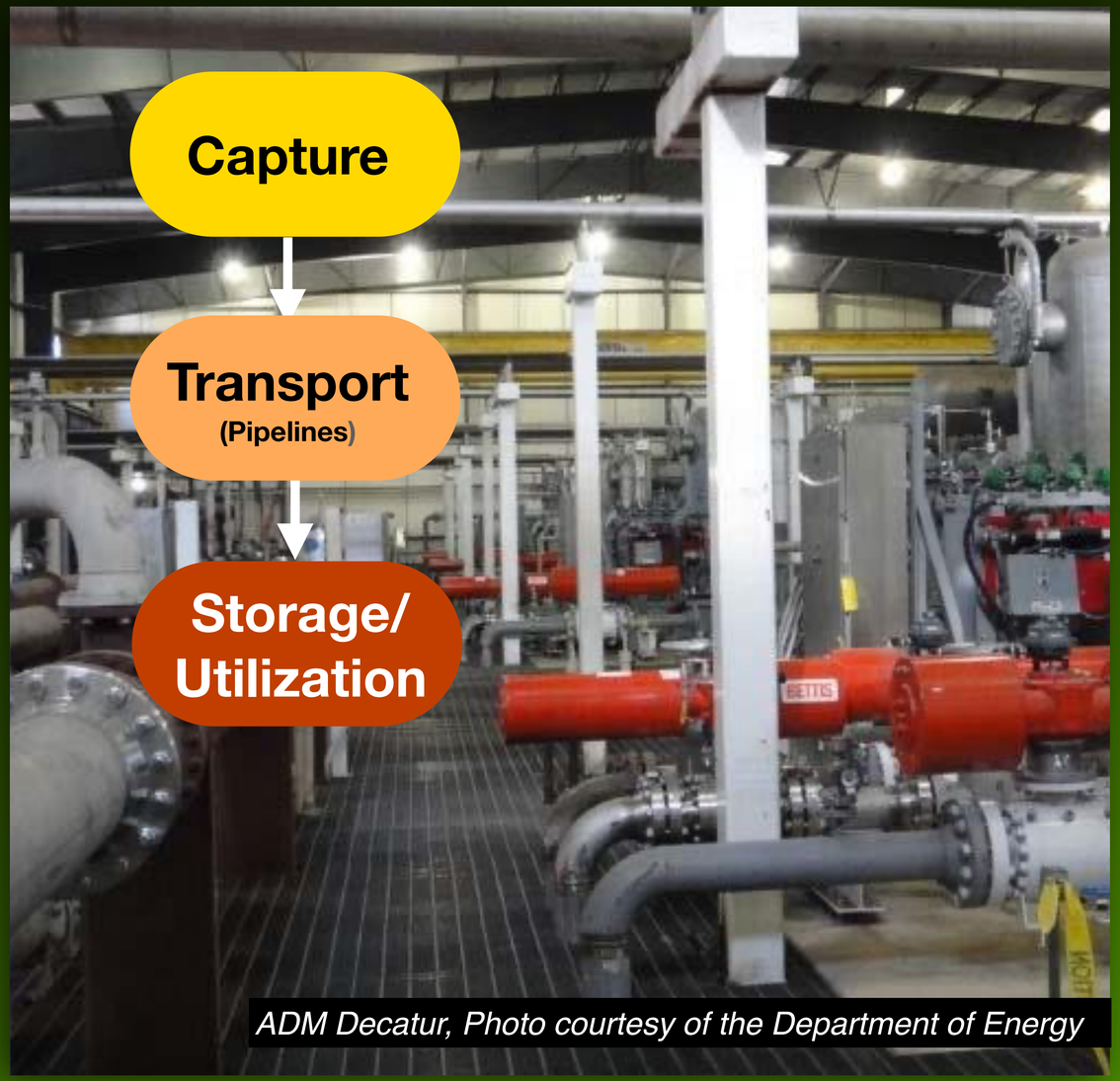
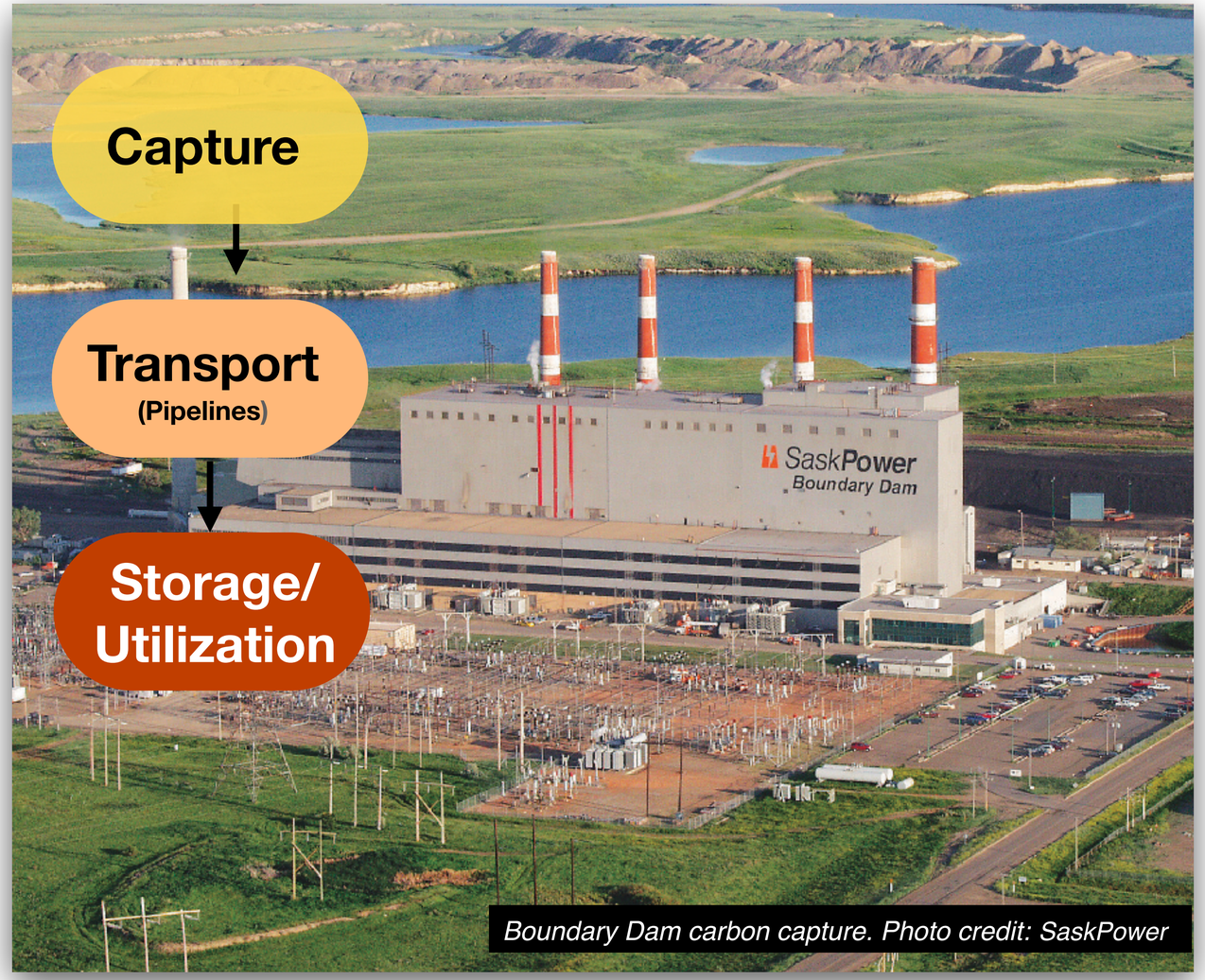
CCS and One Earth CO_2 pipeline



What is CCS?



Boundary Dam carbon capture. Photo credit: SaskPower

Carbon Capture and Store Defined

CCS is the process of capturing and storing carbon dioxide before it is released into the atmosphere

Once the CO_2 has been captured from an industrial or power plant, it is compressed into a liquid state and transported via pipeline to a location where it will be injected deep underground in geological formations

Companies are headed to Illinois, where geology has been determined to be among the best locations in the U.S. to store CO_2

Companies must obtain approval from the Illinois Commerce Commission (pipelines) and U.S. EPA (storage)

Primary concerns CO_2 pipelines

1. Public safety (impacts from pipeline leaks or ruptures).
2. Eminent domain / reduced property values.
3. Insurance coverage - uncertain.
4. Farm impacts from pipeline construction.
5. Relies on massive public subsidies.
6. No integrated plan.
7. No independent analysis required (social, environmental, economic).
8. No meaningful public involvement.
9. Has **NEVER been done** on scale proposed.

