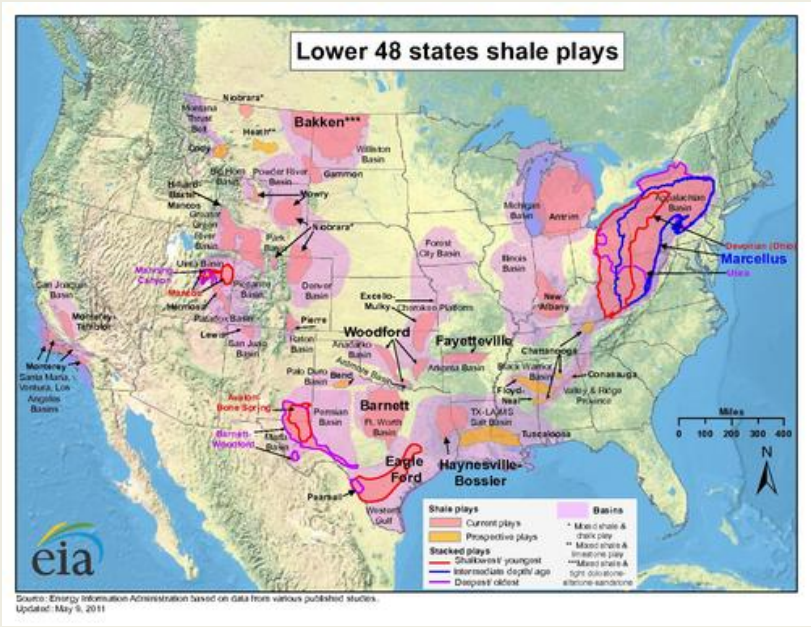
Marcellus shale gas development: recommended best management practices for Maryland

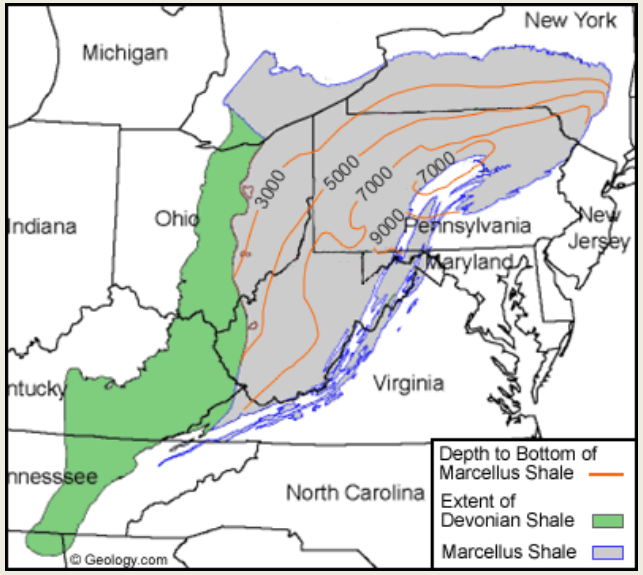
April 15, 2013

Keith N. Eshleman & Andrew J. Elmore
Appalachian Laboratory, University of Maryland Center for Environmental Science

What is the ***Marcellus Shale***?

- Devonian black shale (deposited ~380 My BP) found in the Appalachian region
- Named after town of Marcellus in the Finger Lakes region of NY State
- Contains appreciable quantities of ***hydrocarbons*** (predominantly paraffins)
- One of many shale plays in the U.S.





How much ***natural gas*** does the Marcellus shale hold?

- 2002: 1.9 trillion cubic feet (USGS)
- 2008: 500 trillion cubic feet (Englander)
- Using the latter estimate and recovery rates (~10%) comparable to the Barnett shale in Texas, 50 trillion cubic feet might be recoverable (about 2 years supply of all US consumption)

Project Goals

- Task A: provide a ***literature review*** of best management practices (BMPs) for Marcellus shale gas development (MSGD) in five states (CO, NY, OH, PA, and WV) or endorsed by API (completed September 2012)
  - General/planning/permitting
  - Well engineering and construction practices to ensure integrity and isolation
  - Protecting air quality
  - Protecting water resources
  - Protecting aquatic habitat/wildlife
  - Protecting terrestrial habitat/wildlife
  - Protecting public safety
  - Protecting cultural and historic values
  - Protecting quality of life/aesthetics
  - Protecting agriculture and grazing
- Task B: ***recommend*** suites of BMPs that would be most protective for Maryland (completed February 2013)
- Task C: produce a guidance document that would ***inform regulation*** of MSGD in Maryland (TBA)

Environmental issues: possible impacts of Marcellus shale gas development (MSGD)

- Land surface impacts (terrestrial ecosystems, freshwater aquatic systems, etc.)
- Impacts on water resources (water quality and quantity)
  - Groundwater
  - Surface water
- Air quality impacts
- Induced seismic activity (earthquakes)
- *Climate forcing (CO_2 and CH_4 are both radiatively-active gases)*
- Human environment
  - Public health
  - Public safety
  - Cultural and historic values
  - Quality of life, aesthetics, recreation
  - Economics (energy prices, job opportunities, GDP, etc.)

