Texas Master Naturalists – Habitat Restoration

Gibbons Creek Lignite Mine, Texas

(Jan K. Horbaczewski, November 13, 2021)

Why the Texas Municipal Power Agency (TMPA) and why a coal-fired power plant?

10/6/73 – Start of “Yom Kippur” war between Israel and Arab coalition.

10/19/73 – Support of Israel by the West leads to an oil embargo by Arab states – prices of oil and gas skyrocket.

11/7/73 – President Nixon gives address outlining measures to eliminate U.S. reliance on oil imports.

03/10/75 – Bryan, Denton, Garland, and Greenville) decide to pool resources and build their own power plant to manage cost of electricity for their ratepayers.

05/8/75 – Texas passes legislation to enable creation of Texas Municipal Power Agency (TMPA), a political subdivision of the state of Texas.

June 1975 – Texas passes the Surface Mining and Reclamation Act in preparation for mining of the state’s lignite reserves (federal Surface Mining Control and Reclamation Act not passed until 08/3/77).

10/14/75 – Bryan , Denton, Garland, and Greenville pass concurrent ordinances creating TMPA.

1976 – Railroad Commission of Texas issues Surface Coal Mining Permit No. 1 to ALCOA (Rockdale).

07/11/77 – TMPA starts building Gibbons Creek power plant next to a coal deposit.

11/9/78 – Federal “Powerplant and Industrial Fuel Use Act” signed by President Carter. Purpose to reduce imports of petroleum.

09/8/81 – TMPA receives Texas Surface Coal Mining Permit No. 6.

Powerplant and Industrial Fuel Use Act of 1978

natural gas or petroleum.

(b) STATEMENT OF PURPOSES.—The purpose of this Act, which shall be carried out in a manner consistent with applicable environmental requirements, are—

(1) to reduce the importation of petroleum and increase the Nation's capability to use indigenous energy resources of the United States to the extent such reduction and use further the goal of national energy self-sufficiency and otherwise are in the best interests of the United States;

(2) to conserve natural gas and petroleum for uses, other than electric utility or other industrial or commercial generation of steam or electricity, for which there are no feasible alternative fuels or raw material substitutes;

(3) to encourage and foster the greater use of coal and other alternate fuels, in lieu of natural gas and petroleum, as a primary energy source;

(4) to the extent permitted by this Act, to encourage the use of synthetic gas derived from coal or other alternate fuels;

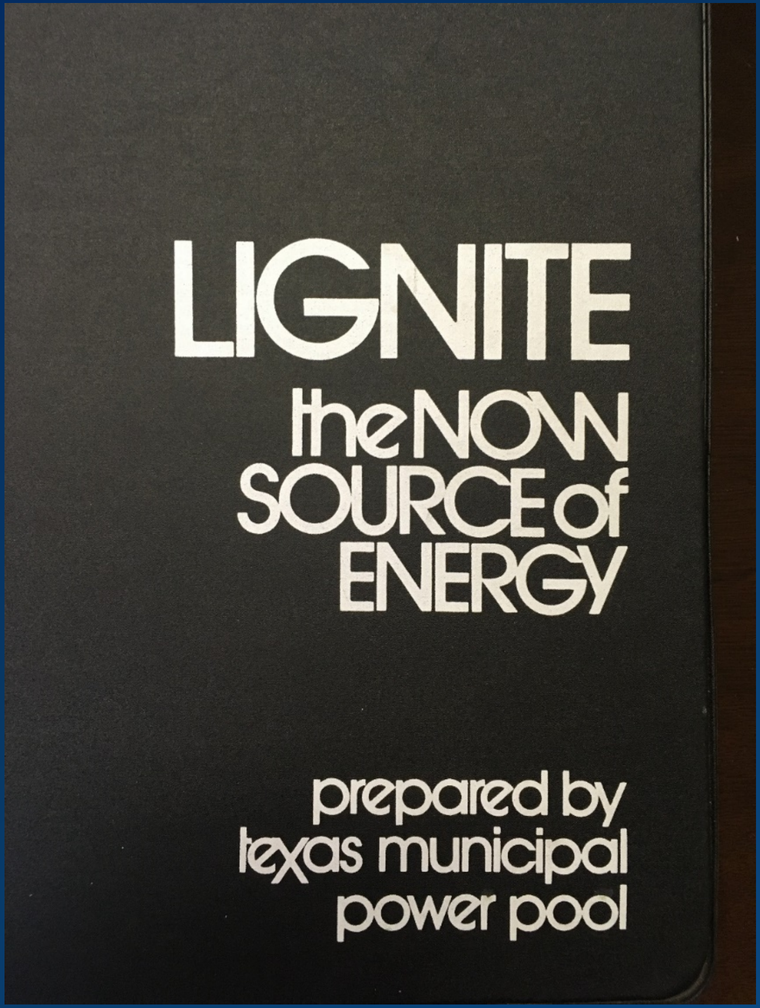
(5) to encourage the rehabilitation and upgrading of railroad service and equipment necessary to transport coal to regions or States which can use coal in greater quantities;

(6) to prohibit or, as appropriate, minimize the use of natural gas and petroleum as a primary energy source and to conserve such gas and petroleum for the benefit of present and future generations;

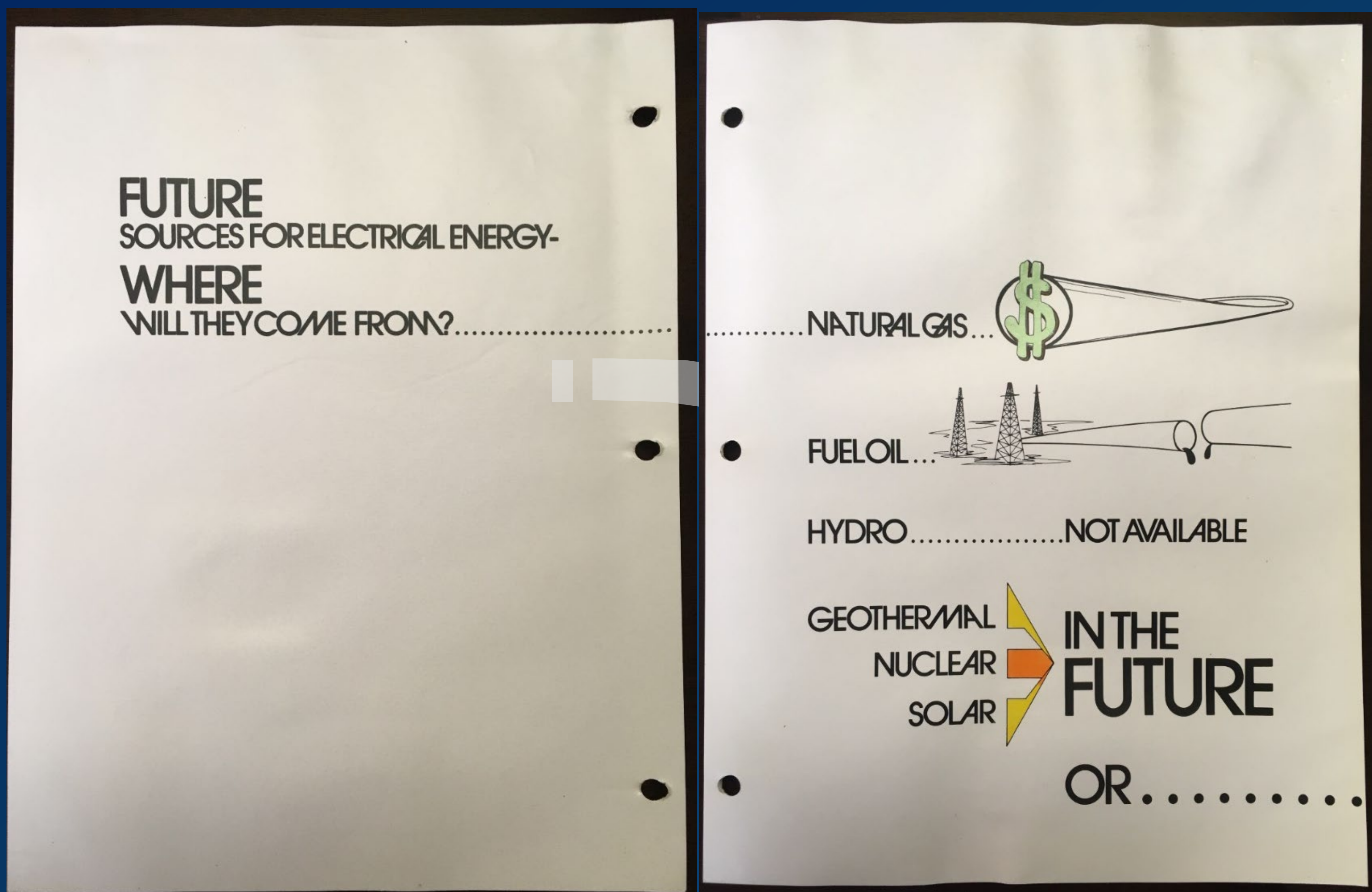
(7) to encourage the modernization or replacement of existing and new electric powerplants and major fuel-burning installations which utilize natural gas or petroleum as a primary energy source and which cannot utilize coal or other alternate fuels where to do so furthers the conservation of natural gas and petroleum;

(8) to require that existing and new electric powerplants and

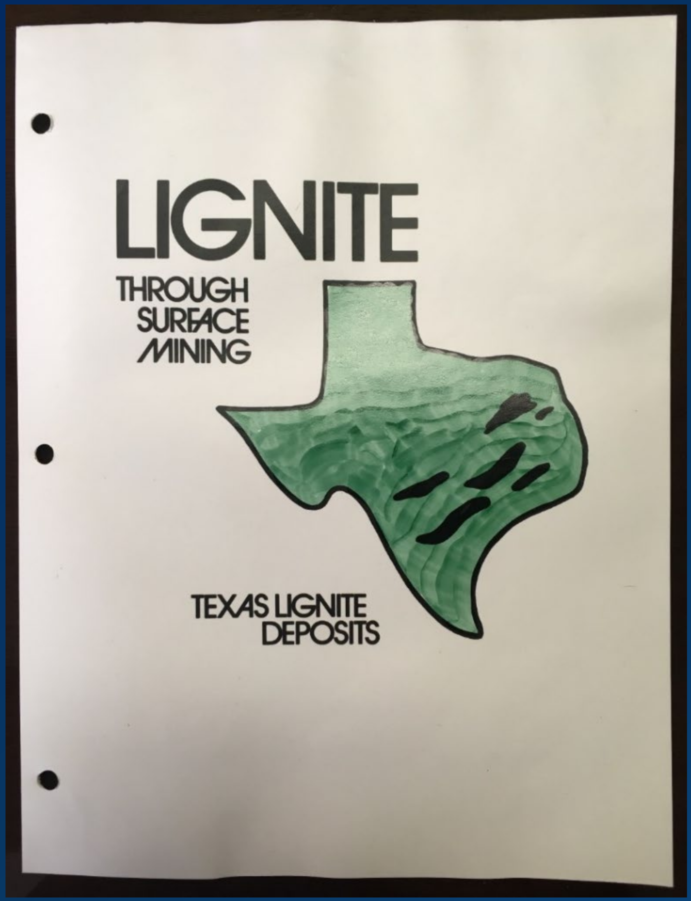
Texas Municipal Power Pool (undated, pre-1975)

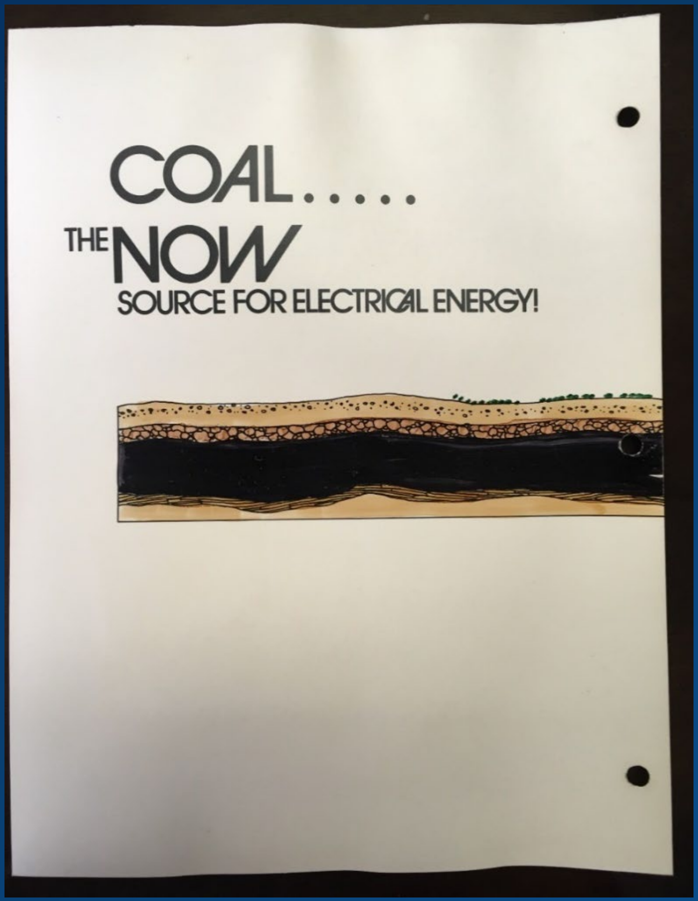


Texas Municipal Power Pool (undated, pre-1975)



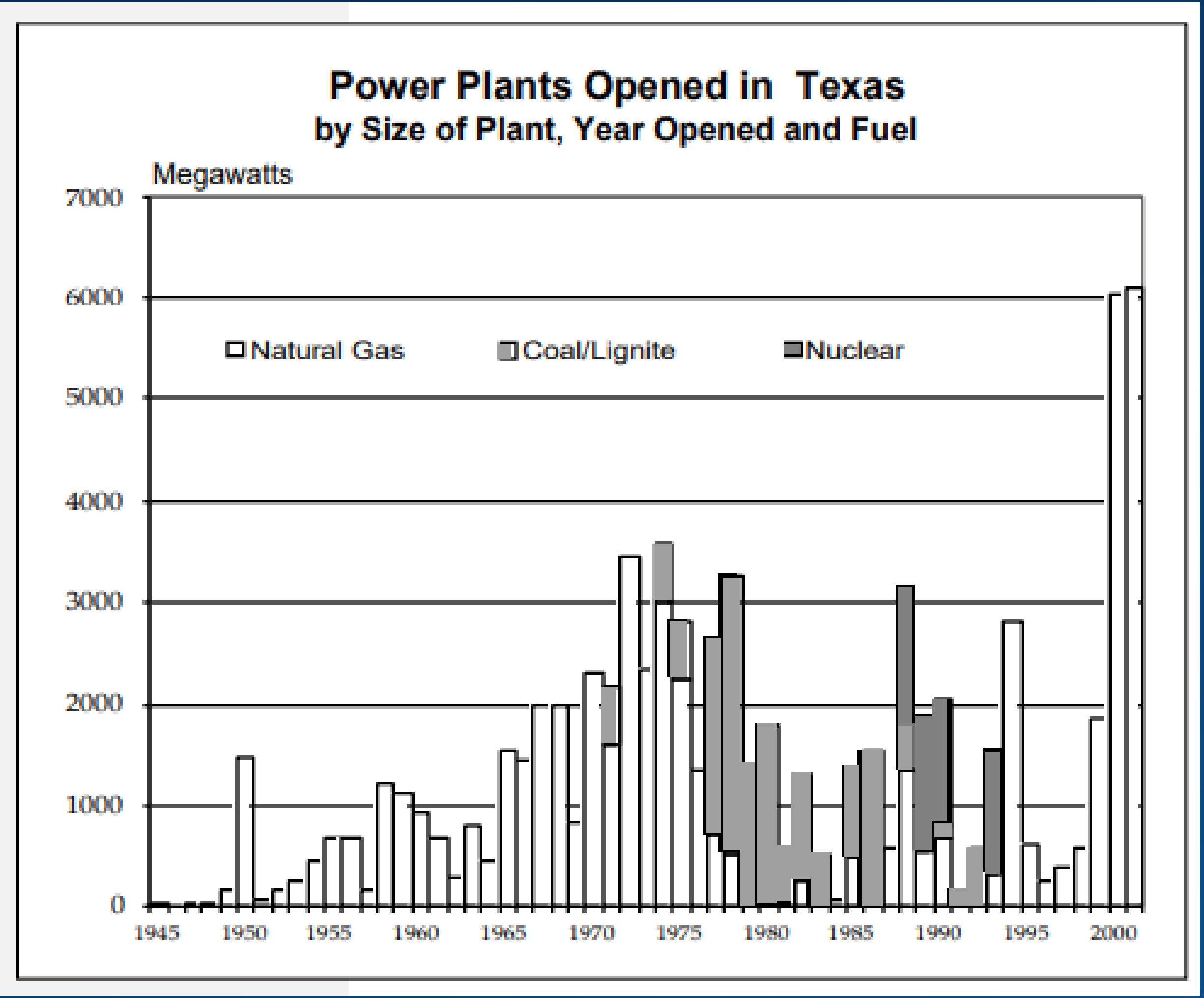
Texas Municipal Power Pool (undated, pre-1975)





Graph from Guide to Electric Power in Texas

(Houston Advanced Research Center and
Institute for Energy, Law & Enterprise, January 2003)



Ethics, Leopold’s Land Ethic, and the Mine Reclamation Ethic

- Ethics – interaction between and among humans.
- Land ethic (Aldo Leopold) – interaction between humans and their environment – habitat management.
- Mine reclamation ethic – planned creation and restoration of entire geosystem, including geology, hydrology, geomorphology, and ecology.

Aldo Leopold's Land Ethic and Habitat Management

Aldo Leopold's Land Ethic and Habitat Management

- Axe – to manage woody vegetation in grasslands and preserve species along riparian habitats and around wetlands.
- Cow – to manage long-term vegetation vs animal gains.
- Plow – to prevent establishment of woody vegetation and to promote perennial forbs and grasses.
- Fire – to manage grasses through controlled burning.
- Gun – to manage wildlife so that the carrying capacity of the habitat is not exceeded.

