Impacts of Blasting on Groundwater Quality in New Hampshire

Prepared for: Drinking Water Source Protection Conference

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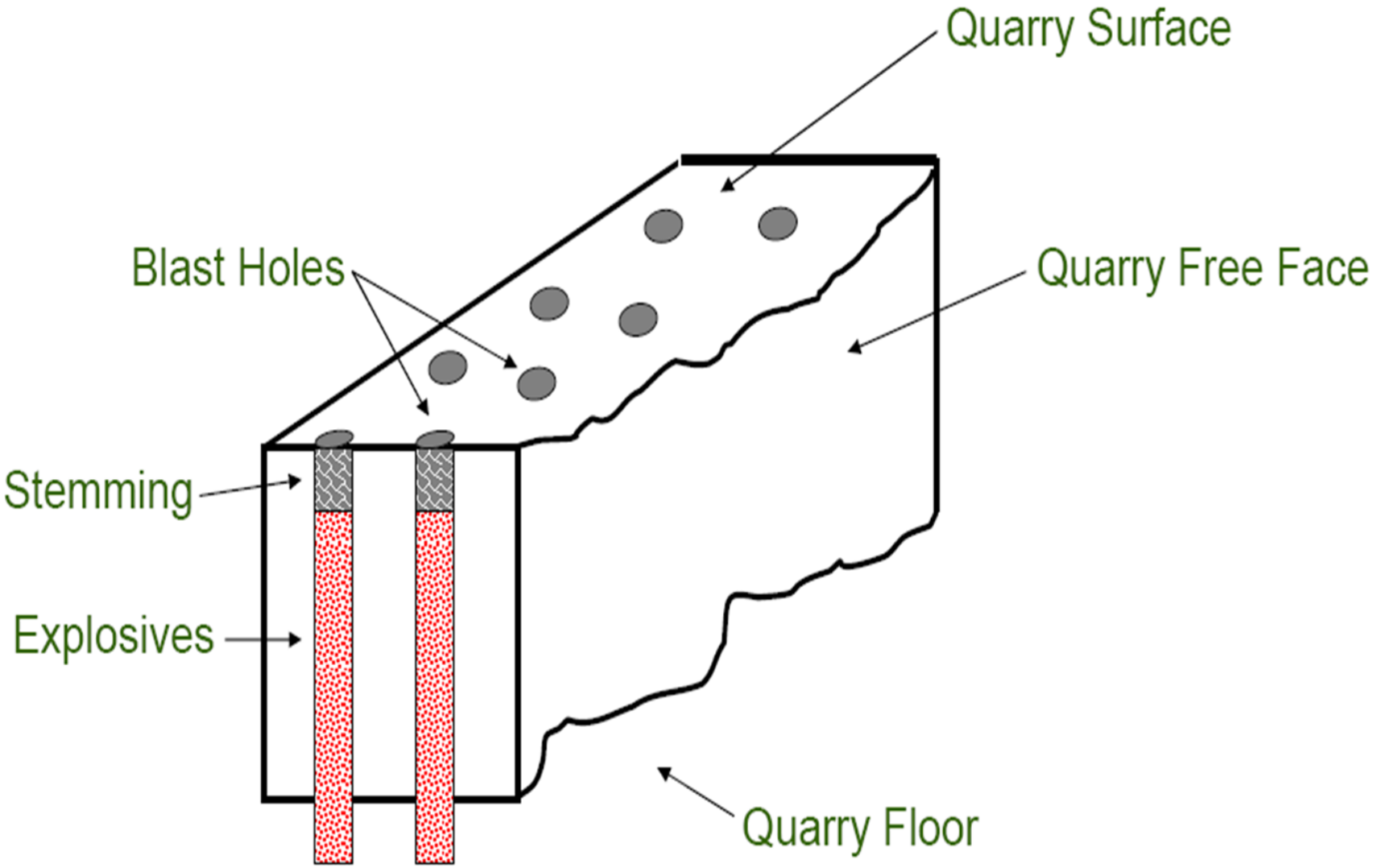
Presentation Outline