CO_2 pipelines differ from oil and gas

PCS Insights, Preventing Fracture in CO_2 Transmission Pipeline Systems

- Transported as supercritical liquid at 1,300 to 2,100 psi.
- With a leak, the rapid release of pressure results in a phase change from liquid to a gas that causes **running ductile fractures**.
- Leaks can get big fast, without warning.
- A large volume of gas escapes in a very short time, depending on the diameter of the pipe and the distance between adjacent valves.
- Gas can travel for over a mile, depending on topography and wind.

Satartia Mississippi, February 2020

Gassing of Satartia. Ziegert, Dan. Huffington Post. August 26, 2021

Satartia, MS CO_2 pipeline rupture

Denbury pipeline rupture 2020
Photo courtesy of the Yazoo County EMA, Mississippi

A 24-inch CO_2 pipeline ruptured in Yazoo County, MS in February, 2020:

- Pipeline weld was stressed by soil movement after days of heavy rain.
- Explosion created a 40-foot deep crater.
- The CO_2 plume released lasted four hours and traveled 1.25+ miles to Satartia.

CO2 displaced oxygen and hugged the ground:

- People in its path became intoxicated, and then convulsed.
- Over 200 people evacuated - rescue was difficult because cars wouldn't run.
- 45 were hospitalized and many have long-term health effects.

Other pipeline leaks …

Denbury pipeline rupture 2020
Figure 4, failed pipeline section. PHMSA failure investigative report. May 2022.

Yazoo County, Near Satartia

On October 2020 a second accident occurred in Yazoo County while reconnecting the damaged pipeline section.

A valve “froze in the open position due to internal ice formation” and gas poured out.

Multiple attempts to close it failed, and residents had to be evacuated on short notice.

The second incident lasted almost an entire day and released 41,000 barrels of CO_2.

The February 22 incident lasted four hours and released 31,407 barrels CO_2

April 3 Sulphur, LA CO_2 pipeline leak

An estimated 2,548 barrels of carbon dioxide (CO_2) leaked from the Exxon pipeline in Sulphur, LA.

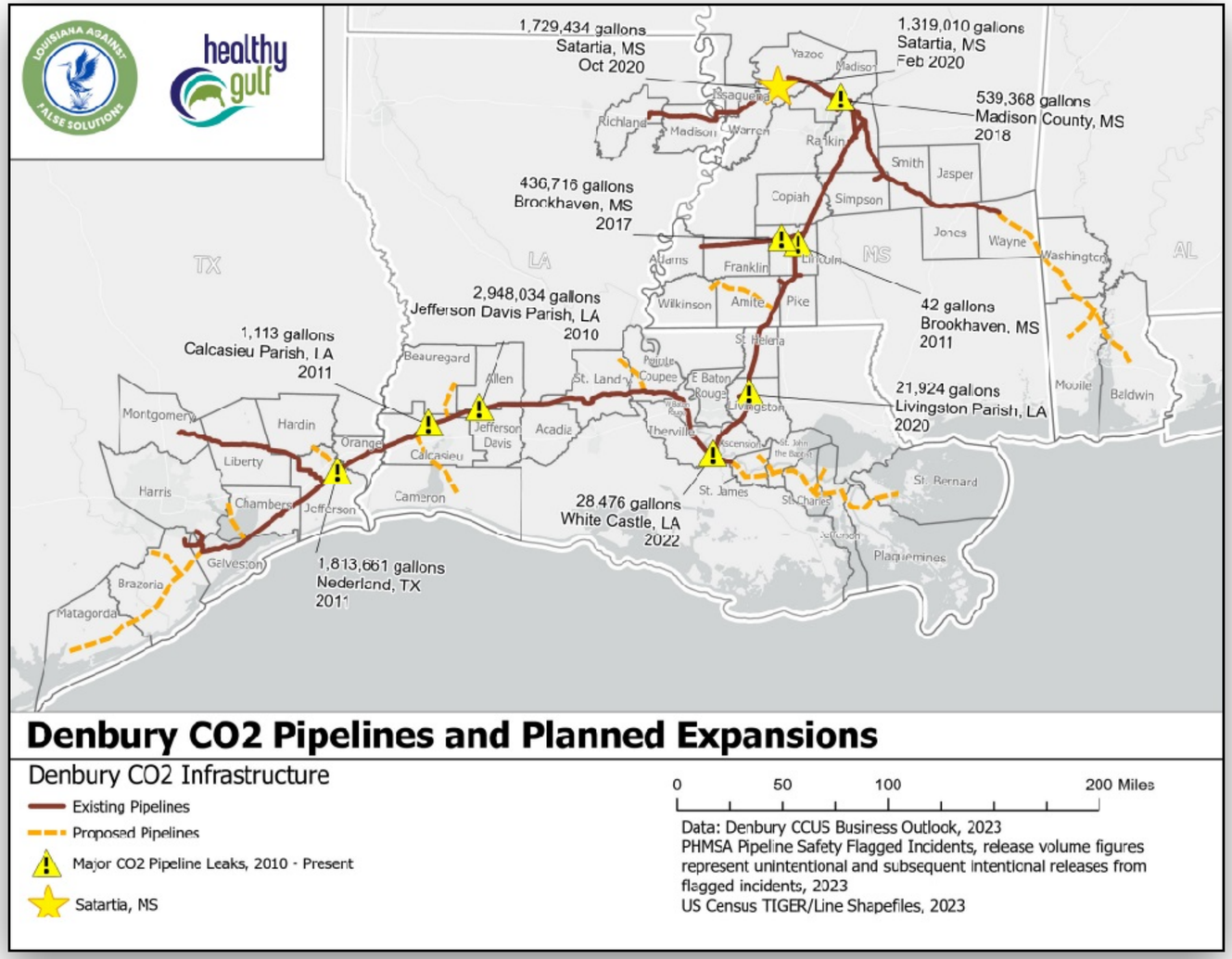
The incident reported to the sheriff by a resident after calls to the company were not answered.

No one was on site and the camera was not working. The company learned about the leak from emergency services.

Company should have known about the leak from pressure loss, and turned it off. Took two hours to get someone on site to stop it.

CO_2 pipeline companies often tout their 24/7 control room. But it is often farmers and residents that place the call.