Aldo Leopold’s Land Ethic and Habitat Management

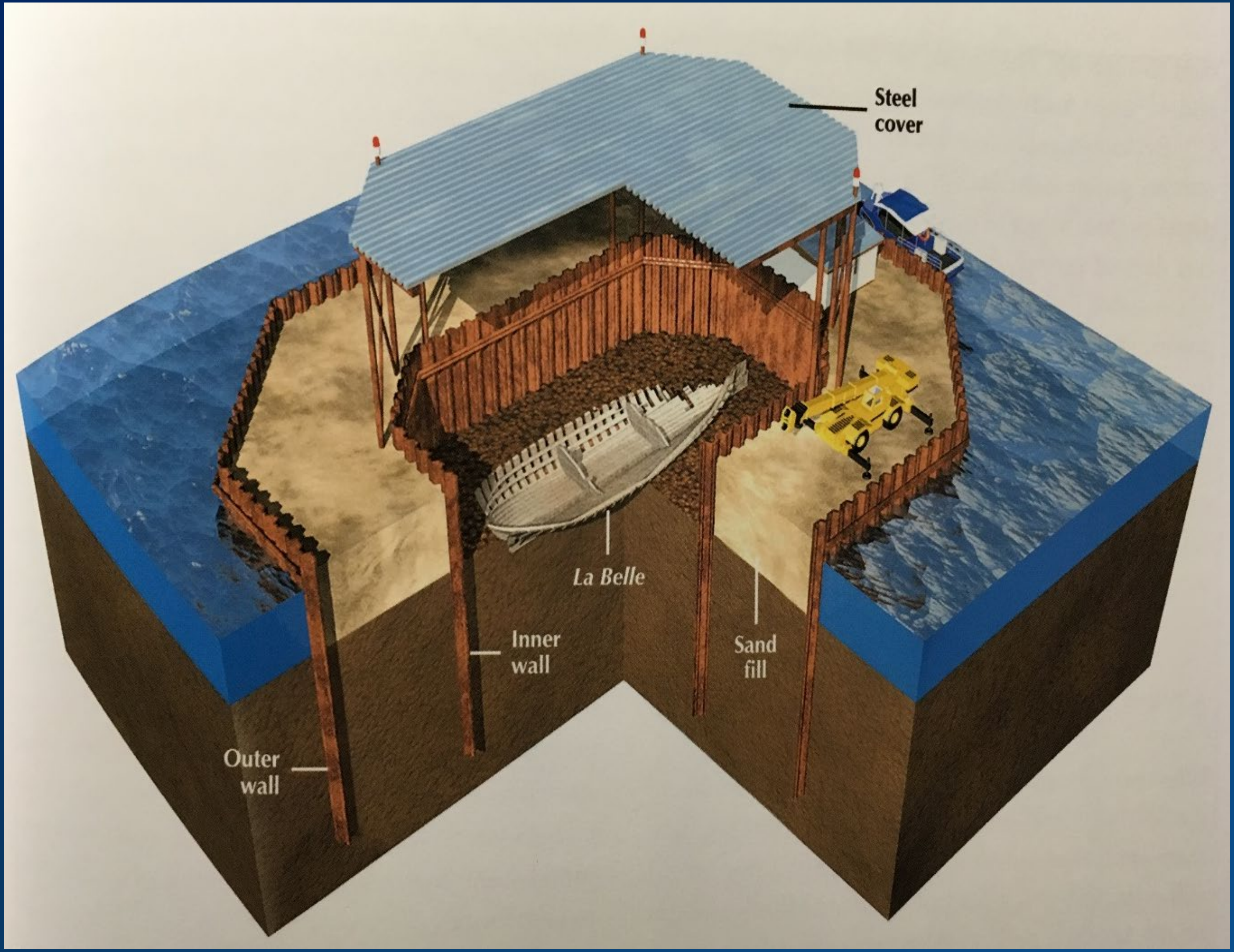
- Aldo Leopold recognized that there is no “ideal historical natural balance” to return to.
- How would we restore pre-settlement prairie habitat to Texas?
- Also, Nature (on Earth) is dynamic, not static – plate tectonics and our atmosphere ensure constant changes to habitats and environment and evolution of life.
- This results in natural erosion (disintegration) and weathering (decomposition) of rocks and the formations of soils.
- The alluvial soils of the Egyptian Nile delta are derived from Ethiopian highlands, the red alluvial soils of the Brazos River floodplain from the red Permo-Triassic formations of the Texas Panhandle.
- The Moon is static… and dead.

Brazos River floodplain soils (Ships clay) – derived from Permo-Triassic red beds in Texas Panhandle

History of changes in habitat of Grimes County and surrounding areas

- 6,500 B.C. – Paleo-Indian hunter-gatherers
- 1685 A.D. – Ill-fated French ship "La Belle" sinks in Matagorda Bay
- 1718 – Founding of San Antonio "Presidio"
- 1744 – Opening of the Misión San Antonio de Valero (the Alamo)
- 1750 – Opening of San Fernando Cathedral in San Antonio
- **1821 – "Old Three Hundred" settlers of Austin's Colony**
- 1833 – Henry Fanthorp arrives in Anderson
- 1836 – Texas Declaration of Independence
- 1836 – Fort Parker and kidnapping of Cynthia Ann Parker
- **1837 – Extermination of bison in east-central Texas**
- 1850 – Grimes County – cotton, corn, cattle, hogs, and sheep
- 1854 – Removal of last Native Indians from area
- 1856 – Construction of Peters Cabin, Grimes County (now in Boonville Cemetery)
- **1876 – Manufacture of barbed wire (Glidden & Ellwood, Illinois)**
- **1878 – Extermination of Southern Plains bison herd**
- 1890 – Two-thirds of cropland in Grimes Co. under cotton
- 1940 – Drastic decline in cotton cultivation in Grimes Co.

La Belle – sank in Matagorda Bay, 1685



Presidio, San Antonio – founded 1718

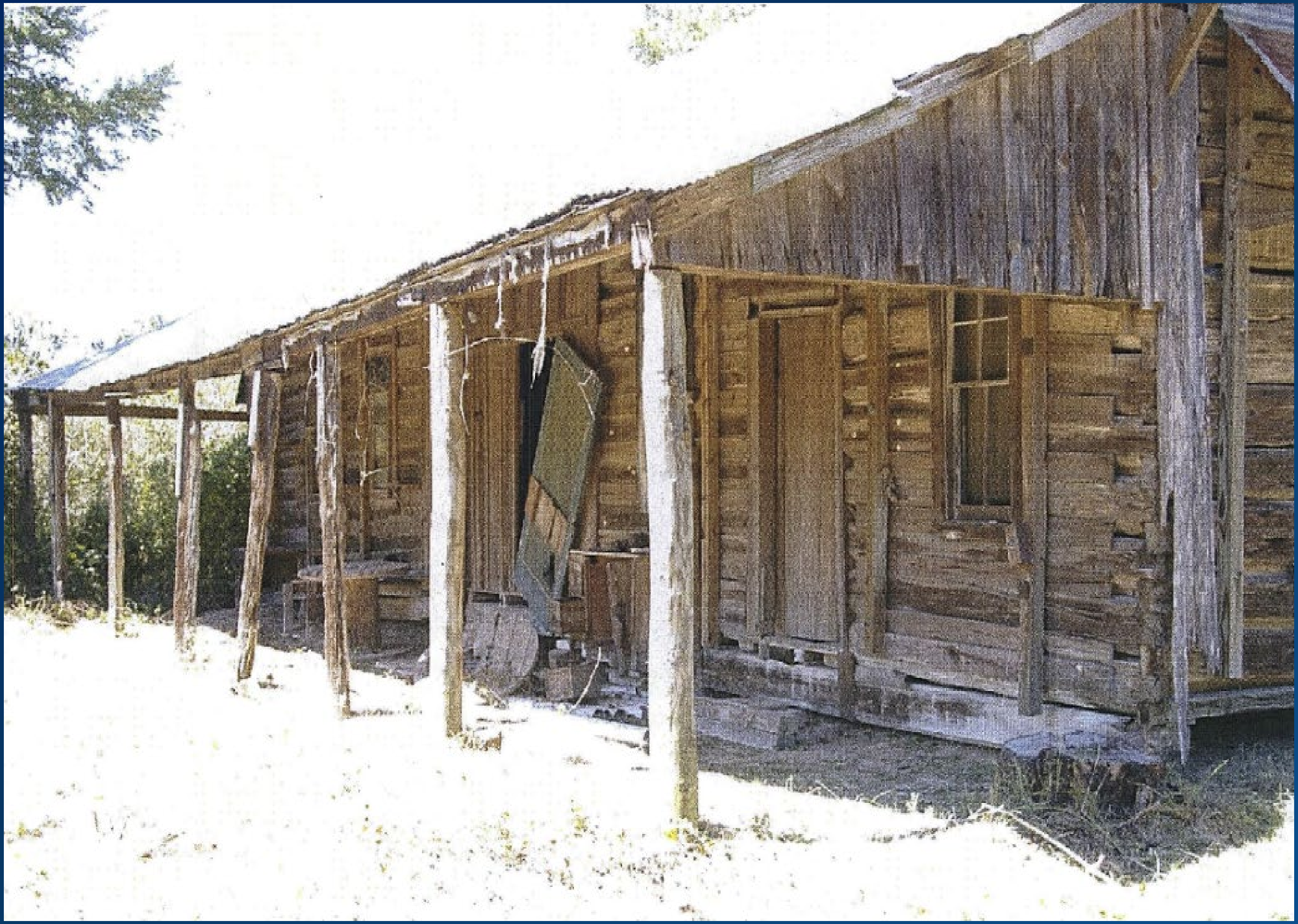
Misión San José y San Miguel de Aguayo, San Antonio, Texas (opened 1782)

Fanthorp Inn (1833), Anderson, Texas

Fort Parker (1836) (reconstruction), on Navasota River near Mexia, Texas

Peters Log Cabin (1856), Grimes County

(as of 2012 – stabilized but unrestored)



Peters Log Cabin (1856)
(as of 2016 – restored at Boonville Heritage Park)

Experiments in habitat restoration
Caprock Canyons State Park, nr. Lubbock

- 700 acres (to be extended to 15,000 acres).
- Prairie grasses – Sideoats grama, Indiangrass, Buffalo grass, Johnson grass, Big bluestem, Hairy grama, Switchgrass, Hairy tridens.
- Home of Texas State Bison Herd (80 head).
- Genetic remnants of original Southern Plains herd (30 million head).
- Southern Plains herd almost completely exterminated over period 1871-1874.
- This was part of federal government policy to disrupt Native Indian way of life.
- Final battles of the Red River War against the Plains Indians were in the area of Caprock Canyons and Palo Duro Canyon (August-November 1874).

Native prairie restoration – Caprock Canyons State Park, near Lubbock, Texas

Caprock Canyons State Park, Texas,
view southeast from Upper Canyon Trail

Caprock Canyons State Park – Texas State Bison Herd – descendants of original Southern Plains bison

Pre-mining habitat of Gibbons Creek Lignite Mine – Post Oak – Blackjack Oak Savanna

- Native soils – claypan soils (alfisols).
- Typically – a few inches of sandy loam topsoil over a dense clay subsoil.
- Vegetation (by weight) – 75% grasses, 20% woody, 5% forbs.
- Climax grasses – Little bluestem, Indiangrass, Brownseed paspalum.
- Other grasses – Switchgrass, Florida paspalum, Purpletop, low Panicums, low Paspalums, Silver bluestem.
- Woody species – Post oak, Blackjack oak, elm, yaupon, hawthorns, and American beautyberry.
- Overgrazing – decreases Little bluestem, Indiangrass, and Switchgrass.

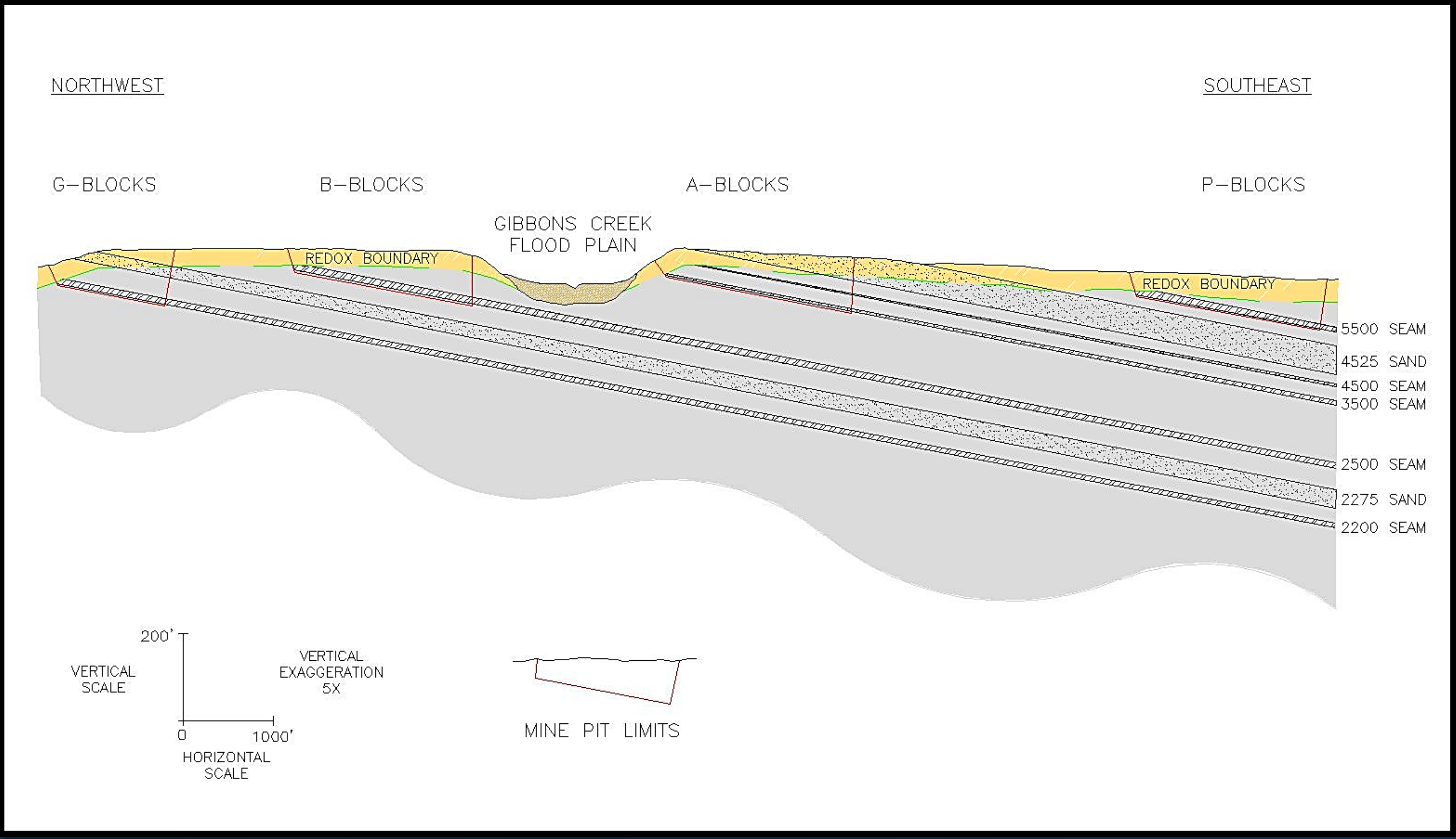
Components of mine reclamation plan and habitat restoration

- Geochemical systems – avoidance of acid-forming sulfide materials.
- Groundwater systems – restoration of water-table.
- Geomorphological systems – re-grading of land with suitable slopes.
- Surface water systems – creation of drainages, ponds, and wetlands.
- Soil systems – construction of new soils to a depth of four feet.
- Vegetation cover – planting of selected permanent species.
- Post-Mining land use – ensuring use for intended purposes.
- Wildlife habitat – creation of suitable habitat for wildlife.

Geochemical systems

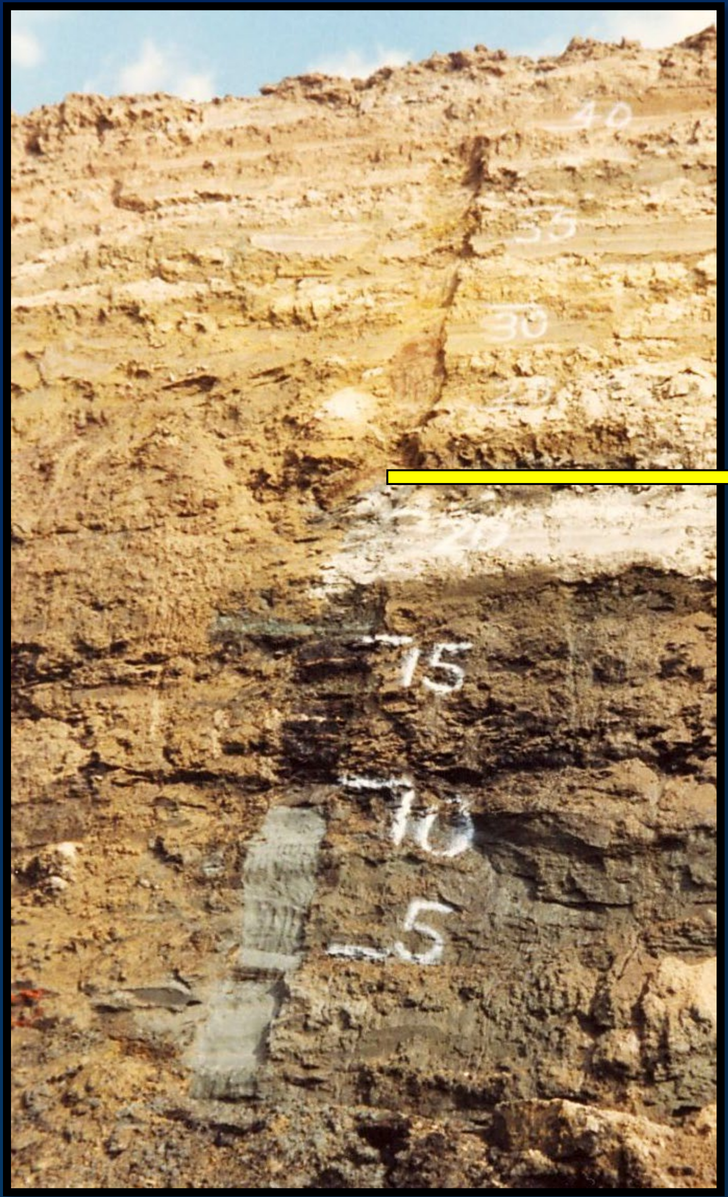
- Avoidance of placement of potential acid-forming materials near the reclaimed surface.
- Significance of sulfide minerals such as pyrite (FeS_2) and potential formation of sulfuric acid (H_2SO_4),
- Importance of "Redox" boundary – separates oxidized geological strata near the surface from reduced strata below the boundary.
- Formation of yellow mineral jarosite (hydrated potassium iron sulfate) diagnostic of acid conditions **(Note: also found on planet Mars).**
- In presence of limestone (calcium carbonate), formation of chemically neutral gypsum (calcium sulfate).
- Acid seeps and their mitigation.