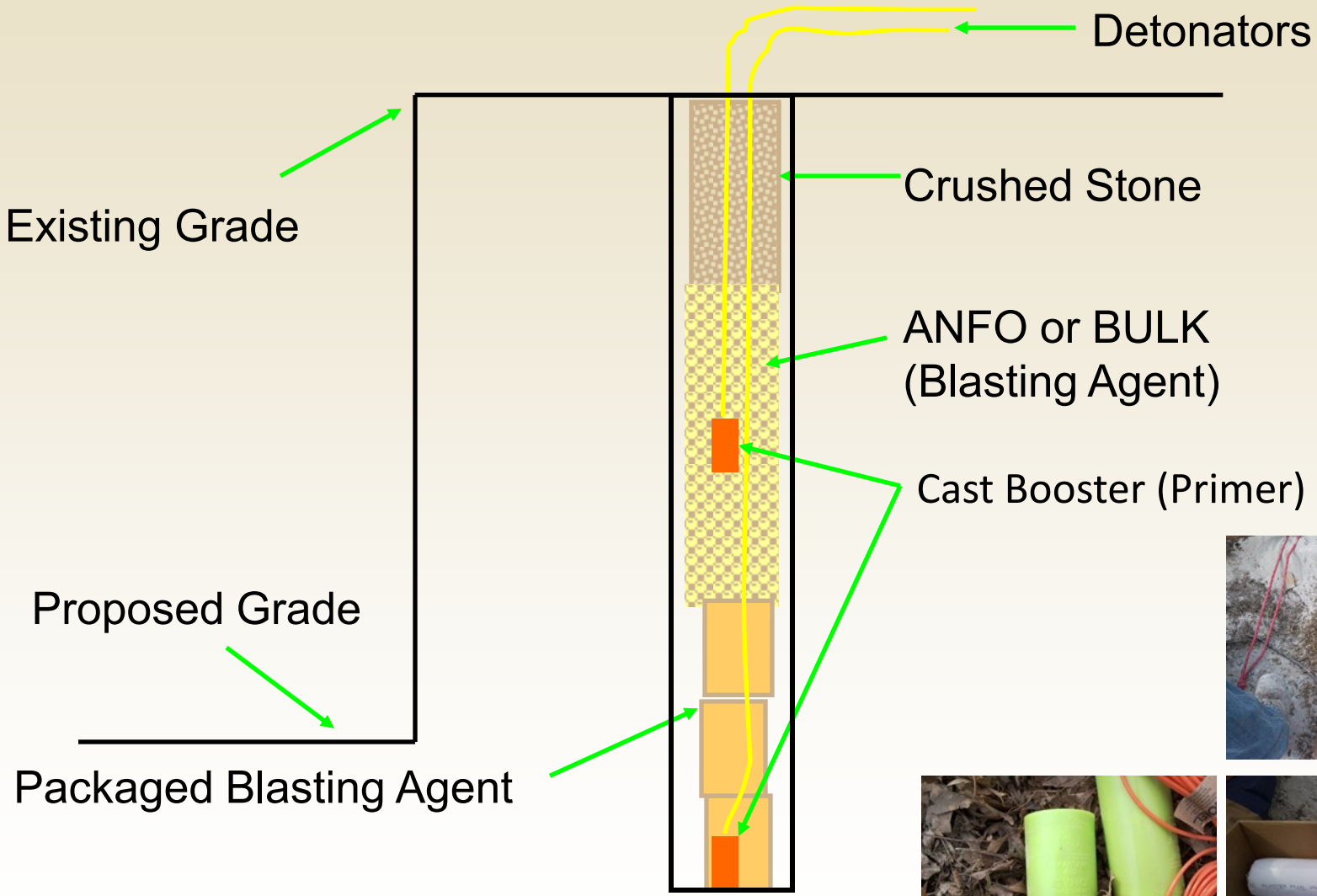
- Blasting's basics and potential to impact groundwater
- Nitrate health implications and risk
- NH sites where the issue occurred
- NH Dept. of Transportation's Approach
- Isotope investigation
- Concluding thoughts

Basics of Rock Blasting

- Blasting is performed to extract valuable raw materials and fuels from the earth or excavate a right-of way
  - Highways, mass transit systems
  - Pipelines
  - Harbors
- Drilling holes in rock at depths, diameters, and at spacing and discharging an explosive product to fracture the rock in a controlled manner.


Quarry Surface
Blast Holes
Quarry Free Face
Stemming
Explosives
Quarry Floor

Cross-Section of Typically Loaded Borehole



Commercial Explosives

- Dynamite
  - Nitroglycerin-based products
- Slurry Explosives: Ammonium nitrate or other nitrates and a fuel sensitizer that can either be a hydrocarbon or hydrocarbons and aluminum
  - Cartridge
  - Bulk (emulsion)
- Dry Products (ANFO) – represents 80% of products used

Blasting Facts

- Powder Factor
  - 0.75 to 1.25 lb/CY
- Percent nitrate by weight for one typical blasting product = ~62%
- Large highway projects in NH have excavated upwards to 370K CY of rock (~460K lbs of explosives), average commercial jobs are ~200K CY but can be higher
- Past 5 years: 1,413,794 CY of rock excavation by NHDOT
  - Average cost for NHDOT rock excavation item:(blasting): $34.63/CY ($11,328,127)

