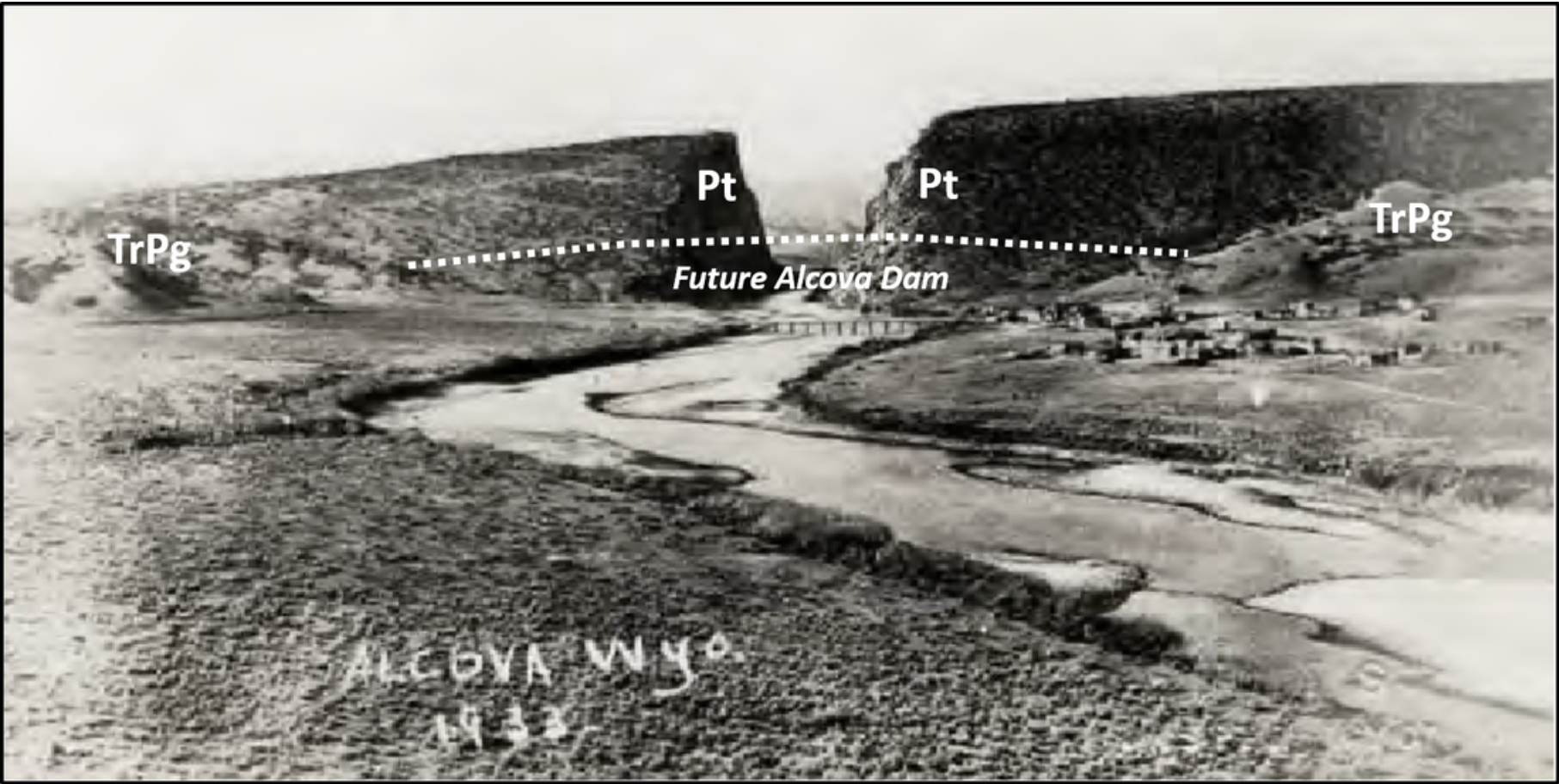
Alcova Dam Area (geologic map 3 above)

The dam is situated just north of the canyon on the backlimb of Alcova anticline. The engineers believed that the Permian Goose Egg Formation would provide a better foundation than the porous Pennsylvanian Tensleep Sandstone that is in the core of the structure. The anticline is elevated by a southwest directed basement fault that trends to the northwest. The fold is a backlimb tightening anticline (shown at location "C" on cross section A-B below) developed on the north limb of the Granite Mountains arch (Sweetwater Uplift).



Geologic context of the Alcova area. Geologic codes: Kcv, Kmt, Kf: Cretaceous Cloverly, Meeteetse-Thermopolis, and Frontier Formations; Js-Jm: Jurassic Sundance and Morrison Formations; Trc: Triassic Chugwater Group; TrPg: Triassic-Permian Goose Egg Formation; Pt: Pennsylvanian Tensleep Sandstone; Mm-MDef: Mississippian Madison Limestone and Devonian Englewood Formation and Fremont Canyon Sandstone.

Image: After Hennings, P., Csoma, A.E., and Zahm, C., 2015, Relationship between Anticlinal Folding and the Evolution of Mechanical Stratigraphy, Rock Mechanics Properties and Reservoir Quality in the Tensleep Sandstone at Alcova Reservoir, Central Wyoming, USA: HGS Dinner Meeting, <https://www.hgs.org/civCRM/event/info?reset=1&id=1536> (<https://www.hgs.org/civCRM/event/info?reset=1&id=1536>)



South view of Alcova Anticline circa 1933 where the dam was later built.

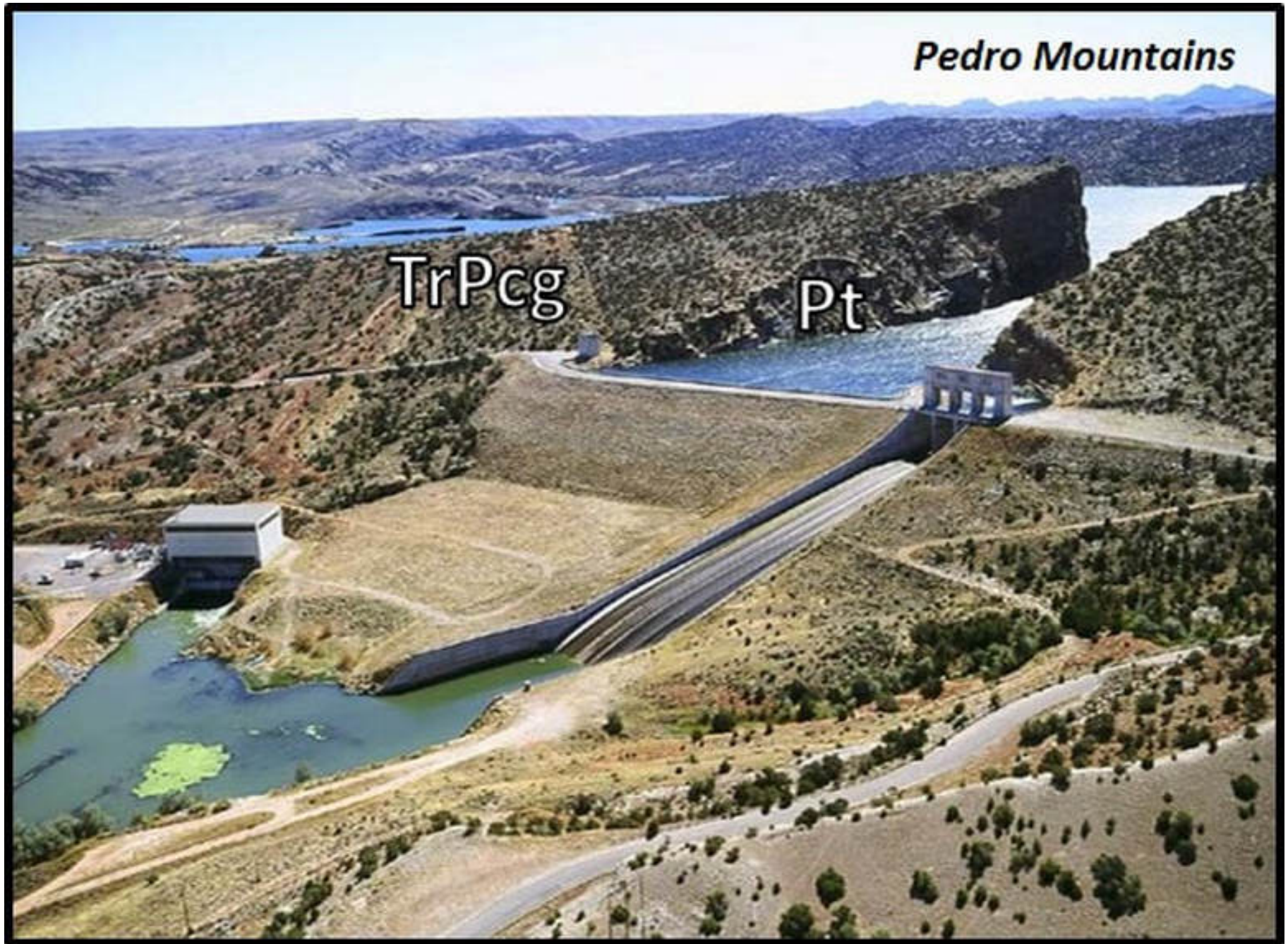
Image: After Cassity, M., 2013, *Building Up Wyoming: Depression-Era Federal Projects in Wyoming, 1929–1943*, Image on p. 79, <http://wyoshpo.state.wy.us/pdf/BuildingUpWyoming.pdf> (<http://wyoshpo.state.wy.us/pdf/BuildingUpWyoming.pdf>).