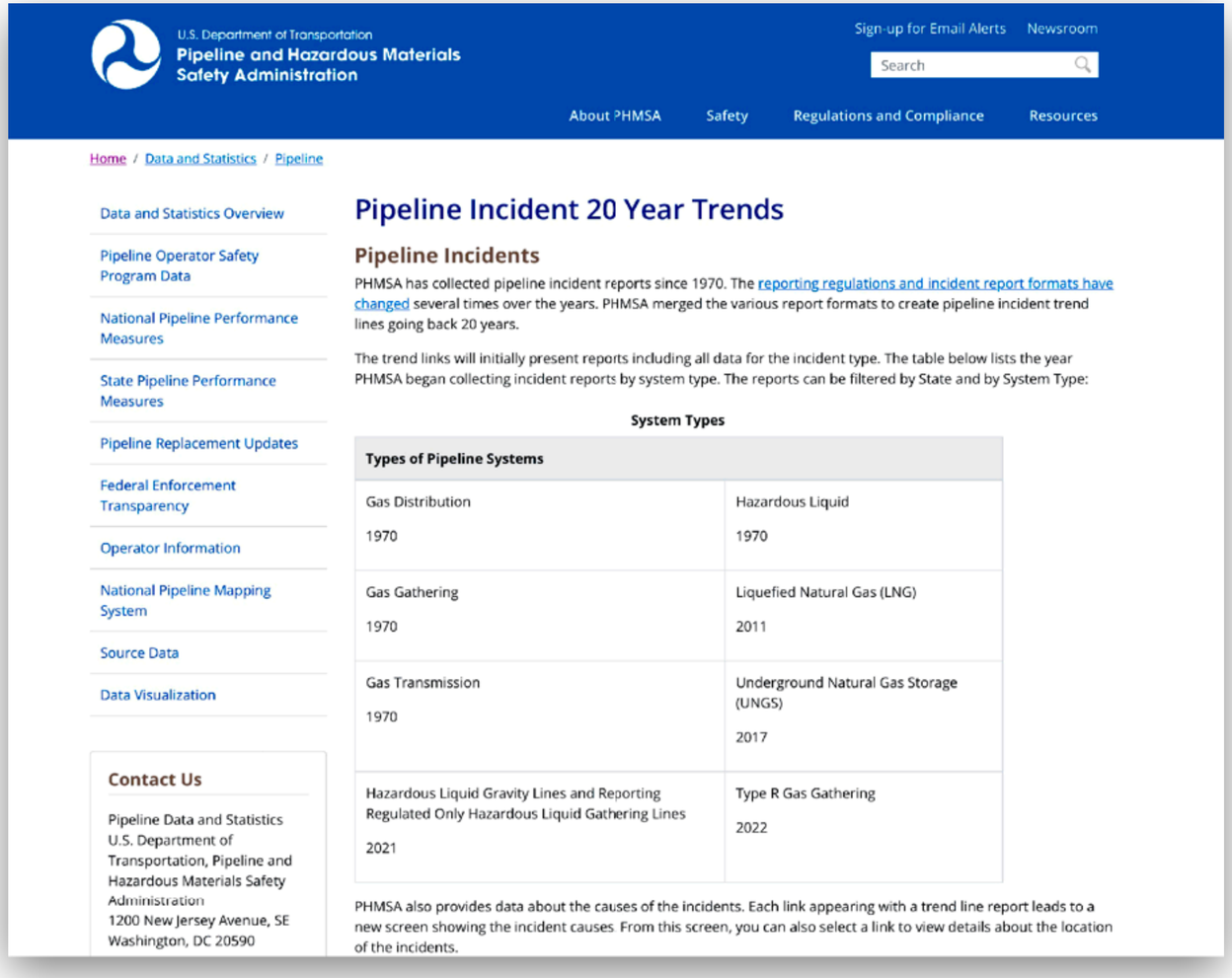
All pipelines leak or rupture



Denbury has reported **8 major CO_2 pipeline leaks** since 2010:

- One disaster and 7 “close calls.”
- This boils down to one accident every other year (2010 -2022) from Port Arthur, Texas to the Mississippi Delta.

PHMSA Database - CO_2 pipeline leaks



U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

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Contact Us

Pipeline Data and Statistics
U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

Pipeline Incident 20 Year Trends

Pipeline Incidents

PHMSA has collected pipeline incident reports since 1970. The reporting regulations and incident report formats have changed several times over the years. PHMSA merged the various report formats to create pipeline incident trend lines going back 20 years.

The trend links will initially present reports including all data for the incident type. The table below lists the year PHMSA began collecting incident reports by system type. The reports can be filtered by State and by System Type:

System Types

Types of Pipeline Systems	
Gas Distribution 1970	Hazardous Liquid 1970
Gas Gathering 1970	Liquefied Natural Gas (LNG) 2011
Gas Transmission 1970	Underground Natural Gas Storage (UNGS) 2017
Hazardous Liquid Gravity Lines and Reporting Regulated Only Hazardous Liquid Gathering Lines 2021	Type R Gas Gathering 2022

PHMSA also provides data about the causes of the incidents. Each link appearing with a trend line report leads to a new screen showing the incident causes. From this screen, you can also select a link to view details about the location of the incidents.

How many accidents? Look it up!

- Most CO_2 pipelines were built in the 1980s and 1990s. One source - often natural - used for EOR.
- Just 5,300 miles of CO_2 pipelines exist today. But that's an increase of 800 miles since 2015.
- This contrasts with the more than 3 million miles of natural gas and oil pipelines that cross our country.
- Between March 2010 and October 2023 there were 75 pipeline incidents reported. Most were in unpopulated areas.
- With the increase in the number of pipelines AND their complexity (more than one source) we can expect to see more accidents.

Causes of pipeline accidents

CAUSE	PERCENT	SUBTYPES
Equipment Failure	**53.03%**	1.52% Failure of equipment body 18.18% Malfunction of control / relief equipment 24.24% Non-threaded connection Failure 7.58% Other equipment failure 1.52% Threaded connection / coupling failure
Incorrect Operation	**15.15%**	1.52% Equipment not installed properly 6.06% Other incorrect operation 6.06% 1.52% Valve left or placed in wrong position 6.06% Wrong equipment specified or installed
Material Failure	**13.64%**	6.06 % Construction, installation or fabrication related 1.52%. Environmental cracking 6.06% Original manufacturing related
Corrosion failure	**10.61%**	10.61% External corrosion
Other Causes	**6.07%**	4.55% Miscellaneous 1.52% Damage by car truck or other motorized vehicle
Natural Force Damage	**1.52%**	1.52% Heavy rains/floods

Why pipelines fail

Over 90% of CO_2 pipeline accidents result from engineering/equipment/material failure or incorrect operation.

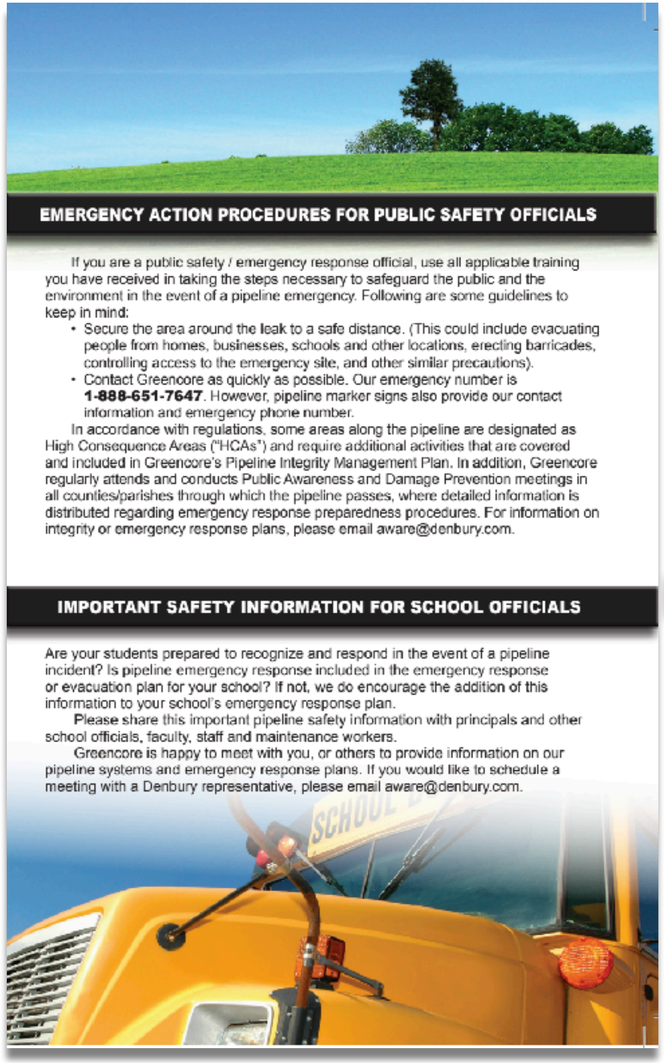
It's likely PHMSA will upgrade its rules to address these problems.

But once in the ground, CO_2 pipelines won't benefit from mandated safety improvements.

OES needs to wait for PHMSA to complete its rule-making process.

Source: Xi et al . Carbon Dioxide Pipelines: A Statistical Analysis of Historical Accidents. Journal of Loss Prevention in the Process Industries. 2023.

Safety Brochure, Greencore pipeline



EMERGENCY ACTION PROCEDURES FOR PUBLIC SAFETY OFFICIALS

If you are a public safety / emergency response official, use all applicable training you have received in taking the steps necessary to safeguard the public and the environment in the event of a pipeline emergency. Following are some guidelines to keep in mind:

- Secure the area around the leak to a safe distance. (This could include evacuating people from homes, businesses, schools and other locations, erecting barricades, controlling access to the emergency site, and other similar precautions).
- Contact Greencore as quickly as possible. Our emergency number is **1-888-651-7647**. However, pipeline marker signs also provide our contact information and emergency phone number.