Blasting's Potential to Impact Groundwater

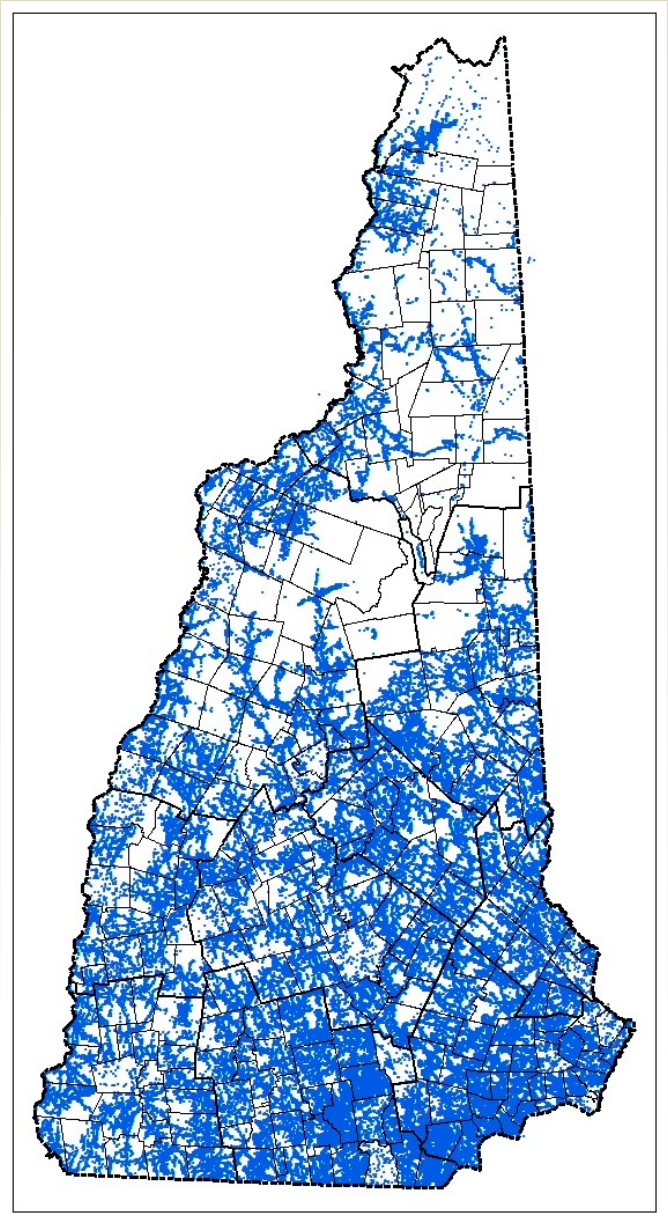
- Improper Best Management Procedure's (BMP's)
  - Loading practices, explosive selection, prevention of misfires, spill prevention measures and mitigation
- Leaching of nitrate from unexploded nitrate bearing compounds
  - Measure of blasting operation efficiency
- Injection of soluble gasses into the subsurface by blasting
- Oxidation (nitrification) of reduced nitrogen components of explosives

Nitrate Health Implications

- Environmental Protection Agencies (EPA) MCL for nitrate set to protect against methemoglobinemia (Blue Baby Syndrome) is **10 mg/L**
  - An oxygen deficiency that can induce illness and death in infants
    - Risks:
      - Babies less than 6 months old
      - Pregnant women
      - Elderly

Water Resources and the Risk

- 60 water bodies and multiple wells are used as public supplies in NH – water quality requirements however easily influenced by outside sources
- An estimated 42% of residents rely on private self-supplied drinking water
  - No state or federal requirements on water quality or quantity for private supplies (only design, construction, and placement)



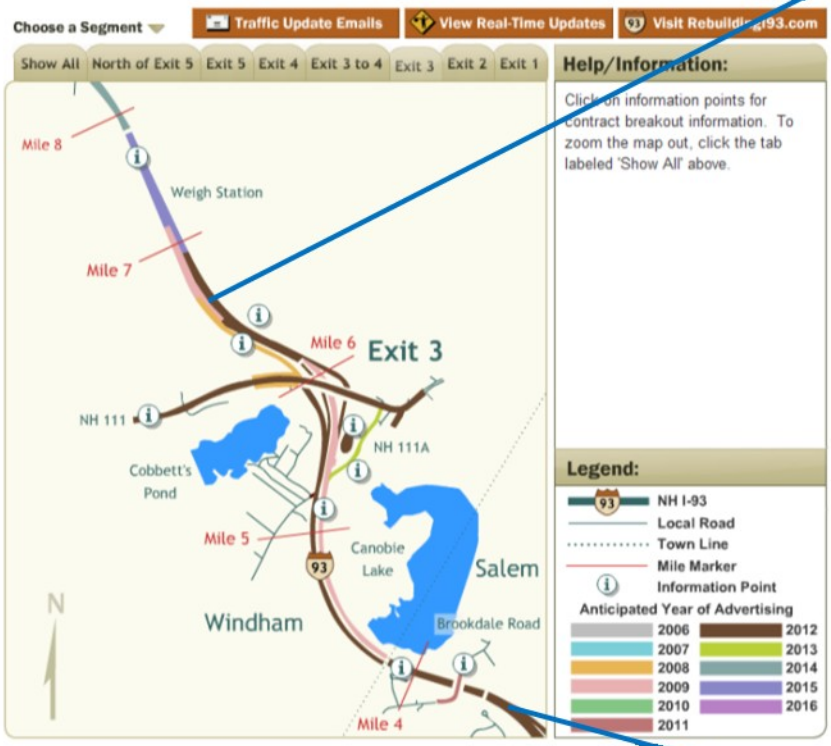
New Hampshire Sites

- Selected sites in NH with drinking water supplies that were impacted by a regulated contaminant attributed to blasting activities by environmental regulators:
  - Concord-Merrimack SPCA (DES ID – 201310041)
  - Merrimack Premium Outlets (20080411-01)
  - Merrimack Home Depot
  - Windham Ledge Road (200711031)
  - Windham 13933K (NHDOT Contract)

