Assessing Wellbore Integrity Risk in the Gulf of Mexico for Potential CO_2 Storage Applications in Depleted Fields

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Outline

Overview of Offshore Well Integrity

- Our Scope
- Summary of Risks
- Other Offshore Well Integrity Analyses

Methodology

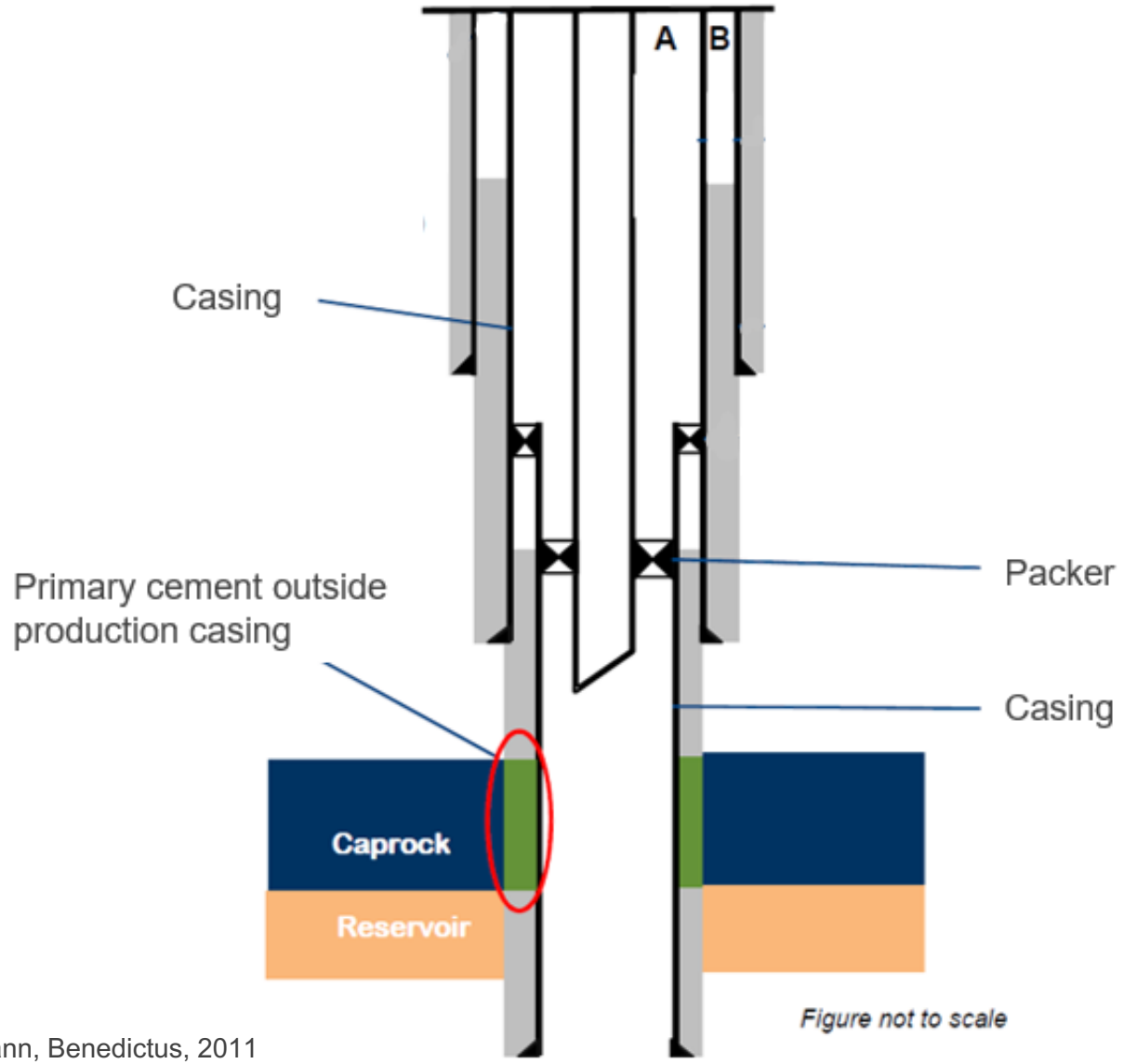
- Case Study Areas
- Data Collection
- Well Integrity Risk Assessment Workflow - risks and impacts

Deepwater Case Study

- Summary of data, risk assessment

Scope

- To enable safe CO_2 storage in offshore reservoirs:
- **Develop a workflow for ranking wellbore integrity for potential CO_2 storage applications from well records in depleted fields**
  - Initial scoping tool to be used before finalizing site selection
- Wellbore cement integrity is important, followed by casing integrity
- Can be applied to prospective sites in the rest of Gulf of Mexico