In accordance with regulations, some areas along the pipeline are designated as High Consequence Areas ("HCAs") and require additional activities that are covered and included in Greencore's Pipeline Integrity Management Plan. In addition, Greencore regularly attends and conducts Public Awareness and Damage Prevention meetings in all counties/parishes through which the pipeline passes, where detailed information is distributed regarding emergency response preparedness procedures. For information on integrity or emergency response plans, please email aware@denbury.com.

IMPORTANT SAFETY INFORMATION FOR SCHOOL OFFICIALS

Are your students prepared to recognize and respond in the event of a pipeline incident? Is pipeline emergency response included in the emergency response or evacuation plan for your school? If not, we do encourage the addition of this information to your school's emergency response plan.

Please share this important pipeline safety information with principals and other school officials, faculty, staff and maintenance workers.

Greencore is happy to meet with you, or others to provide information on our pipeline systems and emergency response plans. If you would like to schedule a meeting with a Denbury representative, please email aware@denbury.com.

PIPELINE SAFETY MEASURES

Greencore takes many preventive measures to promote safe, reliable operations of our pipelines and related facilities, including:

- 24-hour monitoring of transmission pipeline operations
- Aerial and ground surveillance
- Regular testing of our pipelines
- Integrity management program

In addition, Greencore works closely with emergency officials in the communities through which our pipeline passes, to provide them with current and up-to-date informaton on emergency response procedures. This includes Public Awareness and Damage Prevention group meetings, training drills and other liaison activities to ensure open lines of communication.

Please call us – or your local law enforcement agency – to report any unusual or suspicious activity in our right-of-way ("ROW") or any unauthorized entry into our facilities.

RECOGNIZING A PIPELINE LEAK

While leaks from pipelines are rare, it is important for you to recognize the following indications that a CO2 release may have occurred through sight, sound or smell:

- Presence of a dense white cloud, fog or ice near the pipeline
- Dead, discolored or dying vegetation within an area of healthy plants
- Hissing, blowing or roaring sound and / or unusual blowing of dirt or dust into the air
- Bubbles in standing water

RESPONDING TO A SUSPECTED LEAK

Safety of the public, environment and company personnel is our highest priority. In the unlikely event of an incident, Greencore will immediately dispatch personnel to the site to control the situation and coordinate with emergency response agencies. We will also take necessary operating actions to minimize the impact of the event.

In the event of a suspected leak:

- Leave the area immediately on foot, walking in an upwind direction.
- Turn off and abandon any equipment or motorized vehicles used in the area and leave the area immediately on foot, walking upwind.
- Warn others to stay away from the area.
- From a safe location, call 911 and then call Greencore's emergency number at **1-888-651-7647**.
- **DO NOT** attempt to operate pipeline valves or extinguish any pipeline leak.
- **DO NOT** drive into a leak or vapor cloud area.
- **DO NOT** make contact with leaking liquids or gases.

Pipeline developers know

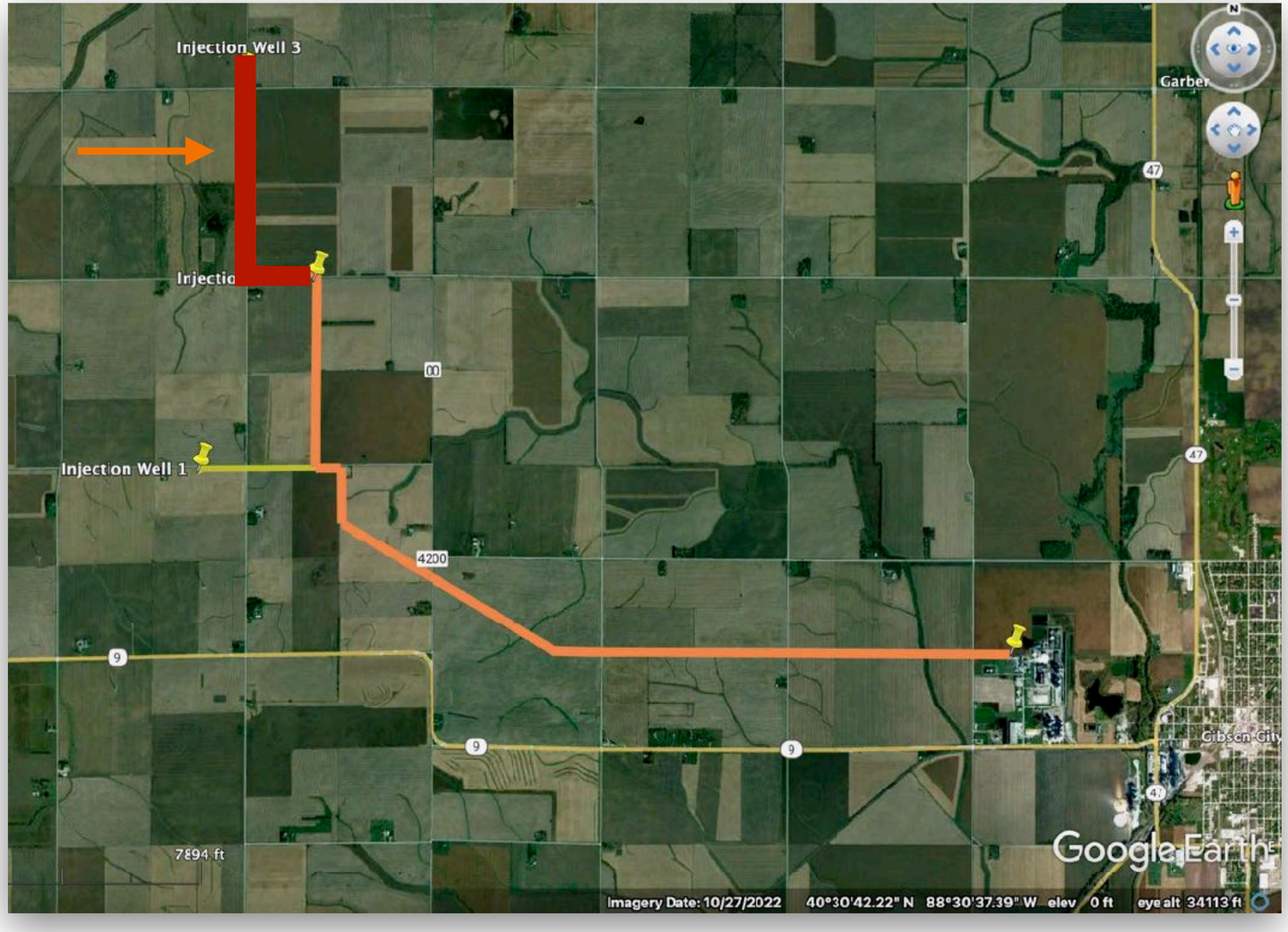
This excerpt from a safety brochure recommends:

- Coordination with public officials.
- Coordination with school officials, faculty, staff, and maintenance workers.
- Public awareness.

What do they say you need to do?Know the signs:

- A leak or rupture can present itself as a dense, white cloud near the pipeline.
- Plants can be dead or dying.
- There can be a hissing or roaring sound or blowing of dirt and debris into the air.
- You might see bubbles in standing water.
- Report a suspected leak or rupture.