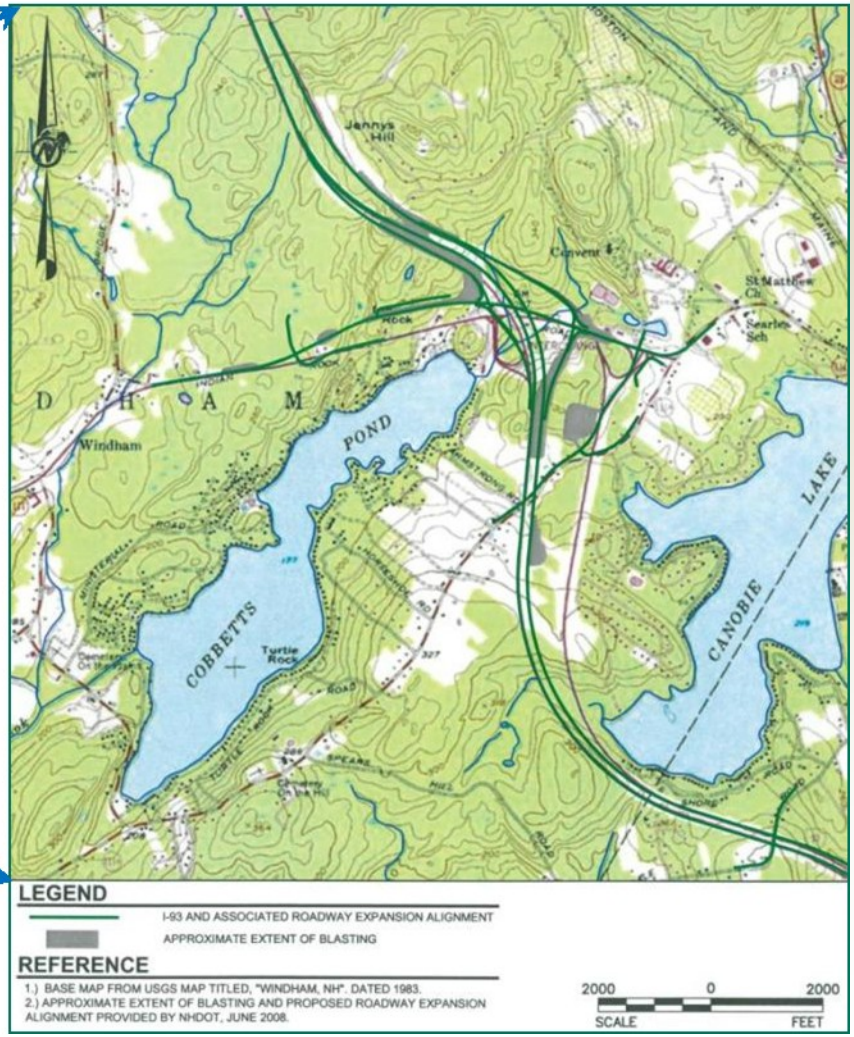
NH Dept. of Transportation Considerations

- I-93 widening project
  - 20 miles of interstate
  - Take 20 red listed bridges out of service
  - New detention basins
  - Realignment of north and south bound lanes
  - Relocation of adjoining roads
  - New Park-and-Ride facility
- Approximately *1.75 million* cubic yards of rock to be excavated