What are best (management) practices (BMPs)?

- Methods, techniques, or processes that produce results that are consistently better than other means, and that can be used as benchmarks.
- BMPs can (should?) evolve over time and become even better.
- In some industries, BMPs can be used as an alternative to mandatory standards (combined with self-assessment)?
- "…involves the entire range of shale gas operations including: (a) well design and siting, (b) drilling and well completion, including importantly casing and cementing, (c) hydraulic fracturing, (d) surface operation, (e) collection and distribution of gas and land liquids, (f) well abandonment and sealing, and (g) emergency response" (U.S. DOE SEAB SGPS 2nd Ninety Day Report, 2011).
- BMPs can be implemented voluntarily, mandated by statutes and regulations, or adopted as part of negotiated lease agreements.

Task B ("Recommended BMPs")

- Assembled a technical team
  - Keith Eshleman, Ph.D. (PI): hydrology, water resources
  - Andrew Elmore, Ph.D. (co-PI): landscape ecology, geospatial analysis
  - Jeanne VanBriesen, Ph.D., P.E.: civil engineering
  - Russell Dickerson, Ph.D.: air quality monitoring & modeling
  - Todd Lookingbill, Ph.D. : terrestrial ecology
  - Steven Guinn (FRA): geospatial data analysis
  - Robert Sabo (GRA): literature review & synthesis
- Synthesized relevant datasets
  - Streamflow
  - Stream network
  - Geology
  - State lands (boundaries)
  - Transportation networks
  - High density population centers
  - Topography (land slope)
  - Land use
  - Environmental constraints (public water supply intakes, water wells, trout streams, Tier 2 streams, endangered species, wetlands, historic/cultural sites, public recreational sites, etc.)
  - Other important data (existing wells, orphan wells, underground mines, caves, caverns, etc.)
- Evaluated BMPs on the basis of existing scientific data where possible (or invoked professional judgment where data are lacking)

Key findings: environmental impacts of MSGD

- There will be impacts (both positive and negative) if Maryland goes ahead
  - But many negative impacts can be minimized (probably not eliminated) through careful and thoughtful planning, appropriate regulation, enforcement, and inspection, and implementation of recommended BMPs
  - A variety of hazards and sensitive environmental resources are distributed across the western Maryland region that must be considered
- Few systematic data-driven studies of the environmental impacts of MSGD
  - Lots of anecdotal observations that are difficult to reconcile and understand
- Research is clearly warranted
  - Identify and quantify pollutant pathways and mechanisms
  - Identify and quantify risks to specific environmental resources
- Important role for monitoring
  - Baseline (pre-development) monitoring to establish benchmarks for assessing impacts and damages
  - Operational monitoring to ensure compliance with standards, increase understanding (when combined with research), detect problems, and provide feedback to the best practices process
  - Not “monitoring for monitoring’s sake” (see NRC, 2012)

Major Recommendations

1. Maryland should develop regulations to support design and implementation of comprehensive drilling plans (CDPs)

- Similar to CO's approach (and program used in PA State Forests)
- Voluntary program (but strongly encouraged/incentivized)
- Plans developed cooperatively with stakeholders to efficiently exploit the gas resource while minimizing impacts on local communities, natural resources, and the environment
- Goal is to channel MSGD (an industrial activity) into areas with fewest resources in harm's way, fewest drilling hazards, and few infrastructure needs
- Densely-clustered, multi-well pads (with co-located ancillary infrastructure)
- <u>Pros</u>
  - More deliberate, limiting the pace of MSGD (allow regulatory apparatus to "catch up")
  - Possible to disturb < 1-2% of land area, maximizing benefits of horizontal drilling
  - Facilitates efficient co-location of ancillary infrastructure
  - Minimize forest clearing and land disturbances
- <u>Cons</u>
  - Unknown administrative/regulatory challenges
  - Maryland lacks the power to enforce "forced pooling" arrangements ("unitization")

