

Environmental Issues for Shale Gas Development: Lessons Learned

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Game Change in Natural Gas

- Shale gas production has transformed the energy picture in America
- In 2009 USA passed Russia as world's leading producer
- Least GHG emissions of fossil fuels
- Part of renewables strategy to ensure reliability

No Room for Mistakes

- Marcellus Shale is in a more densely populated area
- New developments will be closely scrutinized for adverse impacts
- History and experience with other fields can inform and guide a secure cost-effective approach

Key Issues and Lessons Learned

1. Underground Sources of Drinking Water
2. Produced water
3. Development footprint
4. Community compatibility



I. Underground Sources of Drinking Water

- Safe Drinking Water Act requires protection of drinking water sources
- Framework for Underground Injection Control (UIC) program
- Class II wells (oil and gas)
 - Protect underground sources of drinking water
 - <20,000 ppm TDS defines freshwater

First Issue

- Effect of hydraulic fracturing forming conduits to freshwater aquifers
- Public assumes fracturing
 - Is in freshwater aquifers or
 - Will develop conduits to freshwater aquifers

Lesson Learned

- Resistivity logs to define base of freshwater
- Cross sections to illustrate protection of fresh water aquifers
 - Vertical distance
 - Concrete seals
 - Confining units
- Regulatory control on injection pressures provides monitoring and protection
- Variance from requirements a possibility

Second Issue

- Effect of chemical additives on freshwater aquifers
- Chemical packages are proprietary
 - Chemicals not specified
 - Concentrations not specified
 - MSDS of limited use
- Lack of information leads to concern

First Lesson Learned

- ISO 14000 Certification
 - Demonstrates effectiveness of practices on an objective scale
 - Sometimes used in oilfield transactions



Second Lesson Learned

- Globally Harmonized System (GHS) of Chemical Labeling, *e.g.*,
 - REACH program in EU
 - OSHA developed hazard communication regulations
- Can be used as a basis for describing the environmental effects of chemical packages without disclosing compounds and concentrations

II. Produced Water

- Large volumes of water produced by pumping
- Typically saline
- Can contain other contaminants and NORM
- Typically more than needed for injection

Issue

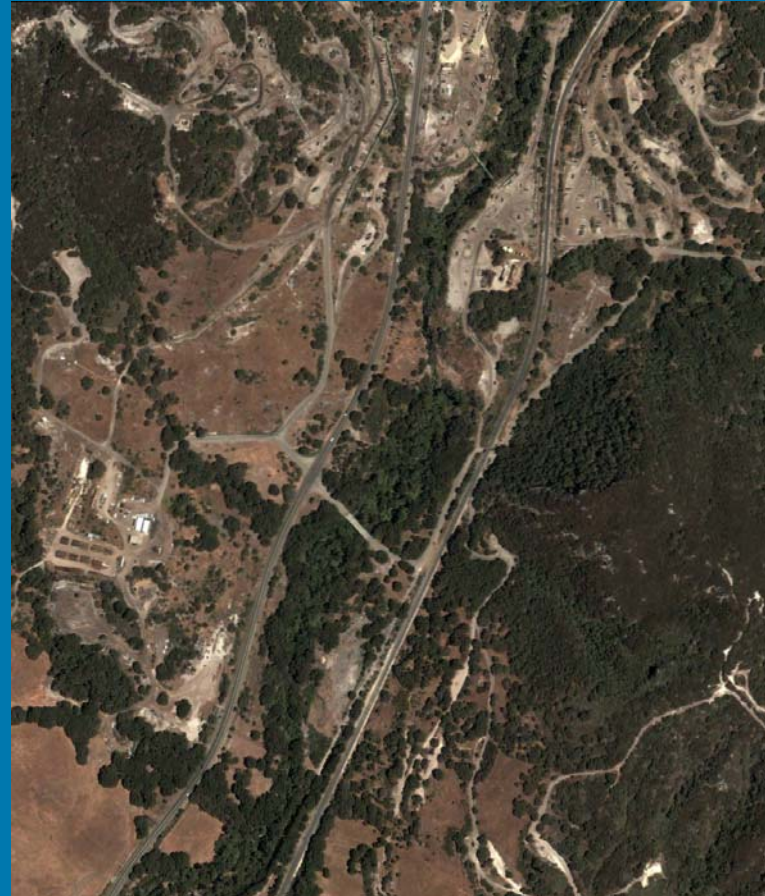
- Produced water of little use at the surface without treatment
- NPDES prohibits inland discharge of produced water to surface waters
- Wastewater treatment plants lack capacity