Adapted from Akemu, Mersemann, Benedictus, 2011

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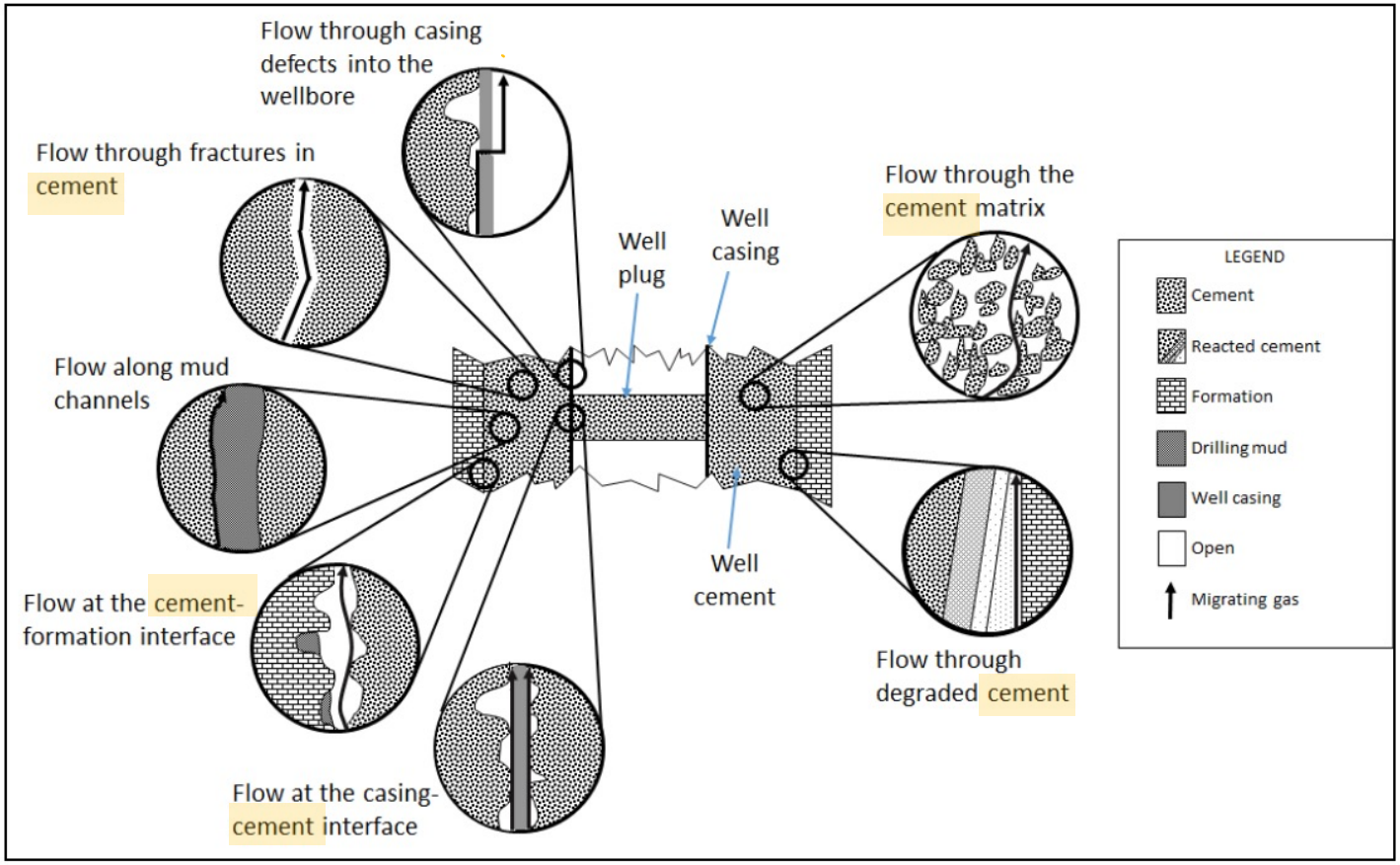
Summary of Leakage Pathways at a Wellbore

Leakage pathways could be from multiple cement defects, casing defects, at the well plug



Gasda et al., 2004

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Other Offshore Well Integrity Analyses

- Australia, Netherlands, U.K
- Focus:
  - cement integrity at caprock and cement plugs, CBLs
  - casing information and any well competition defects (for reuse of legacy wells)

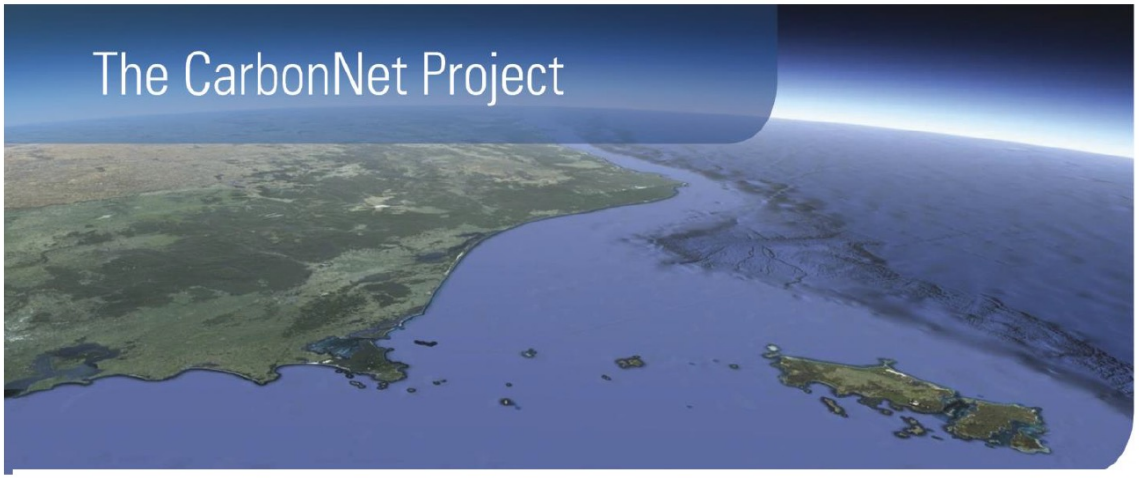
PETERHEAD CCS PROJECT

Peterhead CCS Project

Doc Title: Well Integrity Assessment Report

Doc No. PCCS-05-PT-ZW-7180-00004

Date of issue: 19/09/2014



CATO-2 Deliverable WP3.4-D22

Well integrity assessment of the P18 gas field (TAQA)

Prepared by	Onajomo Akemu (SLB) Ulrike Miersemann (SLB) Tjirk Benedictus (TNO)
Reviewed by	Manuel Nepveu (TNO) Jean Desroches (SLB)
Approved by	J. Brouwer (CATO-2 Director)

Integrity of Wells in the Near-shore Area Gippsland Basin Victoria

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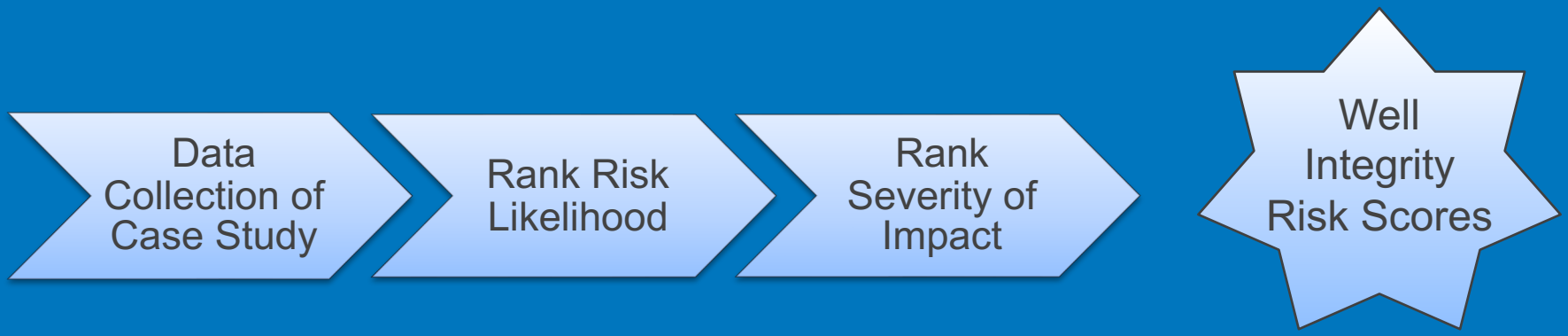
Methodology of Well Integrity Assessment



