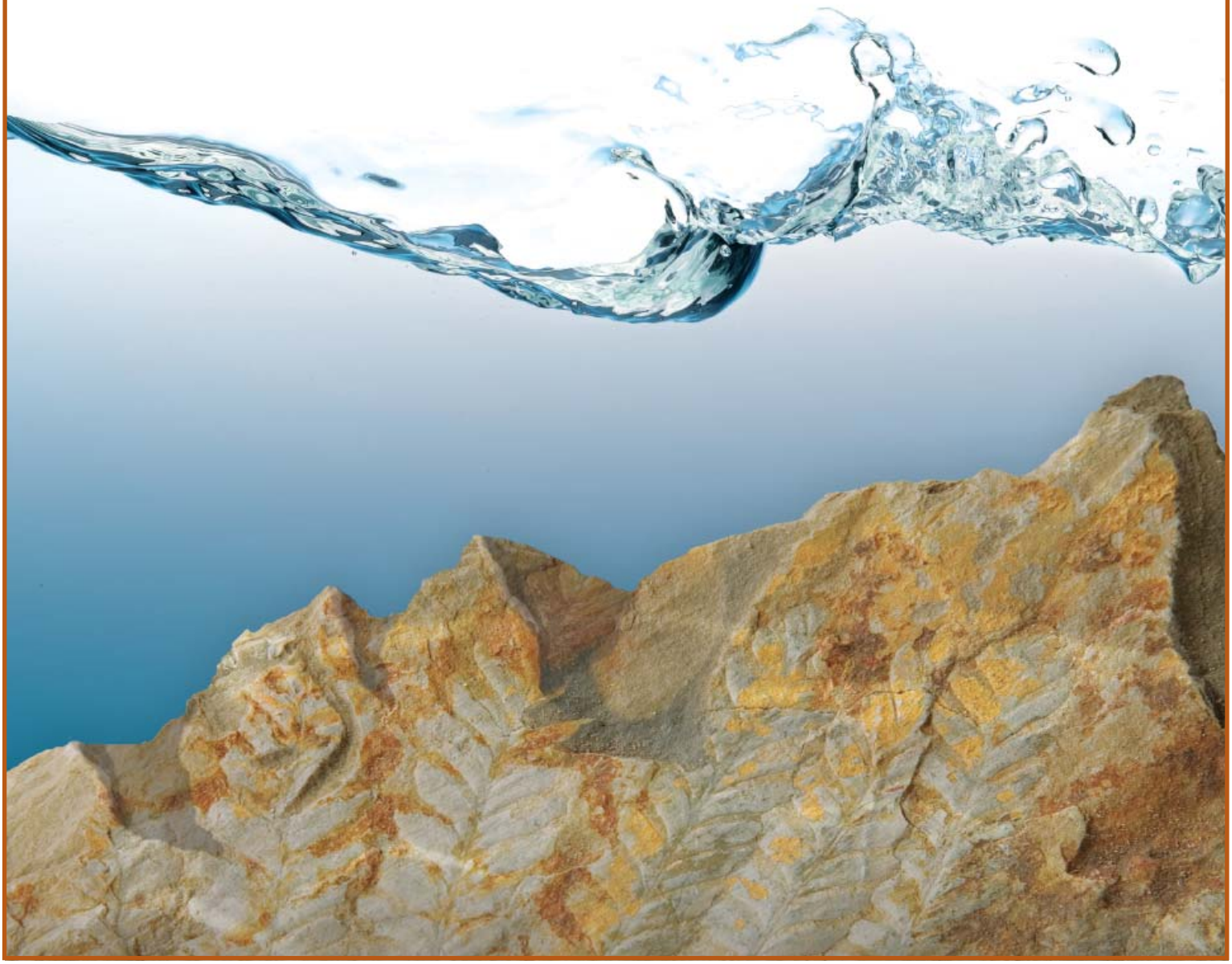
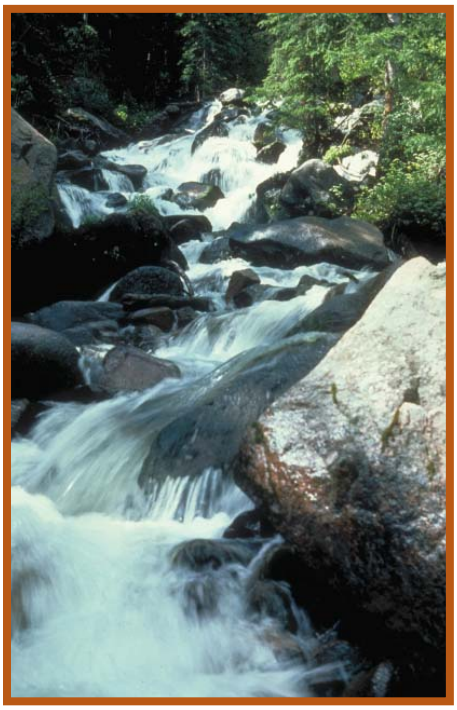
WESTERN RESOURCE ADVOCATES