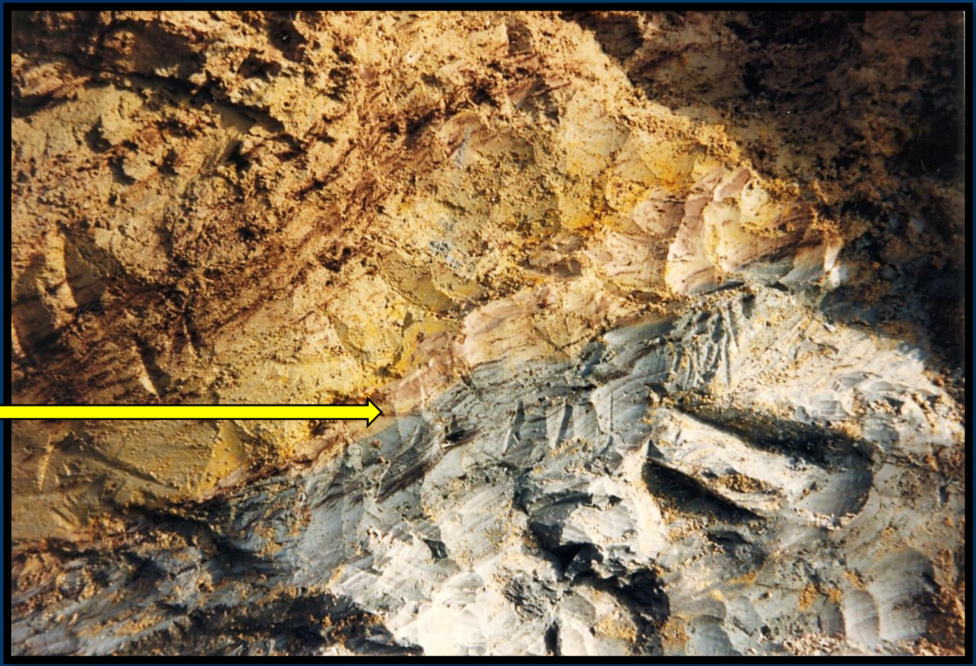
Diagrammatic geological section showing Redox Boundary



Redox Boundary – A3 Mine Block

Redox Boundary in pit highwall – B2 Mine Block





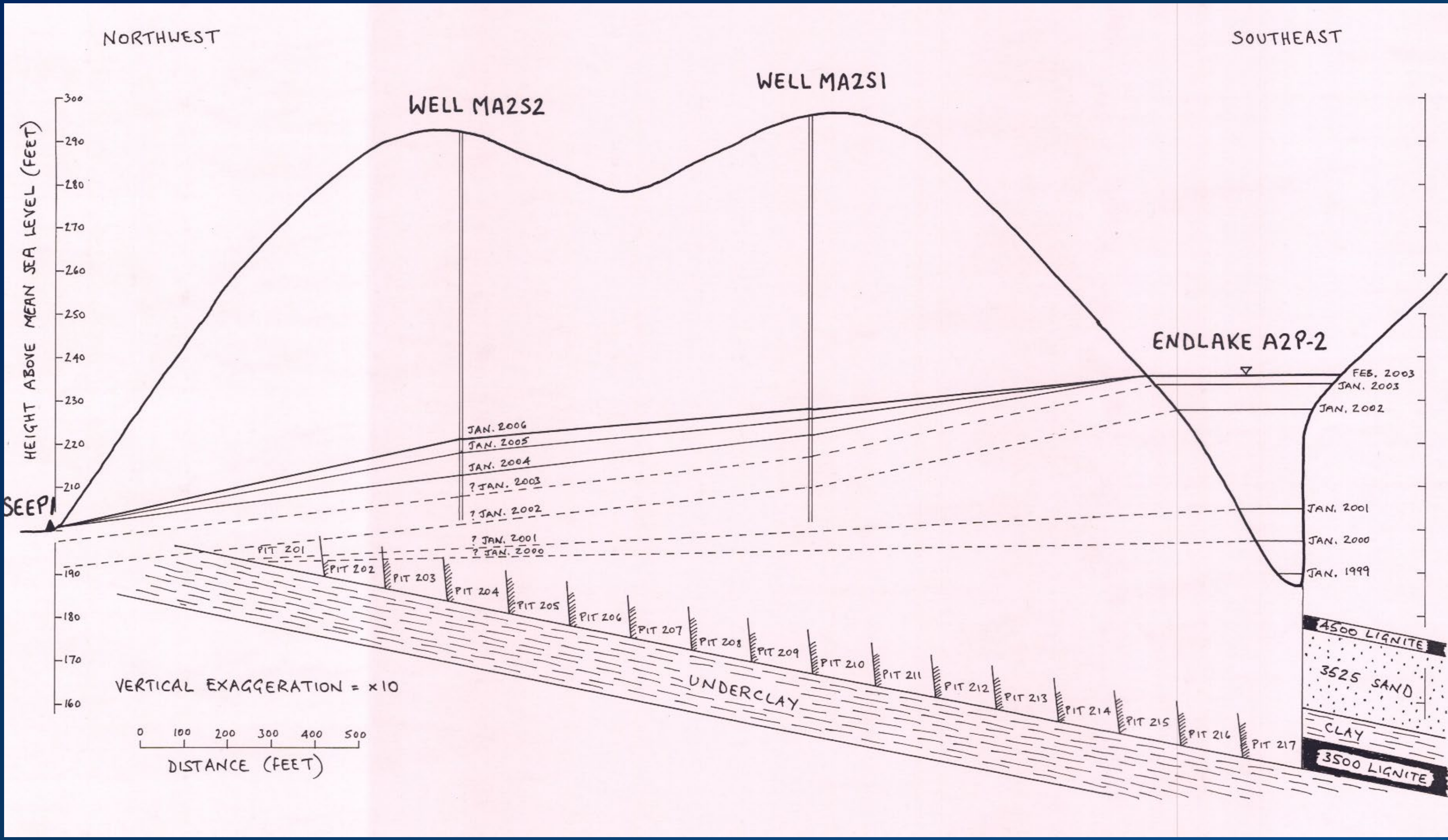
Redox in recent construction borrow pit near mine

Groundwater systems

- Rainfall readily penetrates loose, permeable spoils left by the dragline.
- Ridge-and-valley topography of spoil reduces rainwater runoff.
- Rainwater penetrates through coarser material on spoil slopes.
- Some runoff drains to the mine end pit creating an end-pit lake.
- Water-table forms in spoil in equilibrium with end-pit water level.
- Water-table stabilizes in as little as 3 years after the water level in the end-pit lake stabilizes.
- In A2 Mine Block – started mining coal in 1992, end lakes filled with water by 2003, and water table stabilized by 2006 = 14 years.

Process of mining
(B1 Mine Block, ca. 1984)

Development of water table in A2 Block (1999-2006)



Gibbons Creek Mine – Acid Seep 9A

Geomorphological systems

- First step in leveling of mine spoil is to create a geomorphological surface consistent with the intended post-mining land use (e.g., pasture).
- Slopes are shaped to minimize soil erosion.

Permit 26D – pre- and post-mining slopes

Slope classes	Pre-Mining	Post-Mining
0-2%	42%	53%
2-5%	29%	31%
5-10%	25%	11%
10-15%	3%	3%
>15%	1%	2% (pond embankments)
Total	100%	100%

Surface water systems

- Surface water systems are designed by engineers to handle specified ("design") storm events without erosion or failure.

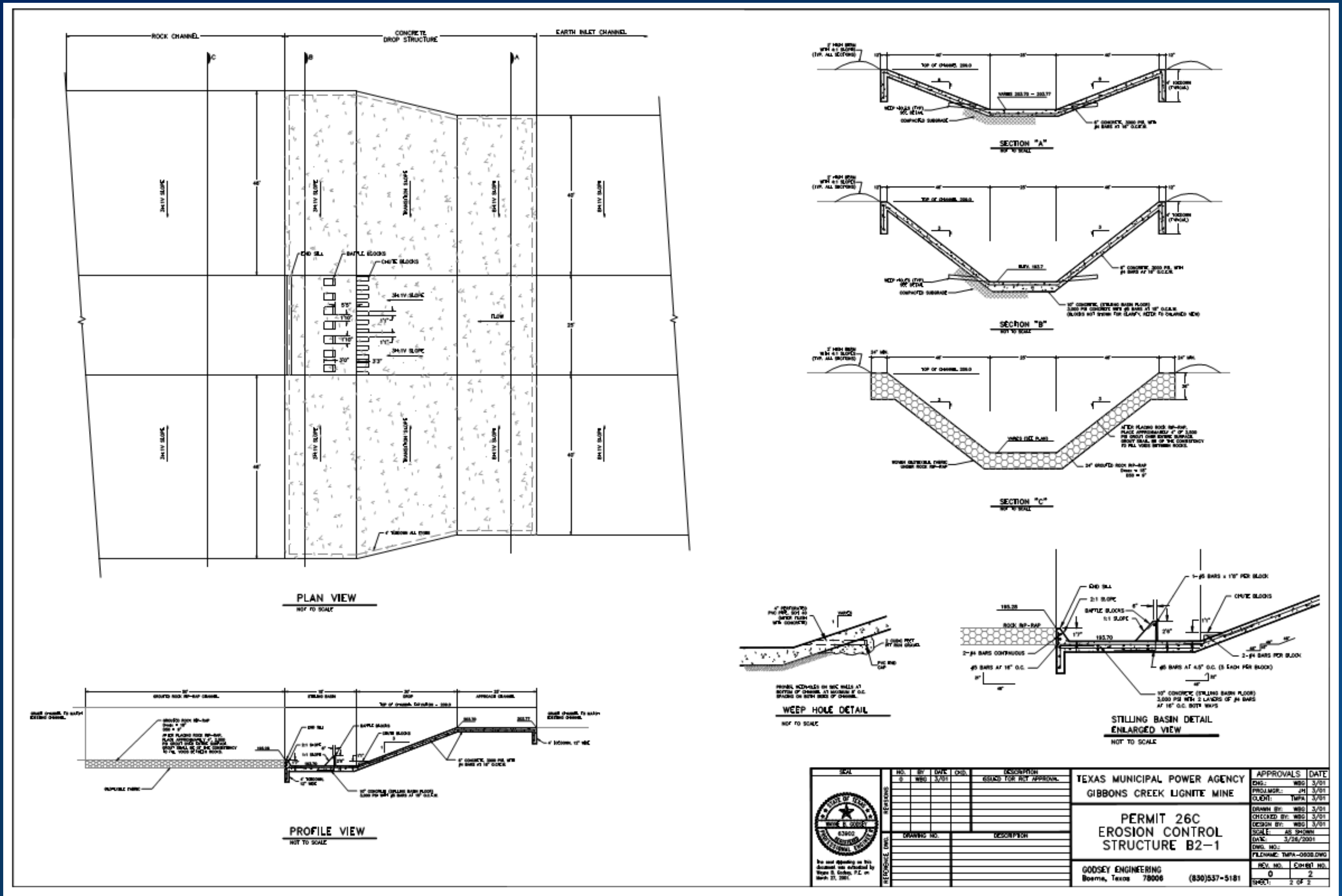
Type of structure	Design storm event	Inches of rainfall
Perennial and intermittent streams	100-yr, 6-hr	8.0 in. in 6 hrs.
Ephemeral streams	10-yr, 6-hr	5.4 in. in 6 hrs.
Pond > 20 acre-feet	100-yr, 6-hr	8.0 in. in 6 hrs.
Pond <20 acre-feet	25-yr, 6-hr	6.4 in. in 6 hrs.
Erosion Control Structure B2-1	¼ Potential Maximum Flood	8.0 in. in 6 hrs.

Erosion Control Structure B2-1

(vertical drop of 10 feet)

Design for Erosion Control Structure B2-1

(Godsey Engineering, 2001)



Pond 10A – main embankment

Construction of End-Pit Lake A3P-1

End-Pit Lake A3P-1 looking northeast

End-Pit Lake A3P-1 looking east

End-Pit Lake A3P-1 looking east

End-Pit Lake A3P-1 looking southwest

(Drone photo, Murphy Hawkins)

End-Pit Lake B2P-3

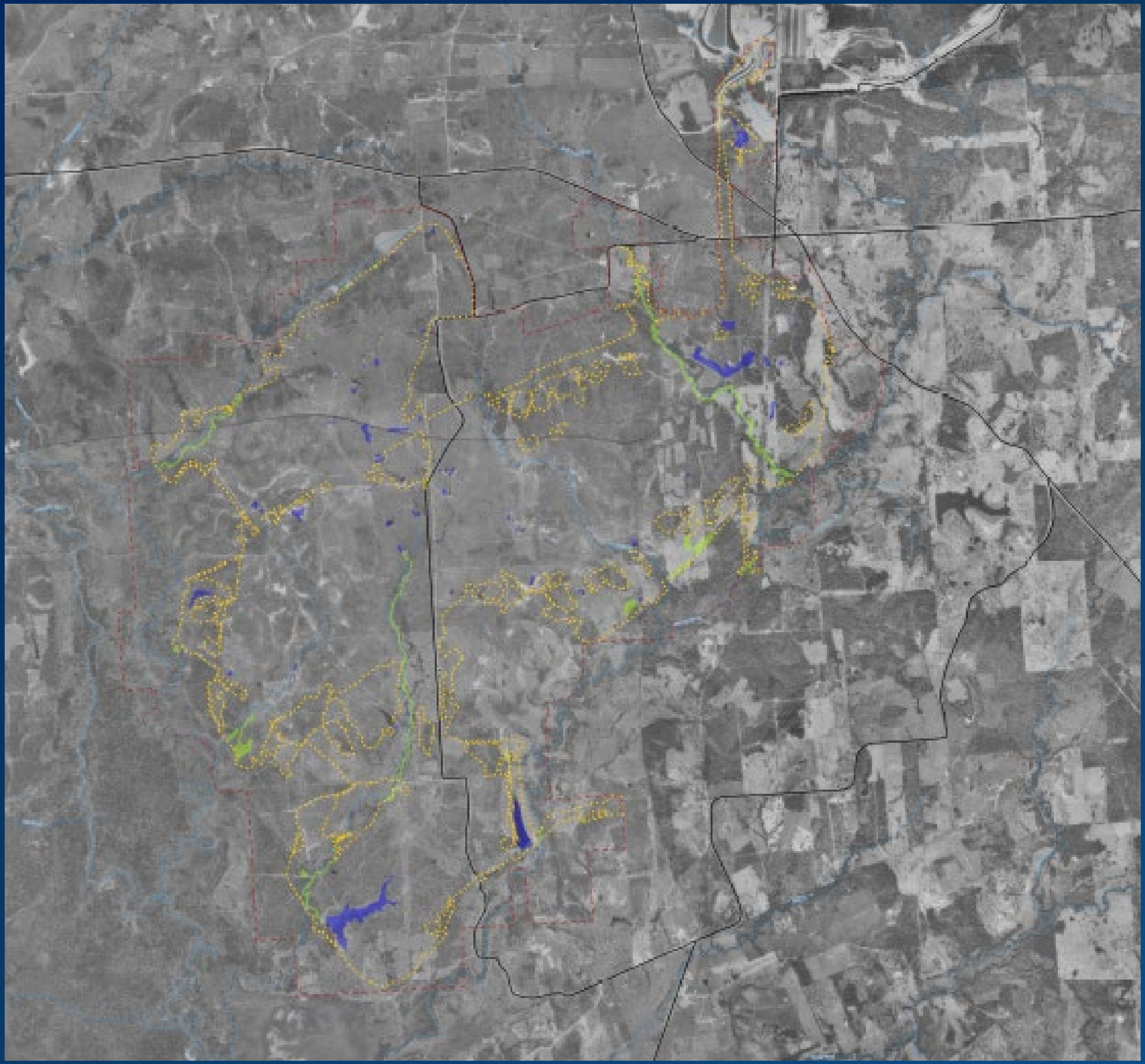
(constructed ca. 1990)

Creation of wildlife habitat – wetlands and riparian corridors / shorelines

- Key part of reclamation plan is creation of fish and wildlife habitat.
- Main regulatory authority is U.S. Army Corps of Engineers.
- The Corps defines "aquatic" habitat as areas of open water greater than 6 feet deep.

Feature	Pre-Mining	Post-Mining	Mitigation ratio
Permit 26D			
Aquatic	98.8 acres	382.3 acres	+3.9
Riparian	97.9 acres	982.8 acres	+10.0
Permit 38D			
Aquatic	80.9 acres	154.8 acres	+1.9
Riparian	88.4 acres	232.4 acres	+2.6

Pre-Mining wetlands – Permit 26D



Post-Mining wetlands – Permit 26D

Wetland in B2 Mine Block
(constructed ca. 1990)

Wetland in B2 Mine Block
(constructed ca. 1990)

Wetland in B1 Mine Block

(constructed ca. 1990)

Blue Waterleaf (*Hydrolea ovata*) – obligate hydrophyte

07/11/18

Pond SP-50 South Islands

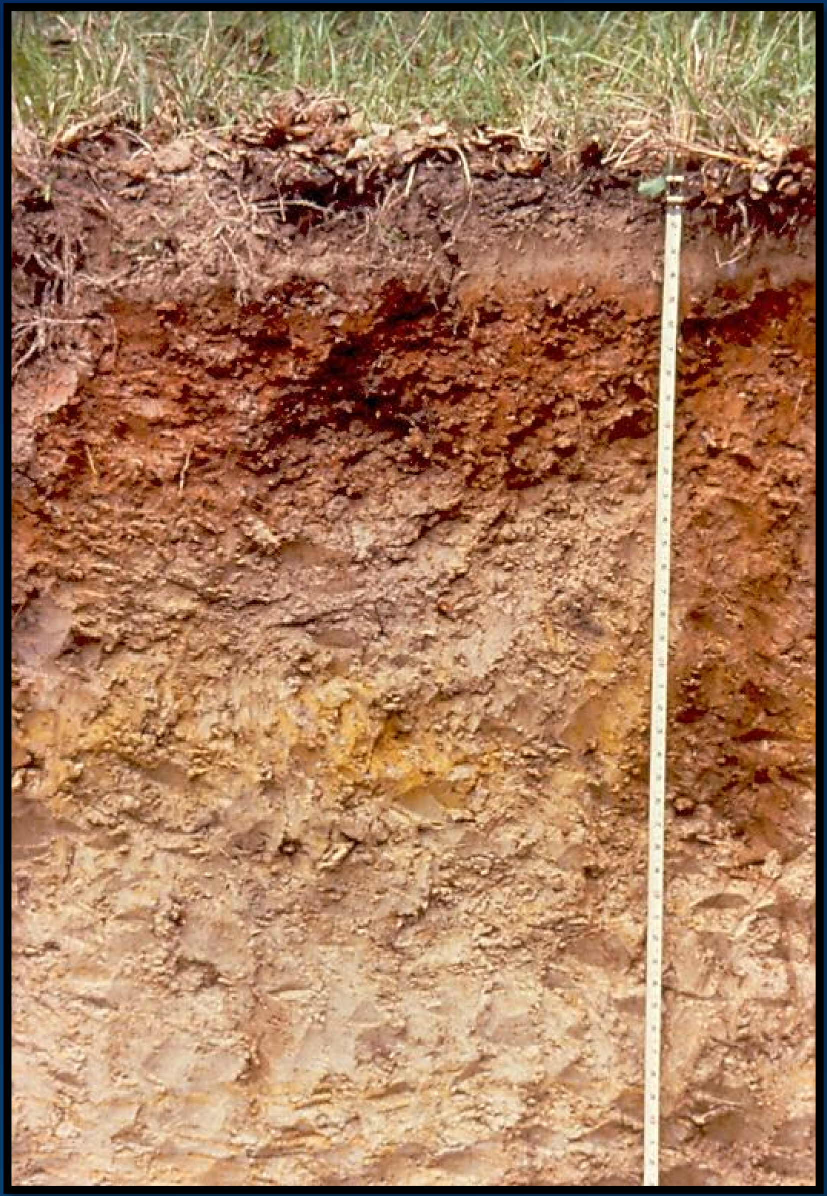
(Islands created 2017; photo taken 06/16/20)

