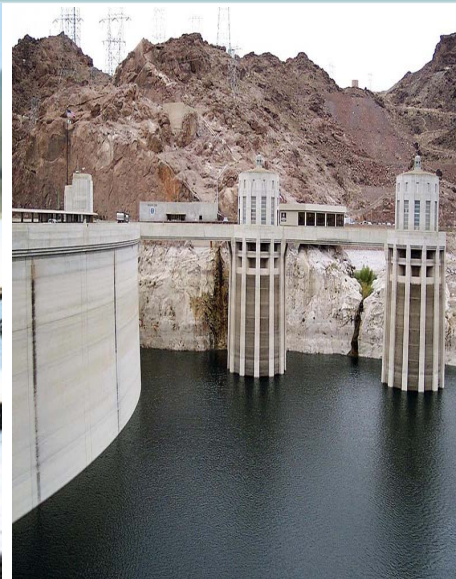


Energy development water needs assessment and water supply alternatives analysis

Benjamin Harding, AMEC Earth & Environmental

The Promise and Peril of Oil Shale

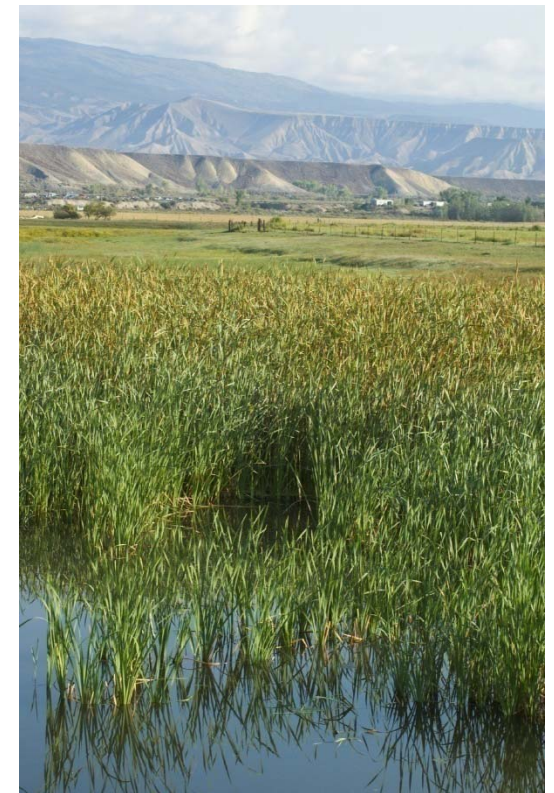
February 5, 2010



Colorado Water for the 21st Century Act (HB 05-1177)



- **Statewide Water Planning Process**
- **Nine Basin Roundtables**
 - Formulate a water needs assessment
 - Conducting analysis of un-appropriated water
 - Propose projects or methods for meeting needs
- **Interbasin Compact Committee**
- **Funding for special studies**



- **Funded under the HB-1177 Process by the Colorado Water Conservation Board**
- **Project of Colorado River basin and Yampa/White River basin Roundtables**
- **Two phases:**
 - Estimating energy development water needs
 - Evaluating water supply alternatives to satisfy those needs



Phase 1 Industry Production Scenarios



Scale	Capacity	Water Requirement
Low	None (R&D)	
Medium	550,000 bbl/day	135,000 af/year
High	1,550,000 bbl/day	380,000 af/year



Phase 2 Approach



- **Refine Water Use Estimates**
 - Review and refine Phase I unit water use
 - Localize water use estimates
 - Develop water use scenarios
- **Evaluate use of Piceance Basin groundwater**
 - Ground water quality
 - Potential tributary connection
 - Overall feasibility of groundwater use
- **Develop water supply project alternatives**
- **Develop model and analyze alternatives**



- **Review history of Athabasca Oil Sands**
 - Surface-mined – (less overburden)
 - Separation process 1926
 - First commercial extraction 1967 30,000 bbl/day
 - 2005 production 760,000 bbl/day
 - 2006 production 1,100,000 bbl/day
 - Long-term growth rate c. 12%
- **Extrapolation to Piceance Basin**
 - Field demonstration of feasibility c. 2015
 - First commercial production c. 2035 (50,000 bbl/day)
 - 1.55 mm bbl/day by about 2060