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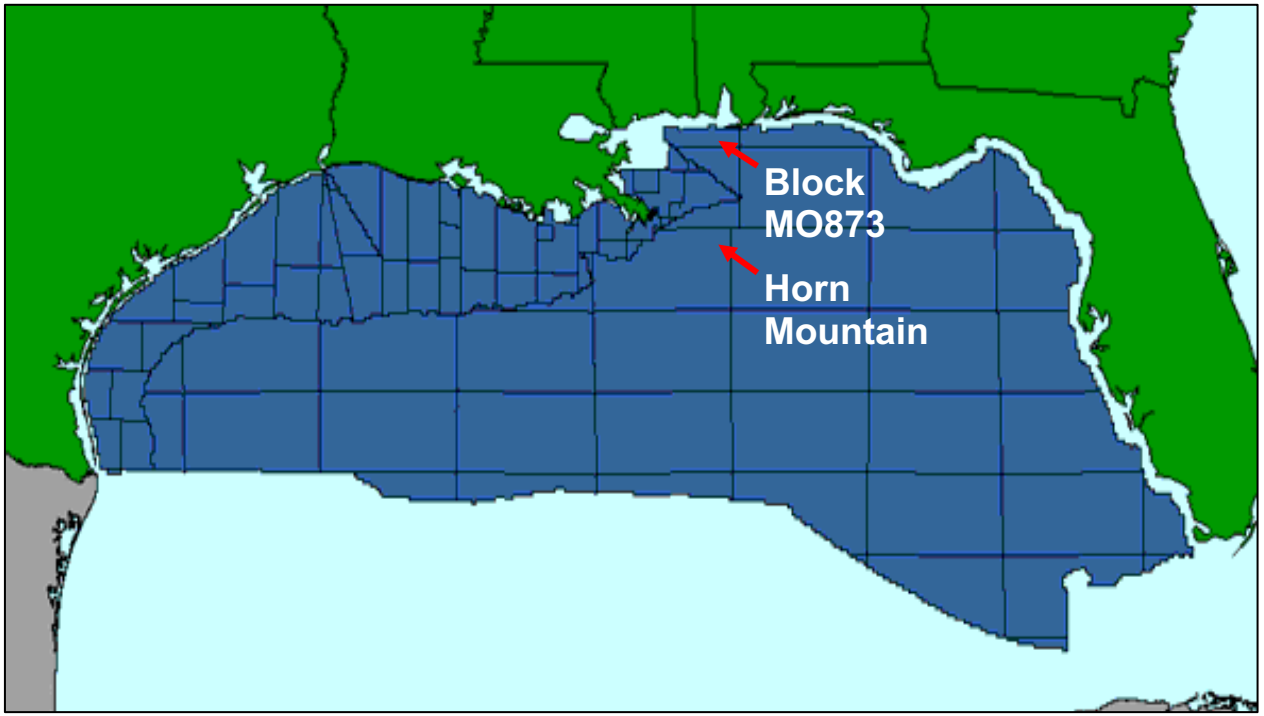
Case Study Areas

- Initial focus is on the Horn Mountain depleted field, Mississippi Canyon and in the Mobile Block
- Chosen to develop a methodology from range of wells
- Methodology can be applied throughout the rest of the study area



https://woodshole.er.usgs.gov/pubs/of2005-1071/htmldocs/catalog.htm

Required Data

- Data requirements for a well integrity analysis were established
- Geologic data
  - Reservoir formations
  - Reservoir characteristics (depth, porosity, permeability)
  - Presence of caprock
- Well ID and Location Data
  - Well API numbers
  - Geographic location of wells
  - Longitude and latitude
- Wellbore data
  - Well construction (age, depth, borehole diameter, casing, cement, etc.)
  - Well status (producing, abandoned, cement plugs, plug depths)
  - Well history (workovers, well corrosion, blowouts)

Data Collection

- Geologic data collection
  - ARI and literature
- Well location and construction data
  - ARI
  - Bureau of Safety and Environmental Enforcement (BSEE), and Enverus
- Data types and formats
  - **Four wells – 185 files**
  - Completion reports, drilling permits, operations reports, SCPs for gas lifts, geophysical logs (caliper logs), PDF files, and image files