Maryland Meadowbeauty (*Rhexia mariana*) – obligate hydrophyte

Pre-Mining (Native) Soils

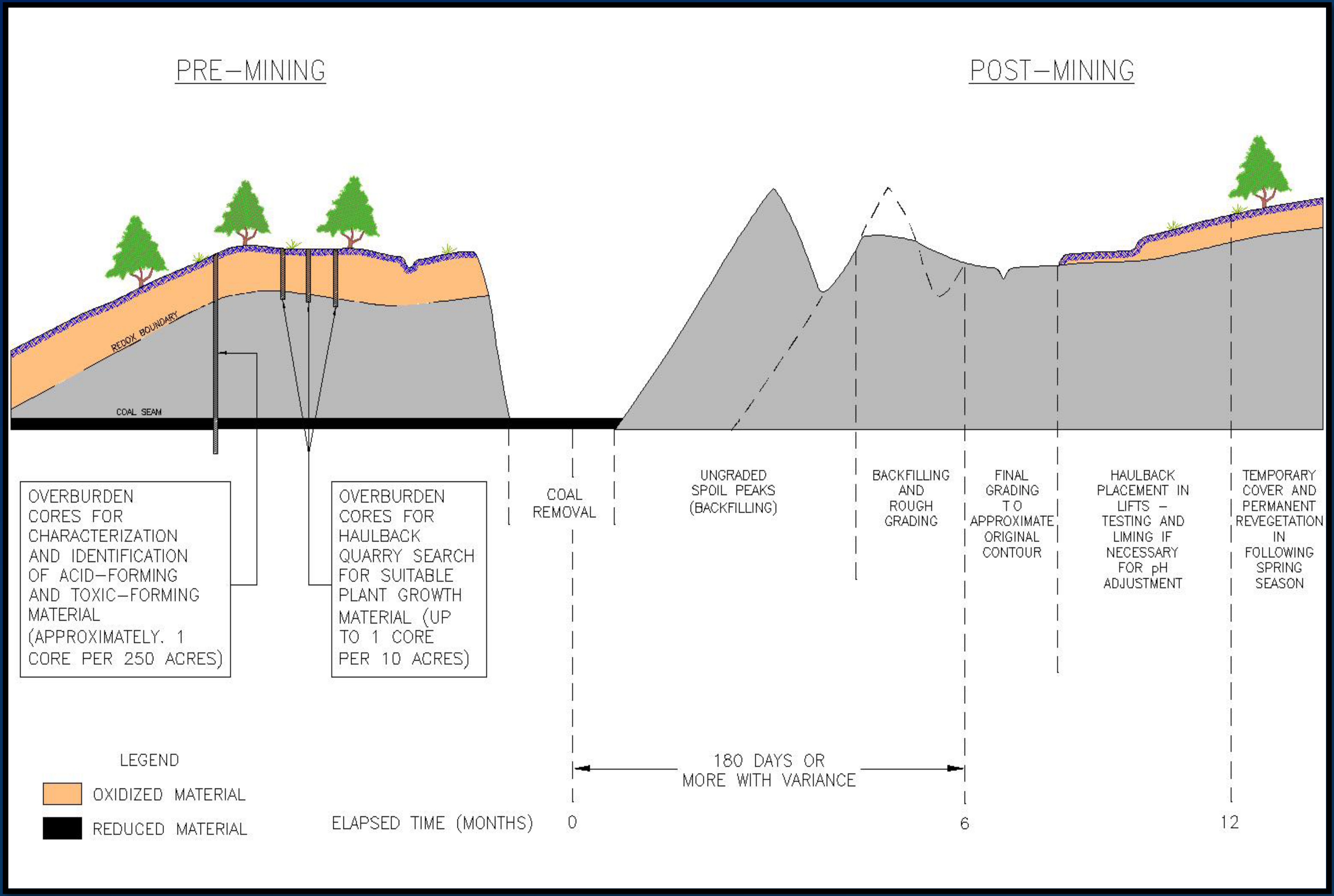
- Main soil series – Arol, Burlewash, Elmina, Shiro, Singleton
- Arol – Aquic Paleustalf (Aquic Pale-ust-alf)
- Burlewash – Ultic Paleustalf
- Elmina – Aquic Arenic Hapludalf
- Shiro – Aquic Paleustalf
- Singleton – Aquic Paleustalf
- Alfisol = soil with claypan
- Ustalf = alfisol in ustic moisture regime (dry 3 months in year)
- Udalf = alfisol in udic moisture regime (dry < 3 months in year)
- Paleustalf = ustalf that has undergone weathering over long time
- Ultic = intergrade to a highly weathered Ultisol
- Aquic = soil with a perched water table
- Arenic = sandy

Native Burlewash soil – Ultic Paleustalf

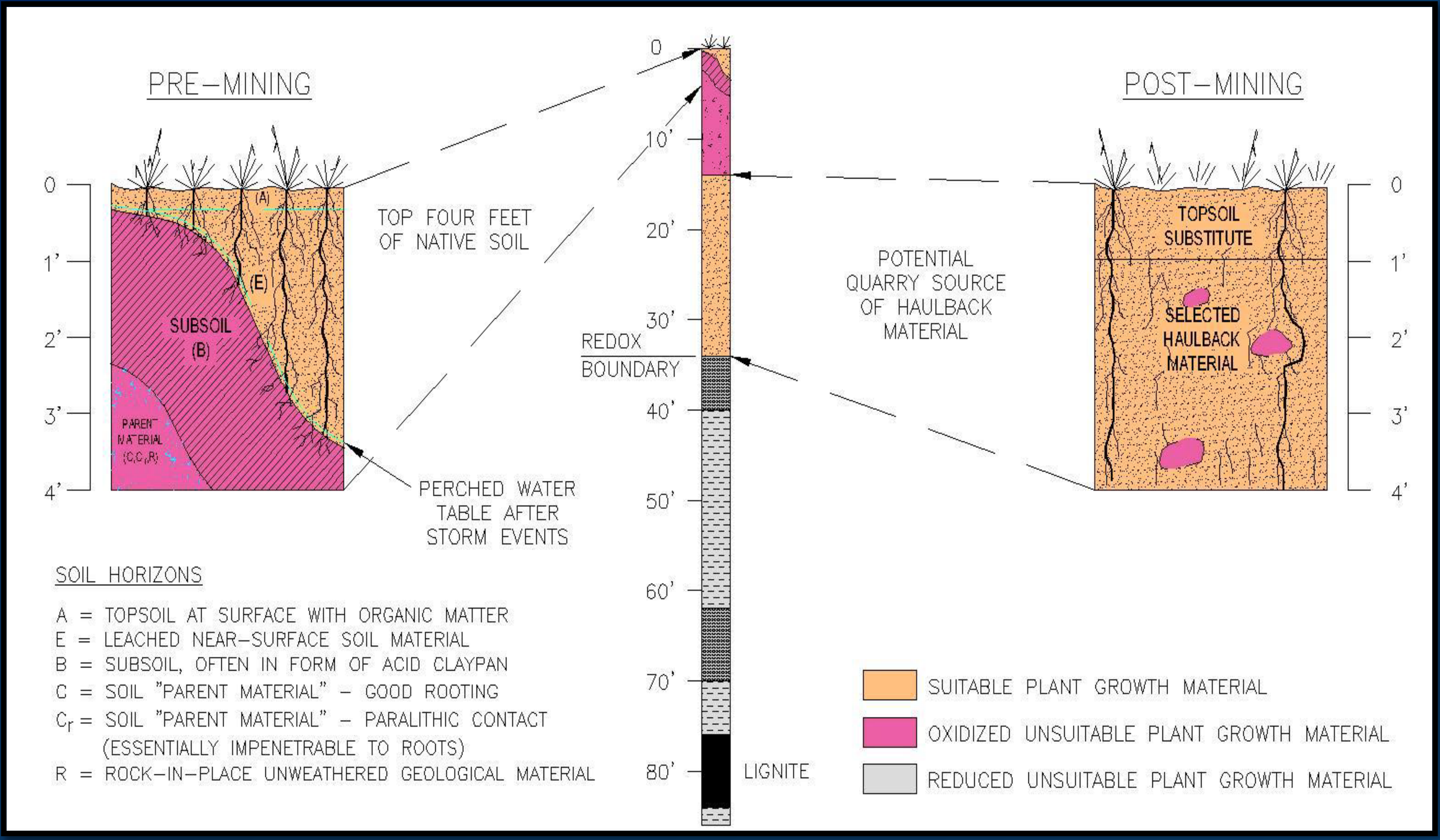


Native Shiro soil – Aquic Paleustalf

Process for creation of new post-mining soil

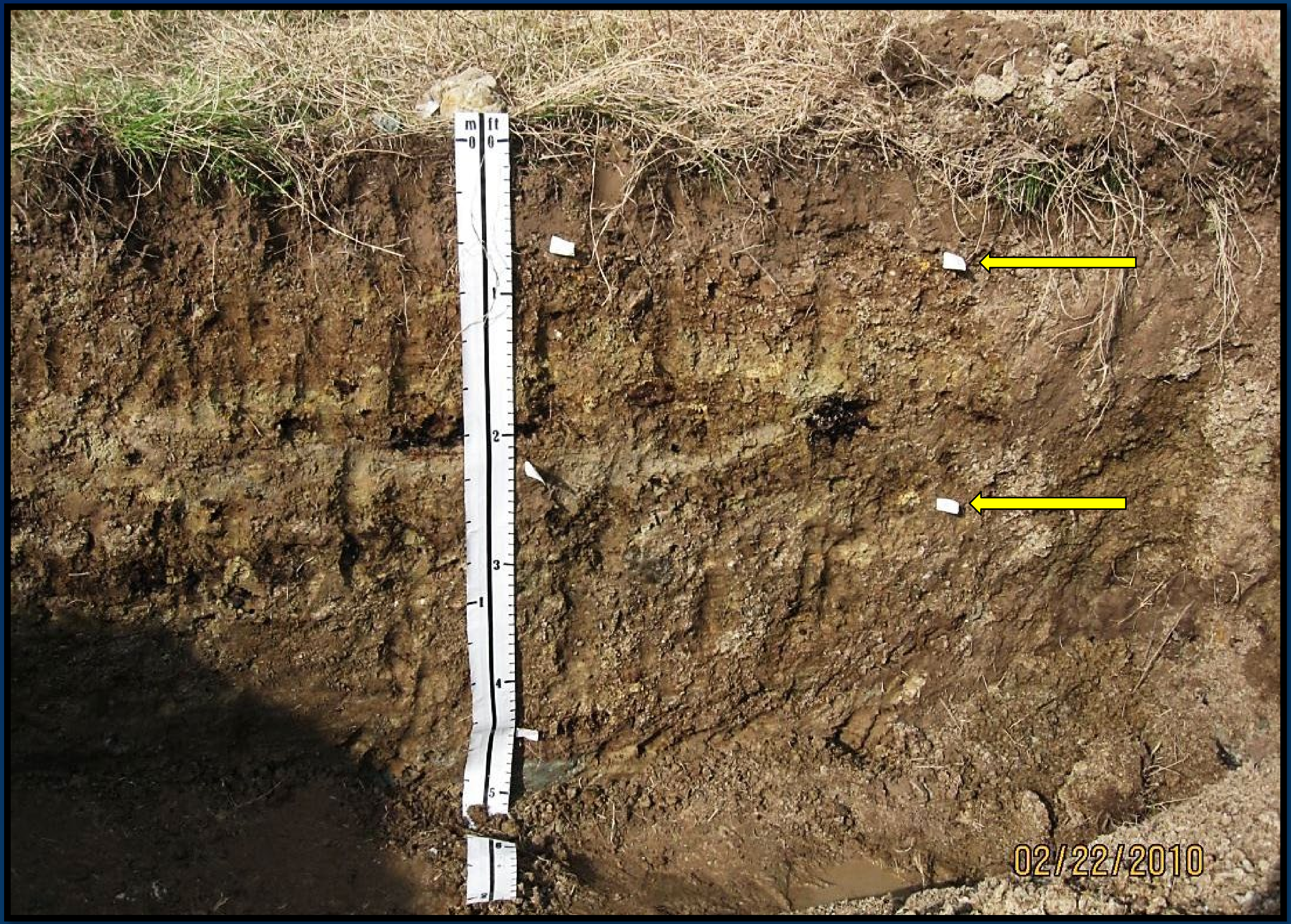


Construction of post-mining soil



Minesoil in Grid X14SE (constructed in 1989) with native topsoil replaced at surface

(Photo Nellie Frisbee)



Detail of decomposed pyrite nodule
(Photo Nellie Frisbee)

Detail of decomposing pyrite nodule

(Photo Nellie Frisbee)

Detail of decomposing pyrite nodule

(photo Rachel Brandt)

Minesoil in Grid P19SE in mixed overburden

(Photo Nellie Frisbee)

Soil in Rock Lake Creek wetland
(constructed ca. 1988)

25-year old minesoil in constructed wetland

Vegetation cover

- Original reclamation plan (1980s) called for native (prairie) grasses.
- But these are “bunch grasses” (e.g., Switchgrass) which have areas of bare soil around their bases.
- Improved grasses (e.g., Bermudagrass) are “sod-forming grasses” which spread over the whole soil surface and do not leave bare spots.
- The regulatory authority requires complete ground cover to minimize soil erosion.
- As a result, most mines in Texas now reclaim to varieties of sod-forming grasses like bermudagrass rather than native grasses.
- At Gibbons Creek we use Coastal and Tifton 78 bermudagrass varieties because these are preferred by local ranchers, respond well to fertilizer, and have high protein content.
- Fortunately, over time, native grasses (e.g., Indiangrass) start invading.

Bunch grasses vs sod-forming grasses (B1 Mine Block)

Switchgrass in G1 Mine Block

Indiangrass in B2 Mine Block

Indiangrass

Sideoats Grama

Post-Mining land use

- Objective of reclamation is to return mined land to a land use equal to, or better than, the pre-mining land use.
- The most common categories of land use are:
- Pasture land – areas of intensively managed improved grasses that can be used for haying or grazing (they can also include features such as tree mottes, wetlands, depressional areas, and drainages).
- Grazing land – areas of native grasses that are not intensively managed and predominantly used for grazing.
- Developed water resources – ponds with engineering designs.
- Industrial/commercial – roads and oil/gas well pads.

Tree mottes planted in A1 Mine Block

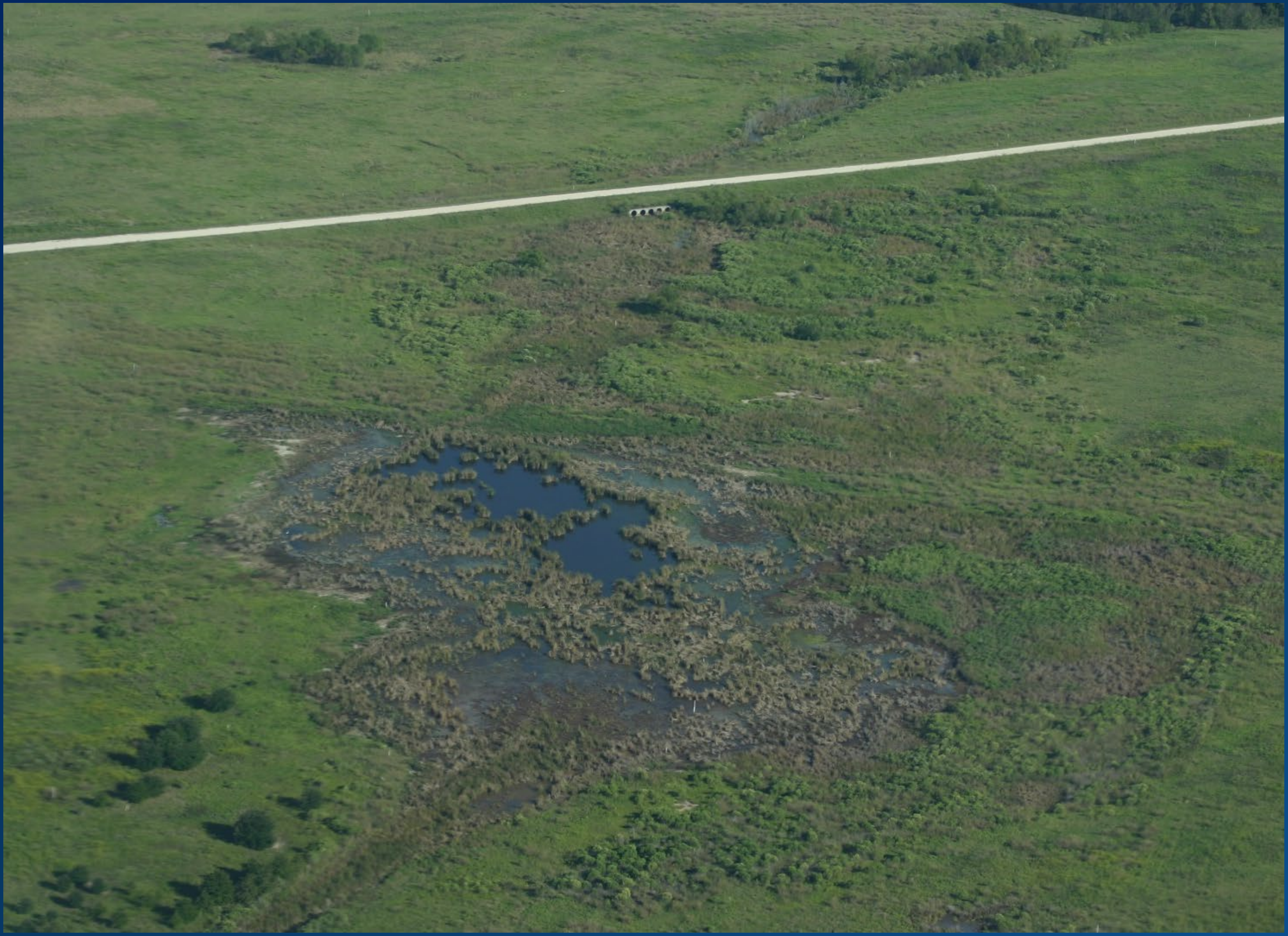
"Volunteer" pine trees in A3 Mine Block

Pastureland in B2 Mine Block

Rock Lake Creek (reconstructed) looking north

(Drone photo, Murphy Hawkins)