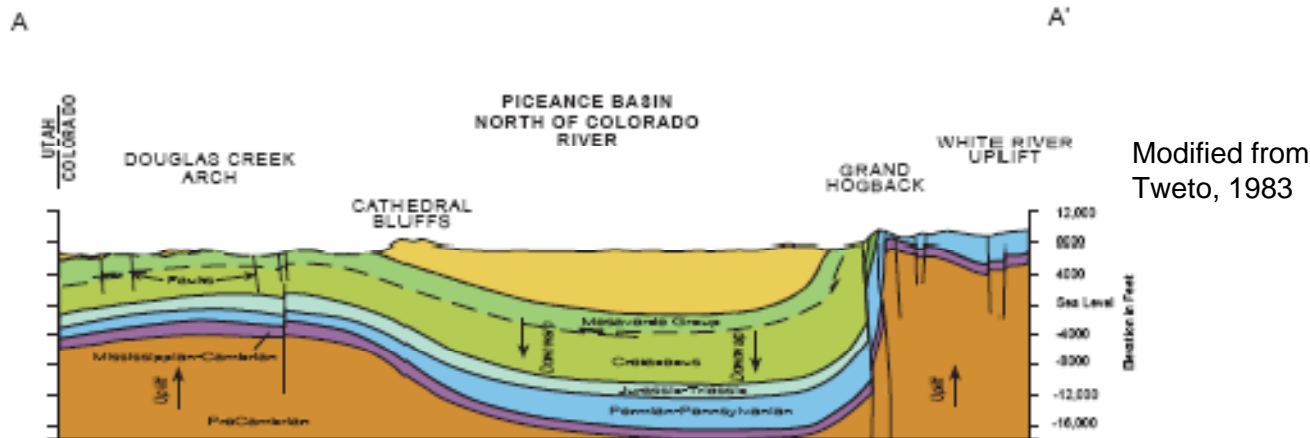
- **What in-situ technology will prevail?**
 - Electrically heated
 - Combustion or other heating method
- **Electrically Heated In-situ**
 - 120,000 GWh/year for 1.5 million bbl/day
 - Colorado total generation (2008): 53,000 GWh/year
- **What will be source of electrical energy?**
 - On-site Combined-cycle Gas Turbines (CCGT)
 - Yampa coal-fired thermal (Craig station approximately 10,000 GWh/year)
 - “Somewhere else”
- **Water requirements**
 - CCGT in-basin
 - Thermal in ????
 - Grid supplied
- **Likely winner: CCGT?**

Phase 2 Water Needs Estimates



Industry Case	1,550,000 bbl/day	550,000 bbl/day
Direct uses	110,000 af/year	42,000 af/year
Water for CCGT	55,000 af/year	19,000 af/year
Water for Thermal	181,000 af/year	61,000 af/year
Colorado Total		
“Somewhere Else”	110,000 af/year	42,000 af/year
Using CCGT	165,000 af/year	61,000 af/year
Using Thermal	291,000 af/year	103,000 af/year

