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Coalbed Methane Produced Water Usability Through Characterization


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Presentation Outline

- ▶ **Coalbed Methane (CBM) Production**
- ▶ **Colorado School of Mines Study Area**
- ▶ **Water Characterization**
 - Produced Water Database
 - Produced Water Sampling
- ▶ **Water Quality Analyses**
- ▶ **Detected Compounds**
- ▶ **Water Quality Module**



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CBM Gas-Water Production

- ▶ Wells perforated along coal seams
- ▶ Water is produced to release pressure allowing methane to desorb from the coal surface
- ▶ Water Production:
 - 30 bbls/day \equiv 1,260 gal/day (per well)
 - Highly variable (time dependent)
- ▶ Water Quality
 - Saline - elevated sodium
 - Highly variable

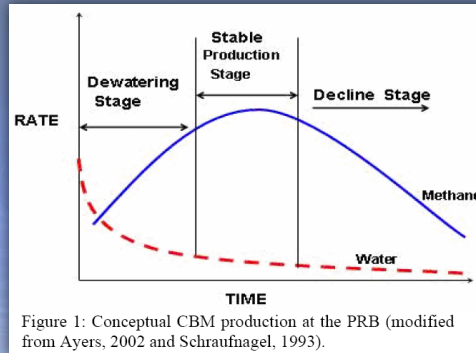


Figure 1: Conceptual CBM production at the PRB (modified from Ayers, 2002 and Schraufnagel, 1993).

- ▶ Commonly treated as a waste product by producers
- ▶ Arid production areas are water scarce

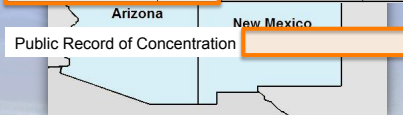
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Characterizing Water Quality

- ▶ Water Quality Database
 - Public Records
 - Producer Information
- ▶ Sampling Campaigns
 - Powder River Basin (31 samples)
 - Atlantic Rim Basin (20 samples)
 - Raton Basin (45 samples)
 - San Juan Basin (20 samples)
- ▶ Additional Information
 - Treatment Issues: Ba, Sr, Si, VOCs, TOC, Bacteria, etc.
 - Regulatory Concerns: As, B, Cr, Ni, CN, BTEX, SAR

Water Quality Constituents and Parameters			
Components	Units	Components	Units
Aluminum	mg/L	Cyanide, free	µg/L
Arsenic	mg/L	Fluoride	µg/L
Barium	mg/L	Nitrate (as N)	µg/L
Boron	mg/L	o-Phosphate	µg/L
Calcium	mg/L	Sulfate	mg/L
Copper	mg/L	Benzene	µg/L
Chromium, total	µg/L	Ethylbenzene	µg/L
Iron	µg/L	Toluene	µg/L
Lead	µg/L	Xylene (total)	µg/L
Magnesium	mg/L	Total Organic Carbon (TOC)	mg/L
Manganese	mg/L	Oil and Grease	mg/L
Nickel	mg/L	Radioactivity, Gross Alpha	pCi/L
Potassium	mg/L	Radioactivity, Gross Beta	pCi/L
Selenium	mg/L	Radium-226 + Radium-228	pCi/L
Silver	mg/L	Uranium	µg/L
Sodium	mg/L	Silica (SiO ₂)	mg/L
Strontium	µg/L	pH	pH
Zinc	mg/L	pOH	pOH
Alkalinity-Bicarbonate	mg/L	Total Dissolved Solids (TDS)	mg/L
Alkalinity (as CaCO ₃)	mg/L	Total Suspended Solids (TSS)	mg/L
Alkalinity-Carbonate	mg/L	SAR	
Bromide	mg/L	Conductivity	µS/cm
Chloride	mg/L	Temperature	°C



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Water Quality Characteristics

▶ TDS Basin Averages

- Atlantic Rim – 2,120 mg/L
- Powder River – 1,310 mg/L
- Raton – 2,640 mg/L
- San Juan – 4,870 mg/L