WATER ON THE ROCKS

Oil Shale Water Rights in Colorado

Executive Summary





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Dan Luecke contributed the sections on the Upper Colorado River Endangered Fish Recovery Program and the Colorado River Compact. Robert Harris researched the decrees for the conditional water rights. Steve Styler generated the many tables. Geneva Mixon developed the maps. The report also benefited from the expert review of Chase Huntley, Amy Mall, Bart Miller, Peter Roessmann, Anita Schwartz, and Barney White.

About Western Resource Advocates:
Western Resource Advocates is a nonprofit environmental law and policy organization dedicated to protecting the West's land, air, and water.

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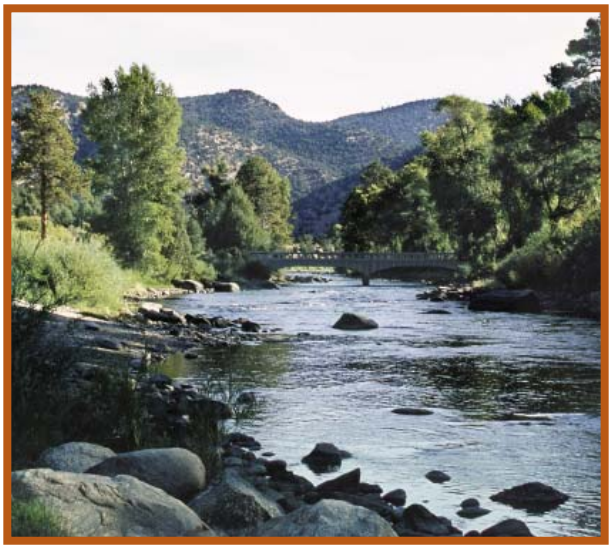
EXECUTIVE SUMMARY

Since the early 1900s, the dream of tapping vast oil shale reserves has drawn energy companies to western Colorado. That dream has proven elusive, for while small quantities of oil have been released after heating shale, commercial production technology remains undeveloped. Past development attempts have failed because of a number of technical, economic, and environmental challenges that have yet to be overcome, despite the billions of dollars invested by both government and industry.

Some members of Congress and a few oil companies suggest the oil shale puzzle may soon be solved. Should this prove to be the case, western Colorado will witness, as Colorado Governor Bill Ritter cautions, "the largest industrial development in the state's history — with enormous implications for all of Northwest Colorado and for the state itself."[1] Oil shale development would bring significant change in western economies, communities, and ways of life. One of the most significant aspects of such change would be in the use of water.



Oil shale development would have tremendous impacts on current and future uses of water — Colorado's most precious natural resource. Water is the lifeblood of the West. It's the foundation of western economies and communities, the basis of political divisions, and often the cause of conflict. Battles over water often pit Front Range cities, such as Denver and Colorado Springs, against West Slope communities, such as Rifle and Grand Junction. Renewed efforts to develop a commercial oil shale industry could once again fan the flames that fuel such battles.

Initial analyses by the RAND Corporation and the U.S. Departments of Energy and the Interior conclude that significant amounts of water will be required to both extract oil from shale and power the extraction processes. Large quantities of water will also be needed to support major infrastructure development and the influx of new workers. It would be folly to discount the crucial link between oil shale development and water resources, ignoring the fact that the arid Rocky Mountain Region is defined by the scarcity of water. Westerners understand this link — and our leaders understand the vital importance of examining potential oil shale development within the context of increasing competition for dwindling water supplies.