Current OES proposal

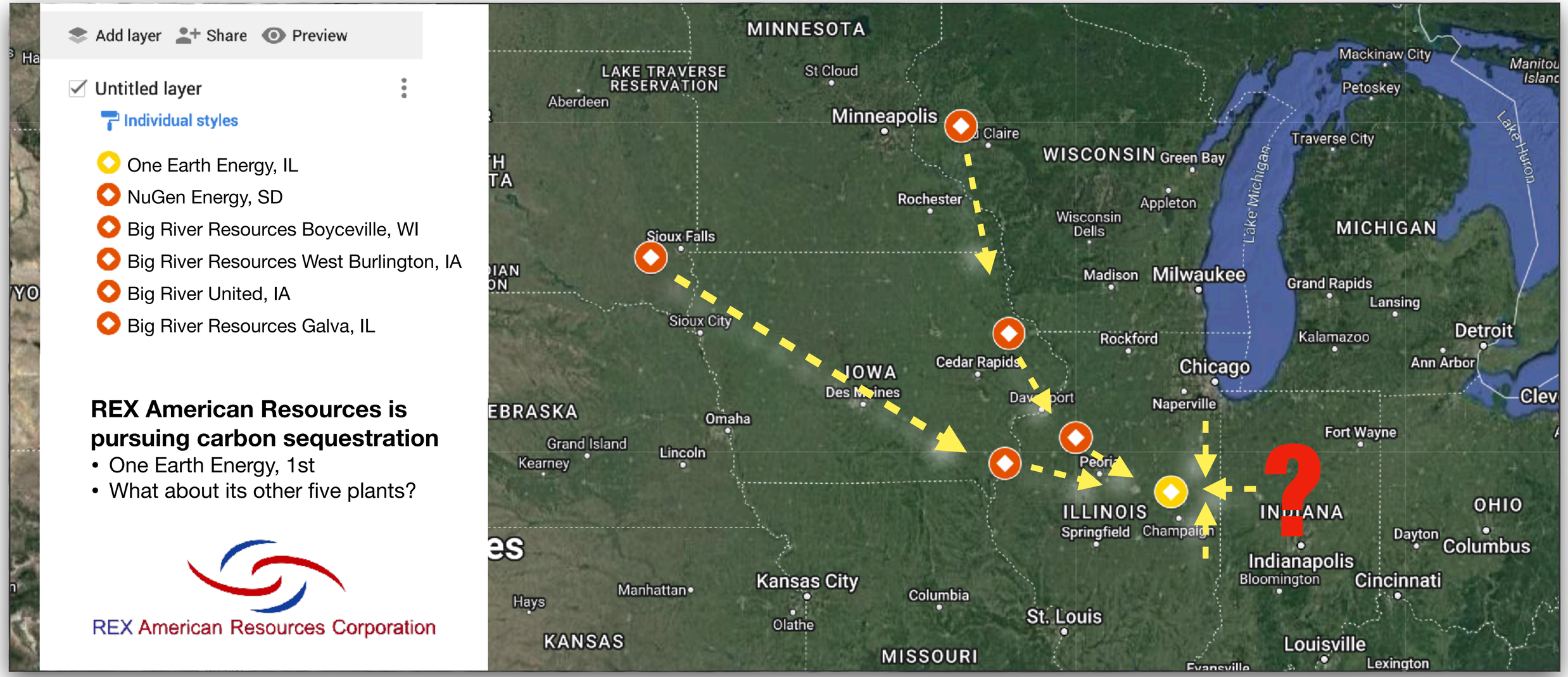


1. Well #3 (and associated pipeline) has been put on hold "**for now**". Shouldn't their plume modeling include that portion of CO_2 pipeline associated with Well #3 if it is still part of their project?

2. Capacity was reduced from 4.5 to 3.0 MMT /year.
   - Still **over 5 times** current need.
   - 2.5 MMT capacity unaccounted for.
   - Anticipate third-party users which will require additional pipelines.

3. OES is considering a 1 MMT direct air capture system with high energy and water use. But no details provided.

OES also planning additional customers



CO_2, a toxic asphyxiant

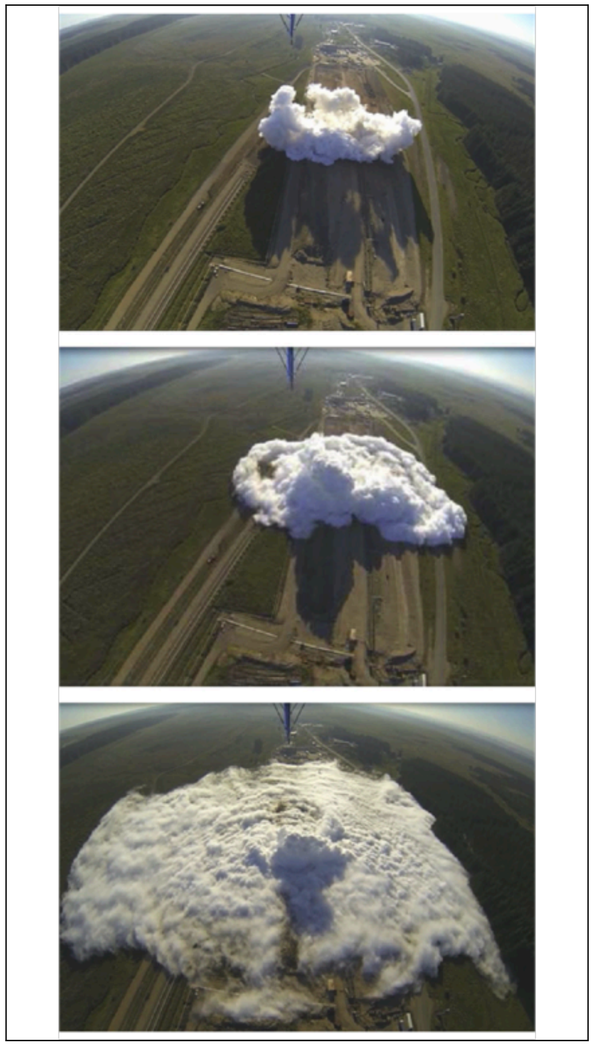
What do we know about CO_2?

In normal room air, carbon dioxide percentages are very low (around 0.04%). It is a colorless, odorless, and nonflammable gas that accumulates near the ground (CO_2 is 1.5 times heavier than air).

Carbon dioxide not only causes asphyxiation by hypoxia but also acts as a toxicant. High CO_2 concentrations can cause seizures, hearing and vision loss, respiratory dysfunction, disorientation, coma or even death - all within minutes.

Concentrations of CO_2 we need to be concerned about:

- 3%: Maximum 15-minute short-term exposure level.
- 4%: Immediately dangerous to life and health.
- 5% to10% Unconsciousness, convulsions, coma and death.



Images courtesy of Dr. Mohammad Ahmad, former project manager, DNV GL

CO_2 Toxicity

CO_2 Concentration (ppm)	Health Effect	Timing
20,000 ppm (2%)	Respiratory center stimulated causing increases in breathing (tidal) volume	Rapid
30,000 ppm (3%)	Moderate respiratory stimulation, increased heart rate and blood	**15 minutes** Short-Term Exposure Limit [CDC]
40,000 ppm (4%)	Increase in breathing rate becomes distressing; development of respiratory acids	**Immediately dangerous to life and health** [NIOSH][1]
50,000 ppm to 100,000 ppm (5% to 10%)	Dimmed sight, sweating, tremor, increased heart rate and blood pressure, and exposure can lead to unconsciousness[2]	Within a few minutes
More than 100,000 ppm > (10%)	Can cause convulsions and coma in less than a minute	Death within 10 minutes
200,000 ppm to 300,00 ppm 20-30%	Loss of consciousness and death	Within one minute

[1]This level can cause confusion and impair ability to respond and get to safety.

[2]Inhalation of high concentrations of CO_2 can sharply lower the pH of blood and tissues (acidosis) causing acute effects on the respiratory, cardiovascular, and central nervous systems.