ENVERUS

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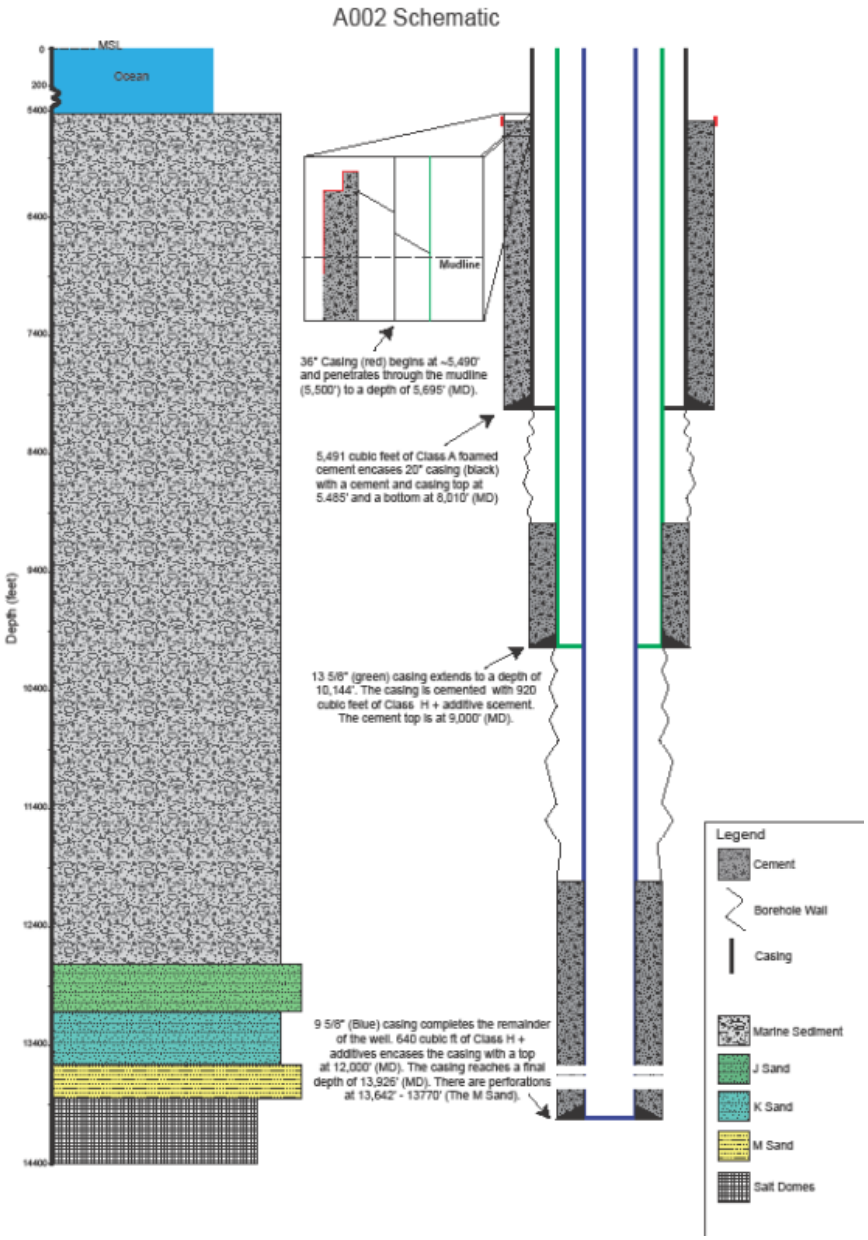
Data Collection

- General Well Data
  - API number, long./lat., depth, age, well trajectory, and status data in an excel file
- Well construction data
  - Casing, cementing depths, cement type, cement additives, and workover history data was provided in PDF and image files



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Well Integrity Risk Assessment Workflow

Risk = Likelihood * Impact

Adapted from Duguid et al., 2017, 2021

Factors of Risk Likelihood	Low Risk (1)	High Risk (5)
Well Status	producing	P&A, dry, unknown, inactive, orphan
Well Deviation	low deviation or deviation >30º	high angle deviation (30º) or unknown
Well Age	post 1990	pre 1950 or unknown
Well Depth	<2600 ft MSL	within injection interval or unknown
Well Type	oil or gas well	water injection well
Well Density	no wells within 0.5 mi	5 wells within 0.5 mi
Suspension Status (compliant, length of suspension)	<5 years	not compliant
Gas Migration of Surface Casing Vent Flow	none	significant
Casing Failure History (SCP)	none	yes
Cement Quality/location (PNL, wellhead T and P, SCP, casing vs bit size)	silica additives, appropriate thickness, through caprock, appropriate casing vs bit size	no silica additives, not through caprock, inappropriate casing vs bit size, or unknown
Cement Thickness/through caprock	100-80%	0-20%
Well Modifications and Sidetracks	No sidetracks/relevant modifications	sidetracks and integrity risk modifications

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Casing Connections	Premium connection	Unknown, inappropriate connection

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P&A Factors of Risk Likelihood	Low Risk (1)	High Risk (5)
Bottom plug depth criteria (TD and bottom plug depth)	0-100 ft	Greater than 1000 ft or unknown
Percent of wellbore plugged (height of cement column/TD)	> 15%	0-5% or unknown

Risk Assessment

Risk = Likelihood * Impact

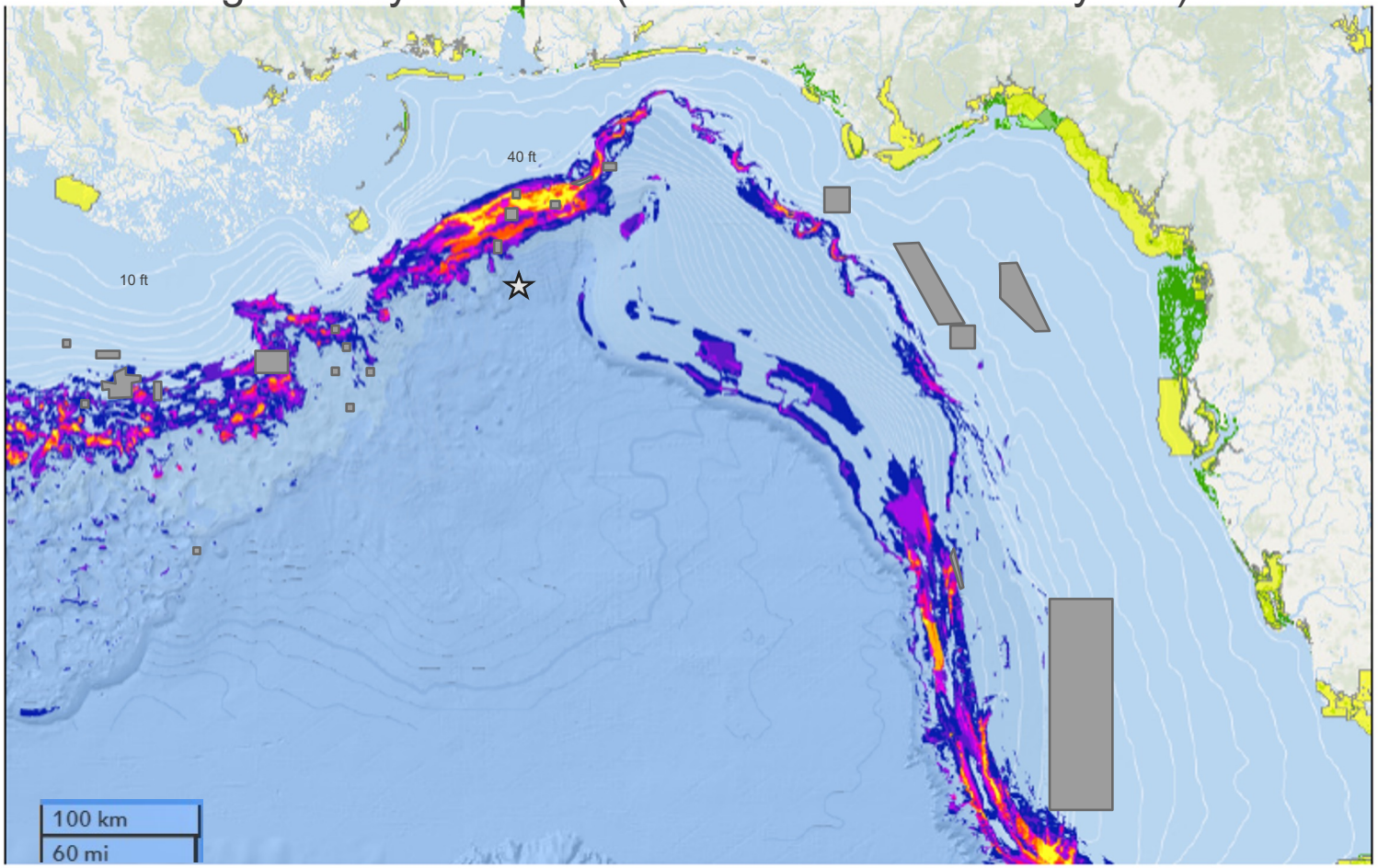
Three impact categories created to assess the severity of impact if there was a leakage within a certain proximity, maps are created for ranking