It is undisputed that oil shale development will stress limited water resources. The question for elected officials and other community leaders are how, when, where, and to what extent. In a May 2008 letter to Congress, Hamlet J. "Chips" Barry III, manager of the Denver Water Board, stated that, "development of oil shale in Colorado could significantly affect

1 Bill Ritter, Jr., Governor of Colorado, testimony before the Senate Committee on Energy and Natural Resources, Oversight Hearing: Oil Shale Resources, May 15, 2008.

the [Front Range Water Users] Council's ability to serve existing customers and the future growth projected for the Front Range of Colorado."[2] That conclusion is significant. What is unclear, however, are the specific impacts on Colorado water and the timing of such impacts.

In order to more fully understand the conflict Barry identifies, Western Resources Advocates (WRA) engaged Larry MacDonnell to investigate the extent of water rights in Colorado held by oil companies, individuals, and water providers that could be used for oil shale development. *Water on the Rocks* frames critically important issues vital to the future of Colorado and the West.

OVERVIEW OF *WATER ON THE ROCKS*

Development would require the use of large quantities of water — perhaps as much as 3-4 barrels of water for each barrel of shale oil for direct use, plus additional water for indirect demands, such as electricity generation and an increased population. Given the magnitude of development the U.S. Department of the Interior's Bureau of Land Management (BLM) projects is one day feasible, as much as 378,000 acre-feet of water could be required annually to support oil shale development, more than the Denver Metro area uses each year. (See Table 1).

Table 1. Estimated Oil Shale Water Demands[3]

Source of Water Demand	Annual Quantity (af)
Direct demand (1.55 million barrels per day)	112,675
Electric power	244,535
Increased population	21,100
Total	378,310

The possible development and use of substantial water for oil shale production raises important considerations for Colorado because of their potential to adversely affect some existing water uses and many expected future water uses. Companies with an interest in oil shale development own enormous portfolios of water rights. While there is great uncertainty with respect to the manner in which these rights will be developed and used, the consequences of such development are unquestionable.

Among the many likely changes in the use of Colorado water resulting from oil shale development are changes in existing irrigated agriculture, limitations on existing and planned water development for the Front Range and the West Slope, and likely limitations on other water development for new uses on the West Slope. While these general impacts are relatively easy to project, it is harder to identify the exact development scenarios and the resulting impacts on a given water right or a specific project.

This report helps frame these and other issues central to the many technical and policy

2 Front Range Water Users Council members are the largest suppliers of municipal, commercial, industrial, and agricultural needs in Colorado. Approximately one-half of the state's population receives water from council members.
3 Colorado, Yampa, and White River Basin Roundtables Energy Subcommittee, Energy Development Water Needs Assessment (Phase 1 Report), September 2008, p. 4-7.

questions posed by oil shale development. The report:

- Projects water requirements associated with oil shale development.
- Identifies all major water rights currently owned by energy companies that could be used for oil shale development in Colorado, as well as conditional rights that could be exercised in the future. Rights are grouped by basin, source, point of diversion, and diversion amount.
- Analyzes legal and hydrological issues of the Colorado River Basin that affect future development of Colorado's allocation under the 1922 Colorado River Compact and subsequent 1948 Upper Basin Compact.
- Explains how the Upper Colorado River Endangered Fish Recovery Program affects and limits additional consumptive uses of water in the mainstem Colorado River.

In order to meet the significant water demands associated with oil shale development, oil companies as well as water supply districts have secured hundreds of water rights throughout western Colorado. They have established conditional water rights associated with more than 200 separate proposed structures, such as reservoirs and pipelines in the Colorado River and White River Basins, which could potentially be developed in support of oil shale production. Many of these rights were established in the 1950s and 1960s, and collectively would enable the direct diversion of more than 10,000 cubic feet per second (cfs) of water and the storage of more than 1.7 million acre-feet (af). In addition, energy companies have acquired full or partial ownership of more than 100 existing irrigation ditches with decreed rights to divert more than 650 cfs in the two basins in proximity to the shale deposits. These rights are summarized in Tables 2&3.