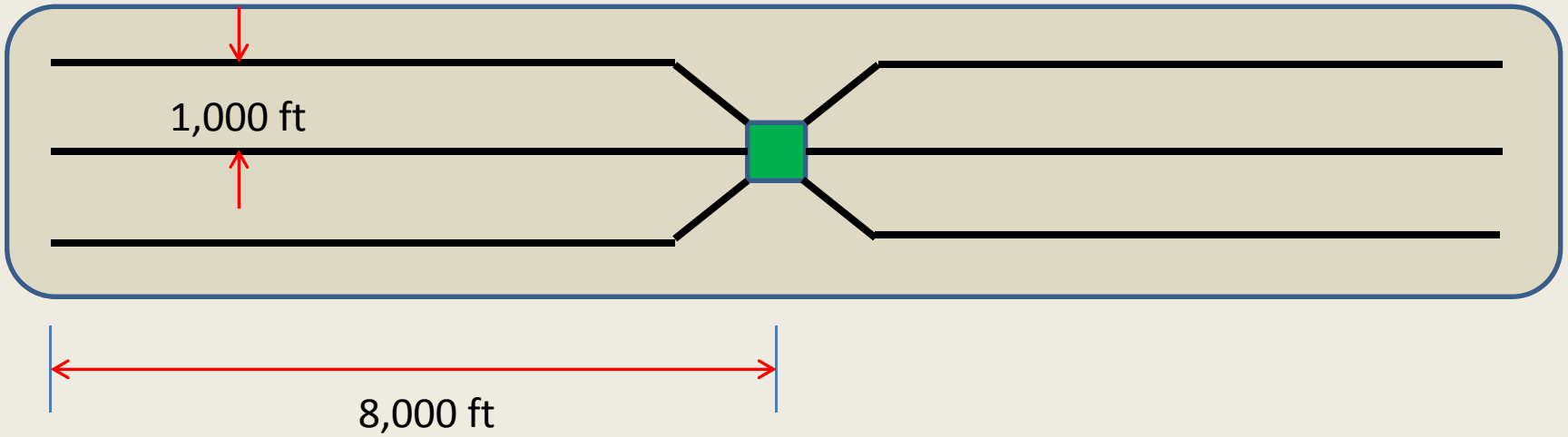
PA DCNR State Forests

- Multi-well pads (typically six wells per pad): 4-7 acres
- 8,000 ft parallel laterals, 1,000 ft on center
- Approximately 1-2 mi^2 of target formation can be drained
  - (3,000 x 16,000)/(43,560 x 640) = **1.7 mi^2**

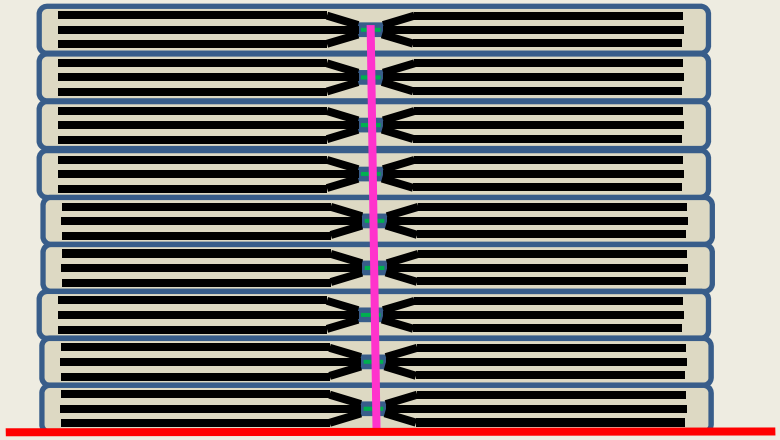
Multi-well pad (wellheads and flowback tanks visible) in Tiadaghton SF

15 acre, 15 MG water impoundment in Tiadaghton SF, Lycoming County, PA

Access road, utility corridor, and compressor station in Tiadaghton SF



An idealized multi-well pad development (ancillary infrastructure not shown)