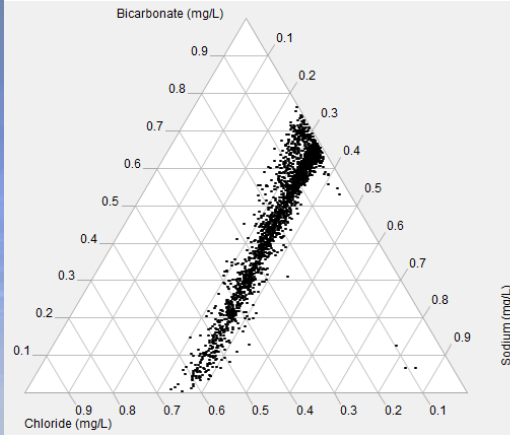
▶ Monovalent Salts

- NaHCO₃
- NaCl

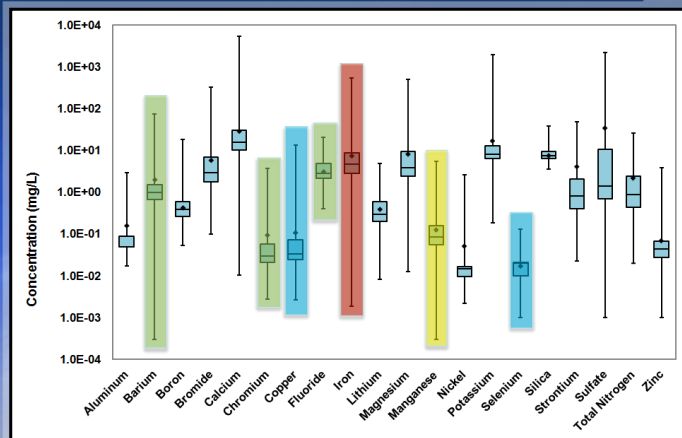
▶ Tri-ion Distribution

- Na, HCO₃ and Cl > 95% of Total Dissolved Constituents
- Proportional Concentrations

Relationship of Proportional Concentrations



Occurrence of Minor Ions



Percentage of wells Exceeding Potable Standards

- < 1 %
- 1 - 10 %
- 10 - 25 %
- > 50 %



Field Parameters, Bacteria and Organics

▶ Field Information

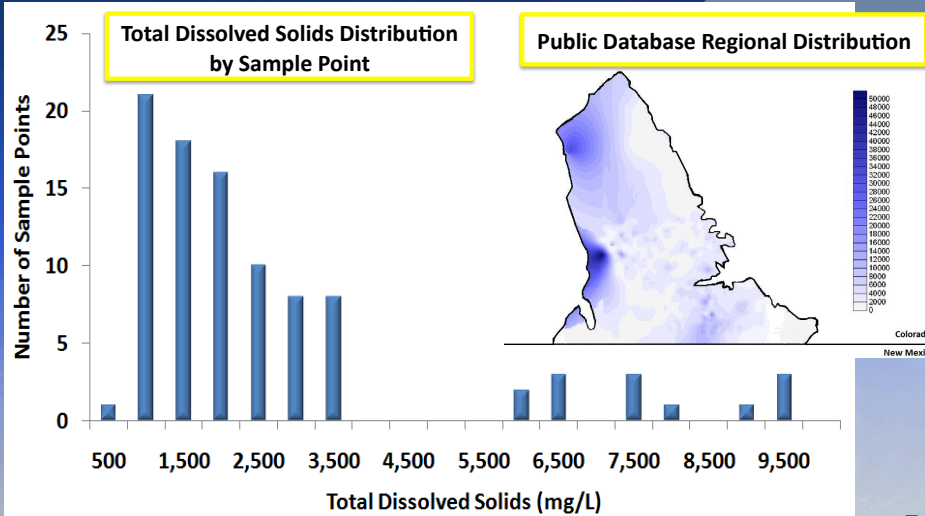
- Elevated Temperatures
 - 20 – 50 °C
- Dissolved Gases
 - CH₄, CO₂, H₂S
- Total Suspended Solids
 - Average: 33 mg/L
- Dissolved Oxygen
 - Generally < 1.0 mg/L