CO_2 plume modeling

If the OES pipeline were to rupture … CO_2 would:

Exceed 50,000 ppm: 4 occupied residences

- *How much more?*
- *Which homes?*
- *Not disclosed*

Approach 50,000 ppm: 3 occupied residences

- *Which homes?*
- *Not disclosed*

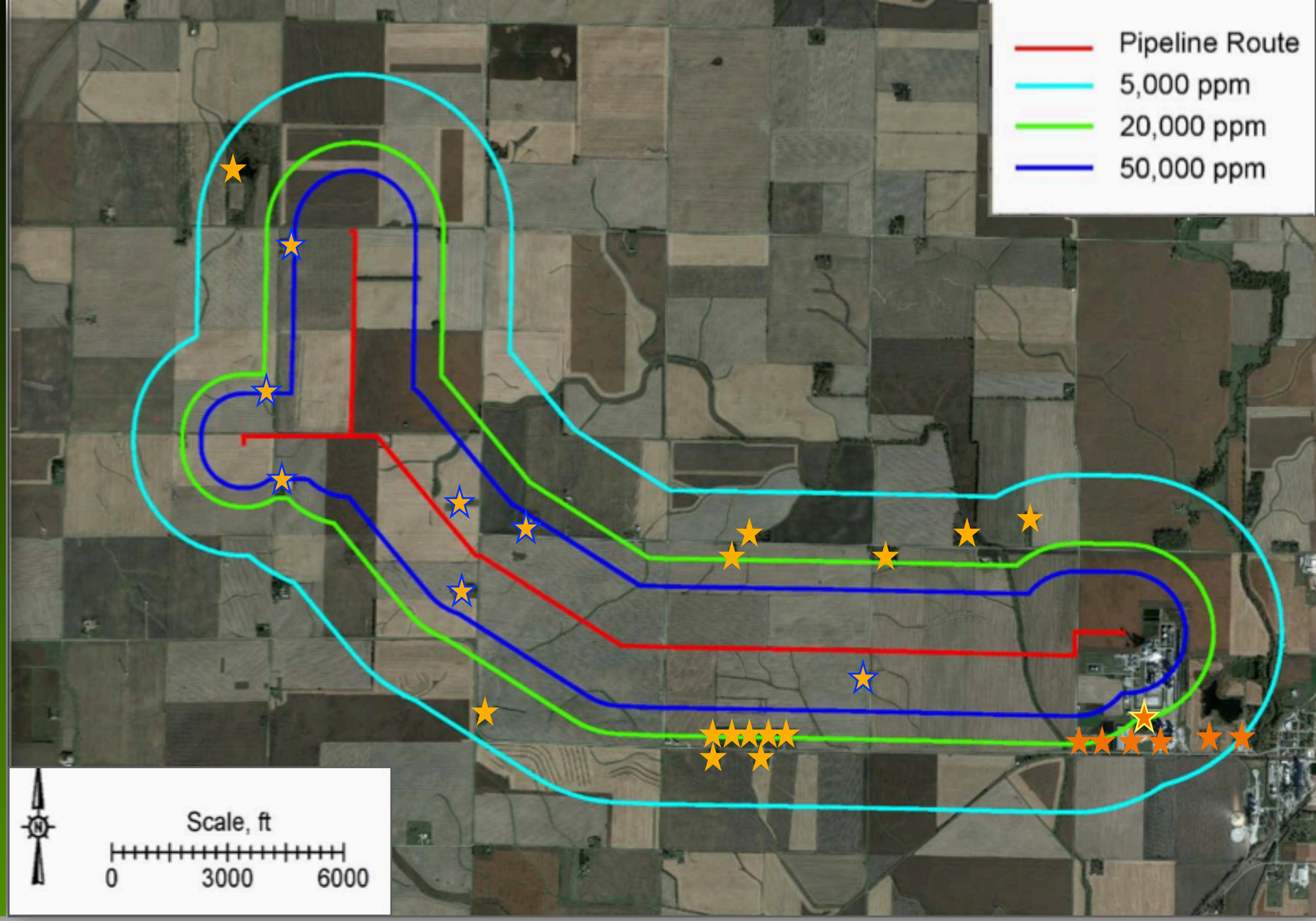
5,000 to 20,000 ppm: 14 occupied residences

- *Which homes?*
- *Not disclosed*

Source: Rebuttal Testimony Mark Ditsworth
OES #23-0708, Exhibit 2.6. March 27, 2024

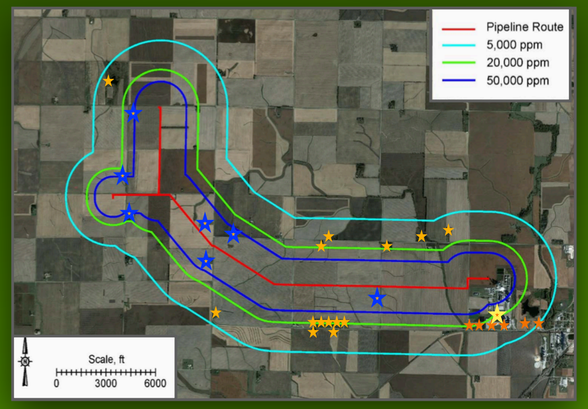
CO_2 plume modeling

- Home
- Home exposed to 5% or greater
- Government Building
- Commercial / Industrial



Source: FIGURE 9
Dispersion Vulnerability Zones for a Rupture During Worst-Case Weather Conditions

CO_2 plume modeling



BUILDING	>50,000 ppm (1,560 feet)	20,000 to 50,000 ppm (2,280 to 1,560 feet)	5,000 to 20,000 ppm (4,040 to 2,280 feet)
Home	575		
Home	970		
Home	975		
Home	1,163		
Home		2,022	
Commercial		2,032	
Government		2,044	
Home		2,086	
Home		2,228	
Home		2,270	
Home			2,310
Commercial			2,405
Home			2,423
Home-Farm			2,533
Home			2,538
Commercial			2,551
Commercial			2,551
Home			2,603
Home			2,636
Home			2,637
Home			2,953
Home			2,984
Commercial			2,993
Home			3,095
Home-Farm			3,300
Home-Farm			3,390
Home-Farm			3,393
Home-Farm			3,628
Home			3,823
Commercial			3,869
Home			3,888

KEY OBSERVATIONS

The worst case scenario shows no impact to Gibson City.

- But wind speed **can affect dispersion** of CO_2 and **the time** people are exposed to this toxic asphyxiant.
- Better modeling, with a variety of wind speeds, atmospheric conditions, and topography would better predict what could happen to Gibson City.

31 buildings are in the plume area, based on distance from the pipeline, **vs. the 21** OES identified.

CO_2 levels for:

- 4 homes would **exceed 50,000 ppm**. But, by how much?
- 4 homes, 1 business, and 1 government building **would exceed 20,000 ppm.** But by how much?
- 16 homes and 5 businesses would be all be **above 20,000 ppm.** But by how much?

Need better CO_2 plume modeling

How accurate is the model used by OES?
PHAST, ALOHA, SLAB, and CANARY are simplistic dispersion models that assume uniform concentrations of CO_2 moving in the direction of prevailing winds.

Dispersion models are simpler to use and provide results more rapidly. However, their accuracy is questioned by many experts.

Computational fluid dynamics (CFD) modeling takes into account more complex atmospheric conditions, topography, and dynamics of explosive eruptions.

The simple model used by Denbury to predict dispersion of CO_2 in the event of a CO_2 rupture near Satartia **got it wrong**. An "after-the fact" more precise model predicted exactly what happened.

OES should use the more precise CFD modeling to protect Ford and McLean County residents.

Need better CO_2 plume modeling

OES needs CFD modeling to show the location and number of homes and businesses that would be exposed to levels of CO_2 at the following levels:

- 50,000 to 100,000 ppm. Residents exposed to levels of CO_2 above 50,000 ppm **could die** before they are rescued.
- 40,000 ppm and 50,000 ppm. 40,000 ppm is **immediately dangerous** to life and health [NIOSH].
- 30,000 ppm to 40,000 ppm. 30,000 ppm for 15 minutes is the **maximum allowable** short term-exposure limit [CDC].
- 20,000 ppm to 30,000 ppm.

Topography. There is a 110-foot difference in elevation, and Gibson City is at the lower level. CO_2 hugs the ground and moves toward lower elevations. **Only CFD modeling can confirm that Gibson City won't be affected in the event of an accidental release**

Need better CO_2 plume modeling

Instead, their proposed solution is to provide oxygen to landowners

This proposal is an outright admission that the OES project is hazardous to life and human health

Emergency Response Plan

OES' emergency plan is a plan to have a plan
The plan includes pre-incident and post-incident procedures by over a dozen individuals with a myriad of responsibilities

Key questions:

- How will local, volunteer first responders be able to respond **within minutes** to life threatening situations? Critically important. Not addressed
- What equipment will be provided … by whom, and who pays? What about maintenance?
- What training will be provided for emergency responders, and by whom?
- How will residents (and first responders) be alerted of a CO_2 release? Will they, too, be trained?

Who Regulates CO_2 Pipelines?