Site Description



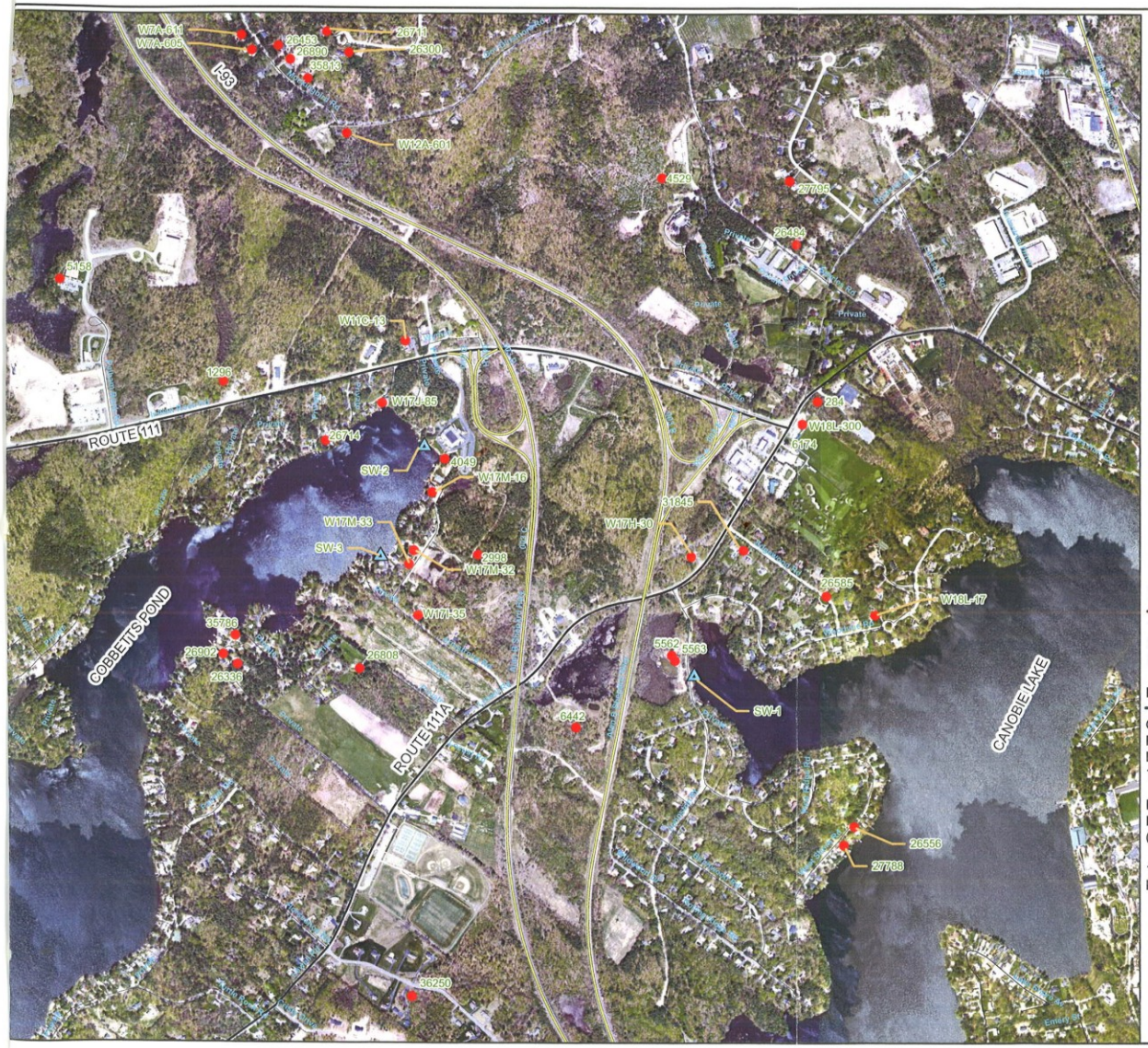
http://www.rebuildingi93.com/



NH Dept. of Transportation Approach

- Drinking Water Baseline Study – Golder Associates, 2008
  - 42 wells and 2 surface water locations were selected for sampling
  - Hydrogeologist Specification Development
  - Best Management Procedures Development (BMP's)
- Based on the drinking water baseline study - implementation of hydrogeologist specification and use of BMP's along the I-93 for corridor improvements commenced

2008 - Baseline Study Sample Locations



LEGEND

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- Locations of Sampled Public and Private Wells
- Location of Surface Water Samples

NOTES:

1.) Some sampled upgradient locations are located outside the Exit 3 area of interest and are not presented on this figure.

REFERENCES:

Ortho Imagery downloaded from USGS Seamless Map Project. Imagery provided by "New Hamshire Department of Transportation Imagery Project" 1'/pixel resolution, Photo date: May, 2005.

Road names and location data aquired from New Hampshire's Statewide Geographic Information System (GIS) Clearinghouse, NH GRANIT.

1983 North American Datum, New Hampshire State Plane diplayed in Feet

0 1,000 2,000 Feet

1 inch equals 1,000 feet

Golder Associates
Manchester, New Hampshire

PROJECT
NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION
I-93 EXIT 3 PROJECT
WINDHAM, NEW HAMPSHIRE

TITLE
GROUNDWATER
AND SURFACE WATER
SAMPLING LOCATION MAP

PROJECT No. 083-86982		
DATE June 27, 2008		
REV. 0	SCALE: AS SHOWN	
DESIGN	EMK	June 20, 2008
GIS	CDS	June 20, 2008
CHECK	JRS	June 30, 2008
REVIEW	APTM	June 30, 2008

FIGURE 9

2008 Baseline Study - Parameters

- Field measurements obtained prior to sampling
  - pH
  - Dissolved oxygen (DO)
  - Specific conductance (SC)
  - Reduction/oxidation potential (ORP or Eh)
  - Temperature
  - Turbidity
- Two suites of parameters: baseline and extended
  - Baseline parameters commonly associated with blasting operations
  - Extended parameters may be present as by-products of blasting or liberated from other environmental sites (e.g., gasoline stations)

2008 Baseline Study - Parameters

Baseline parameters (44 sampling points)

- pH
- Total alkalinity
- Iron
- Manganese
- Arsenic
- Chloride
- Calcium
- Sulfate
- Potassium
- Radon
- Magnesium
- Total hardness
- Total Dissolved Solids (TDS)
- Nitrate
- Nitrite
- Ammonia
- Turbidity

Extended list parameters (15 sampling points of the 44)

- Polyaromatic hydrocarbons (PAHs)
- Diesel range organics (DRO)
- Methyl-tertiary-butyl ether (MtBE)
- Perchlorate

Hydrogeologist Specification

- Included in contracts and requires the contractor to retain a hydrogeologist or environmental consultant to conduct sampling
- Outlines qualification requirements
- Sampling requirements
  - Testing parameters
  - Frequency of testing
  - Locations
  - Reporting