Lesson Learned

- Determine local water users/needs
- Evaluate water quality requirements
- May determine that treatment is required for reuse
- Have a backup plan

Reverse Osmosis Treatment

- Treated produced water can be sold
- Brine can be reinjected
- Backup for NPDES discharge to creek
 - Benefits agriculture
 - Benefits fish and wildlife



III. Development Footprint

- Development Impacts
 - Farmland and open space
 - Habitat
 - Cultural resources
 - Viewsheds
 - Traffic
- Agency issues

Issue: Current Practices



Lesson Learned: Reconfiguring w/Horizontal Wells



LEGEND

-  Specific Plan Area
-  Residential Area
-  Public Park Site
Conceptual Location
-  Open Space*

<i>Planning Area</i>	<i>Units</i>	<i>Gross Acres</i>	<i>Gross Units / Acre</i>
Planning Area 1	107	16.3	6.6
Planning Area 2	226	27.1	8.3
Planning Area 3	404	45.5	8.9
Planning Area 4	250	43.2	5.8
Planning Area 5	213	41.5	5.1
Sub Total	1200	173.6	6.9
Open Space	-----	314.6	-----
Total Site	1200	488.2	2.5

* Includes habitat, oil and gas production, and public facilities.

Note: Transfer of residential units and density among planning areas permitted per section 7.9



IV. Community Compatibility

- Development in more densely populated areas
- Neighborhood and citizen action group are increasingly engaged
- Charismatic leaders



Variable Information Sources

- “I think the location is a sad mistake for the State of California.”
— Dick van Dyke
- “That whole process of getting it into our pipeline ends up putting out more pollution, than the thought that this is a clean fuel.”
— Ted Danson
- “...toxins that it can put in the air can be really harmful in an age of global warming and I am out here because I really don’t want to see this happen.”
— Halle Berry