Impact	Notes	Low Impact (1)	High Impact (5)
Proximity to Environmentally Sensitive Areas*	MPAs, HAPCs, Seagrasses, Deep Sea Coral Habitats and Observations	No ESAs in proximity	Three or more ESAs
Water Depth	Thresholds based on Essential Fish Habitats and Leakage Simulations	>200 ft	<65 ft
Proximity to existing infrastructure/transit*	Transit, existing infrastructure such as pipelines	Low density transit, no infrastructure	High density transit and infrastructure

*Proximity within 0.7 miles -
Established from Oldenburg and Zhang, 2022; ECO2, 2016; and O'Reilly et al., 2022

Proximity to Environmentally Sensitive Areas, Water Depth

For ranking severity of impact (star denotes case study site)



MAP LEGEND

Submerged Lands Act Boundary

NOAA_MPAI_2020_IUCN_GCS

Seagrasses

Patchy

Continuous

Present

Deep-Sea Stony Coral Habitat Suitability

1 - Low

2 - Medium-Low

3 - Medium

4 - Medium

5 - Medium

6 - High

7 - High

8 - High

9 - High

10- Very High

Deep-Sea Coral Observations

HAPC

Contour interval 10 ft Then 25 ft

[Marine Cadastre National Viewer]

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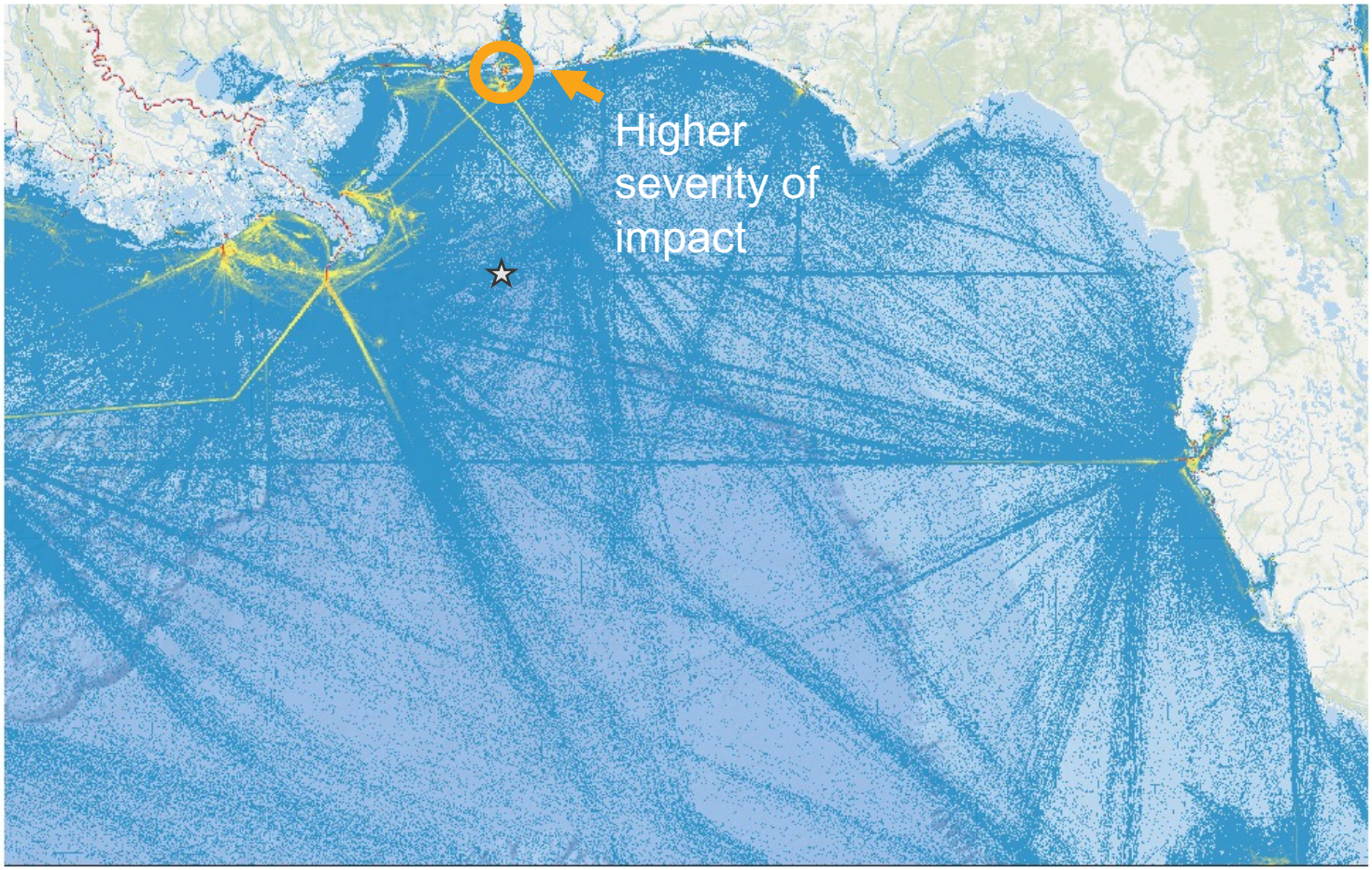
Transit Counts