Water Supply: Groundwater



■ Quality—

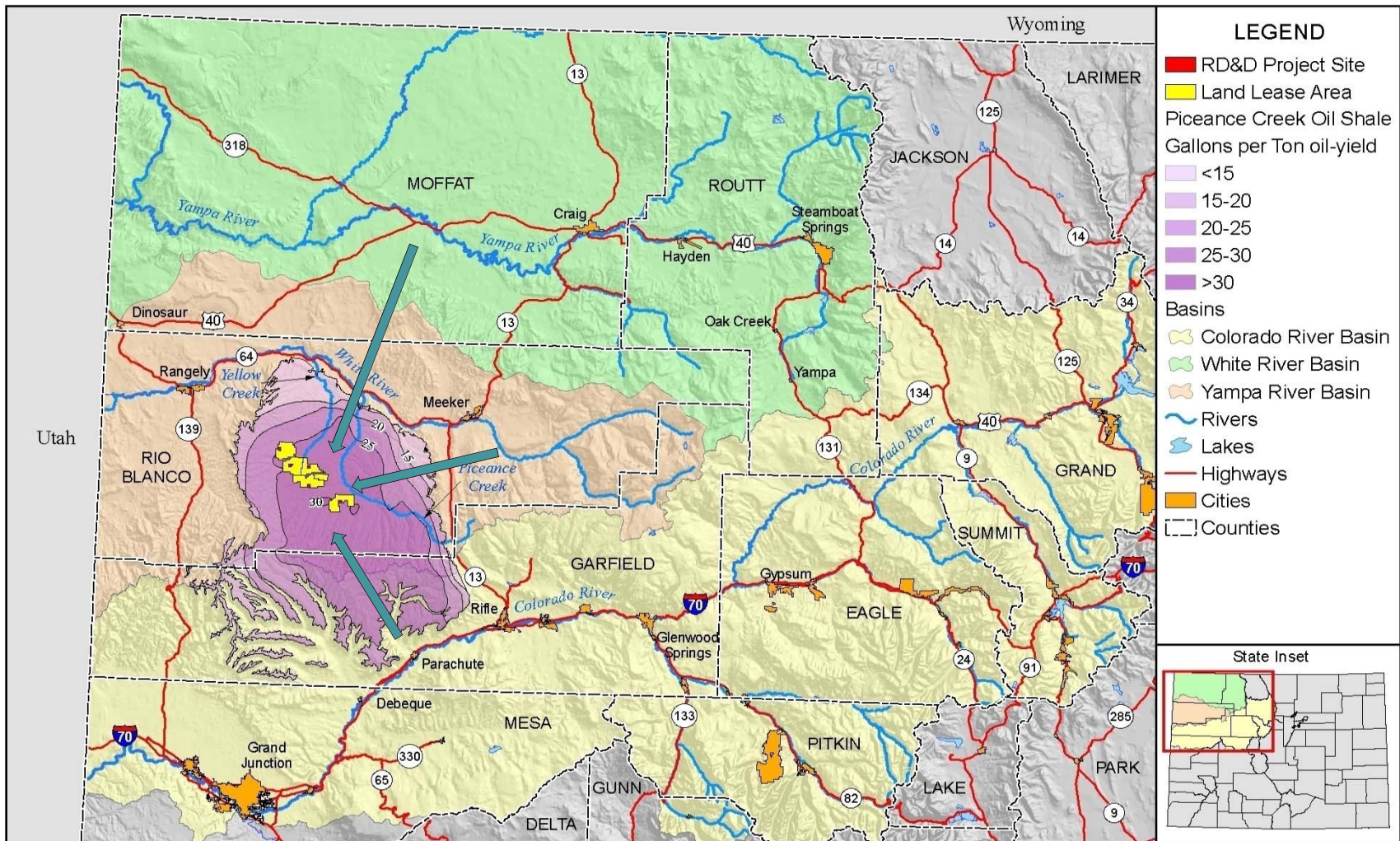
- Ranges from moderately poor to very poor (1,000- > 10,000 mg/l TDS)
- Hard and scale forming
- Will require treatment

■ Quantity

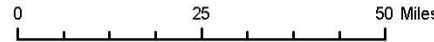
- Most feasible aquifers are probably tributary
- Feasibility of development in other aquifers will depend on site specific investigations

■ Overall—Not likely to be a regional resource

Water Supply: Surface Water



Map compiled 10/2009; intended for planning purposes only.
 Data Source: Colorado's Decision Support Systems, CDOT, USGS