Era	Period	Formation	Map Notation	Lithology	Description	Thickness	Depositional Environment
Mesozoic	Cretaceous	Muddy Ss. / Thermopolis Sh. (Kmt)	Kmt		Thin sandstone, gray, within shale, black	190	Marine
		Lakota Ss. (Kla)	KJcms		Conglomerate and sandstone, tan to yellow	90	Stream
	Jurassic	Morrison Fm. (Jm)			Shale, siltstone, mudstone, and sandstone, variable color	210	Stream
		Sundance Fm. (Jsd)			Sandstone, shale, and siltstone, gray-green	250	Marine
	Triassic	Jelm Fm. (Rj)	TrPcg		Siltstone, shale, and limestone, pink-red	310	Tidal flat
		Alcova Ls. Mombor (Ra)			Limestone, lavender-gray	34	Marine (algal)
Paleozoic	Perm	Chugwater Fm. (Rc)			Siltstone, shale, and sandstone, red	780	Tidal flat
		Goose Egg Fm. (RPg)			Shale, siltstone, and limestone with gypsum, red-orange	370	Marine and tidal flat
	Penn	Casper Fm. / Tensleep Ss. (Pt)	Pt		Sandstone, white to yellow to tan	550	Eolian and marine

Stratigraphic column for Alcova and Gray Reef Dam Sites. The Alcova Dam foundation is in the Permian Goose Egg Formation. The Grey Reef Foundation is in the lower Cretaceous Cloverly (aka Lakota) and Thermopolis Formations.

Image:After Knittel, Peggy, Van Burgh, D.P., Jr., Logue, T.J., Strube, B.E., and Jones, R.W., 2004,

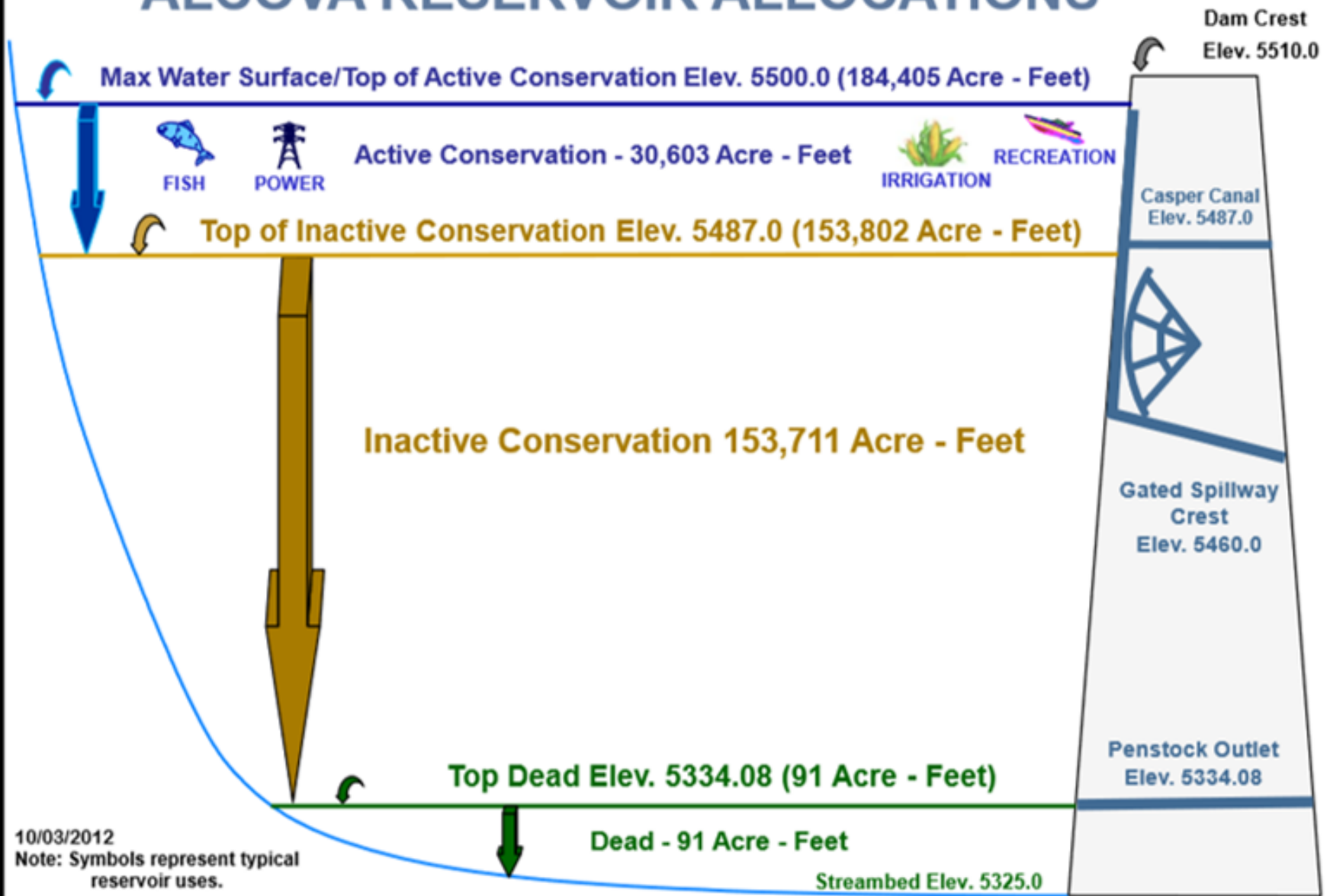
Field guide for the Alcova area, Natrona County, Wyoming: Wyoming State Geological Survey Educational Series 2, Frontispiece, p. iii, <http://sales.wsgs.wyo.gov/field-guide-for-the-alcova-area-natrona-county-wyoming-2004/> (<http://sales.wsgs.wyo.gov/field-guide-for-the-alcova-area-natrona-county-wyoming-2004/>)



South view of Alcova dam.

Image: U.S. Bureau of Reclamation, 2004, Photo C144-600-2002 by Dave Walsh, https://www.usbr.gov/lc/region/g5000/photolab/gallery_detail.cfm?PICIDTYPE=13 (https://www.usbr.gov/lc/region/g5000/photolab/gallery_detail.cfm?PICIDTYPE=13)

ALCOVA RESERVOIR ALLOCATIONS



Water allocations for Alcovia Reservoir.

Image: U.S. Bureau of Reclamation, https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html
 (https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html)

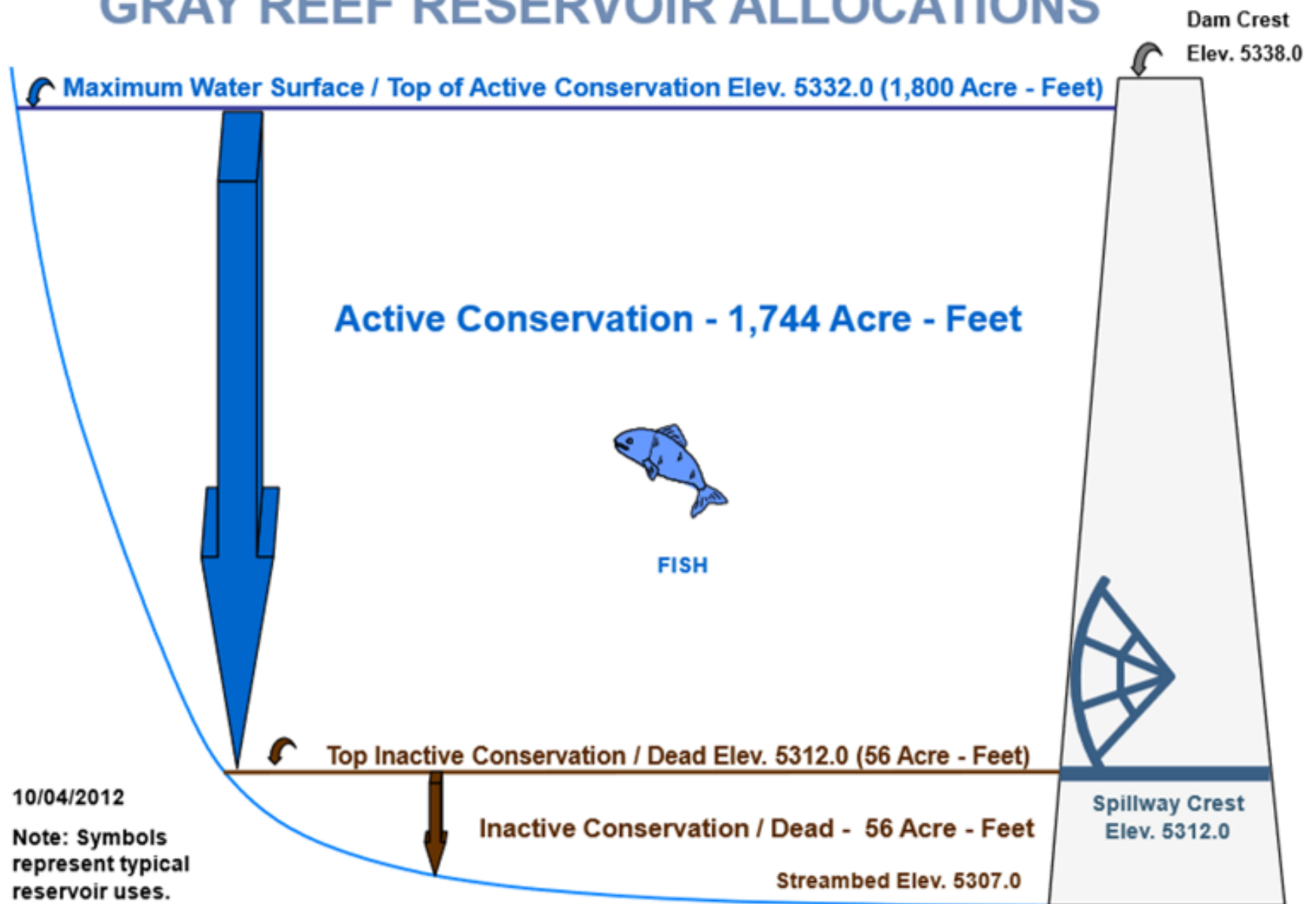
About a mile and a half downstream, just past the next western meander loop of the river, is Gray Reef Dam. The original chosen dam site in the Jurassic Morrison Formation was found unsuitable for construction due to potential for leakage and the location was moved downstream about 300 feet. Here the right abutment is adjacent to the Cretaceous Cloverly Formation and the left rest on Cretaceous Thermopolis Formation. The primary purpose of this small impoundment is to regulate the flow downstream.