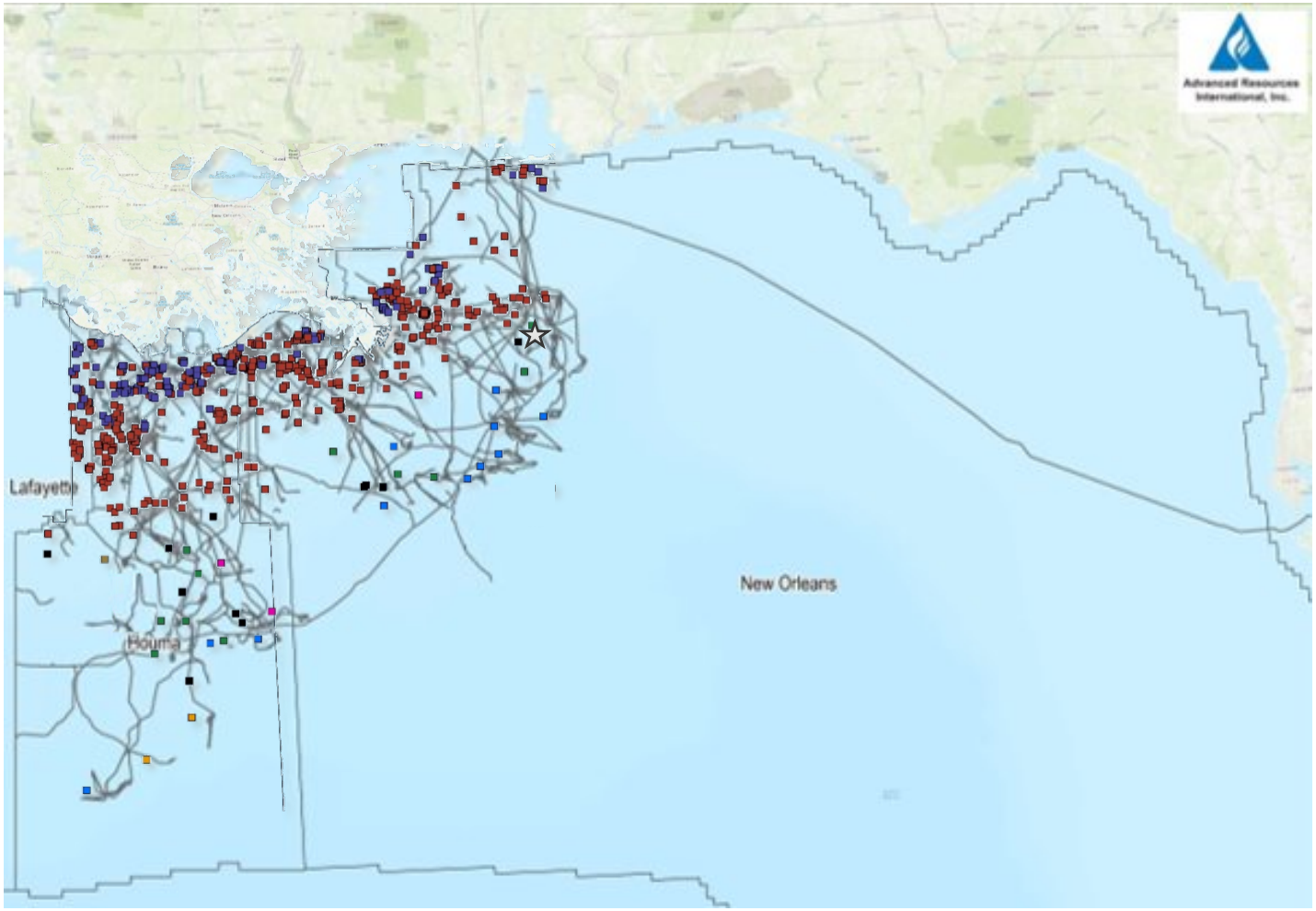
For ranking infrastructure severity of impact (star denotes case study site)



[Marine Cadastre National Viewer]

Infrastructure (Platforms, Pipelines, Wind)

For ranking severity of impact (star denotes case study site)