Water Supply: Develop Conceptual Projects



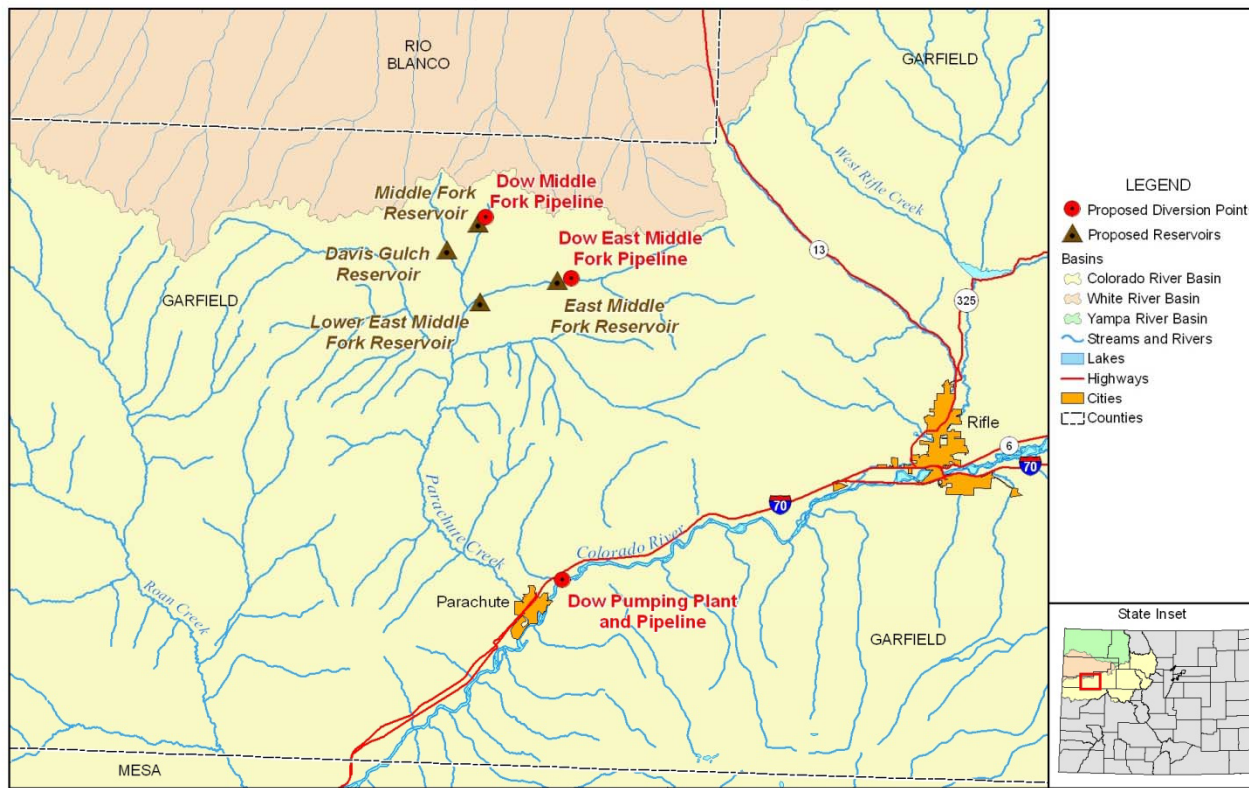
- White River Basin
 - Identified Reservoirs
 - No feasible groundwater
- Imports from Colorado River
 - Exxon change case
 - Other projects?
- Imports from Yampa River
 - Shell proposal



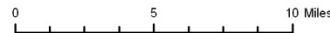
Exxon Mobil Change Case



Proposed Diversion Points & Reservoirs by Exxon Mobil
(Case NO. 08CW199)



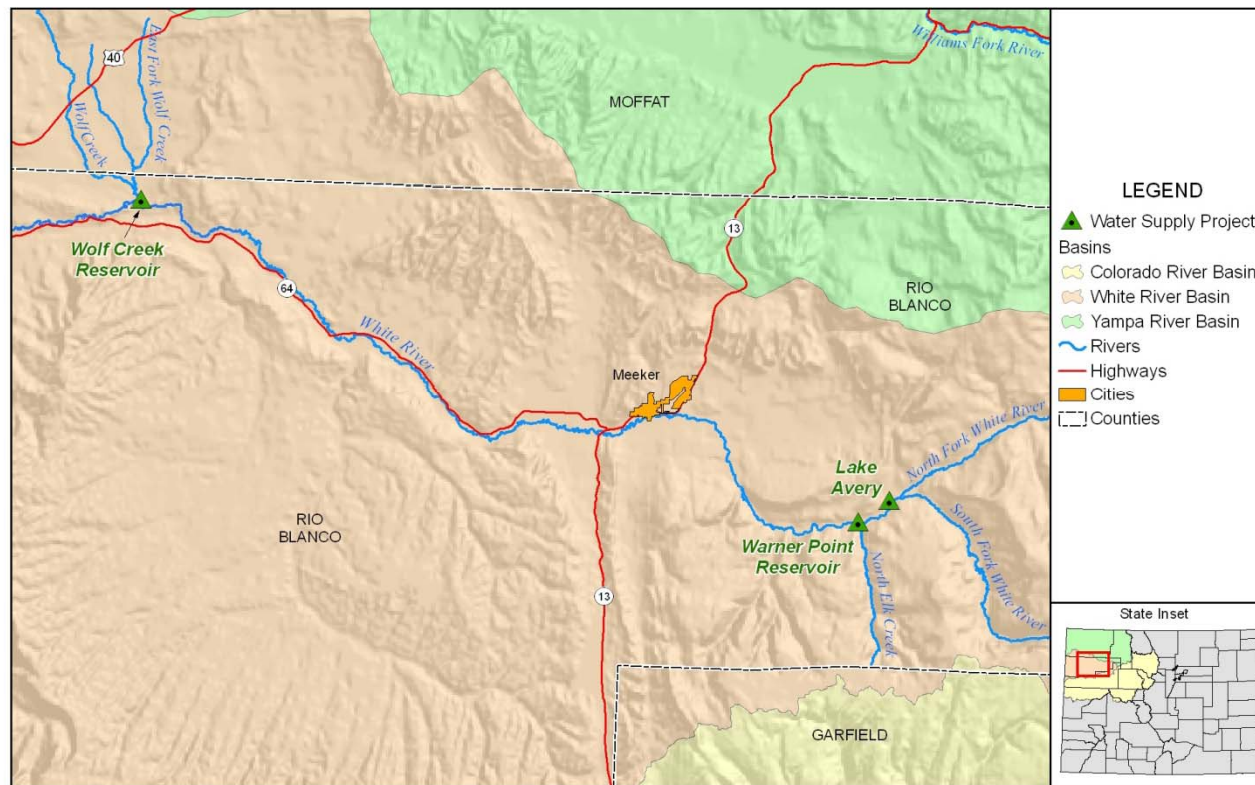
Map compiled 2/2010; intended for planning purposes only.
Data Source: Colorado's Decision Support Systems, CDOT,
Application for Case NO. 08CW199