Southeast view of Gray Reef Dam.

Image: U.S. Bureau of Reclamation, 2004, Photo C499-600-2000 by Dave Walsh, https://www.usbr.gov/lc/region/g5000/photolab/gallery_detail.cfm?PICIDTYPE=27 (https://www.usbr.gov/lc/region/g5000/photolab/gallery_detail.cfm?PICIDTYPE=27)

GRAY REEF RESERVOIR ALLOCATIONS



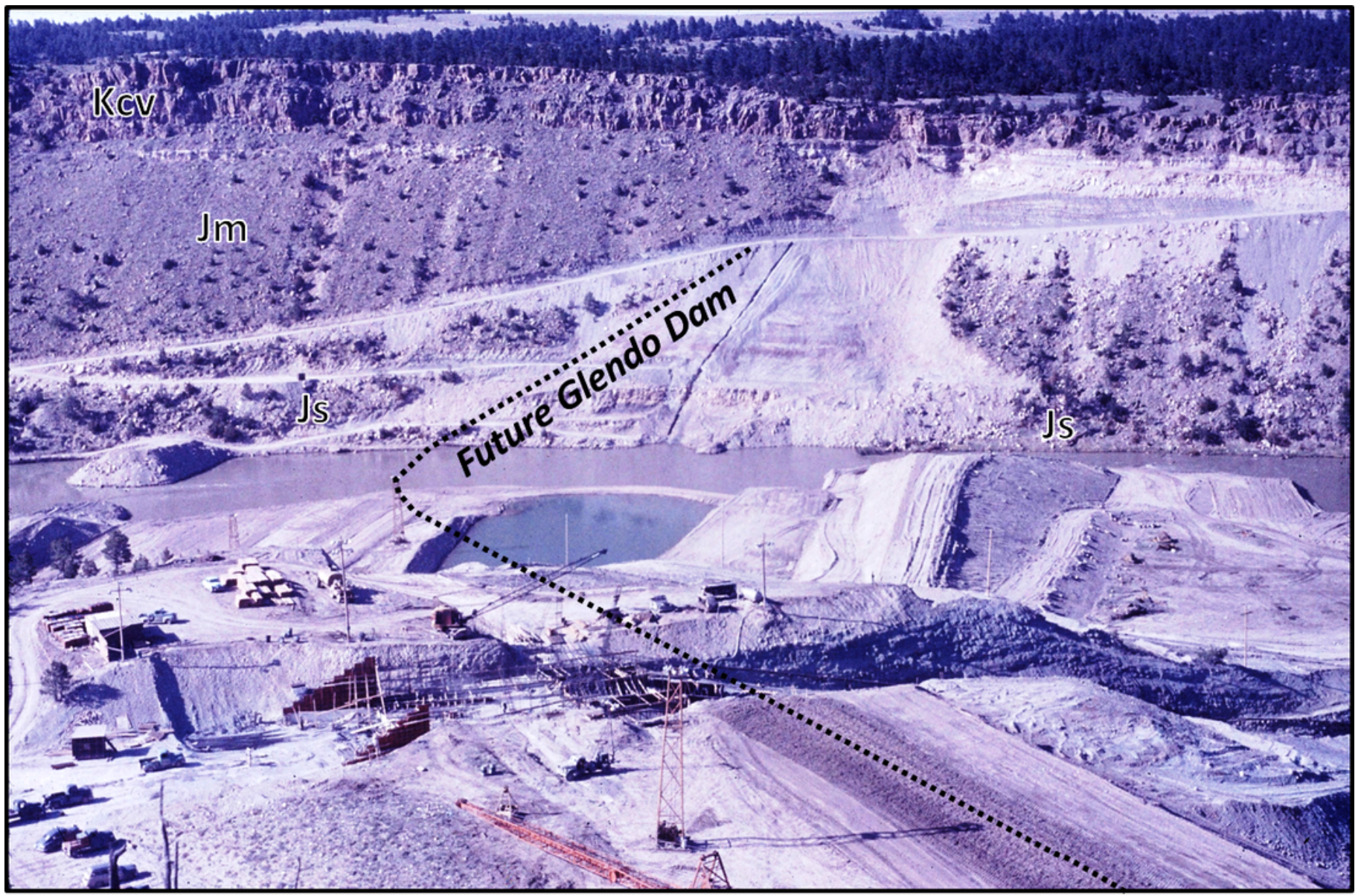
Water allocations for Gray Reef Reservoir.

Image: U.S. Bureau of

Reclamation, https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html

(https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html)

Glendo-Guernsey Dam Area (geologic map 4 above)



Glendo Dam site geology during construction. Geologic codes: Kcv: Cretaceous Cloverly Formation, Jm: Jurassic Morrison Formation, Js: Jurassic Sundance Formation.

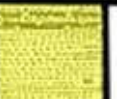
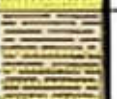







Image: After Digital Collections of Colorado, Colorado State University Photo wmla 14805106, <https://dspace.library.colostate.edu/bitstream/handle/10217/72928/wmla14805106.jpg?sequence=6&isAllowed=y> (<https://dspace.library.colostate.edu/bitstream/handle/10217/72928/wmla14805106.jpg?sequence=6&isAllowed=y>)



North view of Glendo Dam.

Image: After Digital Collections of Colorado, Colorado State University Photo wmla 14805171, <https://dspace.library.colostate.edu/bitstream/handle/10217/72928/wmla14805171.jpg?sequence=71> (https://dspace.library.colostate.edu/bitstream/handle/10217/72928/wmla14805171.jpg?sequence=71).