Blasting Best Management Procedures

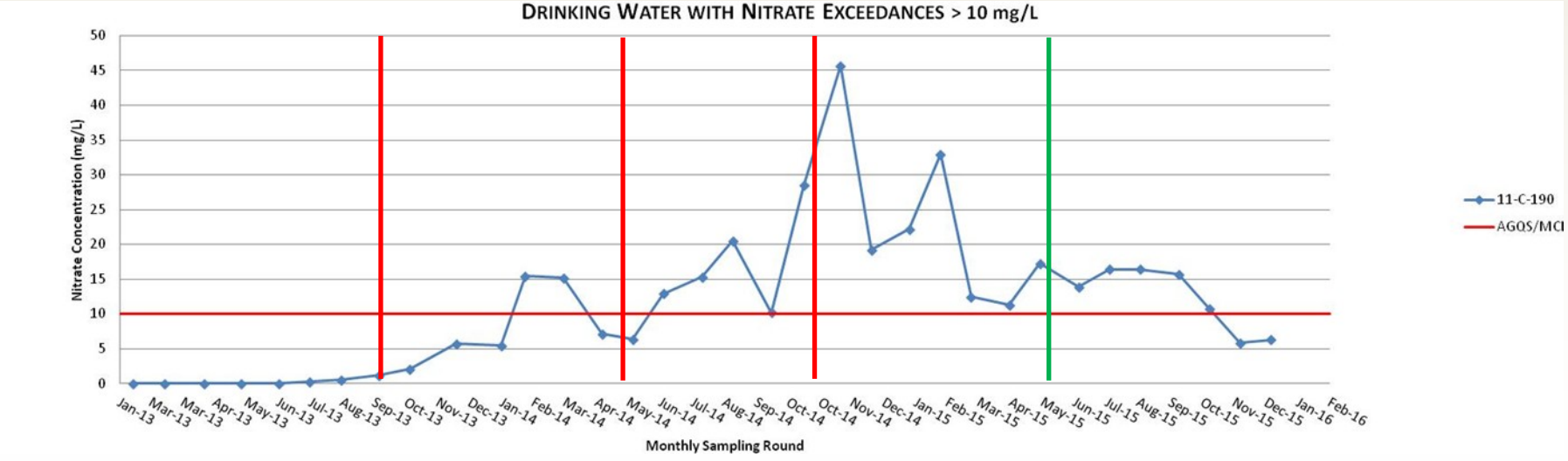
- Blasting observation
- Blasting plan
- Drilling, handling and loading practices
- Blasting performance
- Fragmented rock storage, handling, processing and use
- Treatment of surface runoff

Implementation of Construction Phase Monitoring

- Specification included in 4 contracts
- Drinking water supplies – sampled once before blasting commences for extended list of parameters and monthly for the remainder of the contract for the baseline list
  - Extended: pH, total alkalinity, iron, manganese, arsenic, hardness, TDS, ammonia, turbidity, PAH, TPH, DRO, MtBE, perchlorate
  - Baseline: nitrate, nitrite, ammonia
- Data reported to DOT & homeowners
- Bottled water or treatment systems provided when necessary

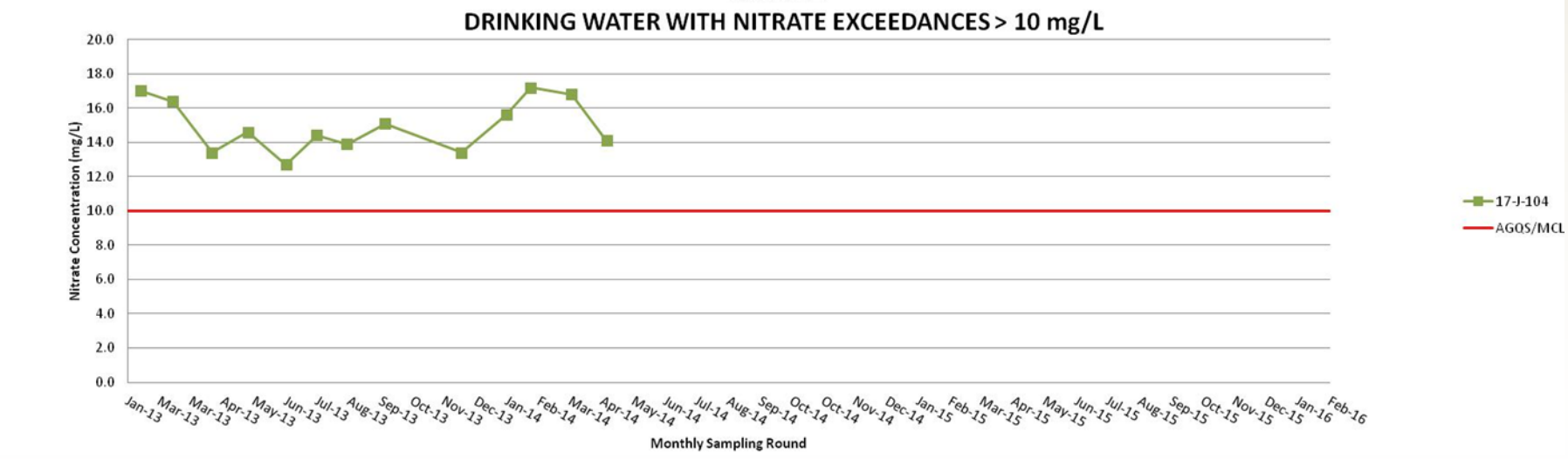
Construction Monitoring Trends

- Parcel 11-C-190
  - Kindergarten facility that was a public water supply (onsite)
  - September 2013 – blasting work began
  - Early May 2014 - Significant blasting adjacent to facility commenced
  - Gap in work in June
  - October 2014 work continued
  - May 2015 -Blasting ended