The Federal Energy Regulatory Commission has determined that it has no jurisdiction over CO_2 pipelines

The Illinois Commerce Commission approves the route and overall plan subject to considerations of economy, infrastructure, public safety, property values, and energy reliability

PHMSA has exclusive responsibility for setting the design, construction, and operation. They have little to no oversight until there is a problem

Rulemaking to improve safety

PHMSA Announces New Safety Measures to Protect Americans From Carbon Dioxide Pipeline Failures After Satartia, MS Leak

Thursday, May 26, 2022
PHMSA 05-22

WASHINGTON - The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) today announced it is taking steps to implement new measures to strengthen its safety oversight of carbon dioxide (CO2) pipelines around the country and protect communities from dangerous pipeline failures. The new measures, as well as an enforcement action taken today are a result of PHMSA's investigation into a CO_2 pipeline failure in Satartia, Mississippi in 2020 that resulted in local evacuations and caused almost 50 people to seek medical attention.

To strengthen CO_2 pipeline safety, PHMSA is undertaking the following:

- initiating a new rulemaking to update standards for CO_2 pipelines, including requirements related to emergency preparedness, and response;
- issuing a Notice of Probable Violation, Proposed Civil Penalty, and Proposed Compliance Order (NOPV) to Denbury Gulf Coast Pipeline, LLC for multiple probable violations of Federal pipeline safety regulations (PSRs). The proposed civil penalties amount to $3,866,734.
- completing a failure investigation report for the 2020 pipeline failure in Satartia, Mississippi;
- issuing an updated nationwide advisory bulletin to all pipeline operators underscoring the need to plan for and mitigate risks related to land-movements and geohazards that pose risks to pipeline integrity like the 2020 incident in Satartia, Mississippi; and
- conducting research solicitations to strengthen pipeline safety of CO_2 pipelines.

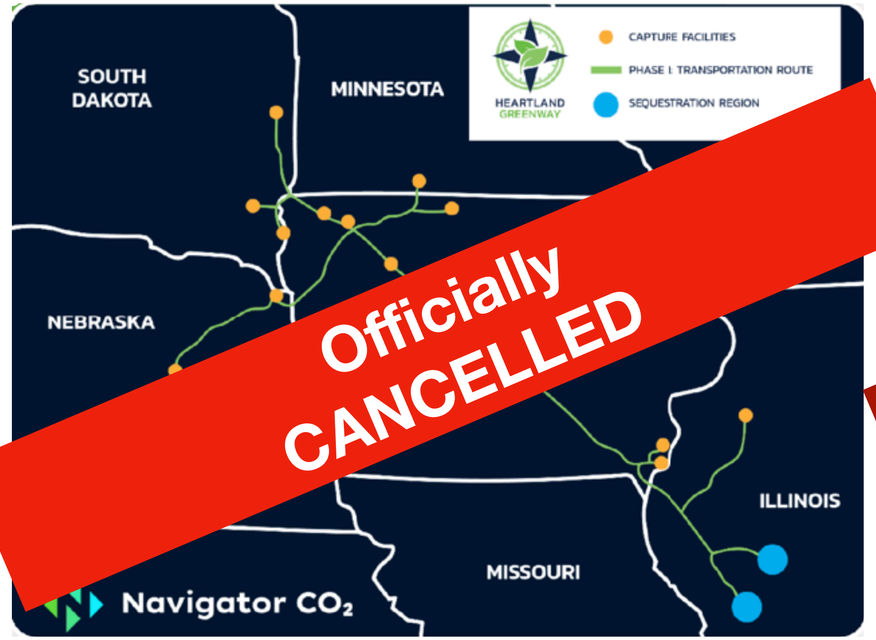
Regulatory Gaps

Yet … pipeline developers are moving forward **before** PHMSA's rule-making is finished

PHMSA currently does not:

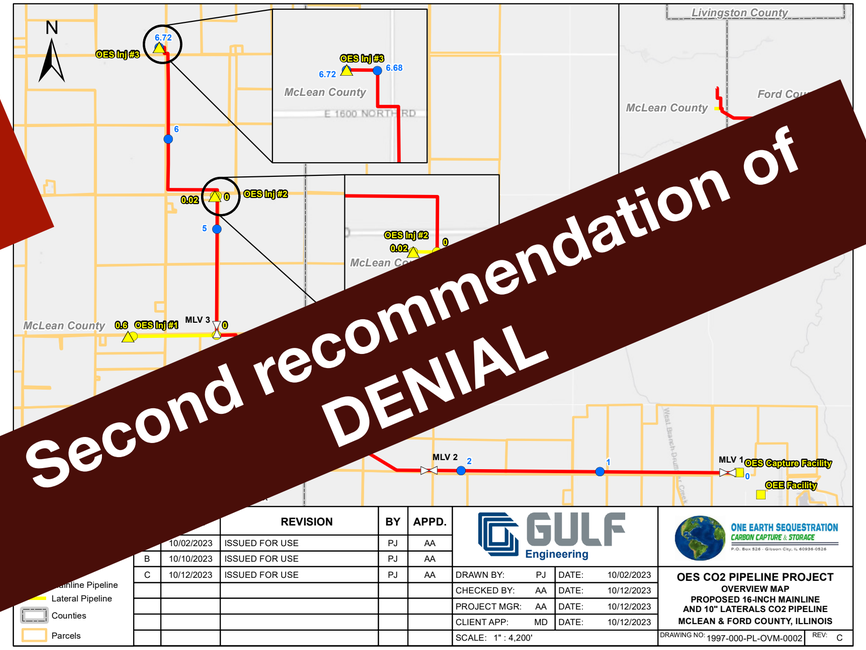
- Regulate pipelines that transport CO_2 as a liquid or gas.
- Have design standards in place to mitigate running ductile fractures.
- Require odorants to detect CO_2.
- Have standards to limit maximum concentrations of impurities, including water.
- Establish standards for plume modeling or safe setbacks.

It’s not just One Earth



Navigator CO2 Ventures
ICC Docket #23—0161

Wolf Carbon Solutions
ICC Docket #23-0475



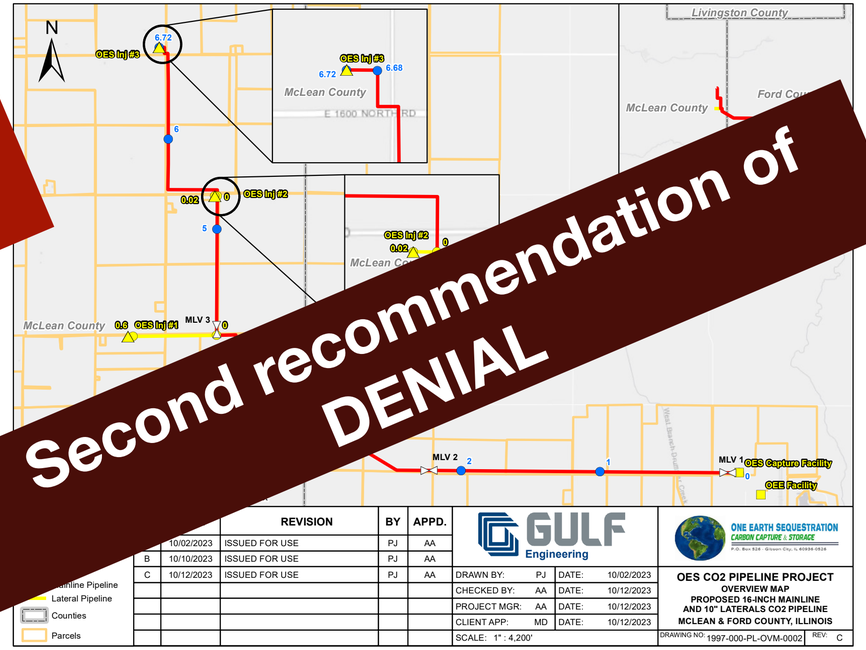
One Earth Sequestration LLC
ICC Docket #23-0708

Three pipeline companies have filed applications with the ICC over the past two years