Reconstructed Rock Lake Creek wetland



Wildlife species observed at Gibbons Creek Mine

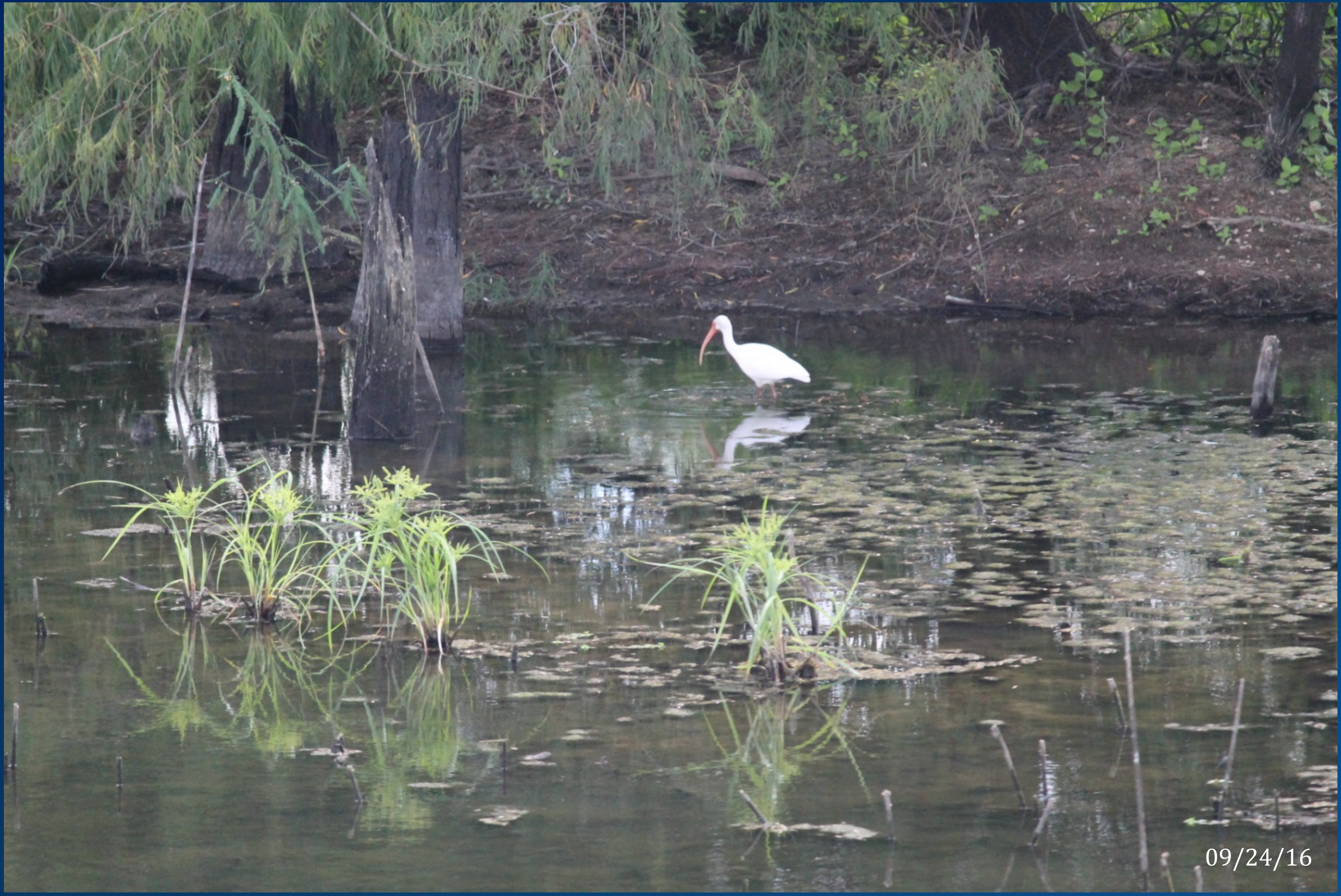
Species	Species
Bald Eagle	Red-Shouldered Hawk
White-faced Ibis	Red-tailed Hawk
White Ibis	Crested Caracara
Wood Stork	Belted Kingfisher
Roseate Spoonbill	Red-Headed Woodpecker
Alligator Snapping Turtle	American Alligator
American White Pelican	Beaver
Anhinga	River Otter
Green Heron	Bobcat
Northern Harrier	Gray Fox
Osprey	Coyote

Bald eagles at Pond DP-1

Bald eagle at Pond DP-1

(Photo Pamela Spaulding)

White Ibis on mine Pond SP-20



Roseate Spoonbills on Pond 10A
(Photo Jacob Eickstead)

Wood storks and roseate spoonbills at mine Pond SP-20

(Photo Ryan Thompson)

Anhinga on mine Pond DP-1

Alligator in spillway of mine Pond DP-1

Cottonmouth at spillway of Pond A3P-1

BREAK

Concepts of global land stewardship

Planetary boundaries hypothesis (Rockström et al., 2009):

- Climate change
- Ocean acidification
- Stratospheric ozone depletion
- Interference with global phosphorus and nitrogen cycles
- Rate of biodiversity loss
- Global freshwater use
- **Land-System change**
- Aerosol loading
- Chemical pollution

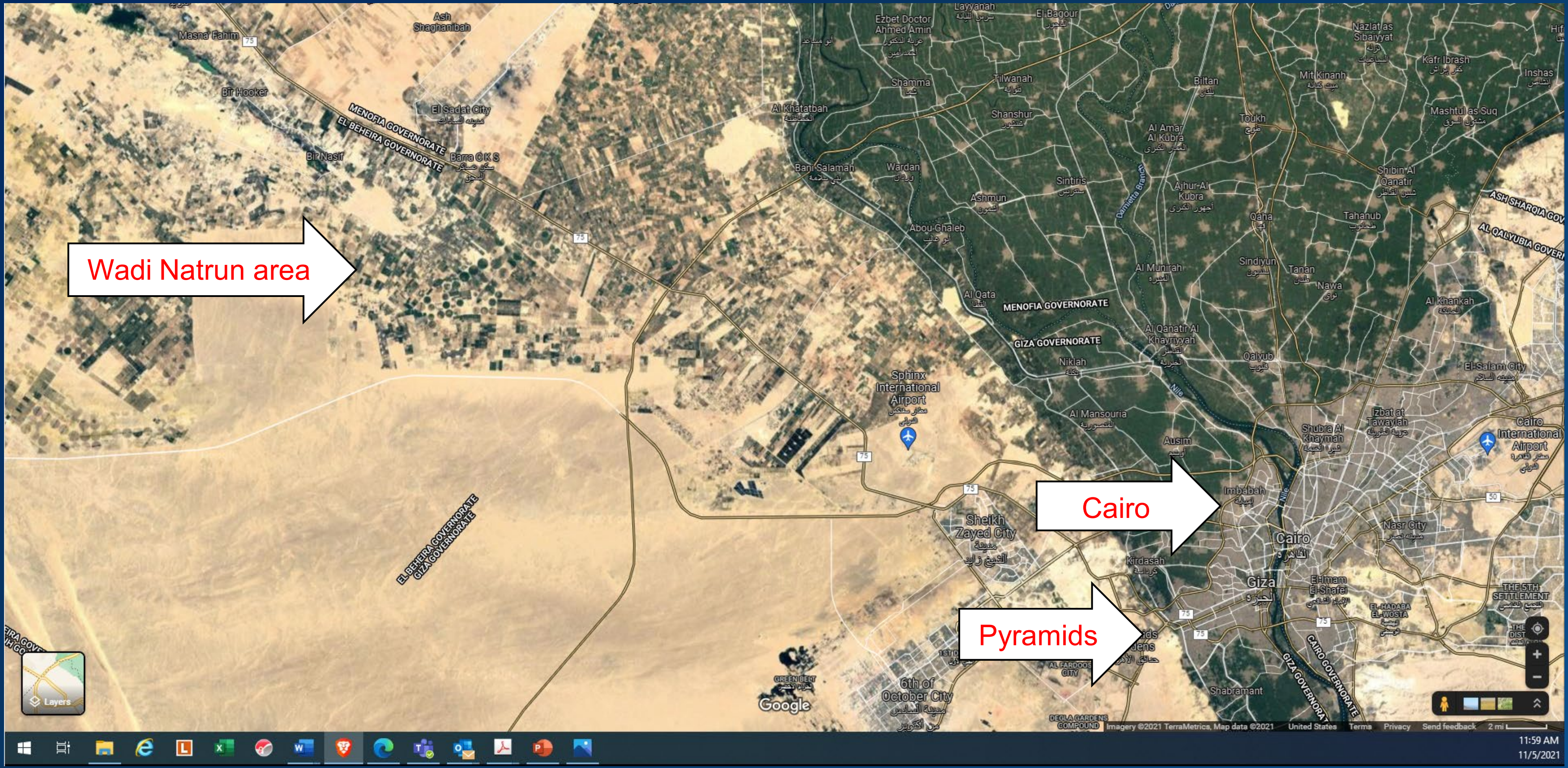
Land stewardship

Prof. Jonathan Foley, Dept. of Ecology, University of Minnesota (2009):

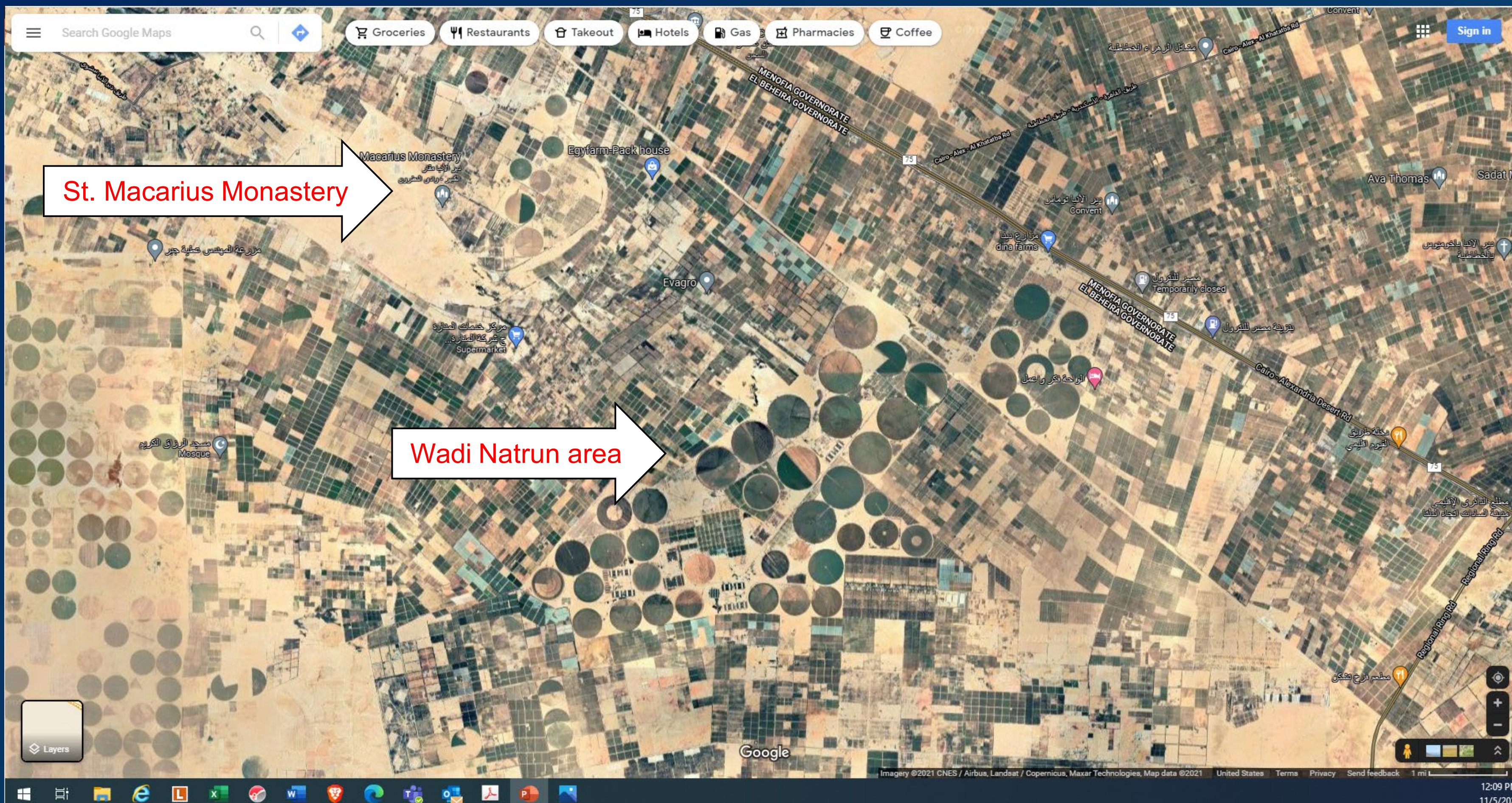
"Although I'm a climate scientist by training, I worry about this collective fixation on global warming as the mother of all environmental problems. Learning from the research my colleagues and I have done over the past decade, I fear we are neglecting another, equally inconvenient truth: ***that we now face a global crisis in land use and agriculture that could undermine the health, security, and sustainability of our civilization***."

Wadi Natrun Project , Egypt
Soil Survey, 1977

Wadi Natrun Area, 2021
(44 years later)



Wadi Natrun Area (detail), 2021



Pressure on the land (2014)

Area	People per km^2	People per km^2 of arable land
Australia	3	43
Norway	14	533
United States	35	179
Mexico	65	436
Honduras	71	672
Egypt	90	2,688
France	121	332
United Kingdom	267	1,077
Malta	1,336	4,036
Texas	40	52
Brazos County	133	168
Grimes County	11	17

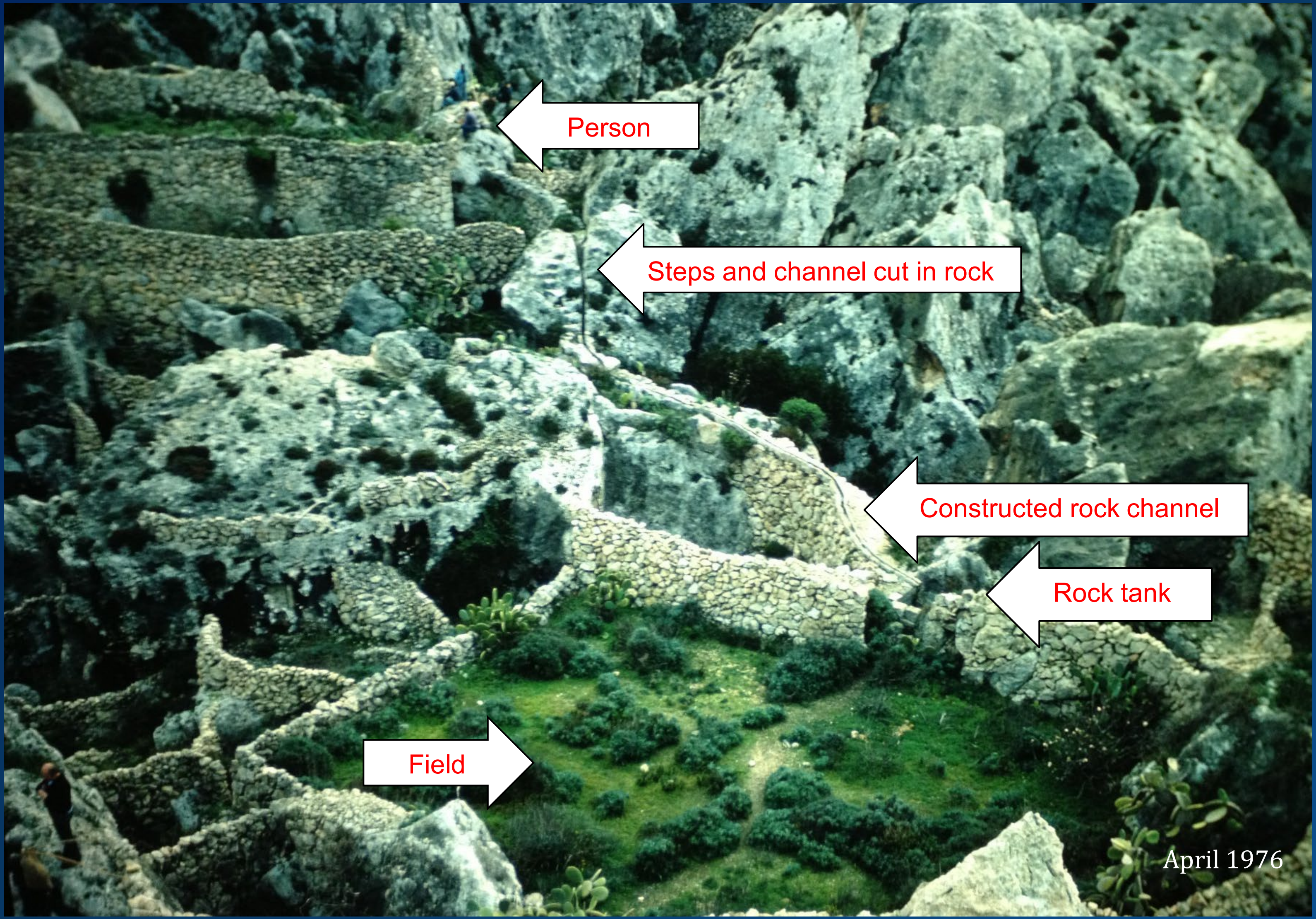
High Plains, south of Amarillo, Texas

Northeast of Paris, France

Island of Malta

Landscape in Malta
(fields in old limestone quarries)

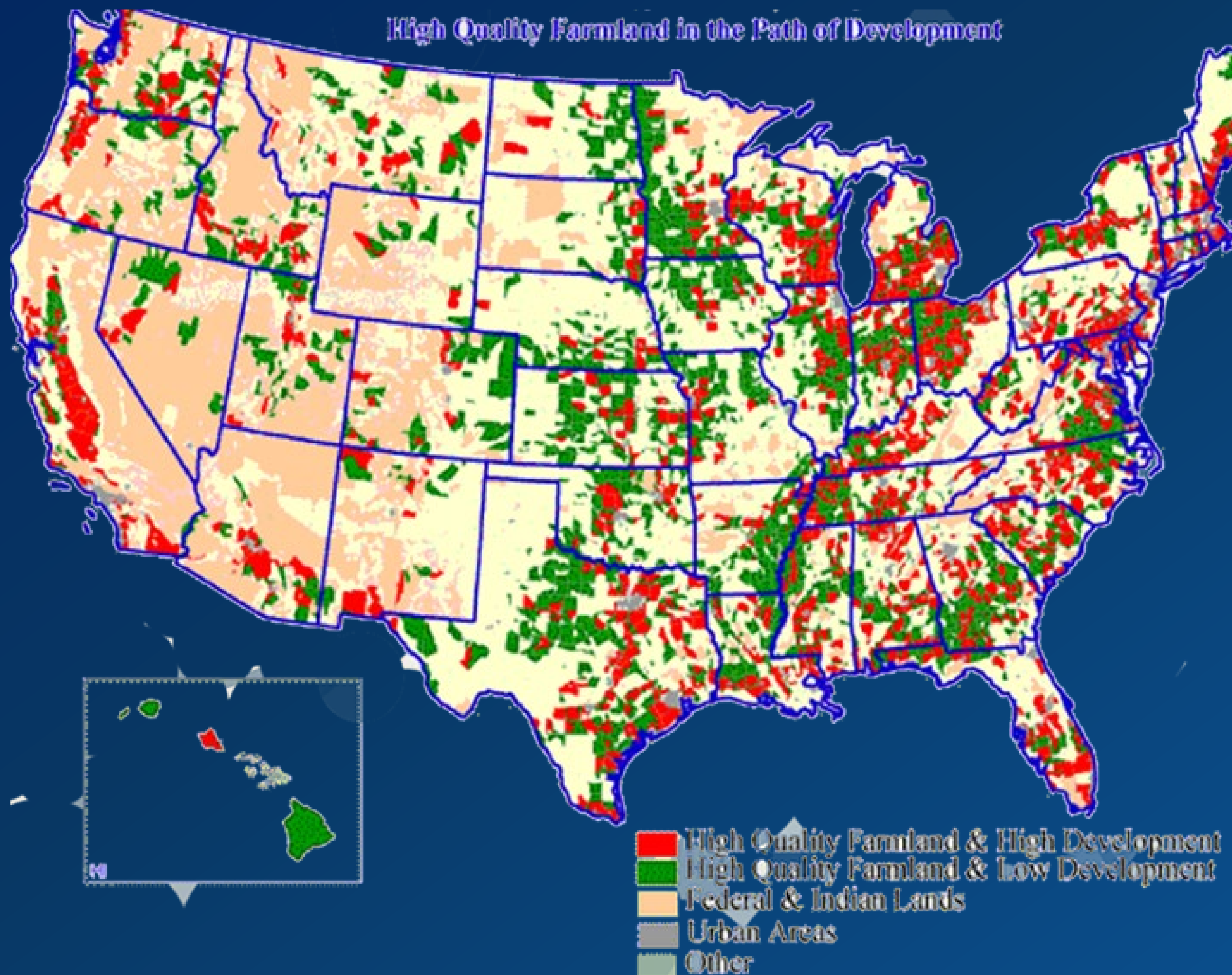
Malta – extreme pressure on the land



Pressure on prime farmland in the United States (1992-1997)