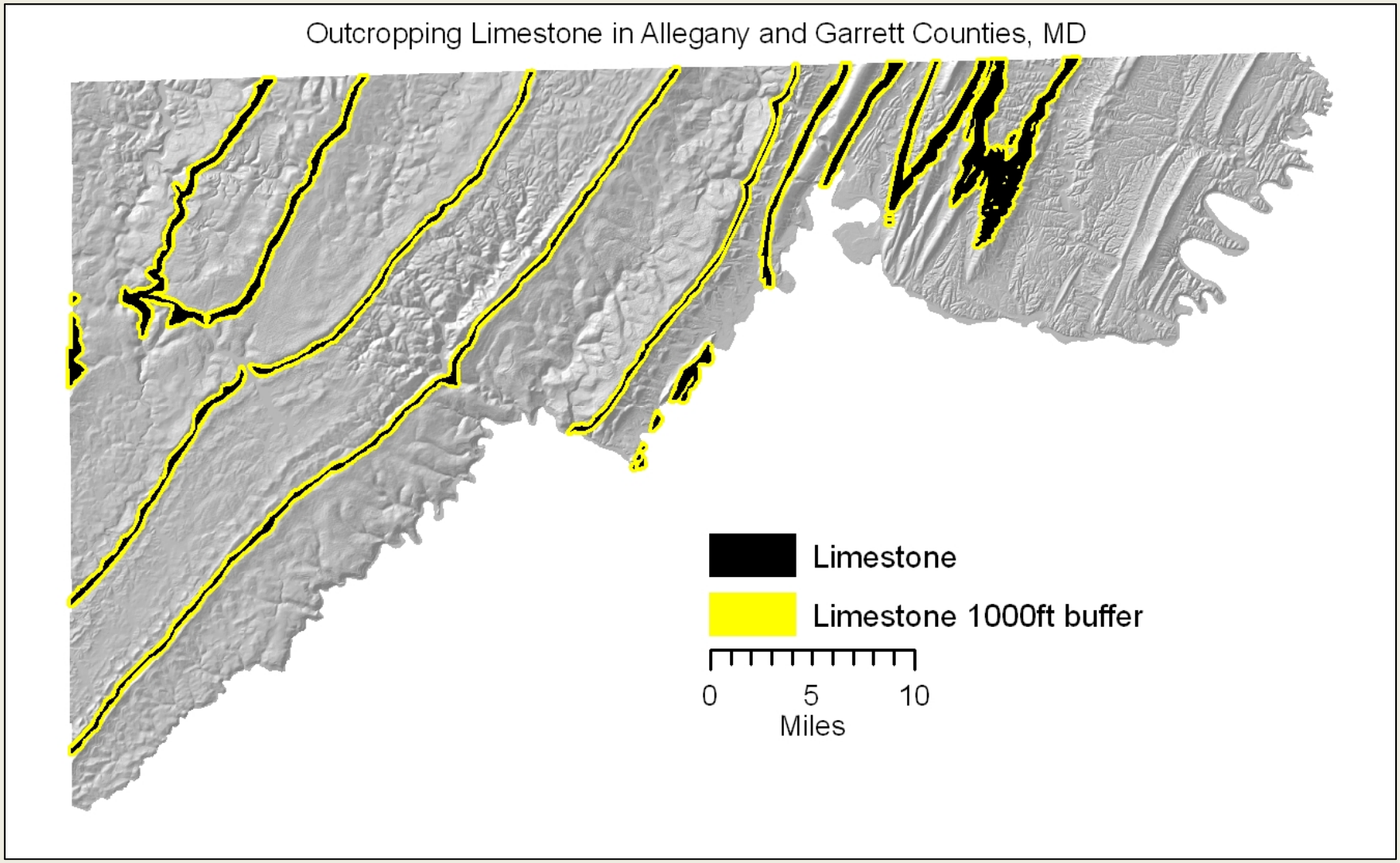
Existing road/transmission pipeline

- *Total area drained* = 18 mi^2
- *Area of pads* = 36 acres
- *Area of roads & utility corridors* = 44 acres (assuming 75 ft wide roads/co-located gas lines)
- In this highly idealized case, *less than 1% of the land area would be disturbed*
- *Caveat:* doesn't include lands disturbed for siting of compressor stations and water impoundments