"Water is likely to be transferred from traditional agricultural uses to industrial uses, resulting in the loss of traditional irrigated agriculture. Changes may also result in an increase in dryland agriculture, and depending on scale it may also result in a transition from traditional agriculture based community to a more urbanized lifestyle."[5]

— Bureau of Land Management,2008

Table 2. Summary of Conditionally Decreed Structures – Colorado River Basin

Proposed Structures by Type	Total Conditionally Decreed Quantities of Water
Reservoirs: 27	736,770.6 af
Pumps and pipelines: 23	1,515.6 cfs
Ditches: 6	3,472.3 cfs
Wells: 5	1.36 cfs
Springs: 44	6.76 cfs
Total structures: 105	Total quantities: 4,996.02 cfs 736,770.6 af

Table 3. Summary of Conditionally Decreed Structures – White River Basin

Proposed Structures by Type	Total Conditionally Decreed Quantities of Water
Reservoirs: 34	1,186,625.8 af
Pumps and pipelines: 33	4,274 cfs
Ditches: 24	1,363 cfs
Wells: 12	54.02 cfs
Springs: 11	2.45 cfs
Total structures: 114	Total quantities: 5693.47 cfs 1,186,625.8 af

Figure 1. Location of the White and Colorado River Basins and the Piceance Basin Oil Shale Deposits

ExxonMobil owns the most rights: 49 conditional claims and ownership in 48 irrigation ditches. Most of its rights are located in the White River Basin. Shell holds 31 conditional rights in the two basins and has purchased ownership in five irrigation ditches. It is now in the process of securing rights on the Yampa River. Chevron holds 28 conditional rights and ownership in 24 irrigation ditches, all located in the Colorado River Basin. Its Unocal subsidiary owns absolute rights to another 48 wells and springs, as well as ownership in 13 ditches in this basin. OXY USA holds conditional rights for 22 proposed structures in the Colorado River Basin. Tosco holds 17 conditional rights and ownership in 14 ditches in the White River Basin. The Colorado River Water Conservation District holds conditional claims to store over 900,000 af of water at locations in the two basins that could serve oil shale development.

In addition to quantifying water rights, the report raises a number of important issues that could disrupt traditional uses of water in Colorado:

1. Impacts on agriculture

Energy companies own large portions of the water rights historically used to irrigate lands in the region. Many of these rights date back to the late 1800s and early 1900s. As pre-Colorado River Compact rights, these diversions would not be affected by a call placed against the Upper Basin states. Additionally, most of the associated water still remains

in irrigation use as energy companies lease back the water to ranchers. Should oil shale development move beyond the research phase, many, if not all, of these rights would be changed in use, and the lands historically irrigated would be taken out of agriculture. The result would be a dramatic transformation of land and water uses in these areas.

2. Impacts on junior users

A second and less obvious outcome of oil shale development would be the displacement of some existing uses by new oil-shale-related uses with senior priorities. Conditional water rights for oil shale development date back to the 1950s. Should these rights be placed into use, they would be senior to all existing uses from the same source of water with subsequent priority dates, thereby affecting rights used both in western Colorado and in Colorado's Front Range. Development would also affect some existing uses established under more junior water rights and would potentially limit much other planned water development from sources on Colorado's West Slope — including plans to take additional water to the Front Range.

3. Restrictions under the 1922 Colorado River Compact

An important uncertainty facing future water development in western Colorado is the legal availability of water for development under the 1922 Colorado River Compact and associated laws and requirements. Water development could be constrained by obligations under the compact, as increased consumption would also increase the risk of a "call" by the Lower Colorado Basin states against the Upper Basin.

4. Impacts on endangered fish

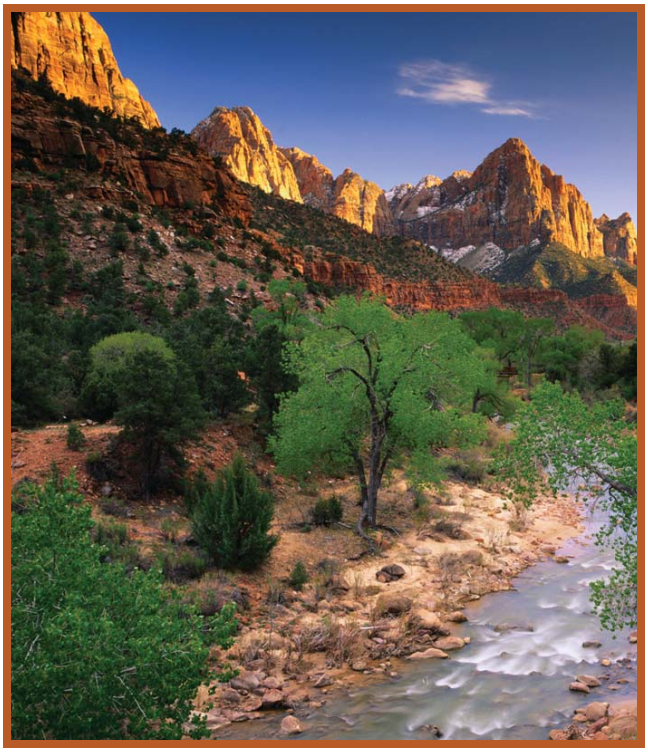
The ultimate extent of new water development is also subject to constraints associated with the Upper Colorado River Endangered Fish Recovery Program. At issue is the continued survival of four species of fish found only in this basin. The U.S. Fish and Wildlife Service has determined that additional depletions of the Colorado River Basin's water would jeopardize the continued existence of these species and any new water development —whether for oil shale or otherwise — must satisfy substantial program requirements intended to protect and recover them.