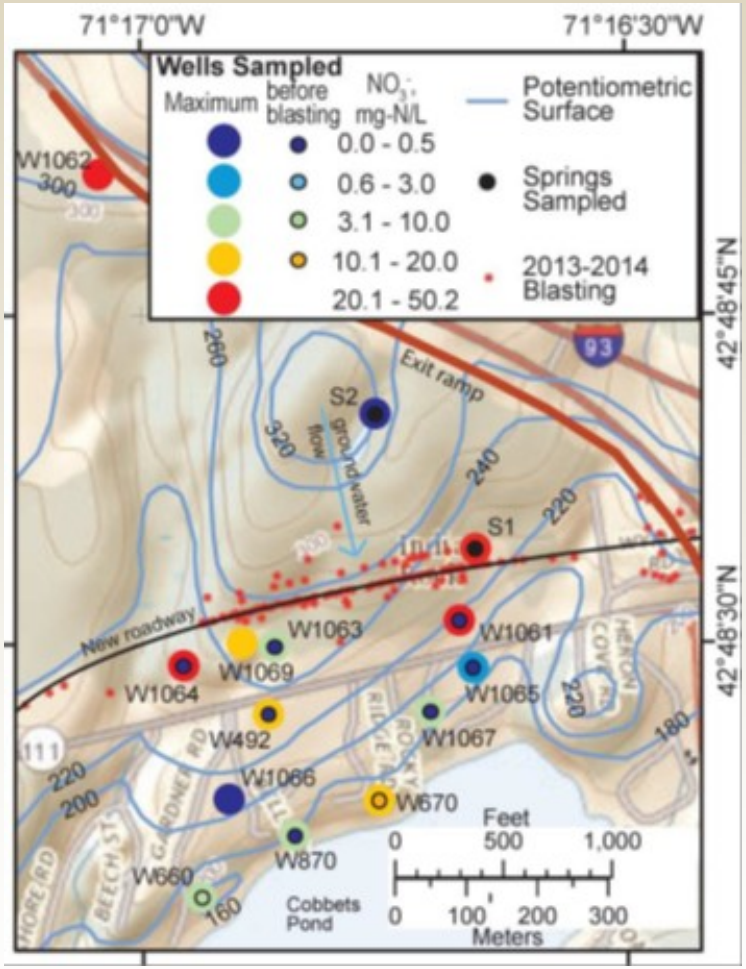
Construction Monitoring Trends

- Parcel 17-J-104 data (private residence) suggested a pre-existing source
- Recent nationwide study found that concentrations over 1 mg/L nitrate indicate human activity
  - EPA - concentrations greater than 3 mg/L generally indicate contamination



Isotopic Investigation

- 2013 - USGS and NHDOT commenced study to evaluate various sources
- Isotope ratios of nitrate and oxygen have been used to evaluate sources in agricultural, urban and other settings
- Opportunity present to test and document the use of isotope ratios to identify sources of nitrate near blasting sites in fractured-bedrock aquifer settings
- 12 wells and 2 springs were selected for isotopic study based on existing data from construction
- Sampled at 2 month intervals



Isotopic Investigation

- Analytical methods:
  - Stable isotope ratios (δ2H and δ18O of H_2O, δ15N and δ18O of NO_3^-, δ15N of NH_4^+ and N_2)
  - Dissolved gases (O_2, Ar, N_2, CH_4)
  - Major elements and ions (Ca, Mg, Na, K, Fe, Mn, Cl^-, Br, SO_4^{2-}, NO_3^-, NO_2^-, NH_4^+, PO_4^{3-})
  - VOC's

Isotopic Investigation - Highlights

- Time series sampling revealed contaminant response times and assisted isotopic identification of multiple nitrate sources
- Bulk emulsions and limited amount of ANFO was used
  - 60-3600 Kg of N could have been “released” = 10-600 mg-N/L over the study area (based on estimated porosity and assumption of undetonated product)
- Collected and sampled rock fragments to characterize leachate
- Collection of groundwater from blasted rock pile
  - Inclusion of unmodified synthetic nitrate end member from explosives that is not commonly found in groundwater...