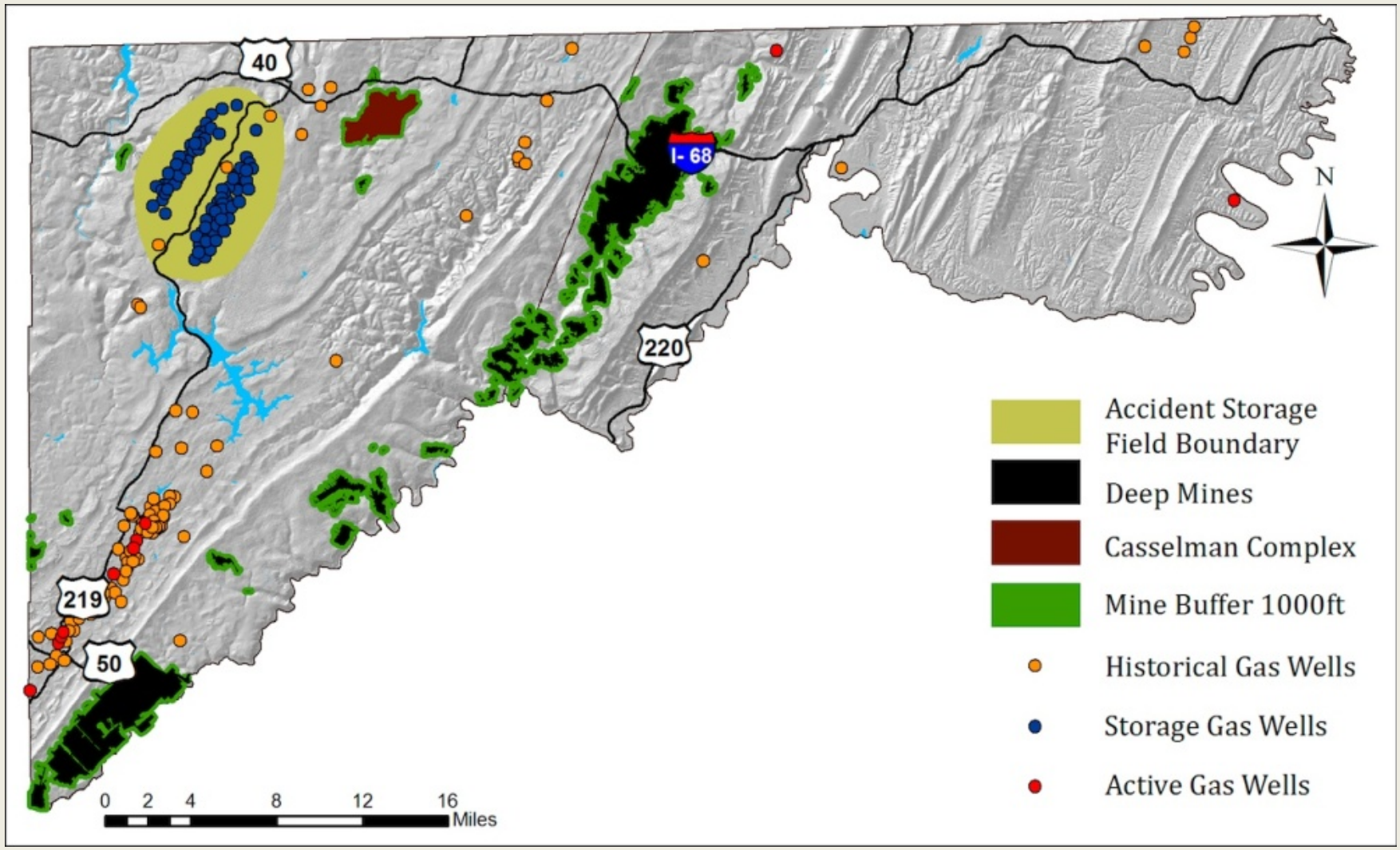
Major Recommendations

2. Maryland should require pre-drilling environmental assessment including:
   - Identification of primary drilling hazards and mapped ecological, cultural, historical, and recreational resources
   - Collection of *at least* two years of pre-drilling site-specific monitoring data (surface and ground water, air quality, etc.)
   - Inventories of rare and endangered species
   - Potential for introduction of invasive species