State	**Loss of prime farmland (acres)**	**Increase over previous 5 years**
Texas	333,000	42%
Ohio	212,000	45%
Georgia	184,000	66%
North Carolina	168,000	1%
Illinois	161,000	137%
Pennsylvania	135,000	23%
Indiana	124,000	65%
Tennessee	124,000	42%
Michigan	121,000	67%
Alabama	114,000	127%

Farming on the Edge – high quality farmland in the path of development
(American Farmland Trust)



Pressure on land in Texas – 1860 to present

(20-year increments)

Year	Population	People per km^2 of arable land
1860	600,000	1
1880	1,590,000	3
1900	3,050,000	6
1920	4,660,000	9
1940	6,420,000	12
1960	9,580,000	18
1980	14,230,000	27
2000	20,940,000	40
2020	29,150,000	55

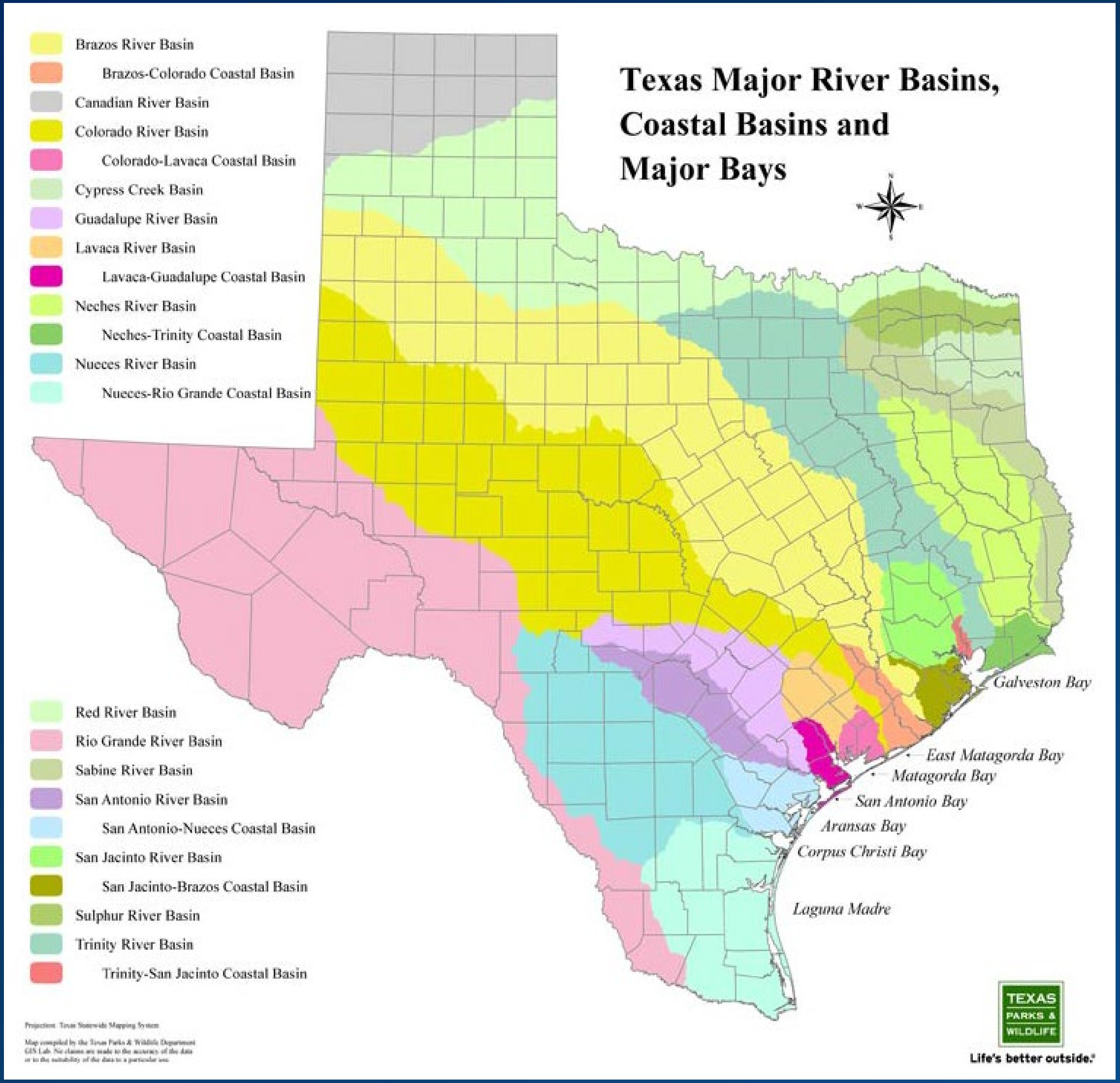
Land fragmentation in Texas

Period	Allocation of land in Texas
1836-1842	Headrights – initially one league (4,428 acres) per head of family, decreasing over the years to 640 acres per head of family
1841-1845	Empresario colonies
1845-1898	Pre-emption rights – 320 acres from unappropriated public domain
1898	Texas Supreme Court declares – no unappropriated land left in Texas

- 2005 – Establishment of Texas Farm and Ranch Lands Conservation Program by state legislature.
- Ecological and agricultural productivity of these lands is maintained and enhanced through Agricultural Conservation Easements.
- January 1, 2016 – program transferred from Texas General Land Office to Texas Parks and Wildlife Department.

River basins in Texas

(Texas Parks & Wildlife Department, 2016)



Stewardship of surface water resources in Texas

- 2011 – Drought – water shortages, curtailment of water rights.
- 2013 – $2B for State Water Implementation Plan For Texas (SWIFT).
- Surface water belongs to state, administered by Texas Commission on Environmental Quality and water authorities.
- State grants “water rights” – order of priority.
- Curtailment of water rights at times of shortage.
- 2015 – “Watermaster” program initiated for Brazos River Basin.
- Lower Colorado River Authority system rate (2022) = $155 per acre-foot.
- Brazos River Authority system rate (2022) = $83 per acre-foot.
- At $83 per acre-foot, value of rainfall in Grimes County

  3.33 ft x 512,192 ac x $83 = $142M/yr!

City of Bryan – Water Conservation Plan

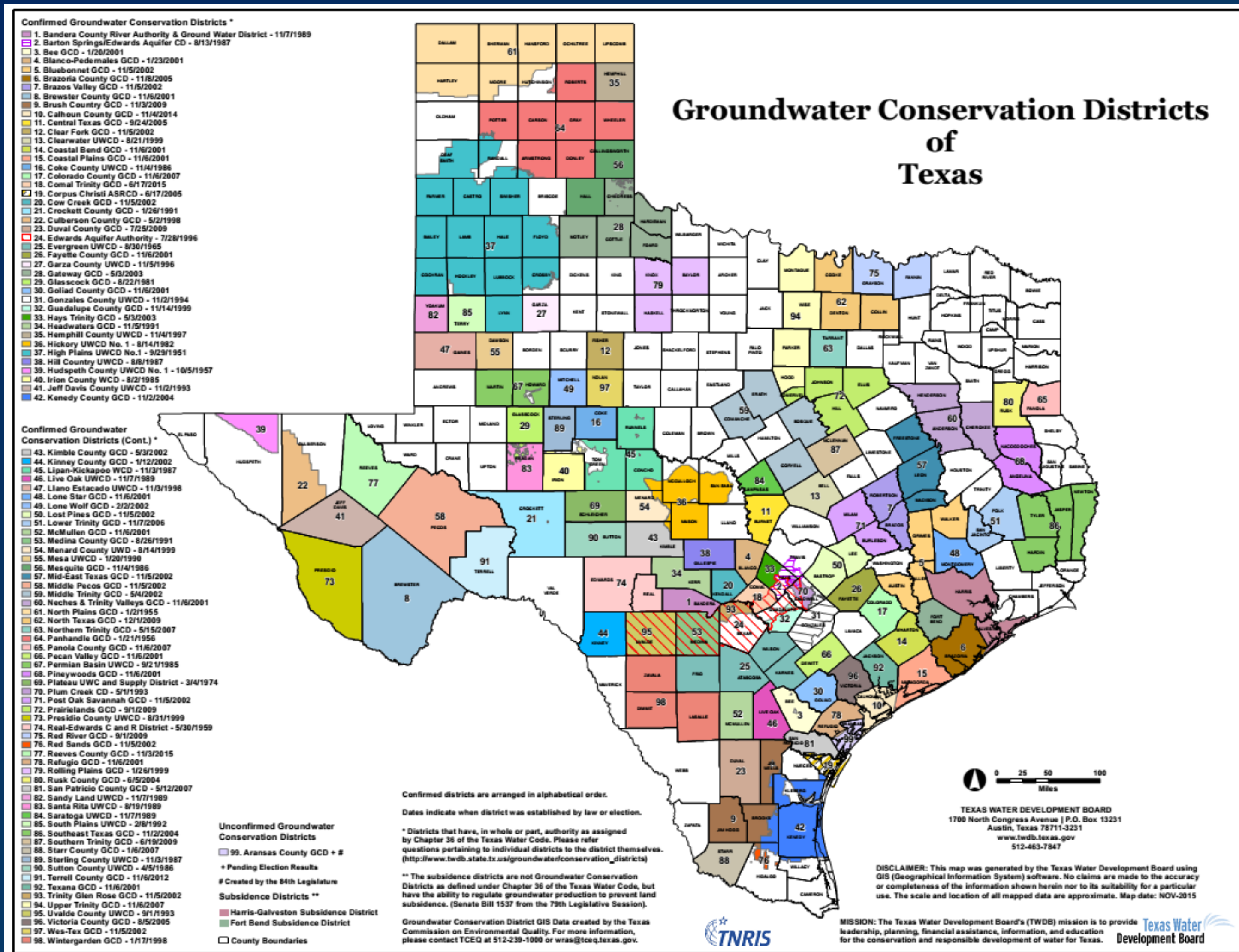
- 2011 – Most intense one-year drought in Texas since at least 1895 (beginning of statewide weather records). City of Groesbeck almost runs out of water.
- 2013 –Texas legislature approves $2 billion to be transferred from "Rainy Day Fund" to new State Water Implementation Fund for Texas (SWIFT) program. Texas Water Development Board (TWDB) to administer SWIFT.
- May 13, 2014 – Bryan City Council passes Resolution No. 3551 adopting a Water Conservation Plan.
- July 21, 2016 – TWDB approves $18 million of financial assistance (multi-year, low-interest loan) to City of Bryan for planning, acquisition, design, and construction of an aquifer storage and recovery project.

Stewardship of groundwater resources in Texas

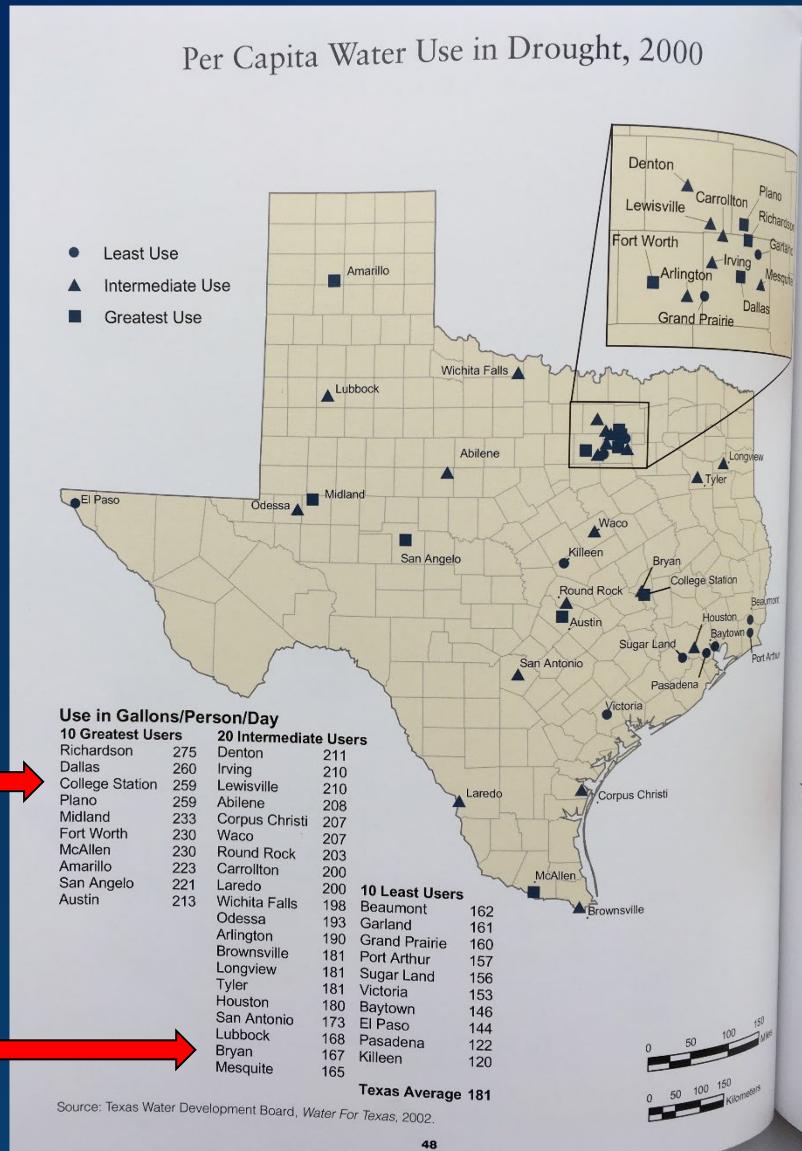
- Groundwater in Texas is governed by the rule of capture.
- The person who owns the land also owns the water underneath it.
- The landowner has the right to pump as much water as he wishes.
- This is not sustainable.
- As a result, there has been a proliferation of groundwater conservation districts in recent years.
- These districts develop groundwater management plans.
- The groundwater management plans are reviewed and approved by the Texas Water Development Board.
- The intent is to effectively manage groundwater resources.

Groundwater Conservation Districts

(Texas Water Development Board, 2016)



How are we doing?



Per Capita Water Use in Drought, 2000

Use in Gallons/Person/Day

10 Greatest Users	
Richardson	275
Dallas	260
College Station	259
Plano	259
Midland	233
Fort Worth	230
McAllen	230
Amarillo	223
San Angelo	221
Austin	213

20 Intermediate Users	
Denton	211
Irving	210
Lewisville	210
Abilene	208
Corpus Christi	207
Waco	207
Round Rock	203
Carrollton	200
Laredo	200
Wichita Falls	198
Odessa	193
Arlington	190
Brownsville	181
Longview	181
Tyler	181
Houston	180
San Antonio	173
Lubbock	168
Bryan	167
Mesquite	165

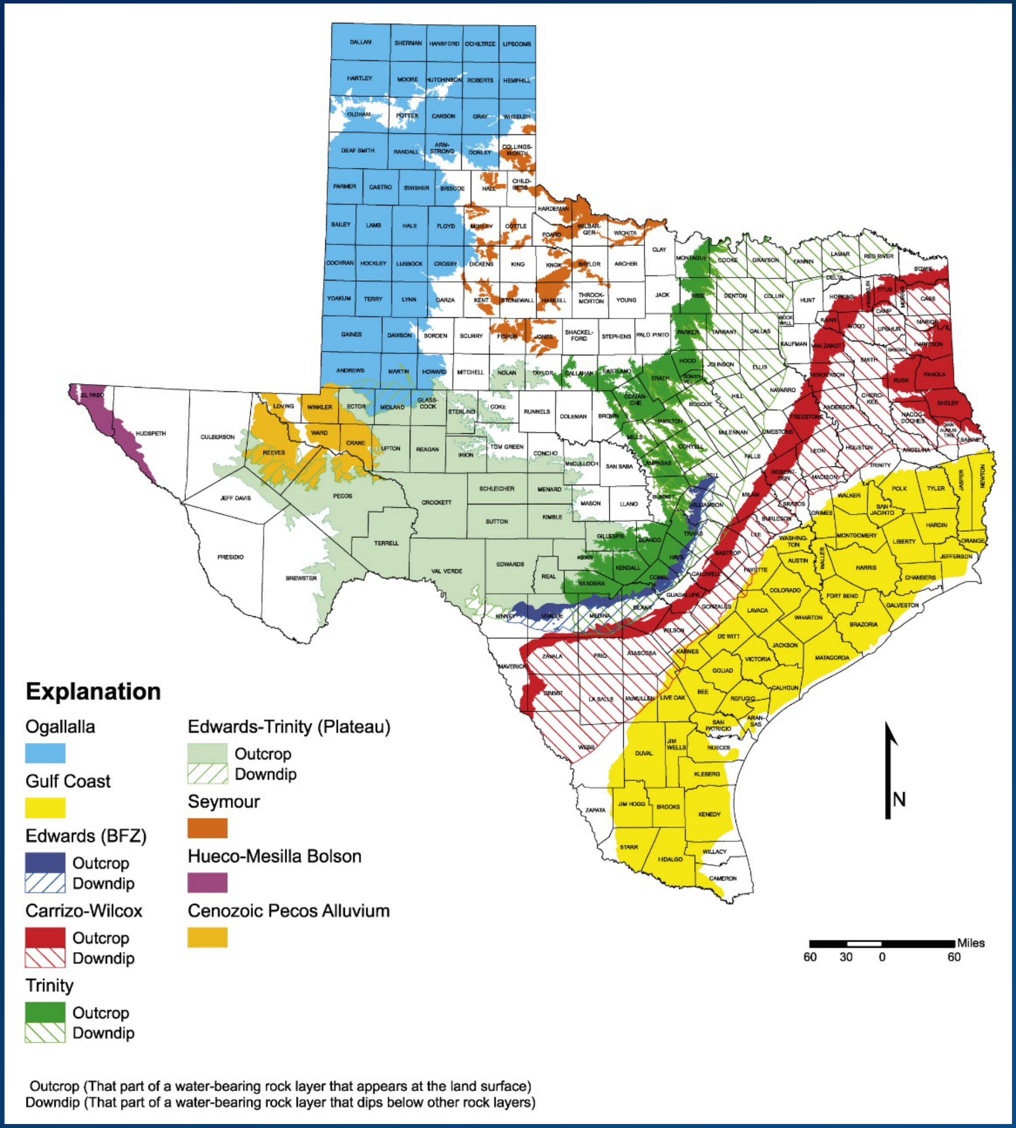
10 Least Users	
Beaumont	162
Garland	161
Grand Prairie	160
Port Arthur	157
Sugar Land	156
Victoria	153
Baytown	146
El Paso	144
Pasadena	122
Killeen	120