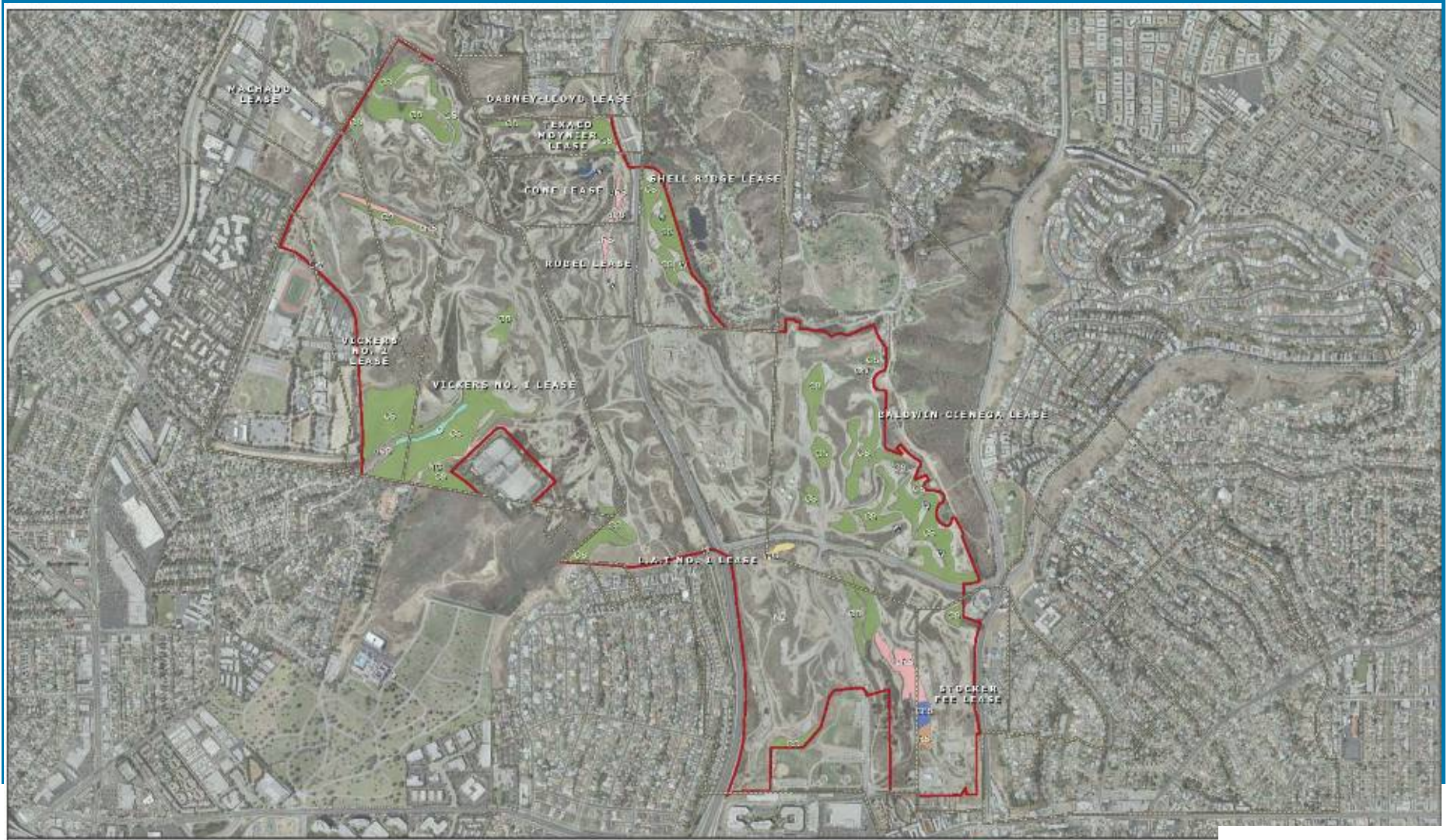
Issues

- Health risks
- Noise
- Odors
- Subsidence
- Induced seismicity
- Vibration
- Diminution in property values
- Viewshed impairment

Lesson Learned

- Proactive engagement
- Know resources and have protections
- Communicate benefits
 - Economic contribution
 - Health and safety
 - Regulatory framework
 - Pro-environment/pro energy independence
- Listen and acknowledge concerns
- Maintain communication dialogue

Field in the Middle of Los Angeles



VEGETATION COMMUNITIES

■ Dryland Sage-Sage (286)	■ Oak Woodland (290)	■ Oak Woodland (29)	■ Wetland (90)
■ Terrestrial Sage-Sage (288)	■ Riparian Woodland (292)	■ Riparian Woodland (291)	■ Disturbed Riparian Woodland (88)

BOUNDARY LAYERS

 Lease Line
 O&G Boundary



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Mapping Environmental Constraints



PALEONTOLOGICALLY SENSITIVE GEOLOGIC UNITS

Recreation or Mineral Use: 30-year or 100-year flood zone, or a geologic unit that is older than approximately 3 feet below existing ground surface.

San Pedro Formation - Consists of poorly consolidated, light gray to light brown, fine to coarse grained sand and silt, and interbedded with thin layers and lenses of gravel. This unit is generally of marine origin. However, it also may contain sand and gravel in its basal layers of clays or in the Riparian Area. This unit is the primary site of hydrocarbon accumulation.

Delgada Formation - Consists of light gray to tan, fine to medium sandstone and interbedded with gray siltstone. This unit is of marine origin and contains locally abundant colonial and bryozoan fossils.

Recreation or Mineral Use: 30-year or 100-year flood zone, or a geologic unit that is older than approximately 3 feet below existing ground surface.

Other - Areas where San Pedro Formation and Delgada Formation are present in the project.

HISTORIC SITES FOR REMEDIATION

- State Well Burial
- State Well
- Catch Basins
- Historical Storage Site
- Fire Storage
- Disposal Site
- Bottomland
- Tank or Tank Farm
- Fire Tank

ADDITIONAL DATA LAYERS

- State Grid Boundary
- CO Boundary
- Basins or Tracts Types:
 - Coyote Butte Shale (CBS)
 - General Inguirita Shale (GIS)
 - General Trees (GT)
 - Native Grassland (NG)
 - Oak Woodland (O)
 - Riparian Shale (RS)
 - Shrubland (S)
 - Grassland Riparian Shale (GRS)



Summary of Lessons Learned

- Issues in Marcellus are not new
- Successful resolution in comparable settings can be translated
- Groundwater protective measures must be transparent
- More protections needed in populated areas
 - There will be concerns
 - Better to guide the development of protections rather than have them imposed
- Effective communication and outreach are imperative

Conclusion

Thank you

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