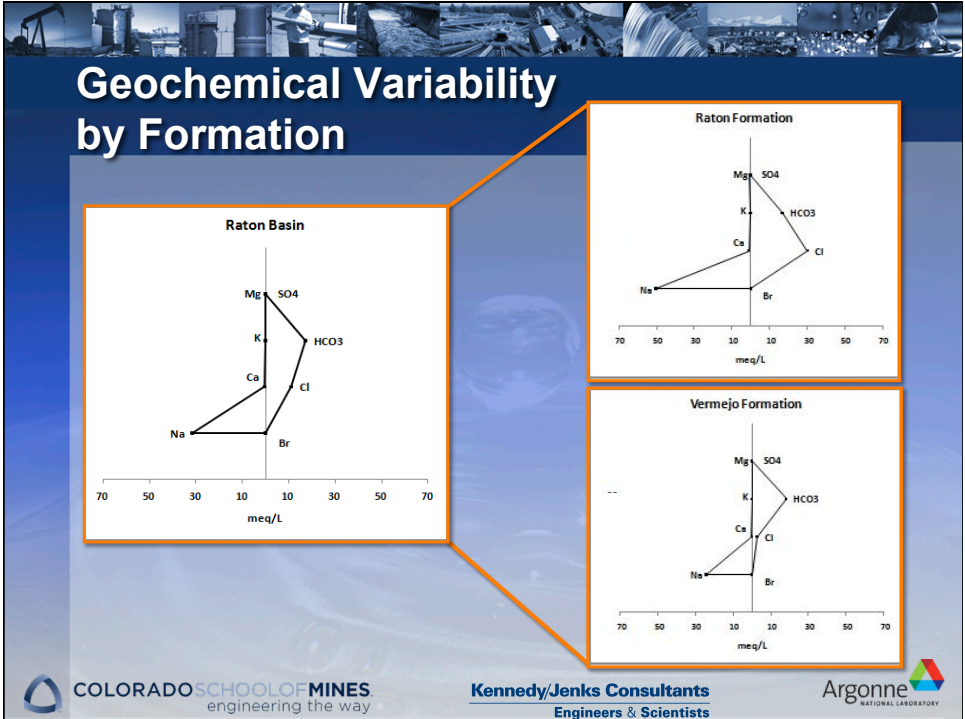
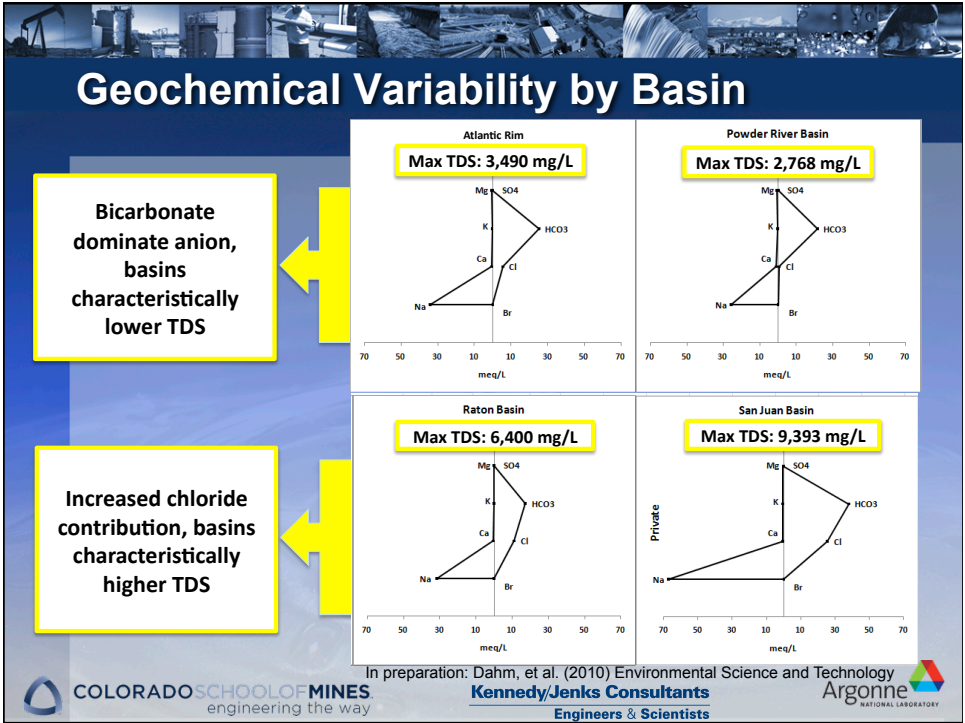
▶ Bacteria and Organic Matter