Drilling Hazards



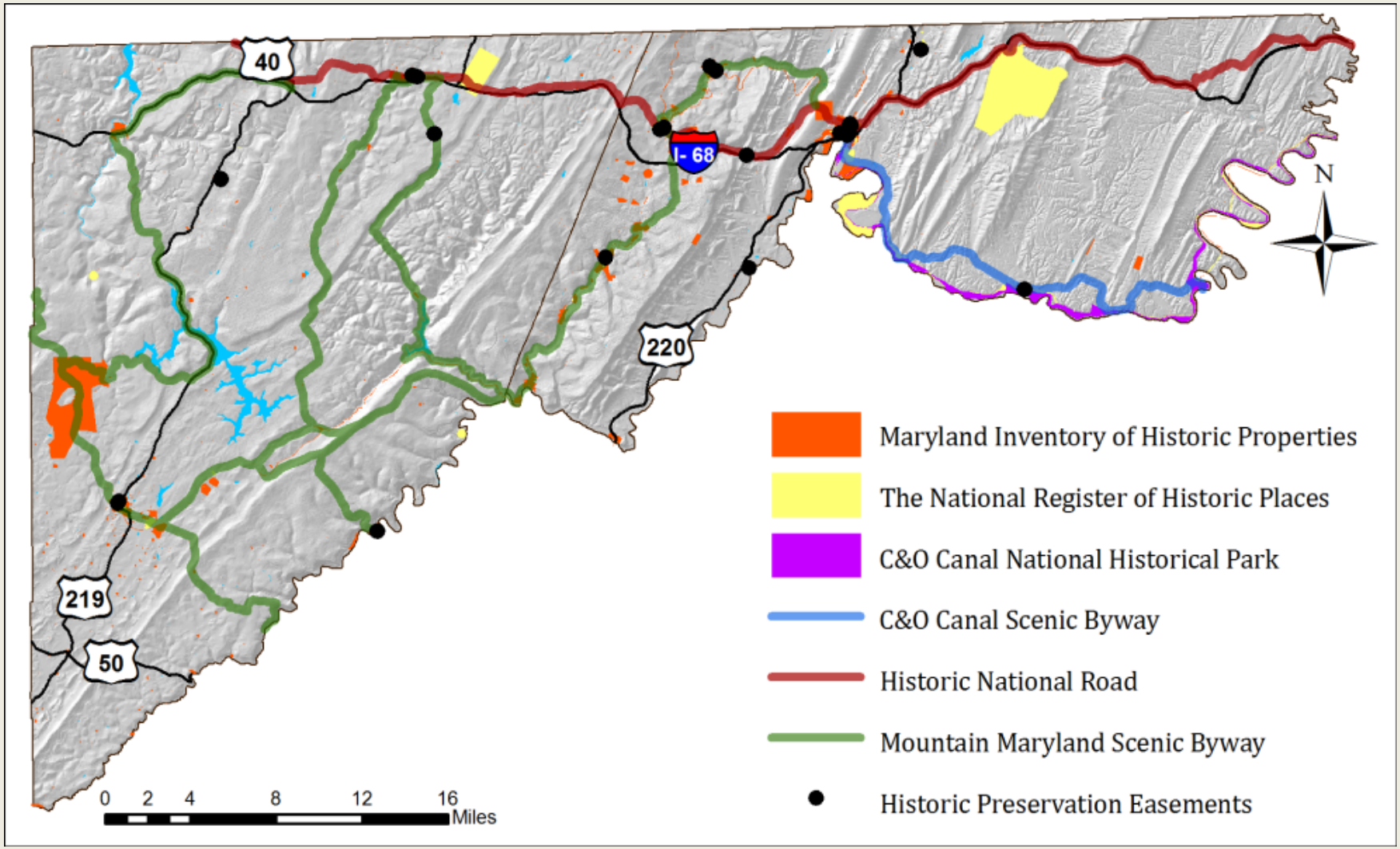
Drilling Hazards



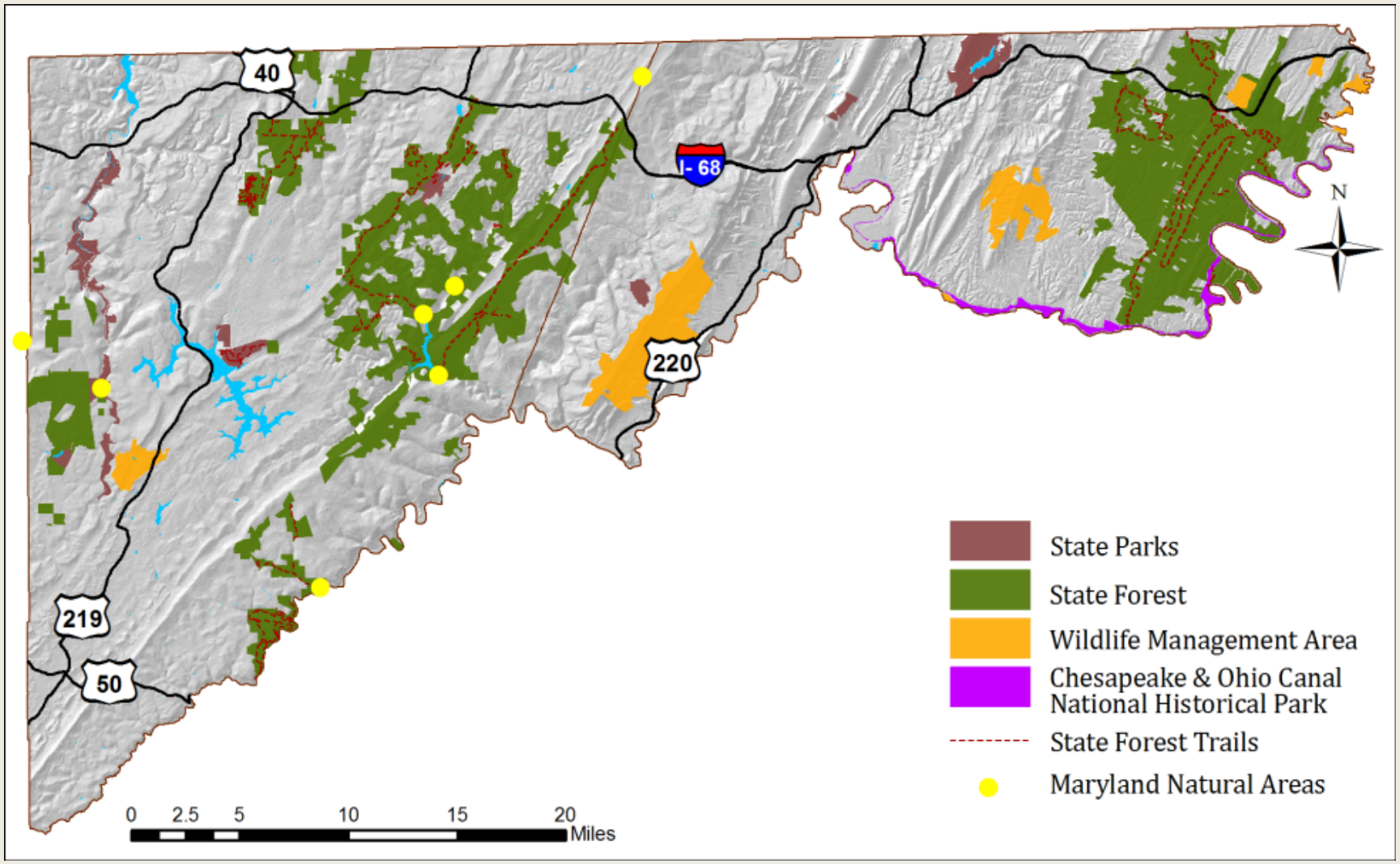
Major Recommendations

3. Primary drilling hazards and sensitive resources should be avoided and Maryland should not permit placement of well pads or *vertical* drilling in these areas
   - Mapped underground voids (outcropping limestone, underground mines)
   - Historic gas wells
   - Areas where the Marcellus formation is within 2,000 vertical ft of the land surface
   - Steep (>15%) slopes
   - Wetlands, floodplains (100-year), and surface waters
   - Priority conservation areas (BioNet I and II), state and federal parks, cultural and historical sites, trails, scenic byways, wildlife management areas, wildlands)