Texas Average 181

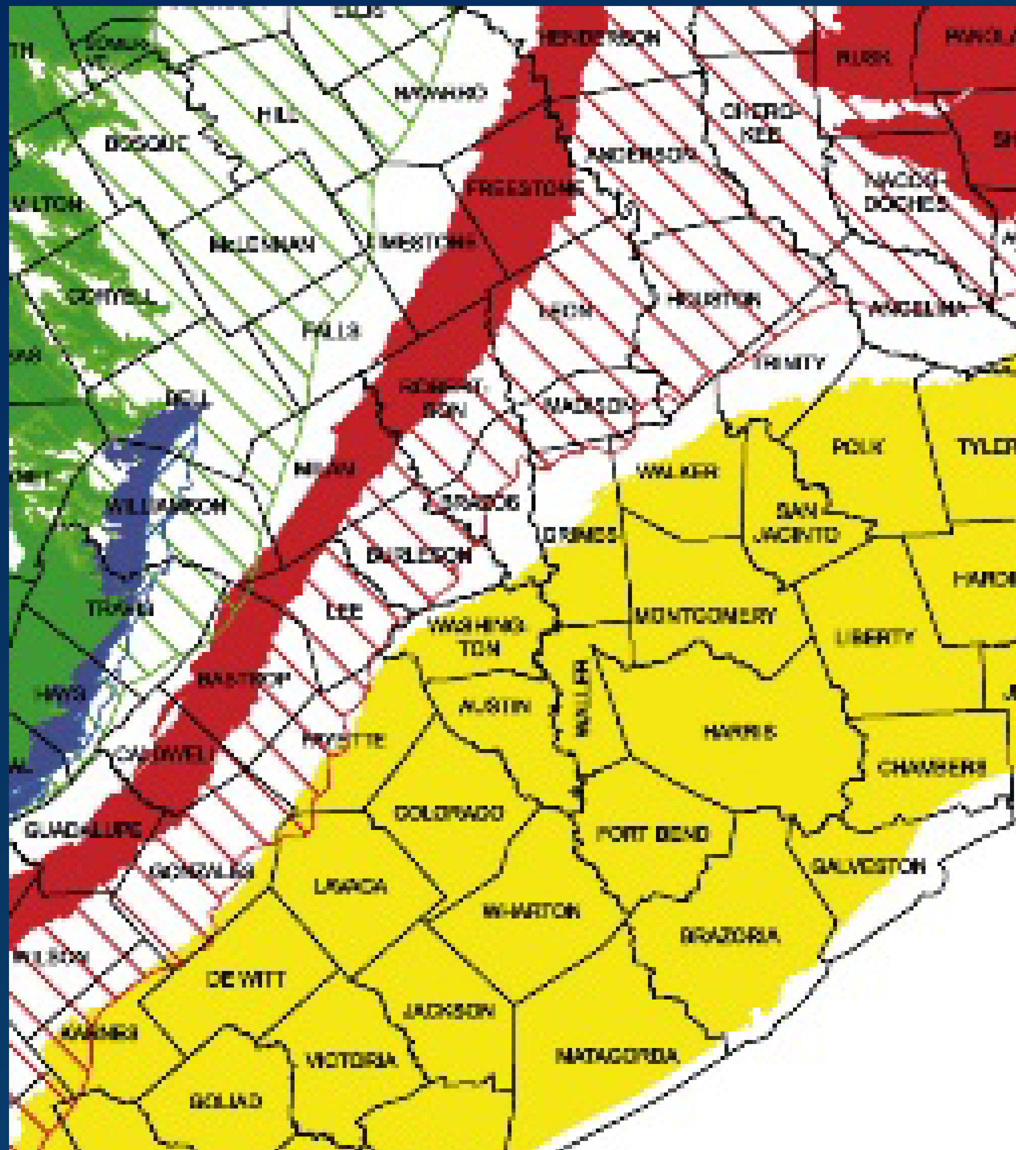
Source: Texas Water Development Board, *Water For Texas*, 2002.

48

Main aquifers in Texas
(Texas Water Development Board, 2016)



Aquifers for Brazos and Grimes Counties



College Station Groundwater Well

10/26/16

Water Supply and Demand – New Braunfels

Comparison of Supply and Demand

Well-managed water utilities in arid areas like Texas predicate their planning on having a "firm" supply of water available, even during a repeat of the worst year(s) of the DOR. NBU's current firm supply will be exceeded by predicted demand as early as 2020. Without additional water sources, NBU's projected demand will exceed its firm yield supply by about 6,500 AFY in 2030 and by 11,000 AFY in 2040. The projections of supply and demand illustrated in Figure 14 show that NBU needs to develop new water sources.

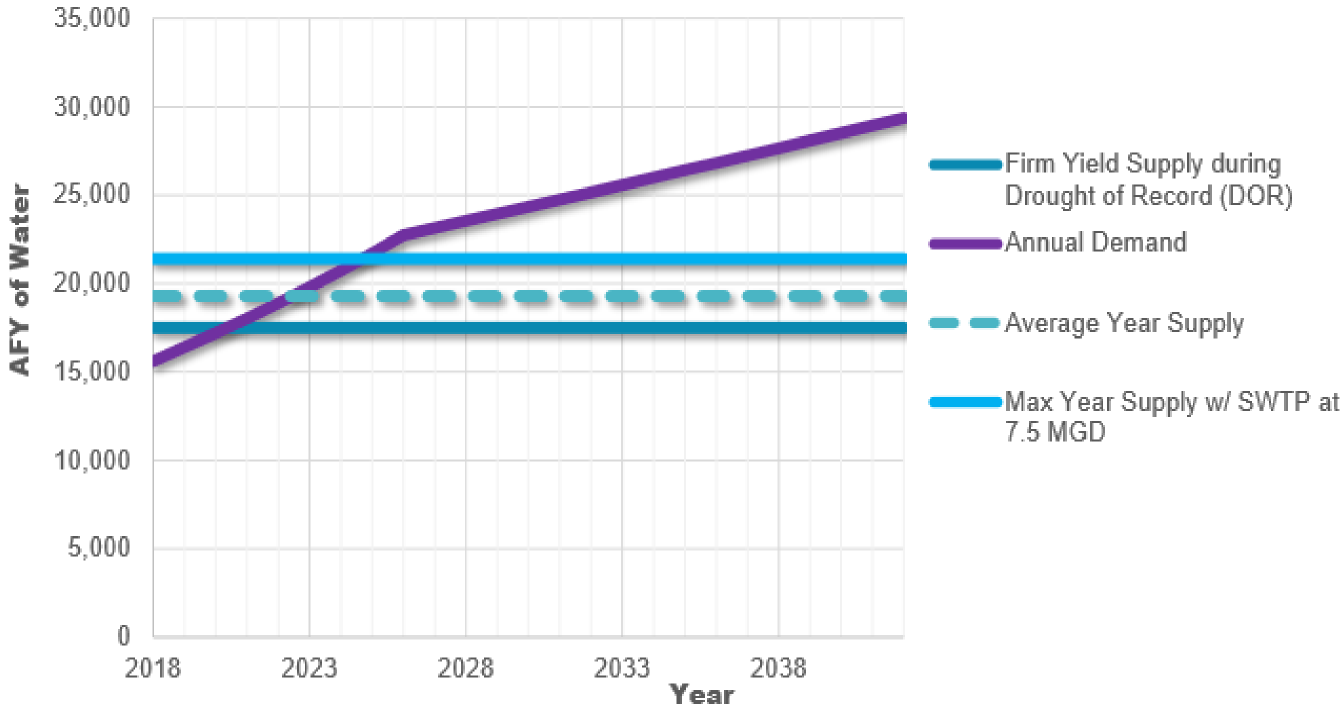
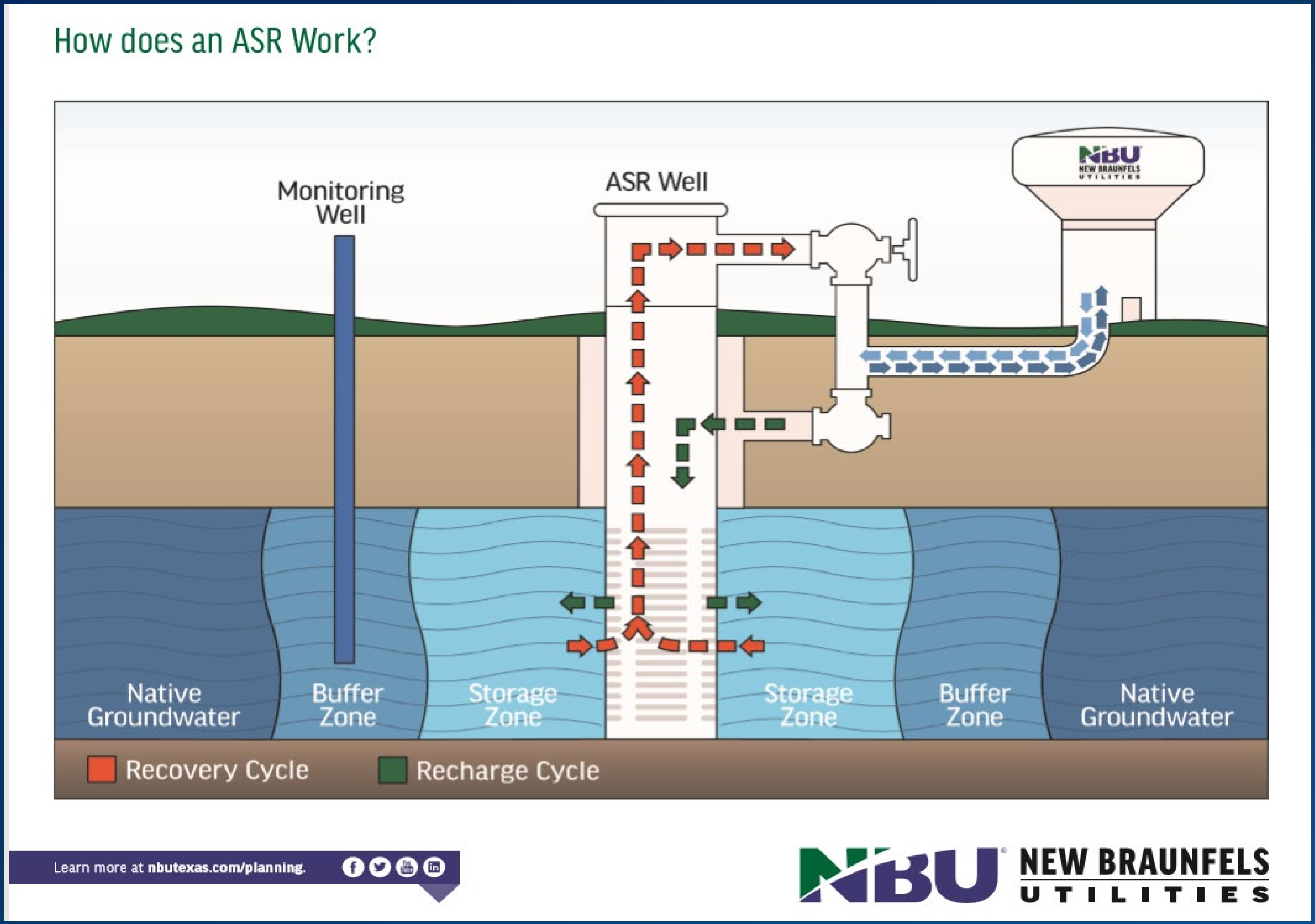


Figure 14: Comparison of NBU's Current Supply and Forecasted Demand

Aquifer Storage and Recovery – New Braunfels



Habitat preservation
Endangered Species

- Navasota Ladies'-Tresses – only orchid indigenous to Texas.
- First discovered in Brazos County in 1945.
- Difficult to preserve even in a university town like College Station (e.g., Lick Creek Park mountain bike trails; Highway 6 widening; clear-cutting of trees for Texas A&M bonfire).

Endangered species – habitat preservation

- TMPA's conservation areas, monitored every year in October-November:

Year	Site C1 (21.1 ac)	Site C2 (47.0 ac)	Site C3 (16.6 ac)	Site C4 (81.3 ac)	Site C5 (18.3 ac)	**Total**
2007	20	21	25	12	4	**82**
2008	53	41	81	178	11	**364**
2009	9	13	6	105	3	**136**
2010	14	7	17	50	10	**98**
2011	0	0	0	4	0	**4**
2012	34	30	71	146	3	**284**
2013	64	65	41	78	6	**254**
2014	68	50	10	35	5	**168**
2015	1	2	1	11	3	**18**
2016	2	8	9	15	175	**209**
2017	87	155	88	377	44	**751**
2018	425	202	418	1,583	75	**2,703**
2019	204	27	95	533	13	**872**
2020	29	19	21	78	5	**152**

Endangered Species
Navasota Ladies'-Tresses Orchid

Photo by
Dr. Hugh D. Wilson,
TAMU
Biology/Horticulture

Endangered Species
Navasota Ladies'-Tresses Orchid

Endangered Species
Navasota Ladies'-Tresses Orchid (C-3 Area)

Public awareness campaign

(*Navasota Examiner*, October 19, 2016)

Check for Ladies'-tresses advises GCAG

BY NICOLE SHUPE
Staff writer

The Grimes Citizen Advisory Group is advising local property owners to check for an endangered flower on their property to "help in the fight" against local eminent domain issues.

According to the Texas Parks and Wildlife, Navasota Ladies'-tresses are a member of the orchid

Stewardship of land for public recreation

- The need for recreational areas is a pressing problem, especially in urban areas.
- New York City – Central Park (843 acres) and imaginative trails such as High Line Park (6.7 acres).
- London – Richmond Park (2,360 acres) is largest "Royal Park" (one of eight former royal hunting preserves converted to public parks by legislation in 1851 – total area = 4,900 acres).
- London – other public recreation areas (e.g., Battersea Park, reclaimed from marshland – 200 acres) + "commons" + "greens" of former villages swallowed up by London + "allotments."
- Gibbons Creek Mine = 11,000 acres.

Central Park (843 acres), New York City

High Line Park (6.7 acres), New York City

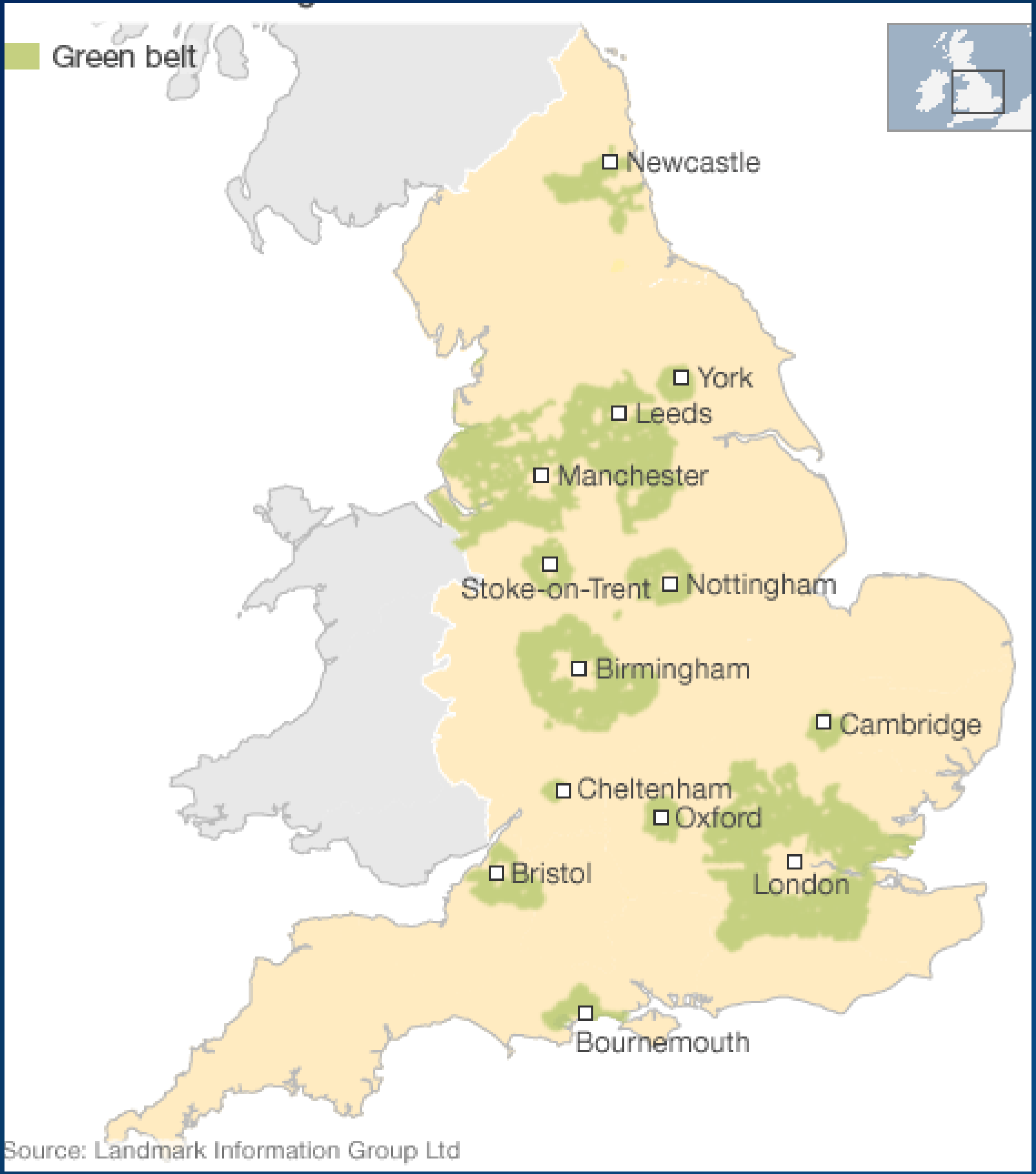
04/29/16

Kensington Gardens and Hyde Park (625 acres), London

“Green” belts and protection of special habitats

- 1935 – UK passes Restriction of Ribbon Development Act.
- 1935 – proposal for “Greenbelt” around London for recreation and preservation of “nature.”
- Since 1970s – Preservation of old trees, prime farmland, ecological networks and “stepping stones,” biodiversity, geodiversity, old buildings, “Ramsar” wetland / waterfowl habitat sites (named after Ramsar, Iran, where convention on wetlands was signed in 1971), and special bird protection areas.