- Bacteria: 4.25 x 10⁶ to 3.96 x 10¹⁰ total plate count/100mL
- Total Organic Carbon:
 - 0.3 to 8.9 mg/L
- BTEX: San Juan and Raton Basin Detected



Relative Salinity and Distribution



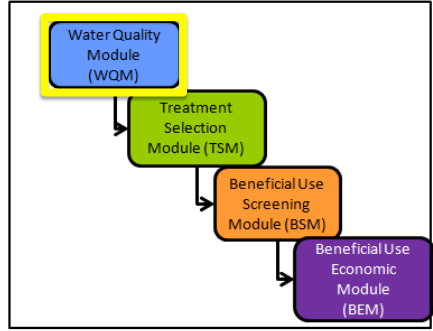


Water Quality Module

Objectives

- ▶ Utilize produced water quality database
- ▶ Encompasses observed variability
- ▶ Output comprehensive constituent list for the Treatment Selection Module
- ▶ Format into Excel™ based macro enabled workbook
- ▶ Downloadable from the RPSEA project website

TOOL ORGANIZATION



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Produced Water Treatment and Beneficial Use Screening Tool

Water Quality Module

Sponsored by:

OUTPUT

← WQM Menu

Project Information

State	Colorado
Basin	San Juan
Formation	All Formations
Design Percentile	75

Water Flow Information

Water Flow Rate Units	MGD	bbl/yr	AFY
Average Water Flow Rate	7.94E-03	1.89E+02	8.90E+00
Peak Water Flow Rate	1.35E-02	3.21E+02	1.51E+01

Next Module →

Final Constituent Values

Alkalinity (as CaCO ₃)	4400.00 mg/L	Fluoride	2.19 mg/L	Selenium	0.05 mg/L
Alkalinity-Bicarbonate	4680.50 mg/L	Iron	5.04 mg/L	Silica (SiO ₂)	12.62 mg/L
Alkalinity-Carbonate	0.00 mg/L	Lead	0.06 mg/L	Silver	0.00 mg/L
Aluminum	0.23 mg/L	Lithium	2.50 mg/L	Sodium	2352.50 mg/L
Arsenic	0.01 mg/L	Magnesium	16.00 mg/L	Strontium	6.50 mg/L
Barium	13.25 mg/L	Manganese	0.19 mg/L	Sulfate	8.05 mg/L
Benzene	120.00 µg/L	Nickel	0.05 mg/L	Temperature	35.60 °C
Boron	1.74 mg/L	Oil and Grease	2.00 mg/L	Toluene	2.10 µg/L
Bromide	12.61 mg/L	o-Phosphate	6.28 mg/L	Total Dissolved Solids (TDS)	7789.51 mg/L
Calcium	43.00 mg/L	pH	8.00 pH	Total Nitrogen (as N)	0.59 mg/L
Chloride	612.00 mg/L	Potassium	16.00 mg/L	Total Organic Carbon (TOC)	3.62 mg/L
Chromium	0.02 mg/L	Radioactivity, Gross Alpha	4.50 pCi/L	Total Suspended Solids (TSS)	51.75 mg/L

Integrated Framework Tool: Water Quality Module

Purpose of WQM: Provide comprehensive data for treatment design

- ▶ Incorporates variable water quality data
 - Region
 - Coal Formation
 - CBM Basin
- ▶ Allows user data QA/QC
- ▶ Works as a precursor providing water quality data to the Treatment Selection Module (TSM)



An Integrated Framework for Treatment and Management of Produced Water

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