Marine Cadastre National Viewer

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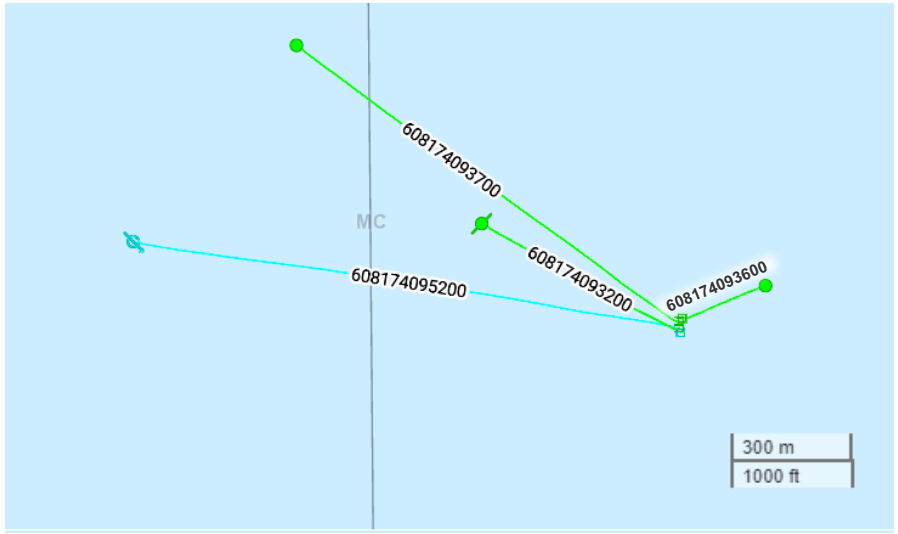
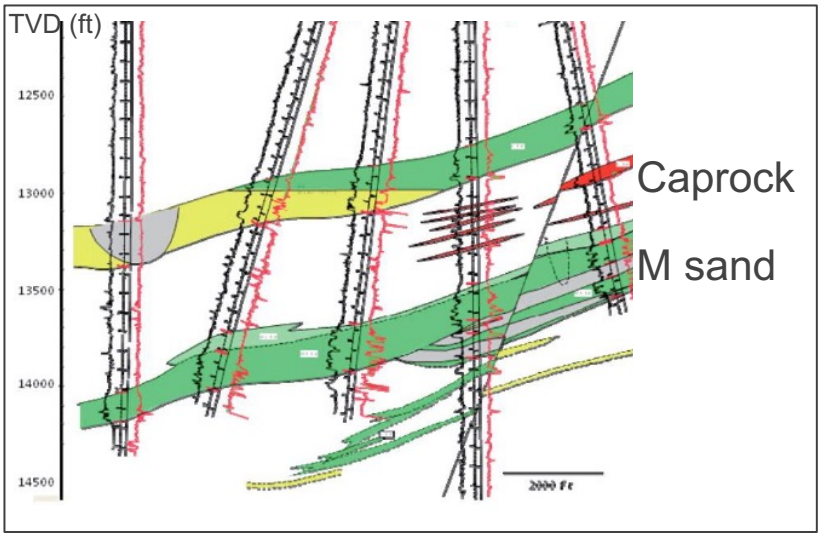
Deepwater Case Study: Overview



- Horn Mountain - Miocene turbidite sands with recent history of oil and gas production
- Caprock is ~ 600 ft of mudstones above the M sand carbon storage target (ARI)
- Proximal to several other wells



Well	Spud Date	TVD (feet)	Comments	Status (BSEE)	Status (Enverus)
A002	2001	13770	gas lift after initial production	TA	Active
A003	2001	14248	gas lift after initial production	TA	P&A
A004	2001	14241	gas lift after initial production	TA	Active
A006	2001	14515	water injection well	TA	P&A

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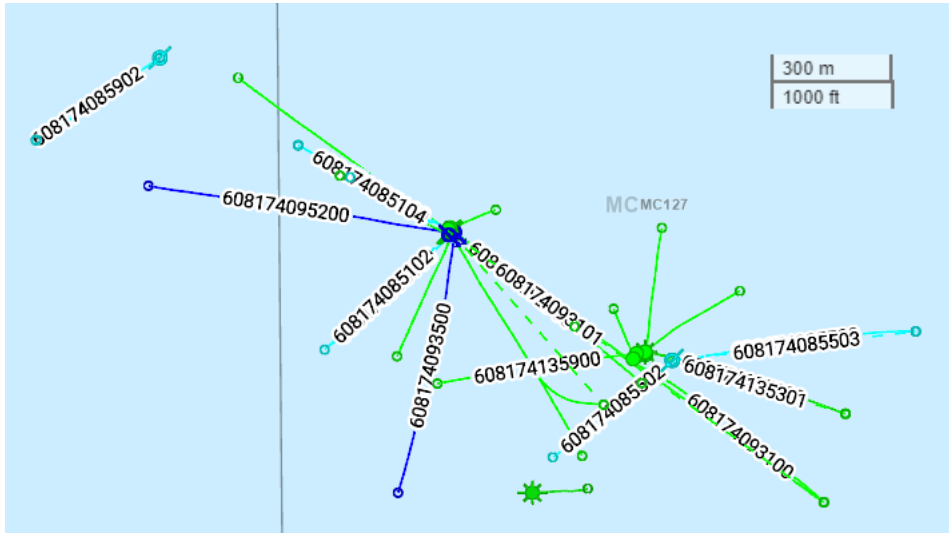
Deepwater Case Study: Overview



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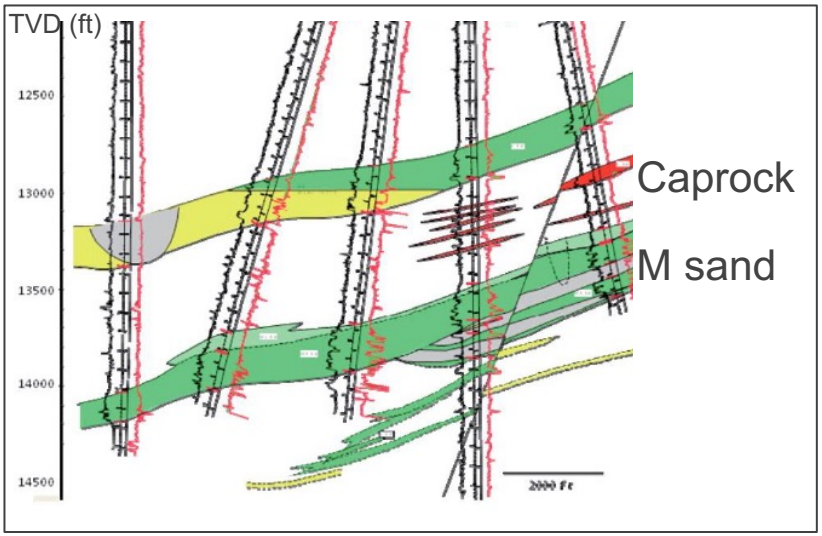