Greenbelts in England



European Green Belt Initiative
(along alignment of former “Iron Curtain”)

Habitat restoration
Urbanites and NIMFY (Not In My Front Yard)

Professor David N. Laband, School of Economics, Georgia Institute of Technology (2001):

- Urbanites do not place high value on biodiversity – evidence is in their residences.
- They spend hundreds, even thousands, of dollars on maintenance of lawns and grounds in an unnatural state.
- This behavior shows that **they place a higher value on aesthetically pleasing ecological deserts than on personally promoting biodiversity**.
- But they demand biodiversity through regulation of rural dwellers.
- This is politically easier for decision makers because voters do not have the regulatory burden and do not bear the costs (directly).

Prairie grasses? - NIMFY

Conclusions – Mine Reclamation

- Mine reclamation offers a rare opportunity to create new habitat.
- This does not happen spontaneously – reclamation plans are based on detailed science and engineering.
- They involve many aspects of the environment – geology geomorphology, soils, hydrology, ecology, and preservation of cultural resources.
- Ethics is man's relationship with other humans (anthropocentric).
- Aldo Leopold's "land ethics" is man's relationship with the land (to maintain the health of the biotic community).
- Mine reclamation is man's relationship with all aspects of his environment – from re-forming geological systems to creating habitat.
- Man's intimate interaction and concern for his post-mining environment could be considered a "mine reclamation ethic."

Conclusions – Land Stewardship

- As populations grow, pressure on the land is increasing rapidly.
- It may be the most important "Inconvenient Truth."
- It is not politically "trendy" because:
  - It is complex and does not lend itself to simplification and "sound bites."
  - It affects all voters (not just industry).
- It is already a serious challenge in many parts of the world, but not in the U.S. (for the most part).
- But in the U.S., and even in Texas, we are **beginning** to strain our land resources – our farmlands, surface water, and groundwater.
- Land is becoming increasingly fragmented affecting agricultural productivity, habitat, and wildlife.

Unintended consequences of “green” projects
(Solar farm, Grimes County, Texas)

10/21/21

Pressure on resources

- Land – 3,240 acres (658,000 panels) to generate 270 MW (12 acres per MW).
- International Renewable Energy Agency projects that there could be 78 M tonnes of solar panel waste by 2050 (est. amount for 2016 was 0.25 M tonnes).
- Solar panel contain lead and cadmium which can be leached out of fragments of solar panels by rainwater. Electric Power Research Institute (EPRI) does not recommend disposal in regular landfills.
- To switch **just the UK's fleet of 31.5 M Internal Combustion Engine Vehicles** to Battery-Electric Vehicles will require:
  - 208,000 tonnes cobalt (twice annual world production)
  - 164,000 tonnes lithium carbonate (three-quarters of annual world production),
  - 200 tonnes of neodymium (annual production)

Food for thought – pressure on resources

Table 1 | **Anticipated increase in demand for the 12 most needed commodities for delivering a green energy future**

Commodity	% increase in demand in 2050 compared with 2018
Graphite	494
Cobalt	460
Lithium	488
Indium	231
Vanadium	189
Nickel	99
Silver	56
Neodymium	37
Lead	18
Molybdenum	11
Aluminium	9
Copper	7

Data source: World Bank Report in 2020

Field trip – Pond SP-50 Islands Project
(April 20, 2018)

Field trip – Pond SP-50 South Islands
(April 20, 2018)

Field trip – Pond SP-50 South Islands

November 4, 2021

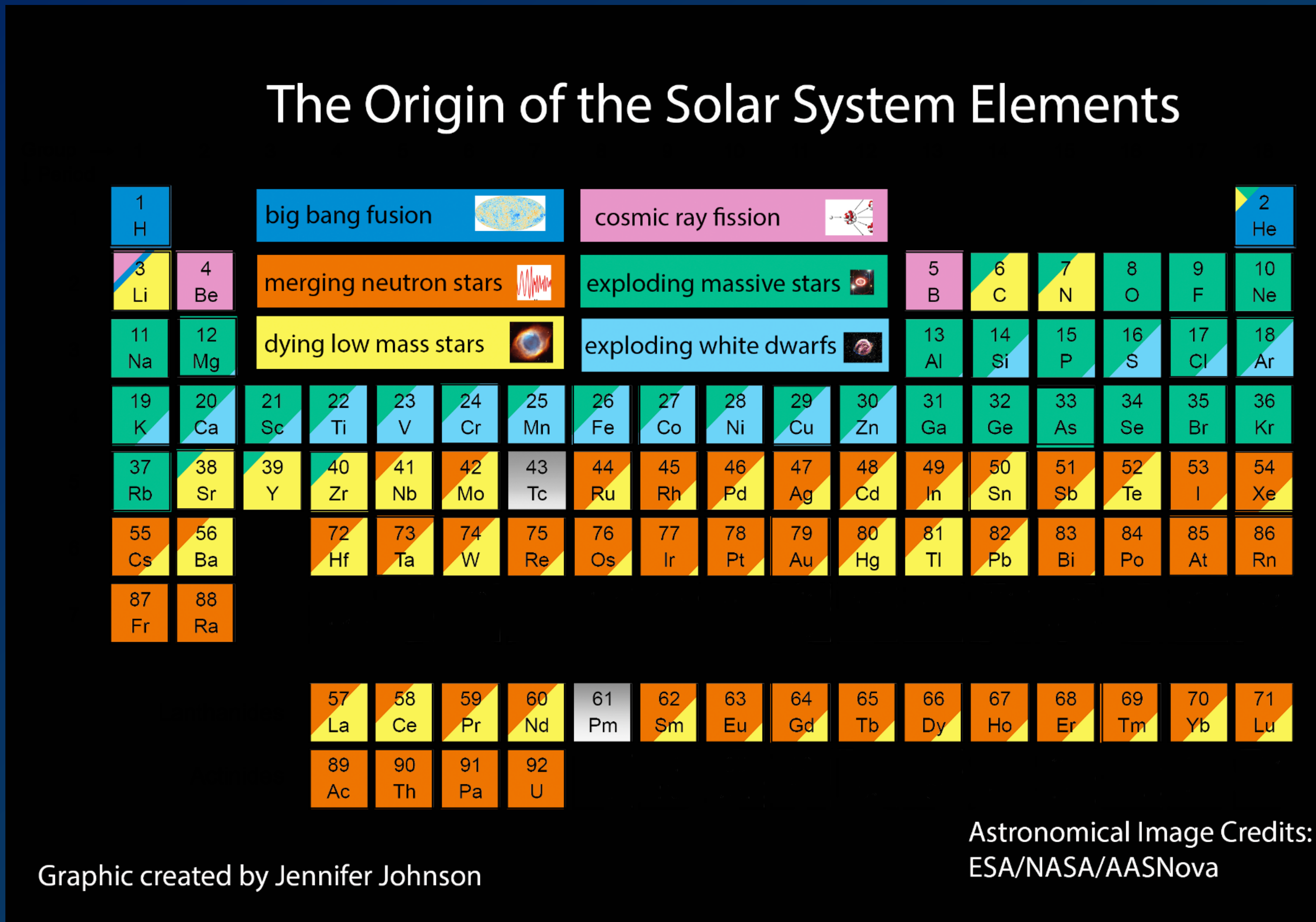
(Photo Jason Corley, Railroad Commission of Texas)

Field trip – Pond SP-50 South Islands
November 4, 2021)
(Photo Jason Corley, Railroad Commission of Texas)

Field trip – Pond SP-50 Islands Project

4-year old soil

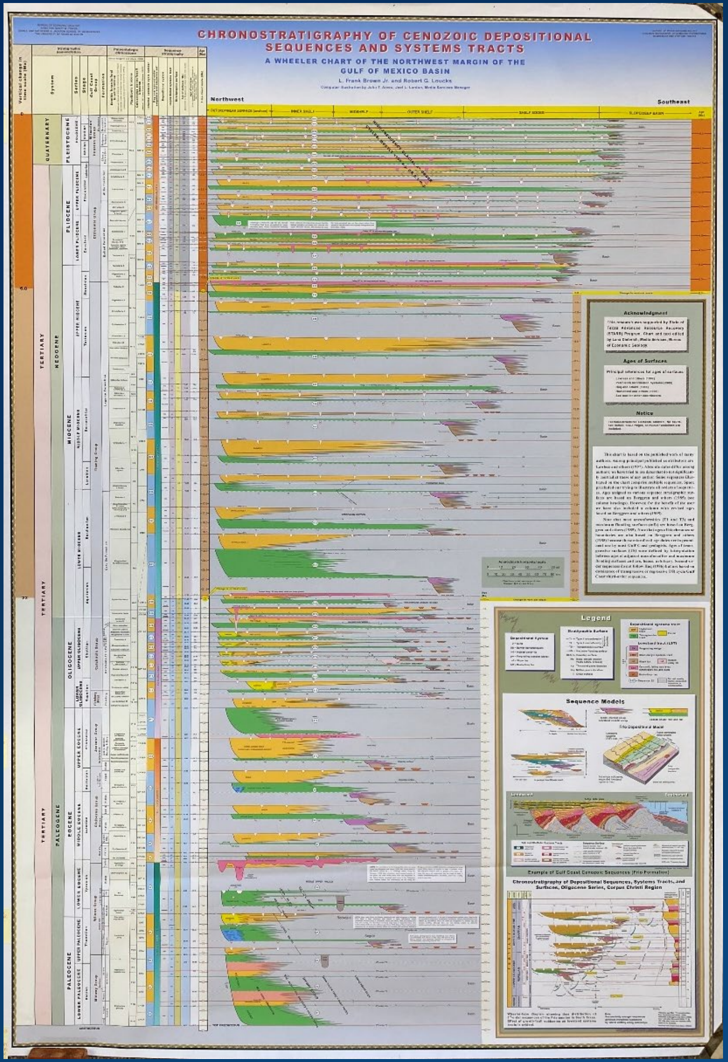
The End – the “Big Picture”



Pressure on land – waste management

- Mining – sand, gravel, and aggregate – United Nations Global Sand Observatory (GSO) – 40-50 billion tons per year. Construction sand needs to be angular, not rounded like desert sand. High-purity sand needed for glass, solar panels, computer chips, and fracking.
- Mining – phosphorus – essential for fertilizer, found in few countries – U.S. China, Morocco (Global Phosphorus Research Initiative.
- Mining – Rare Earth Elements – Scandium and Terbium + 15 others. Needed for powerful magnets in wind turbines to electronic circuits in smartphones. 97% of world's supply comes from China.

Gulf of Mexico - sea-level changes




essentia
overachieving H_2O
9.5 pH
or higher
purified
water
electrolytes
for taste
IONIZED
HYDRATION
12 – 33.8 fl oz (1.06 qt) (1 L) bottles (Net 405.6 fl oz (3.2 gal) (12 L))


6
1 liter
Bottles
Great Value
Hydrate
Antioxidant
Water
Vapor Distilled Water
With Electrolytes
for Taste and Antioxidant Selenium
6 - 33.8 FL OZ (1 QT 1.8 FL OZ) 1 L BOTTLES
202.8 FL OZ (1 GAL 2 QT 10.8 FL OZ) 6 L TOTAL

Tektite


UNITED STATES OF AMERICA
IN GOD WE TRUST
LIBERTY
QUARTER DOLLAR


SLIDE FOCUS

Chesapeake Bay Impact site and North American strewn field

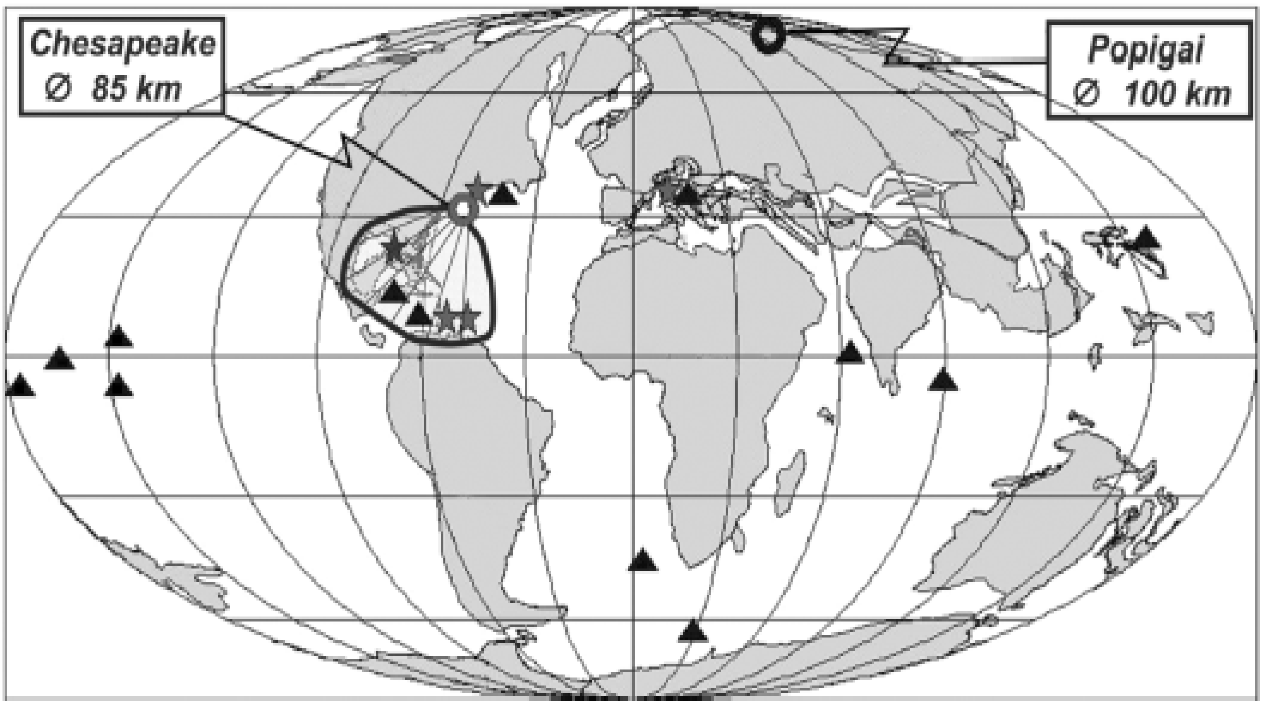
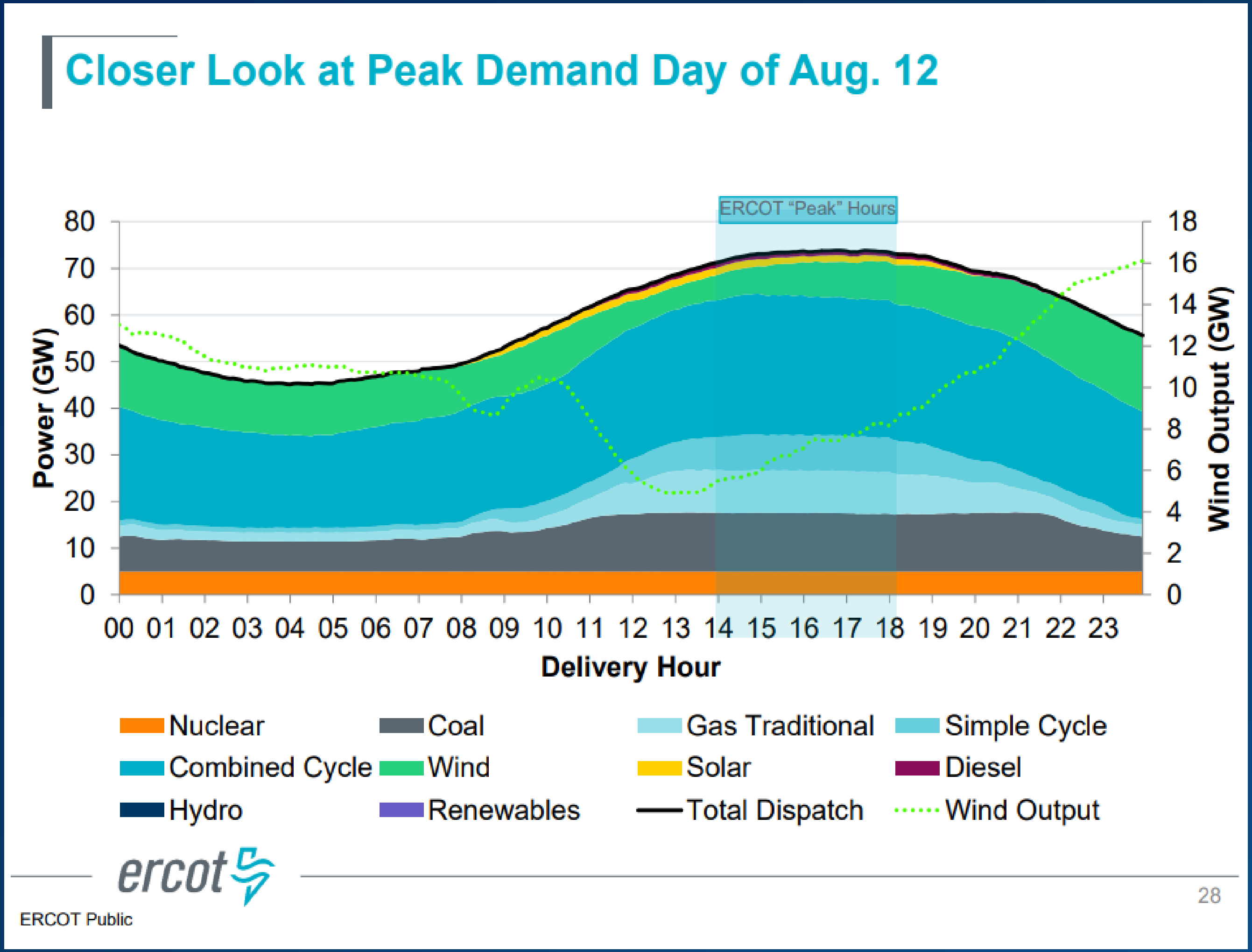


Fig. 1. The global distribution of ejecta material in the Upper Eocene (according to Simonson and Glass 2004) and the locations of the Popigai and Chesapeake Bay impact craters. Plate tectonic reconstruction for t = 35 Ma was done with the Internet tool by Schettino and Scotese (2001). Ø = diameter of the final crater. Triangles stand for locations containing Popigai ejecta material, stars for those with Chesapeake Bay–related ejecta. The North American tektite strewn field is outlined by a black line. Note that, according to Collins and Wünnemann (2005), the final Chesapeake Bay impact crater would have had only a diameter of about 40 km if it had formed on land.

Electricity supplies on August 12, 2019 in Electric Reliability Council of Texas (ERCOT) system

(Dispatchable v. Non-Dispatchable; frequency control and spinning reserve)



Any Questions?