It’s not just One Earth

Navigator CO2 Ventures
ICC Docket #23—0161

Wolf Carbon Solutions
ICC Docket #23-0475

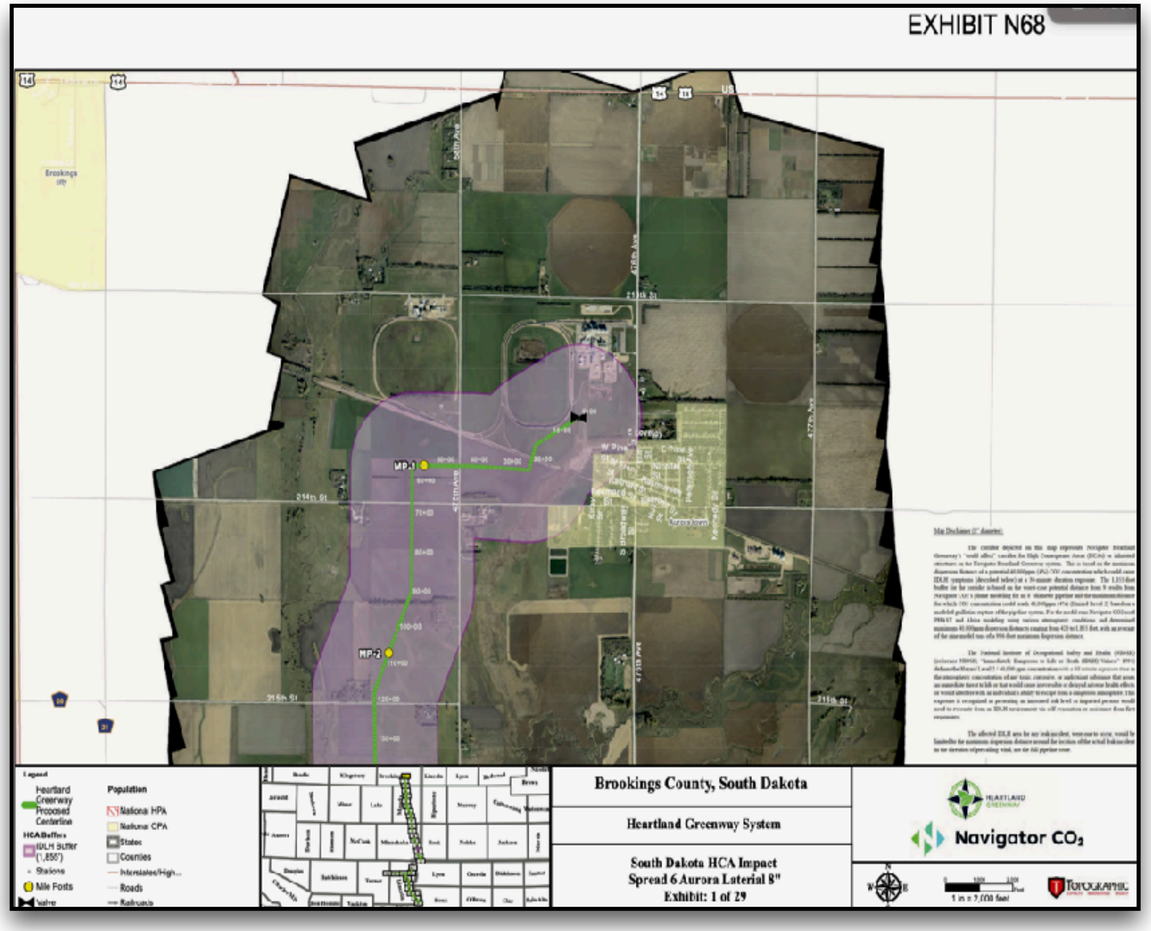


One Earth Sequestration LLC
ICC Docket #23-0708

Primary concerns by the ICC have been tied to PHMSA rules

But neither PHMSA nor the ICC can regulate setbacks

Illinois must set criteria for routing

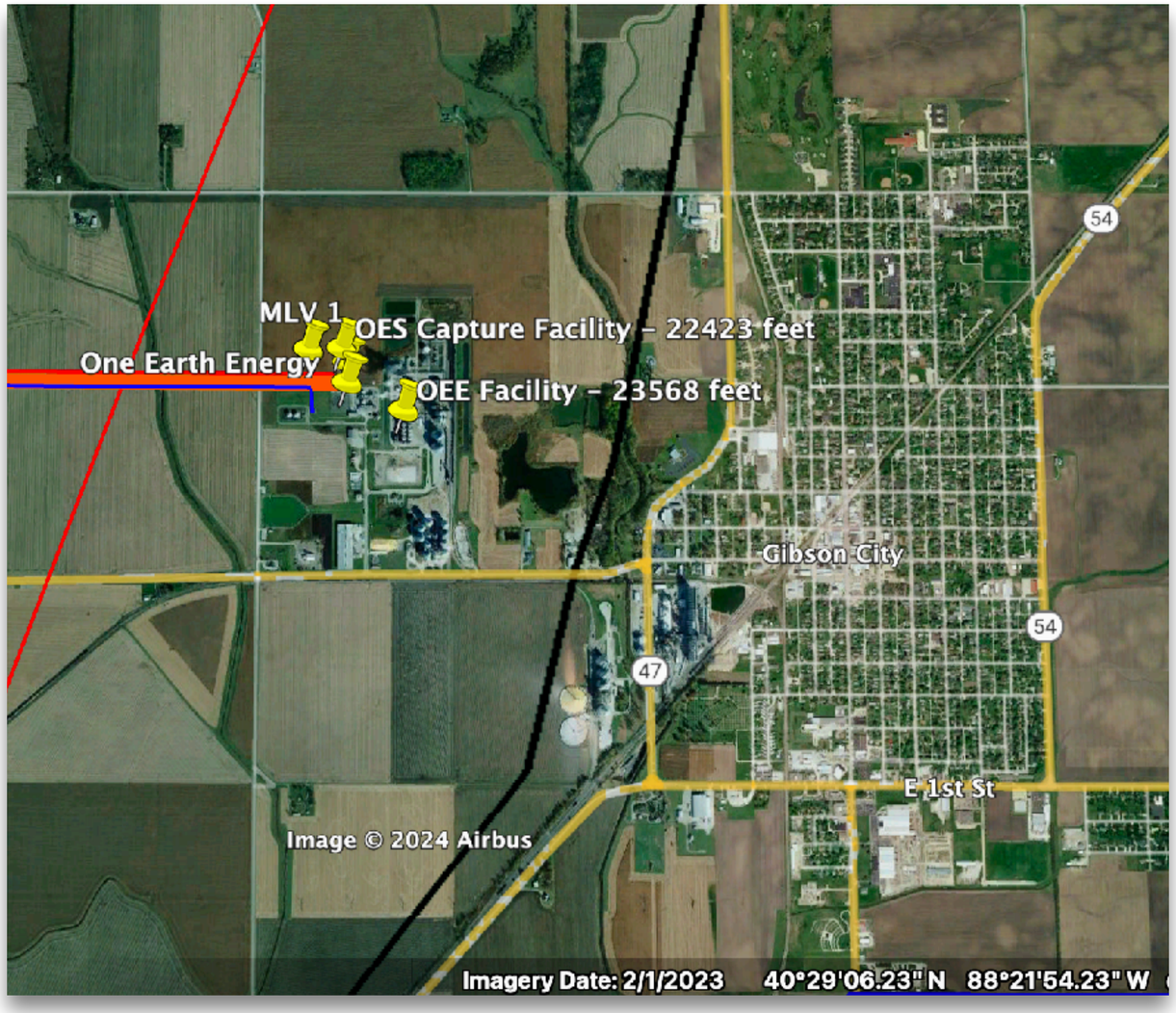


Source: Navigator CO_2 Ventures
Plume modeling, South Dakota

Support HB HB5814 and SB3920, the Carbon Dioxide Transport and Storage Protections Act, and a CO_2 pipeline moratorium in place until these regulations are in place to protect Illinois residents. These bills would require:

- The State of Illinois to study the effects of CO2 on humans and set threshold criteria that can be applied to a developer's proposal.
- Developers to use the most precise modeling available (currently CFD).
- A robust public process. Developers would be required to consult with local governments and the general public, taking into account input **before** finalizing their route

CO_2 Pipeline “takeaways”



OES is part of a **massive buildout of CCS infrastructure planned nationwide** driven by billions of dollars in subsidies, without:

1. Full understanding of short- and long-term impacts
2. Adequate public awareness and input
3. Full transparency of:
   - Plume modeling and impacts on people
   - Emergency planning commitments.
   - Full project build-out
4. Adequate protections at the local, state, and federal levels

Questions or need more information?

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