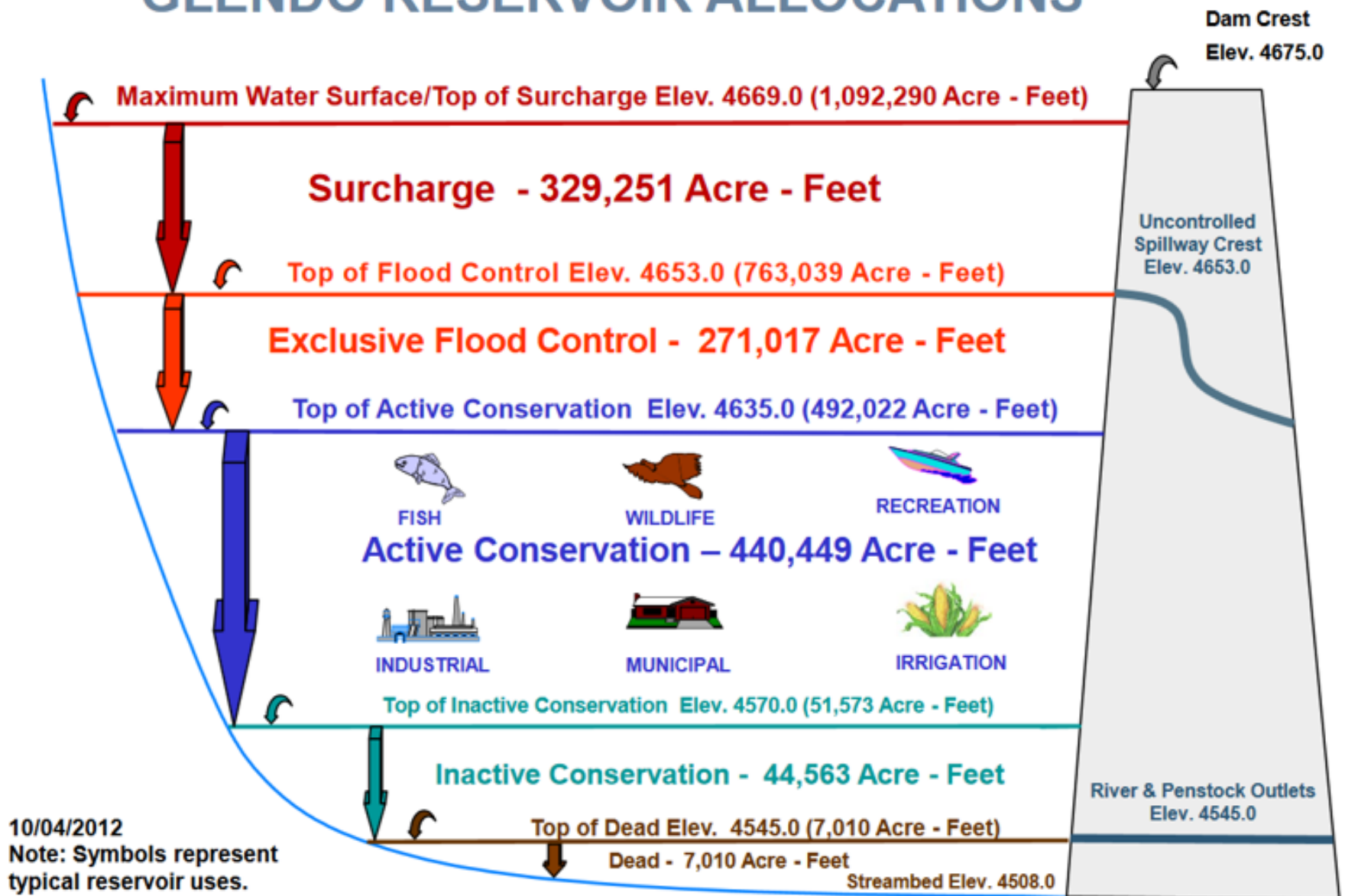
Glendo Dam is located on southeast dipping Mesozoic rocks at the mouth of Wendover Canyon, 155 miles downstream of Alcova Dam. The basal sandstone of the Cretaceous Cloverly Formation is exposed along the ridge of the gorge at the dam site. The Jurassic Morrison and Sundance Formations form the slope and base of the canyon walls. Older sedimentary rocks are exposed upstream in Red and Platte River Canyons. The Pennsylvanian Hartville Formation is the oldest exposed unit along the northern portion of Glendo Reservoir. Horizontal beds of Tertiary sediment lap over older Mesozoic and Paleozoic units on both sides of the reservoir. These are Oligocene- and Miocene-age remnants of fill that covered the Rockies and extended onto the Great Plains. Elevations range from 4,500 to about 5,100 feet in the area.

Era	Period	Formation	Thickness	Map Notation	Lithology	Description
Mesozoic	Cretaceous	Cloverly	120-260	Kc		Sandstone, gray, weathering tan, fine-grained, clean, sparkly, thin-bedded in upper part; interlaminated with gray sandy shale near top; numerous worm trails.
						Claystone, gray and black to pink, very fine grained, plastic; interbedded with fine-grained sandstone.
						Sandstone, gray, weathering tan, clean, sparkly, massive to thickly bedded; chert-pebble conglomerate near base; thin shaly zone locally present in lower part.
	Jurassic	Morrison	150-220	Jm		Claystone, green, pinkish near middle, soft, waxy; thin hard buff sandstones at top.
						Limestone, light gray to pale turquoise green, poorly-bedded, nodular; sparse chert grains and pebbles; gray shale near middle; sparse large <i>Chara</i> seeds near base.
						Claystone, pale green to pale purple and pink, moderately hard, siliceous; numerous nodular limestones and limy nodules throughout; thin gray to tan hard sandstones; abundant <i>Chara</i> seeds and ostracodes in more limy beds.
		Sundance	Upper	50-100		Sandstone, ochre yellow to brown, fine- to medium-grained, pseudo-collitic, porous in lower part, thin-bedded in upper part, nonglauconitic, is conspicuous and widespread; contains numerous large rounded frosted grains, pelecypods and gastropods similar to marine forms, and fish and reptile remains.
						Shale, dull green, fine-grained, fissile, flaky in upper part; grades down into silty sandy and limy highly glauconitic beds; abundant belemnite fragments.
			Lower	125-300		"Ammonite zone", siltstone, light ochre yellow, hard, very limy, nodular, with irregular ragged fracture; very glauconitic; conspicuous and widespread zone; contains numerous belemnites, ammonites, and pelecypods.
						Shale, gray to brown, silty, soft, highly glauconitic; thin glauconitic sandstone partings.
			Basal Ss	30-100		"Belemnite sandstone", light tan to gray, fine- to medium-grained, hard, limy, sparsely glauconitic; forms conspicuous vertical cliffs at most outcrops; bed of belemnites in top ferruginous layer of sandstone.
						Sandstone and shale, buff to greenish gray; thin irregular bedding, with numerous mid cracks, ripple marks and worm borings in upper part; weathers to steep slopes at most outcrops.
						Sandstone, red to yellowish tan and buff, very fine grained, ferruginous, limy, massive in part; forms rounded ledges at most outcrops; thin gray-green waxy shale forms reentrants near base.

Stratigraphic column of Mesozoic Formations exposed at the Glendo Dam site. The Sundance Formation is the bedrock for the dam foundation and, with the Morrison Formation, for the abutments.

Image: After Love, J.D., Denson, N.M., and Botinelly, T., 1949, *Geology of the Glendo area, Wyoming*: U.S. Geological Survey Oil and Gas Investigations Map OM-92, Sheet 2, https://ngmdb.usgs.gov/Prodesc/proddesc_5455.htm (https://ngmdb.usgs.gov/Prodesc/proddesc_5455.htm).

GLENDO RESERVOIR ALLOCATIONS



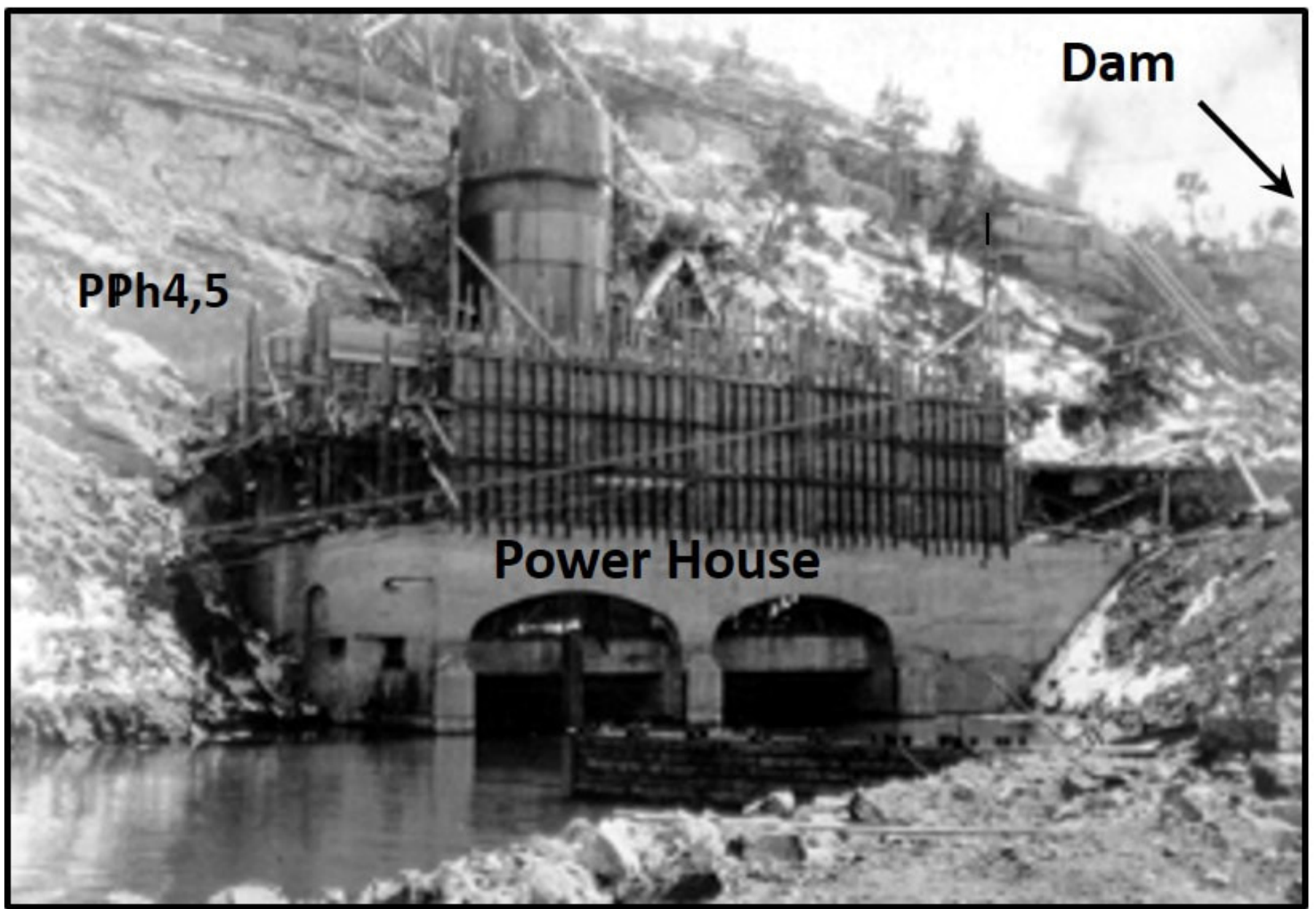
Water allocations for Glendo Reservoir.