WRA'S CONCLUSIONS FROM THIS REPORT AND OTHER ANALYSES

Water on the Rocks is all the more significant when viewed in the larger socioeconomic context of oil shale development. By synthesizing *Water on the Rocks* and other analyses of potential energy development in Colorado, Utah, and Wyoming, WRA has reached the five conclusions described below.

Conclusion #1: Commercial oil shale development would transform western Colorado communities.

Water for oil shale will partially come at the expense of agricultural use. The vast majority of agricultural water rights are held by oil companies in Rio Blanco County, an area of the state where the local economy depends heavily on existing agriculture. Should commercial oil shale development take off, oil companies would transfer water currently used for agriculture to oil shale production. Thousands of acres historically irrigated would be taken out of agriculture, resulting in a dramatic transformation of land use and associated water



uses in the region from an agricultural to an industrial landscape.

Anticipated changes in populations necessary to support large-scale industrial development add to the changing uses of water. With rapid industrialization comes the ripple effect of increased populations and related infrastructure needs.

A second impact resulting from oil shale development that requires careful examination is the development of senior conditional water rights. While these rights have not yet been exercised, they have priority dates that are senior to many developed water rights on which Colorado's economy depends today. As we discovered through his extensive research of the hundreds of conditional water rights held by energy companies, many of these rights date back to the 1950s. Once oil companies begin using these rights for oil shale development, other users whose rights are junior to oil shale rights could see use of their rights curtailed.

Conclusion #2: Oil shale development in western Colorado would affect Colorado's Front Range communities and must be thoroughly evaluated and understood.

Front Range water providers, such as the Denver Water Board and the Northern Colorado Water Conservancy District, agree with the Colorado River Water Conservation District on one key conclusion — oil shale development will stress and/or compromise future water projects as well as existing projects that are subject to calls from senior in-basin rights and compact curtailment throughout Colorado.

Denver Water and other Front Range water providers divert several hundred thousand acre-feet of water annually out of the Colorado River Basin. While much of this water is senior to conditional water rights established for oil shale development and thus is less likely affected by such development, others such as the Northern Colorado Water Conservancy District's Windy Gap Reservoir are junior. Moreover, because of increasing needs on Colorado's Front Range, plans are in place to boost water deliveries to Denver and other cities by enlarging existing transbasin diversions and developing new projects. For some of these new projects, water utilities would rely on a combination of both older, pre-oil shale rights and newer junior rights. Those junior rights could be impacted by oil shale development.

To some outside of the West, these conflicts may appear minor in relation to the need to increase domestic oil production. To those of us in this arid region, how such conflicts are resolved bears directly on Colorado's economic prosperity, future growth, and environmental protection.

> "Production of unconventional fuels (oil shale, coal to liquids, heavy oil) produces more CO2 than is produced when using conventional petroleum."[9]
>
> — U. S. Department of Energy, 2007

Conclusion #3: Oil shale will accelerate climate change and will further stress water availability.

Climate change exacerbates and potentially eclipses all other foreseeable stresses on the environment in the region. Oil shale development poses serious climate threats as production will likely result in the generation of huge quantities of greenhouse gas emissions. While the specific impacts are hard to predict, scientists of all disciplines are sounding the alarm. Here is what we do know:

1. The West is getting hotter.

Climate models project Colorado's average temperature will warm 1.5 to 3.5°F by 2025, relative to the 1950-1999 baseline, and 2.5 to 5.5°F by 2050.[4]

2. The West is getting drier.

Recent hydrologic studies of the Upper Colorado River Basin project multi-model average decreases in runoff ranging from 6% to 20% by 2050 compared to the 20th century average.[5] Relative to the 1950-2000 baseline, evaporation is projected to exceed precipitation by 1.24 inches in the period 2021-2040.[6] This difference compares to that of the Dust Bowl years. [7]

3. Droughts will increase.

As global warming continues, the International Panel on Climate Change (IPCC) predicts more intense and longer droughts, as characterized by the severe drought that began in the western United States in 1999 and continues today. Moreover, whereas past droughts have been caused by natural variability in ocean and atmospheric circulation (e.g., La Niña events), climatologists predict future drying will be caused by an overall warming.