White River Reservoirs



Proposed Water Supply Projects - White River Basin

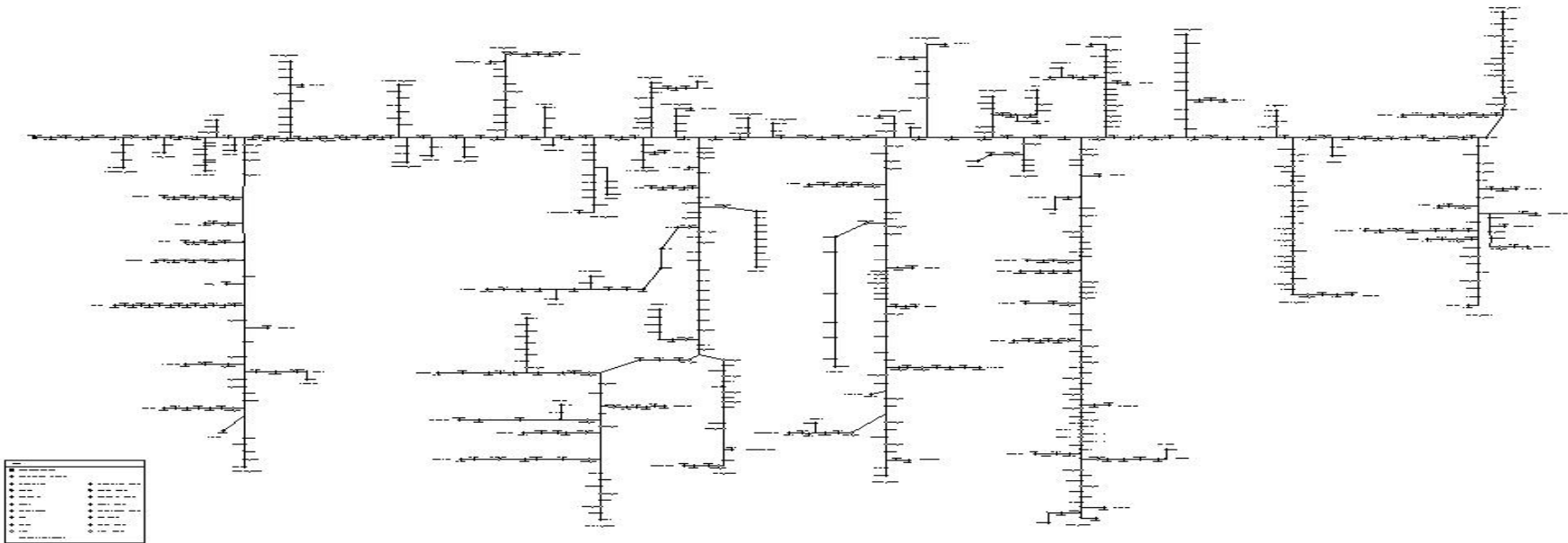


Map compiled 2/2010; intended for planning purposes only.
Data Source: Colorado's Decision Support Systems, CDOT, USGS,
White River Study (12/1983)

0 5 10 Miles



- Develop water rights “portfolio” from identified “energy” rights
- Associate Water Rights with Facilities
- Disaggregate demands to nodes
- Disaggregate annual demands to model time step
- Evaluate performance of project/water rights



- **Will there be any oil shale industry?**
- **If there is an industry, can its scale be managed?**
- **What in-situ technology will be used?**
- **Where will the electricity come from?**
- **Where will upgrading and refining be done?**
- **Development approach?**
 - Coordinated
 - “Scramble”
- **How much water will be available?**