Image: U.S. Bureau of

Reclamation, https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html

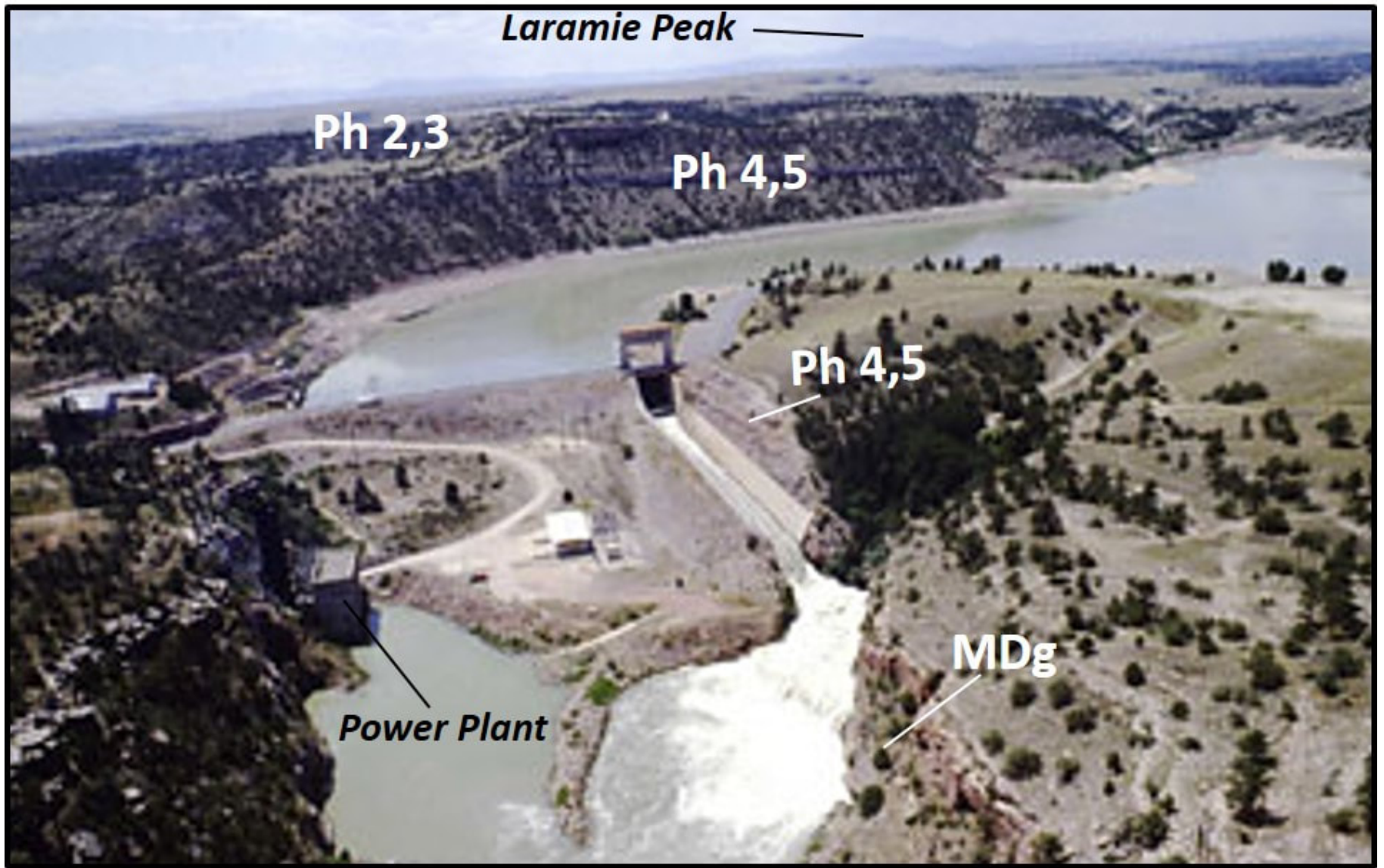
(https://www.usbr.gov/gp/lakes_reservoirs/wyoming_lakes.html)

Guernsey Dam is in a canyon carved along the southwestern margin of the Hartville Uplift. It is the last U.S. Bureau of Reclamation along Wyoming's North Platte River. The foundation rests on Pennsylvanian Hartville formation. Lower Paleozoic to Precambrian rocks poke through the Tertiary fill in the area to the southeast. The Archean rocks include metasedimentary and metavolcanic units that are part of the Central Wyoming greenstone belt. This diverse complex of rocks represents ancient basins that formed along the margins of the Wyoming Craton extending from the Granite Mountains to the Hartville Uplift. They were deformed, metamorphosed, and enfolded as terranes accreted to form the future Equality State. In the Guernsey area the North Platte River flows southeastward within an inner boggy valley with terraces surrounded by higher pediment surfaces and canyons cut in the older Paleozoic rocks.



Guernsey Dam and power plant under construction.

*Image: After National Park Service, <https://www.nps.gov/articles/wyoming-guernsey-dam.htm>
(<https://www.nps.gov/articles/wyoming-guernsey-dam.htm>)*



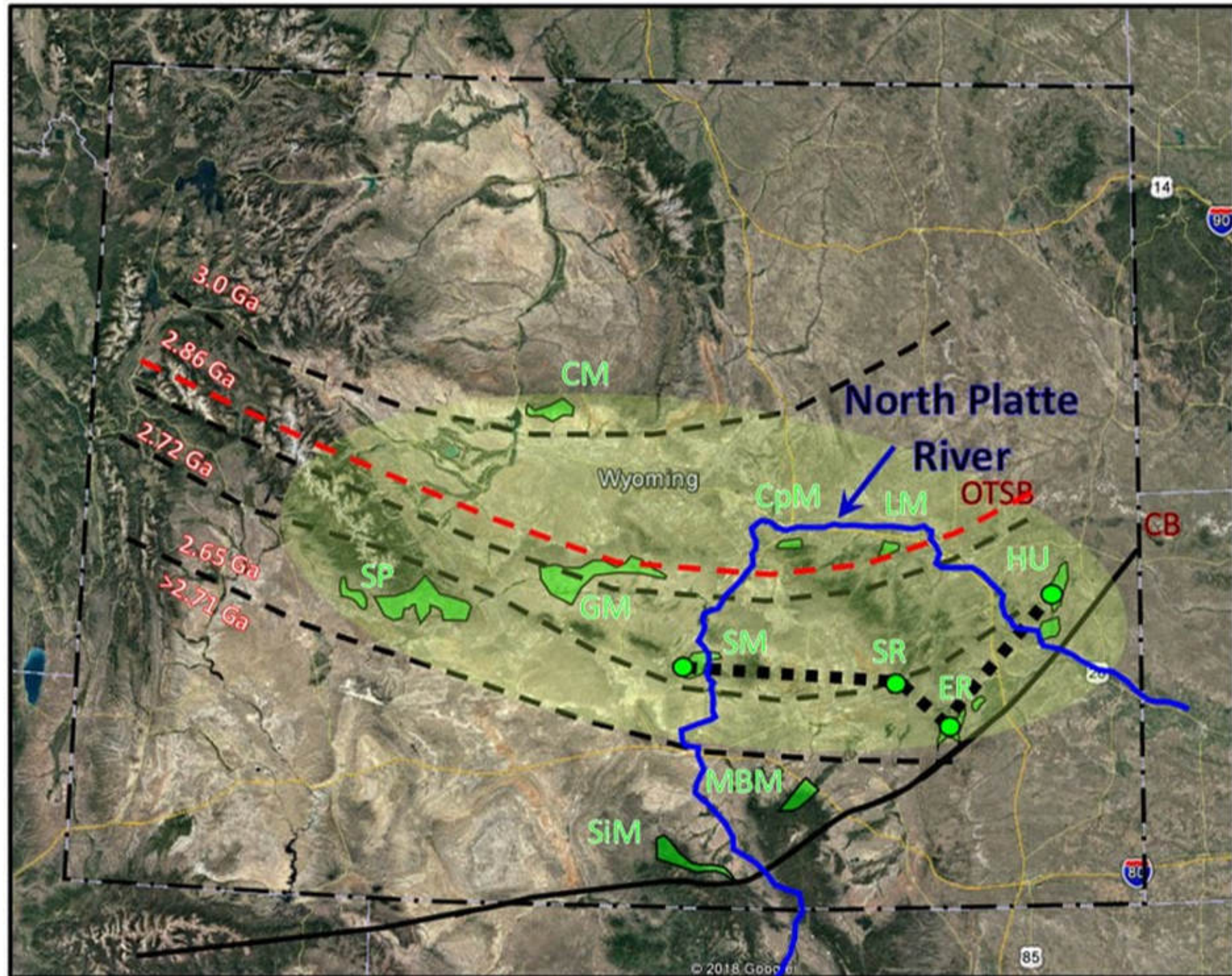
Southwest view of Guernsey Dam.