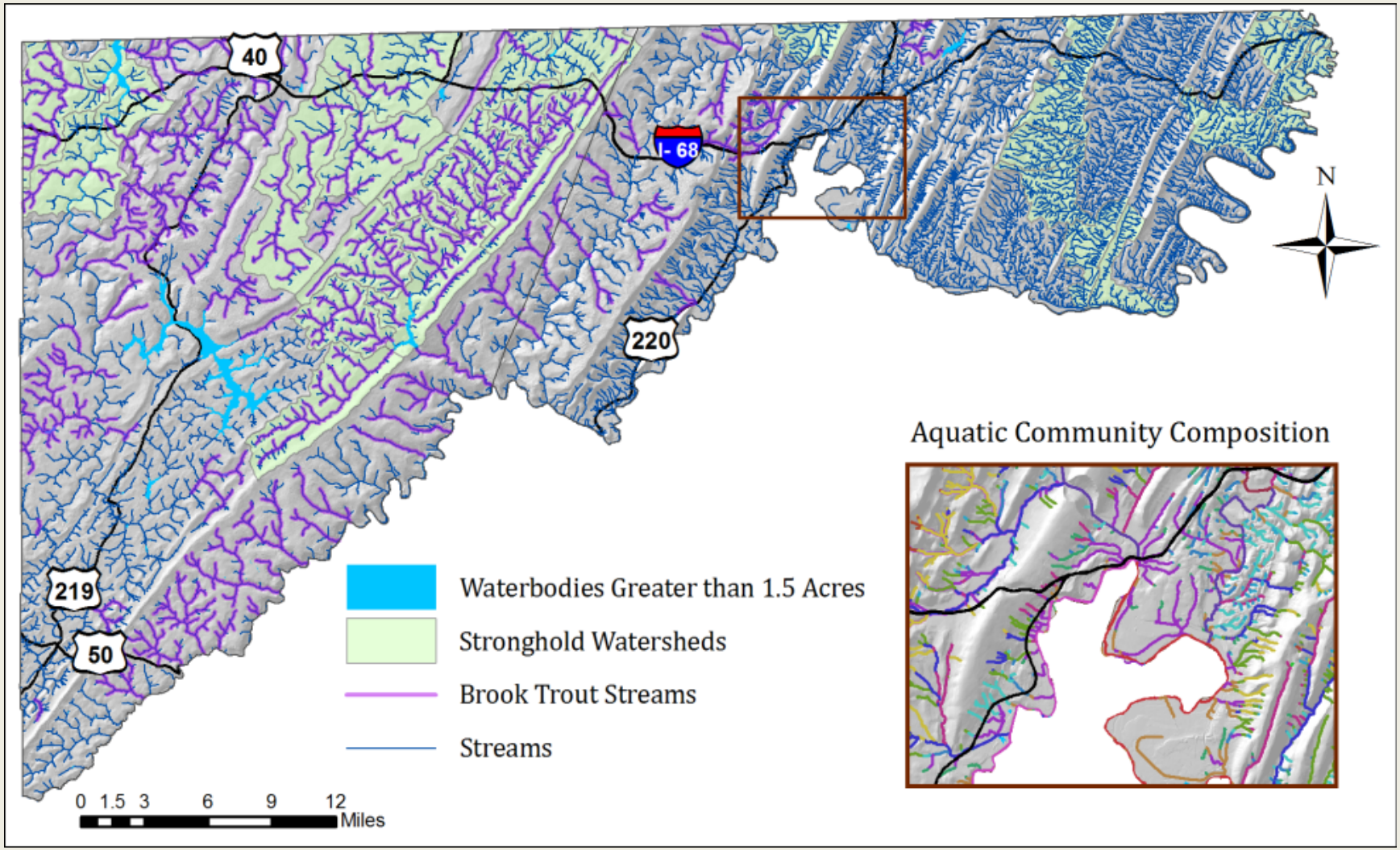
Historical and cultural resources



Recreational resources



Sensitive ecological resources



Major Recommendations

3. Specific setbacks and buffers should be used to provide additional protection

Table 1-1. Summary of recommended setbacks for resource protection and public safety.

From	To	Distance	Chapter
Aquatic habitat (defined as all streams, rivers, seeps, springs, wetlands, lakes, ponds, reservoirs, and floodplains)	Edge of drill pad disturbance	300 ft	Chapter 5 and 6
Special conservation areas (e.g., irreplaceable natural areas, wildlands)	Edge of drill pad disturbance	600 ft	Chapter 5
All cultural and historical sites, state and federal parks, trails, wildlife management areas, scenic and wild rivers, and scenic byways	Edge of drill pad disturbance	300 ft	Chapter 8
Mapped limestone outcrops or known caves	Borehole	1,000 ft	Chapter 1 and 5
Mapped underground coal mines	Borehole	1,000 ft	Chapter 1 and 3
Historic gas wells	Any portion of the borehole, including laterals	1,320 ft	Chapter 1 and 3
Any occupied building	Compressor stations	1,000 ft	Chapter 9
Any occupied building	Borehole	1,000 ft	Chapter 9
Private groundwater wells	Borehole	500 ft	Chapter 4
Public groundwater wells or surface water intakes	Borehole	2,000 ft	Chapter 4

Major Recommendations

5. Maryland should insist on implementation of a variety of state-of-the-art mitigative BMPs
   - Closed-loop drilling systems
   - Zero-discharge well pads for stormwater & 2° containment
   - On-site treatment of wastewater with a goal of 100% water reuse
   - Use of line power for drilling motors, compressors, etc.
   - Restrictions on cumulative impervious cover (<2%) in selected high-value watersheds
   - "No net loss of forest" requirement
   - Limits on hours of drilling operations
   - Enhanced transparency and public notification process
   - Construction of sound barriers and visual screens
6. Operators should be required to follow—at a minimum—API's RPs and standards for well planning, well design, well construction, well completion, and well decommissioning.

Next Steps

- Meetings with the Governor's Safe Drilling Commission to explain recommendations and answer questions
- Complete Task C (preparation of a guidance document that would inform regulation of MSGD in Maryland): *TBA*