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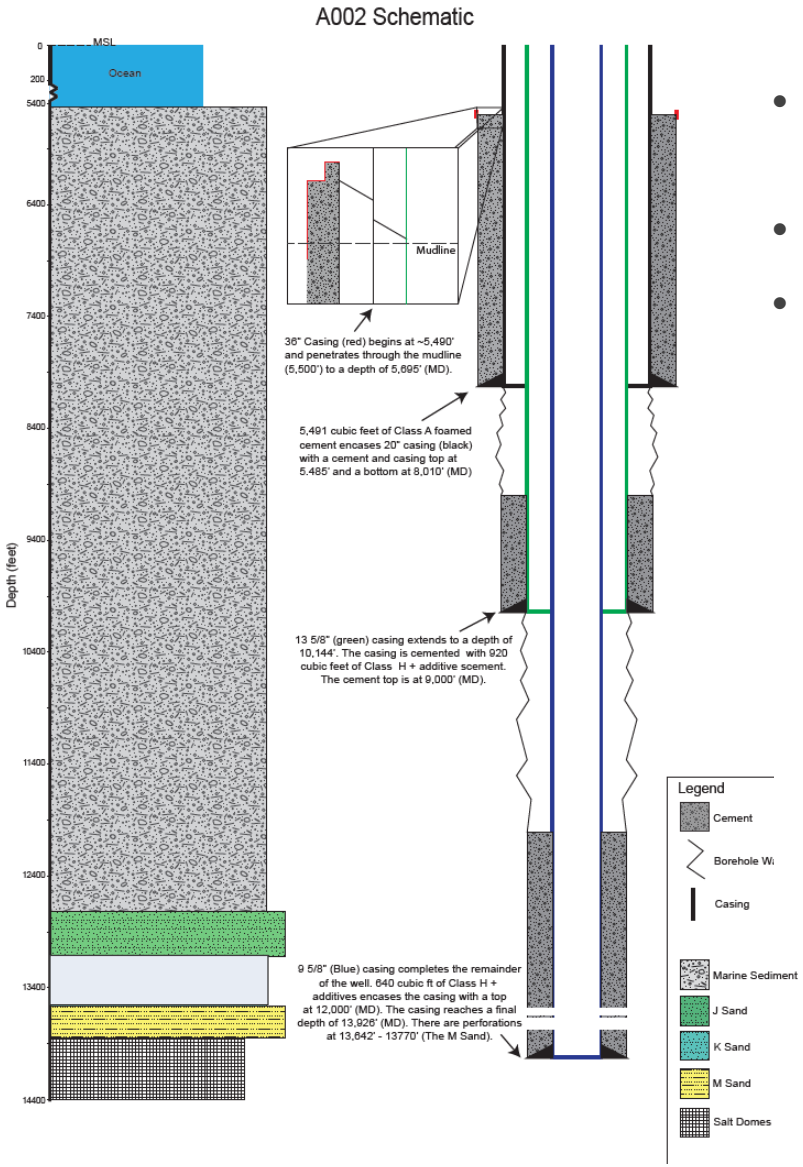
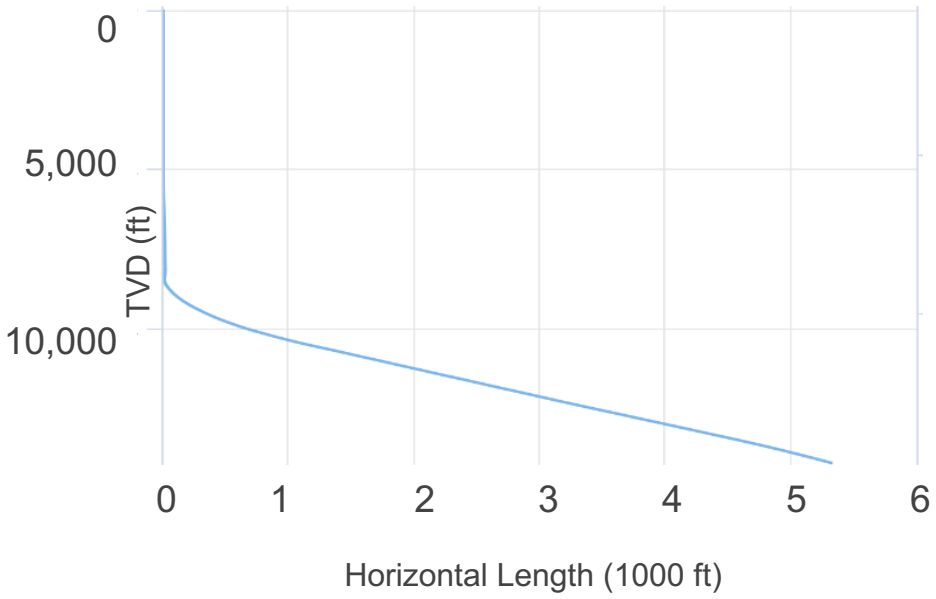
Deepwater Case Study: Well Construction



- Well construction data - Class A and Class H cement, additives unknown
- Deviation overall is not at 30°
- One well - records B annulus leakage from gas lift (leak from casing connection or through cement from reservoir)



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Deepwater Case Study: Risk Assessment

Overall wells are low risk, except A003 with the casing failure history and A006 water injection well

Factors of Risk Likelihood	Low Risk (1)	A002	A003	A004	A006
Well Status	producing	2	2	2	2
Well Deviation	low angle deviation	2	2	2	2
Well Age	post 1990	1	1	1	1
Well Depth	<2600 ft MSL	4	4	4	4
Well Type	oil or gas well	1	1	1	5
Well Density	no wells within 0.5 mi	5	5	5	5
Suspension Status	<5 years	1	1	1	1
Gas Migration of Surface Casing Vent Flow	none	5	5	5	5
Casing Failure History (SCP)	none	1	5	1	4
Well Head Type	dry wellhead	5	5	5	5
Cement Quality/location (PNL, wellhead T and P, SCP, casing vs bit size)	silica, appropriate thickness, through caprock, appropriate casing vs bit size	1	1	1	1
Cement Thickness through caprock	>2600 ft	2	1	2	1
Well Modifications and Sidetracks	no sidetracks or modifications	1	1	1	1
Total Risk Likelihood		44	47	44	51
Total Impact		4			
Risk Score		**176**	**188**	**176**	**204**

Summary of Case Study and Future work

- **Legacy wells are a potential leakage pathway that have to be considered when scoping out carbon storage reservoirs**
  - Cement at caprock and cement plug data are important factors
  - Deepwater case study is relatively low risk (although missing CBL and SCP test data). Wells with failed pressure tests and injection wells are higher risk.
- 2nd case study - continental offshore waters, Miocene play
- 3rd case study - state waters, deep Jurassic play?
- Address and highlight data gaps - CBLs, construction details, etc
- **More detailed well integrity dataset?**

Acknowledgements

Advanced Resources International, Inc.

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It can be done

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