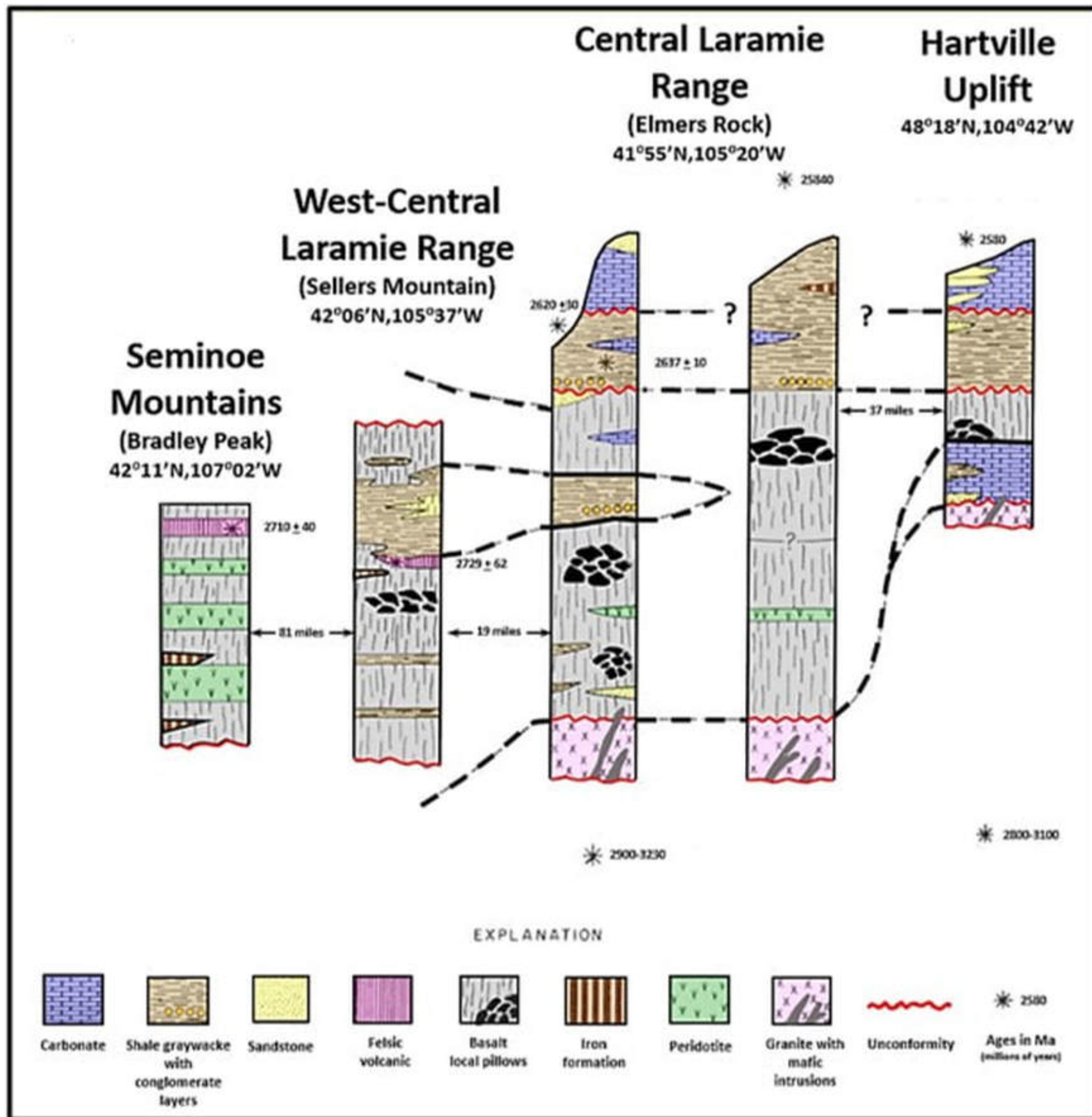
Image: U.S. Bureau

Era	Period	Formation	Thickness	Geologic Code	Lithology	Description
Mr	Triassic	Chugwater	150-435	Irc		
Paleozoic	Permian	Goose Egg	Gypsum and red shale	230-310	TrPge	Gypsum or anhydrite, snowy white, in thick and thin beds separated by red shale partings; sparse thin gray dolomite partings, some with pink chert
						Shale, brick red, soft, silty
						Limestone, purple to gray, fine-grained, hard, crinkled bedding
		Minnekahta Ls	20-40			Shale, red, soft, limy
						Limestone, purple to bluish in lower part, yellow to pink near top, fine-grained, thin bedded, silty near top; forms conspicuous slabby ledges; sparse chert and chalcedony
						Shale, brick red in lower part; conspicuous purple limy shale with thin shaly limestone partings near top; thin soft silty shaly sandstones in lower part; geodes and nodules of purple and gray chert
	Pennsylvanian	Hartville	Opeche Sh	25-75		Sandstone, light gray, weathering tan and yellow, medium-grained, nodular, limy, crossbedded, soft, porous, contains rounded grains
			Division I	900-1225	PPh1	Dolomite, lavender, fine-grained; some purple chert
						Sandstone, light gray, yellow, medium-grained, soft and porous, crossbedded in part, very limy, with rounded frosted grains
						Sandy limestone or limy sandstone, dull red, coarsely bedded in lower part, more regularly bedded in upper part; top 10 feet massive sandy light-purple limestone with red and gray chert; irregular masses of dark-red fine-grained quartzite near middle
						Limestone, bright red, silty, sandy, shaly, soft; forms conspicuous red zone; appears brecciated in lower and middle parts
			Division II	PPh2		Limestone and sandstone breccia; limestone is purplish-red; sandstone is red; a jumble of locally derived material, probably the result of collapse following leaching out of gypsum and possibly salt; no evidence of rounding or transportation of rock fragments
						Dolomite, light gray to pink, fine-grained, earthy, bedded; some limestone layers; contains gastropods, pelecypods, and brachiopods of late Pennsylvanian or early Permian
						Sandstone, red, dolomitic, cross-bedded, medium-grained, soft, porous
						Dolomite, gray, interbedded with pink crinoidal limestone, contains fusulines
			Division III	PPh3		Chert, gray, thin-bedded, an excellent horizon-marker over a wide area
						Limestone and dolomite, light gray, poorly bedded
						Sandstone, gray, limy, grades to a sandy limestone in some places; excellent widespread horizon-marker; contains Virgil (?) fusulines
						Dolomite, red, limy, soft, underlain by gray massive limestone; contains Virgil (?) fusulines
Mississippian			Division IV and V	PPh4,5		Dolomite, gray, massive, cavernous; contains local lenses of sandstone
						Sandstone, gray, medium-grained, soft, cross-bedded; commonly forms reentrants
						Dolomite, gray, massive, chalky; weathers soft; Missouri fusulines just below middle
						Limestone, gray and in lower part commonly dolomitic; black and petroliferous near top, massive, widespread; excellent horizon-marker; contains abundant Missouri fusulines
			Division VI	RMh6		Sandstone, gray, medium-grained, widespread; excellent horizon-marker
						Limestone, gray, massive; lower half forms prominent ledges; red to brown chert fusulines just below middle concretions concentrated along bedding planes near middle. Des Moines fusulines 4 feet below top
						Limestone and siltstone; limestone is gray, massive, with lenticular beds of dolomite and sandstone, contains red chert concretions as much as 10 inches in diameter 50 feet above base in northeastern part of area; siltstone is purple to gray, thin-bedded to laminated; sequence contains numerous zones with early Des Moines fusulines
						Dolomite, purple to white, brittle, blocky; lavender shale parting near middle; poorly preserved, fusulines present
			Guernsey	Mg		Sandstone, quartzite, and siltstone, light gray, with some pink mottling, dolomitic; tan quartzite forming widespread horizon-marker near middle
						Variable sequence consisting of shale, green, pink, and red, interbedded with white to gray limestone and dolomite and red and green claystone and siltstone; soft and poorly exposed; contains several zones of Atoka or early Des Moines fusulines
						Limestone, gray to pink, massive in lower part, thin-bedded in upper part, hard, forms ledges; Atoka fusulines directly below middle, and near top
						Limestone, pink to gray, coarse-grained, crumbly; looks like breadcrumbs on weathered surface; contains the fusulines <i>Millerella</i> , conodonts, bryozoans, corals, brachiopods, trilobites, pelecypods, crinoid fragments, and enhioid fragments; some species resemble those of Mississippian age and others Pennsylvanian

Stratigraphic column for the North Platte canyon in the Guernsey Dam location. The dam foundation lies on Division IV and V of the Pennsylvanian Hartville Formation.