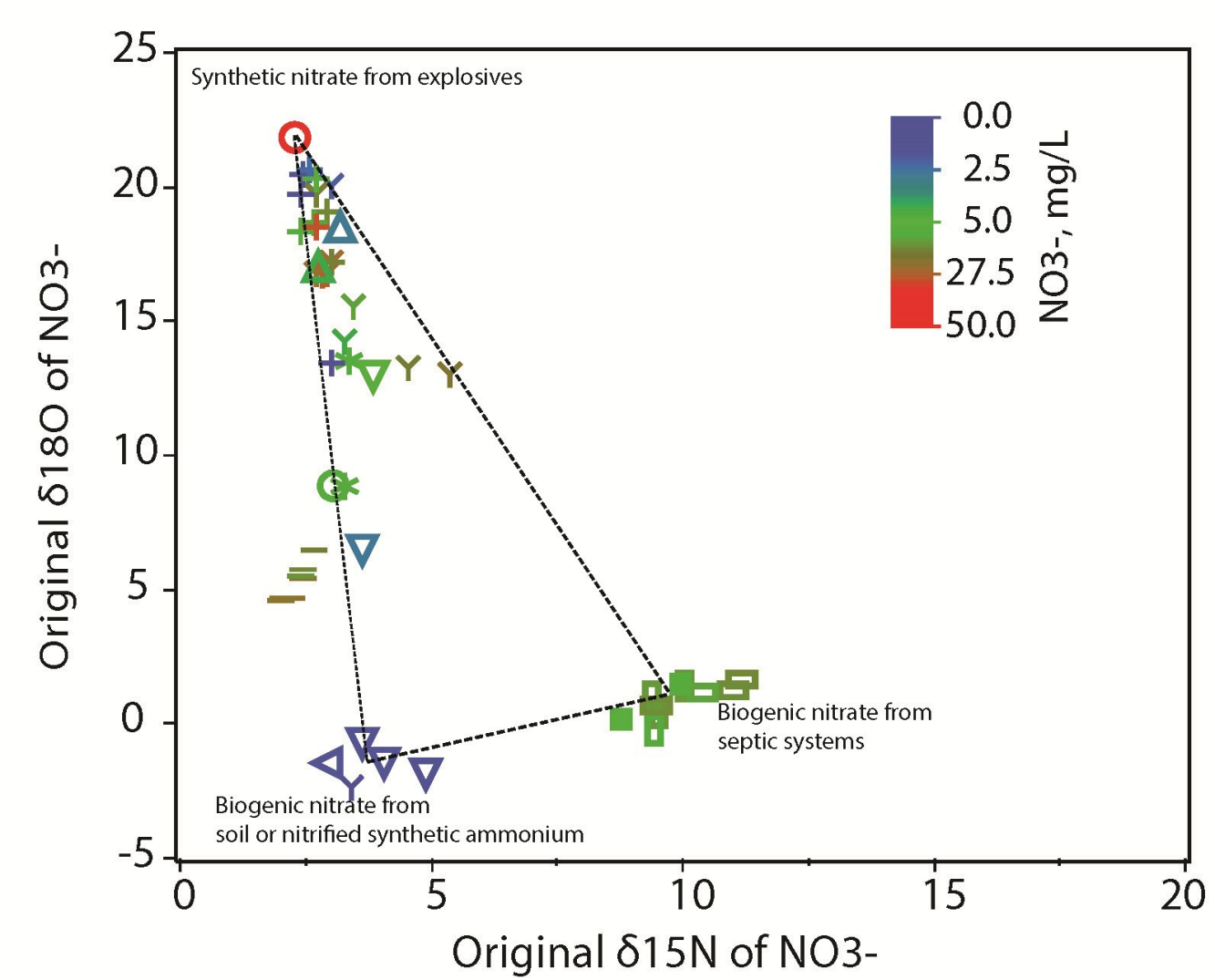
Isotopic Investigation Results

- There were 3 distinct sources of nitrate in groundwater
  - Synthetic from blasting products
  - Biogenic from microbial nitrification of synthetic nitrate (soils, fertilizer)
  - Biogenic nitrate from septic systems
    - Others that plotted represent mixing zones with multiple sources
- End members of the plot well represented by samples from the blasted rock and groundwater draining from the blasted rock pile along with lakeside homes with septic influence
  - On site fertilizer was ruled out as a source (urea based) <0.5% of total synthetic nitrogen used for blasting

Isotopic Investigation Results

Evidence for multiple sources of NO3-

(Reconstructed initial nitrate using gas data)



Environmental Science and Technology

Report available at the New England Water Science Center USGS website: http://newengland.water.usgs.gov/

- James R. Degnan, John Karl Bohlke, Krystle Pelham, David M. Langlais, and Gregory J. Walsh, 2015, Identification of groundwater nitrate contamination from explosives used in road construction: Isotopic, chemical, and hydrologic evidence: Environmental Science and Technology, doi:10.1021/acs.est.5b03671. (PDF file)

DES Regulatory Role/Program Interaction

- Alteration of Terrain permit process identifies sites with >5K CY of

B. Will blasting of bedrock be required? YES☐ NO☐ If yes, estimated quantity of blast rock: _____ cubic yards.
If yes, standard blasting BMP notes must be placed on the plans, available at:
http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-10-12.pdf

If greater than 5,000 cubic yards of blast rock will be generated, a groundwater monitoring program must be developed and submitted to DES. Contact the AoT Bureau for additional detail.

- Drinking Water Groundwater Bureau
  - Reviews groundwater monitoring plans/data
  - Investigates complaints
  - Educates municipalities and provides local regulation guidance
- Waste Division gets involved if AGQS are exceeded (ENV-Or 600).

NHDES Blasting / Groundwater Protection Guidance Document

- Best Management Practices (BMPs)
- Model language for local regulation
  - Background Information
  - BMPs
  - Monitoring
  - Third-party oversight

WD-10-12 - Rock Blasting and Water Quality Measures That Can Be Taken To Protect Water Quality and Mitigate Impacts 2010

Other Rock Blasting Regulation in New Hampshire

- Department of Safety (Saf-C 1600)
  - Regulates individuals that possess and use explosives
  - Has minimum protection requirements for protection of structures

- Municipalities may implement additional requirements in blasting ordinance to protect structures

Conclusions/Future Considerations

- NH Alteration of Terrain permit process governs sampling on private projects with >5K CY of rock blasting through environmental regulatory agency
  - When water quality violations are found - sites become managed though regulatory agency
- NHDOT approach
  - Evaluation of groundwater sampling programs for contracts with >5K CY of anticipated blasting (risk based approach)
  - BMP'S are included in our standard specification for rock excavation
  - Manage the impacts
- Utilizing various sampling techniques (multiple lines of evidence) the drinking water impacts can be managed as can *liability (consider the source)*

Questions?