4. Streamflows will change.

Throughout the 20th century, much of the United States has experienced higher streamflow and precipitation, with a corresponding decrease in the duration and severity of drought. The notable exception is the West and Southwest. With drought comes a trend toward reduced mountain snowpack and earlier spring snowmelt runoff, both of which affect water availability and quantity. [8]

5. Ecosystems will be disrupted and wildlife will be affected.

The IPCC also concluded that recent warming is already strongly affecting ecosystems and wildlife, disrupting the natural timing of seasons and leading to loss of wildlife, including diminished fishing and hunting opportunities in the West. [9]

4 Western Water Assessment, Colorado Climate Change: A Synthesis to Support Water Resource Management and Adaptation, report done for the Colorado Water Conservation Board, 2008, p. 1.

5 *Ibid.*

6 Seager, Richard, Mingfang Ting, Isaac Held, Yochanan Kushnir, Jian Lu, et. al., "Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America", Science: 316 no. 5828 (May 2007): 25.

7 From 1932 to 1939, the annual difference between evaporation and precipitation was 1.29 inches higher than average; during the 1950s Southwest drought (1948-1957), it was 1.87 inches higher than average.

8 The University Corporation for Atmospheric Research, "Synthesis and Assessment Product 4.3 (SAP 4.3): The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States", (May 2008), http://www.sap43.ucar.edu/, accessed December 8, 2008.

9 Intergovernmental Panel on Climate Change, "Summary for Policymakers," Climate Change 2007: Fourth Assessment Report, Synthesis Report", United Nations Environment Programme, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

Importantly, federal officials project oil shale production would not reach full capacity before 2050, the same time that climatologists believe runoff in the Colorado River Basin will have dropped by 6-20% over 20th century levels. The convergence of events would further stress water availability, compounding the challenges and constraints associated with the Upper Colorado River Endangered Fish Recovery Program and allocations under the 1922 Colorado River Compact.

Conclusion #4: Water needs must be quantified and supply sources identified before committing to commercial oil shale leasing.

Future municipal development, power production, instream flows for federally endangered fish, and other types of energy development are expected to rely on water from the Colorado River. However, as a result of anticipated changes in climate, population, and changing land uses both within and outside the Colorado River Basin, the margin of uncertainty regarding water availability is troubling.

Estimates of water needed to directly support oil shale development vary by 400%. According to the RAND Corporation, one to three barrels of water would be needed for construction, operation, and production for every barrel of oil produced via in-situ methods;[10] 2.6 to 4 barrels of water would be needed for every barrel of oil produced via retort. [11] When electricity demand is added, these estimates jump to five barrels of water for every barrel of oil produced. Water used for refining (called "upgrading") further increases the water demands. These margins are significant, especially when the BLM estimates peg potential oil shale development at 2 million barrels per day.

Bruce Lytle, a hydrologist who has evaluated water needs associated with oil shale development, points out that the BLM's analysis of water needed is deficient, noting the BLM's analysis:

- Does not adequately evaluate site-specific water supplies in river basins where oil development may occur.
- Fails to assess impacts from oil shale development in forcing the retirement of agricultural water rights and the dry-up of agricultural lands.
- Does not sufficiently address water rights issues related to hydraulic interconnection of aquifers, permanent changes to surface and groundwater systems, water quality, and mitigation of impacts related to either surface or groundwater supply development.

Conclusion #5: Energy demands must be quantified and sources identified before committing to commercial oil shale leasing.

The BLM estimates that a 100,000-barrel-per-day (bpd) oil shale operation using in-situ conversion technology would likely require 1,200 megawatts (MW) of electricity. That amount of energy roughly equates to the amount needed to serve a city of 500,000. To produce one million barrels of shale oil per day would require ten new power plants and five new coal mines. In addition to the water required to extract the resource, water would also be needed to power the extraction process.

10 In-situ retorting involves heating the oil shale while it is still underground and then pumping the resulting liquid to the surface.