Image: After Denson, N.M., and Botinelly, T., 1949, Geology of the Hartville uplift, eastern Wyoming: U.S. Geological Survey Oil and Gas Investigations Map OM-102, https://ngmdb.usgs.gov/Prodesc/proddesc_5247.htm (https://ngmdb.usgs.gov/Prodesc/proddesc_5247.htm).

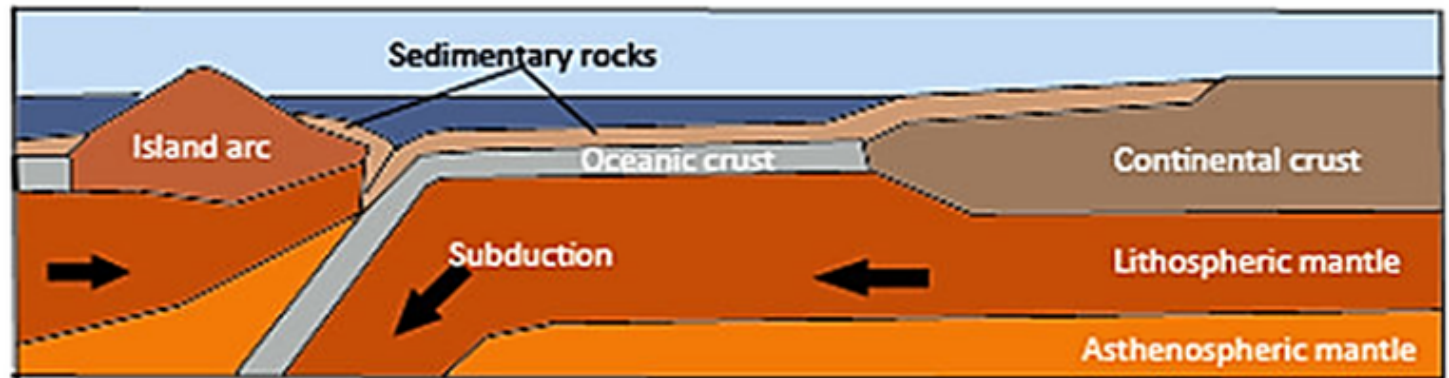




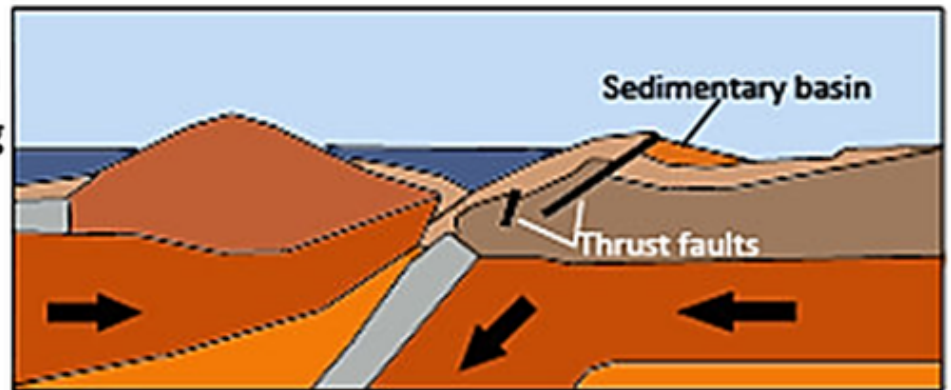
Central Wyoming Greenstone Belt (shaded light green) are aligned with Archean suture zones. West to east correlation of Archean greenstone complexes in south-central Wyoming. Location of cross section shown on Wyoming greenstone terrane image by dotted black line. Abbreviations: CM: Copper Mountain, CpM: Casper Mountain, ER: Elmers Rock, GM: Granite Mountains, HU: Hartville Uplift, LM: Laramie Mountains, MBM: Medicine Bow Mountains, SiM: Sierra Madre, SM: Seminoe Mountains, SP: South Pass, SR: Sellers Rock. Red dashed lines show Archean basin boundaries (suture zones) with age in billions of years (Ga) labeled. The Cheyenne Belt (CB) suture zone with the Colorado Province shown by solid red line.

Image: After Houston, R.S., Erslev, E. A., Frost, C. D., Karlstrom, K. E., Page, N.J., Zientek, M.

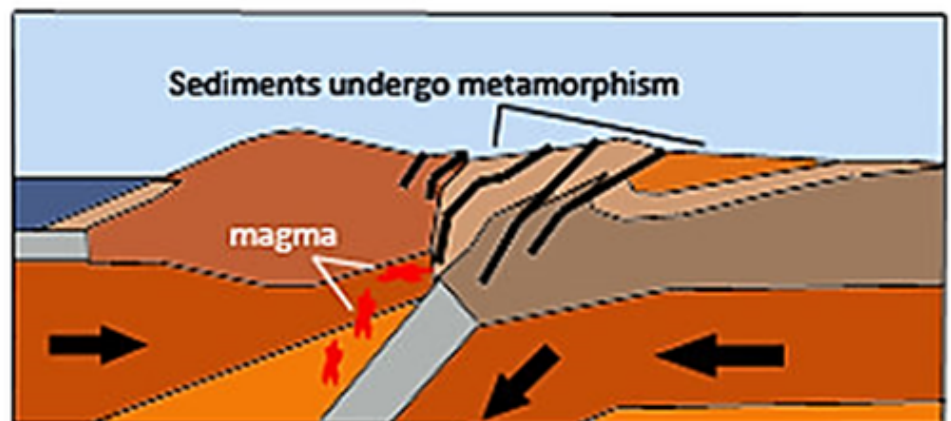
L., Reed, J. C., Jr., Snyder, G. L., Worl, R. G., Bryant, B., Reynolds, M. W., and Peterman, Z. E., 1993, The Wyoming province, in Reed, J. C., Jr., Bickford, M.E., Houston, R.S., Link, P.K., Rankin, D.W., Sims, P.K., and Van Schmus, Precambrian: Conterminous U.S: Boulder, Colorado, Geological Society of America, The Geology of North America, v. C-2, Fig. 13, p. 146.



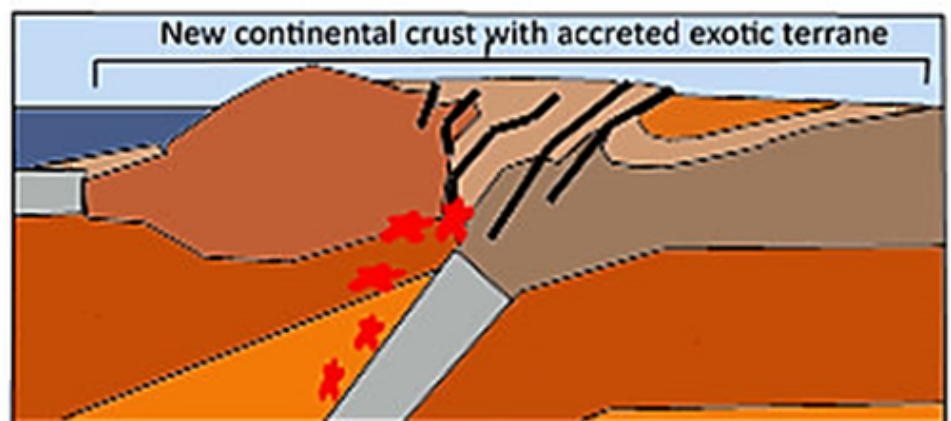
As subduction progresses, the island arc and continental crust resist being subducted and are pulled together, pinching sediments between them. Thrust faults develop.



The oceanic crust subducts and island arc collides with the continental crust causing sediments to be metamorphosed and deformed. Subducted oceanic crust melts in the mantle and plutons rise along subducted pathway.



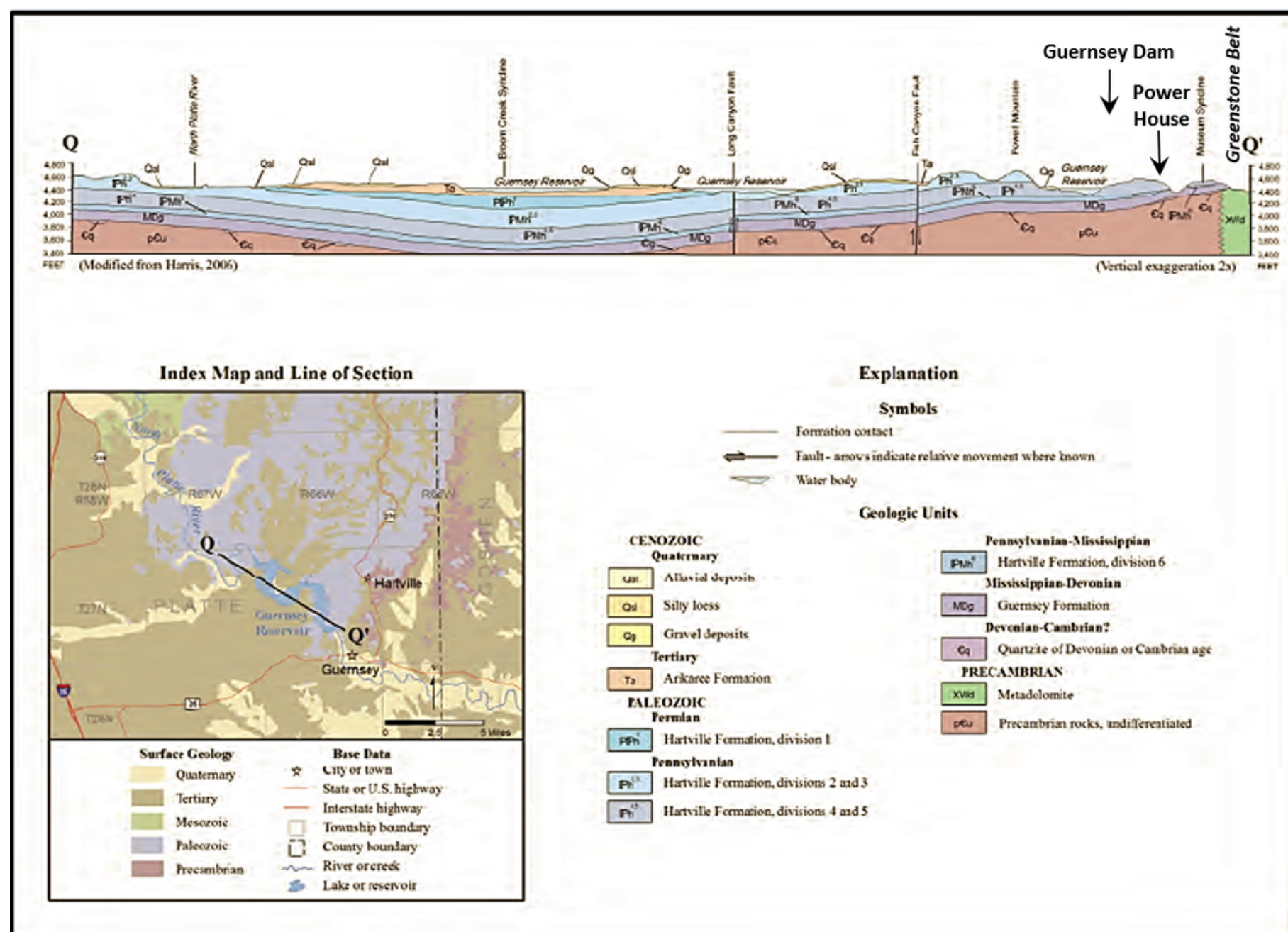
The island arc becomes sutured to the continental crust. Rising plutons become emplaced in the lower crust and drive additional metamorphism of sediments (greenstone belt). Subduction below the suture zone ceases.



Evolution of greenstone belts.

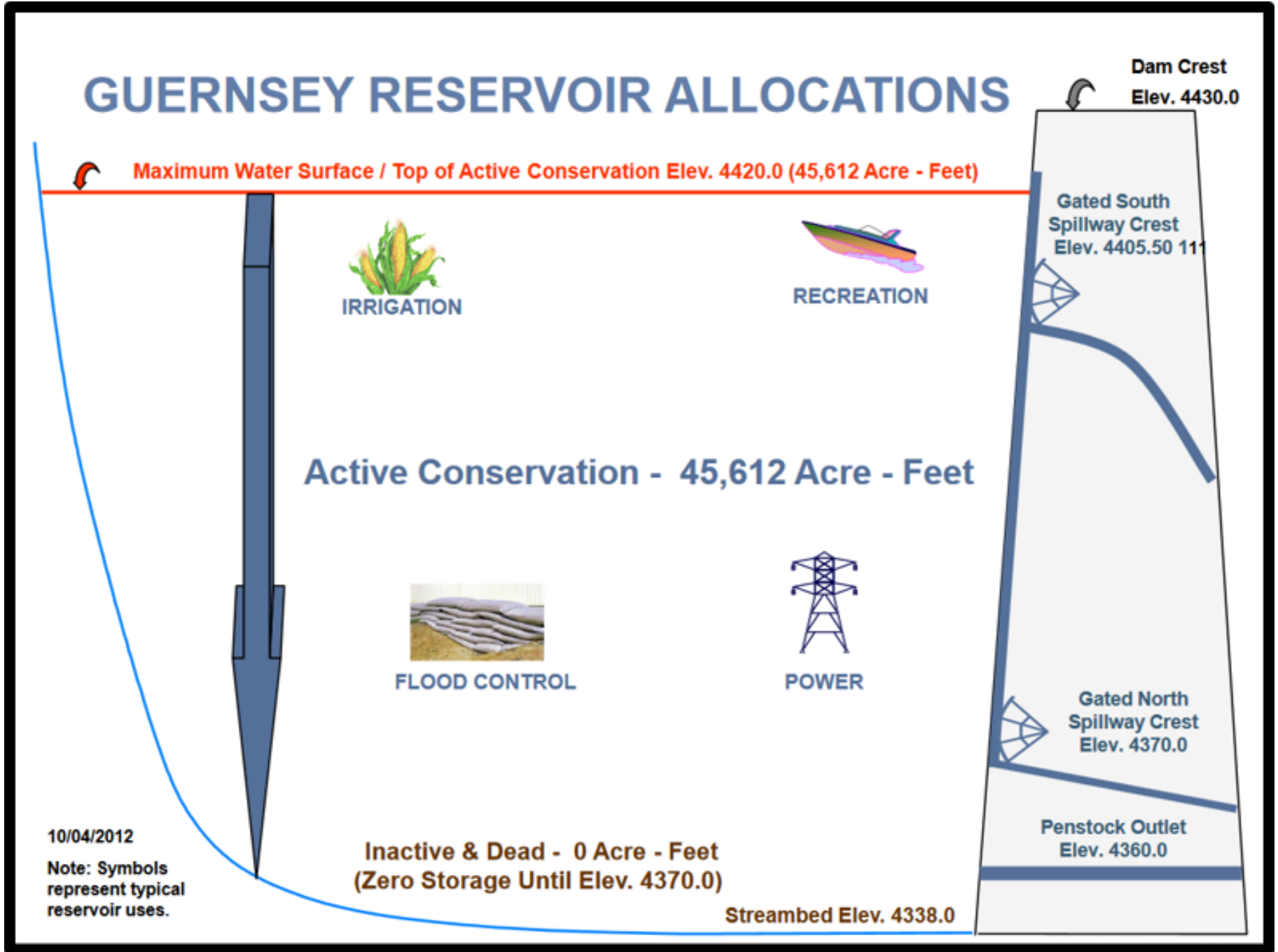
Image: Revolverly Image of Grouse Creek Block

accretion, <https://www.revolvey.com/main/index.php?s=Accretion+%28geology%29>



Guernsey Reservoir area geologic cross section. Precambrian rock of the Central Wyoming greenstone belt shown on the right-hand side of the section.

Image: Ver Ploeg, A., Taboga, K., and Taucher, P., 2013, Chapter 4, Geologic Setting: Groundwater Study Level I, Platte River Basin Water Plan, <http://waterplan.state.wy.us/plan/platte/2013/gw-finalrept/gw-ch04.html> (<http://waterplan.state.wy.us/plan/platte/2013/gw-finalrept/gw-ch04.html>).



Water allocations for Guernsey Reservoir.

Image: U.S. Bureau of Reclamation

The North Platte River Basin was where some of the first bits of continents rose above the primordial ocean. As plate tectonics continued, accretion of terrestrial blocks formed protocontinents. Ancient marine basin sediments and igneous rocks were crushed between accreting island arcs and continental masses. Repeated collisions generated Himalayan-scale mountain belts and basins in Wyoming during the Precambrian. The Pathfinder Uplift of the Ancestral Rockies rose in the area from Laramie to Casper when South America crashed into North America in the Paleozoic. After the Laramide elevation of the Rocky Mountains in the latest Mesozoic and early Cenozoic, erosion by water, wind and gravity soon filled the basins with sediment that lapped up and over the mountains. Only the highest peaks poked through the blanket of sediment. Then beginning about 17 million years ago the Rocky Mountain region began to rise. The rejuvenated streams carved down through the soft sedimentary layers into the crystalline basement rocks. The topography created by the streams provided the U. S. Bureau of Reclamation ideal locations for their water development projects.

The basin was also the home of Fort Laramie, the first Army Post in Wyoming. It was the path emigrants traveled over the Rocky Mountains on the road west. The Pony Express followed the same route. The southeastern part of the state is where Wyoming's stock industry began. The Union Pacific selected the gangplank for the path of the Transcontinental Railroad. The U.S. Bureau of Reclamation constructed seven dams along the river to promote the development of Wyoming. The North Platte River region has the most irrigated land in Wyoming. It also has the highest population density in the state, with the three largest cities: Cheyenne, Casper, and Laramie. All the human history took place on a part of the earth with well over three billion years of geologic history. And that is the end, and the beginning, of seven dam things along the North Platte.

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