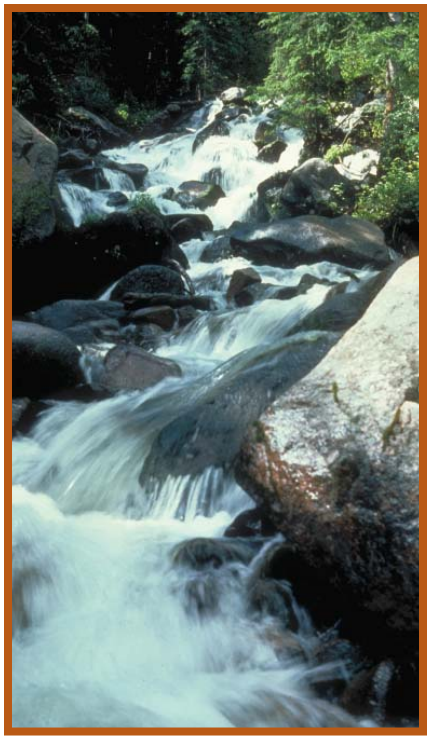
11 The shale is first mined and then heated to a high temperature.

> "We need to be thoughtful about our approach, especially in light of the magnitude of such development. In fact, if the Department of the Interior were to authorize a commercial oil shale industry in Colorado, the development would constitute the largest industrial development in the State's history — with enormous implications for all of Northwest Colorado and for the State itself."[18]
>
> — Colorado Governor Bill Ritter, Jr., 2008

Because oil shale technologies remain in their infancy, it is difficult to ascertain how much energy development would be required or the source of such energy.[12] Nevertheless, the Colorado River Water Conservation District estimates that the BLM's goal of full-scale oil shale development (2 million barrels per day) could require as much as 244,532,000 af of water to power oil shale development.[13] One of the critical policy issues Congress and federal officials must ask is whether the huge volumes of energy required to produce shale is an appropriate use of such power. A closely linked question is whether the associated water needs are an appropriate use of increasingly limited water supplies.

WRA's final conclusion: Develop the information necessary to make informed decisions. Oil shale development is fraught with uncertainty. While *Water on the Rocks* sheds light on the nexus between oil shale development and water, the unknowns are still paramount. Uncertainties regarding water availability and water requirements also include:

- Sequencing of development projects
- Rate of consumption
- Power generation needs
- Competition for shared resources
- Impacts of perfecting conditional water rights on junior users
- Impacts of climate change



The link between oil shale and water is complex. Whether changes faced by communities will be incremental or seismic is difficult to predict. Nevertheless, while the specific impacts are difficult to quantify, the BLM's prediction that western Colorado will transition from an agricultural society to an industrial society is well-grounded.

Governmental officials at the local, state, and federal level continue to warn policy makers in Washington, D.C. that the knowledge base is simply not there to make informed decisions. By gambling on oil shale and failing, the state could once again fall victim to the boom and bust cycles that characterize fossil fuel development. Colorado cannot afford to again compromise its financial well being, but that is what oil shale proponents are asking us to do.

WRA opposes development of oil shale resources in the West unless and until industry and government demonstrate that proven technologies can develop oil shale without unacceptable environmental, climate, economic, or social costs. The industry has barely begun to address that challenge.

12 Although there is no one measure of energy quality, energy return on investment (EROI) is a commonly used calculation of how much energy is needed to locate, extract, and refine an output of energy. An EROI of 1 would be breaking even. Reported oil shale EROIs are in the range of 1.5:1 to 4:1, with a few extreme values between 7:1 and 13:1. See, for example, Cutler Cleveland and C. Hall, Presented at ASPO -US conference Denver November 10, 2005, available at http://globalpublicmedia.com/events/564. See also "Unconventional Oil: Tar Sands and Shale Oil - EROI on the Web, Part 3 of 6," available on the The Oil Drum Web site at http://www.theoildrum.com/node/3839.

13 Colorado, Yampa, and White River Basin Roundtables Energy Subcommittee, Energy Development Water Needs Assessment (Phase 1 Report), September 2008, p. 5-9.

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Western Resource Advocates' mission is to protect the West's land, air, and water. Our lawyers, scientists, and economists: 1) advance clean energy to reduce pollution and global climate change; 2) promote urban water conservation and river restoration; and 3) defend special public lands from energy development and unauthorized off-road vehicle travel. We collaborate with other conservation groups, hunters and fishermen, ranchers, American Indians, and others to ensure a sustainable future for the West.

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