ROSS REPORT

REGIONAL OIL SHALE STUDY

OS-06

ENVIRONMENTAL

INVENTORY, ANALYSIS and IMPACT STUDY

PICEANCE CREEK BASIN

RIO BLANCO and GARFIELD COUNTIES, COLORADO

Prepared For

The State of Colorado

by

Hubert D. Burke

and

Evan C. Vlachos, Ph. D.

1974

THORNE ECOLOGICAL INSTITUTE

2305 CANYON BLVD.

BOULDER, COLORADO 80302

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PREFACE

Authority

This report summarizes a field study by Thorne Ecological Institute that resulted in 26 technical papers as well as current literature relating to selected components of the environment and the probable effects of various alternatives of oil shale development upon those components.

The study is one of four comprising the Regional Oil Shale Study authorized and administered by the Department of Natural Resources of the State of Colorado.

Objectives and Scope

The objectives of the Environmental Inventory Analysis and Impact Study were (1) to examine a number of the more sensitive components of the ecosystem and to establish baselines from which changes in the environment due to oil shale development could be evaluated and (2) to evaluate the effects of a series of alternatives and the long-range consequences for all interrelated aspects of physical and human environments.

FORM OF THE REPORT

Because of the great amount of data collected in the process of compiling this environmental statement, the meaning could be lost in the mass. Therefore, it was decided to base this report on only such data as are needed to illustrate the statements and recommendations. The data, methodology, analysis, detailed discussion, and the probable impacts are contained in supporting technical papers. These papers are separate so that anyone wishing to pursue selected subjects in more detail can obtain the individual reports of his interest. The reports are numbered "Regional Oil Shale Study ROSS-1, ROSS-2, etc.

The reports are available from the Colorado Geological Survey 1845 Sherman St., Denver, Colorado, 80302 for the cost of reproduction and mailing.

ROSS - 1 Recreation Resources of the Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973, 34 pp. by Howard R. Alden PhD.

ROSS - 2 Scenic Resources of the Piceance Creek Basin. May 1973. 46 pp. by Hubert D. Burke.

ROSS - 3 Wildlife in the Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 147 pp. by Alexander T. Cringan PhD.

ROSS - 4 Soils of the Piceance Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 28 pp. by Charles J. Fox.

ROSS - 5 Archaeology and History of the Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 13 pp. by Calvin Jennings PhD.

ROSS - 6 Surficial Geology and Geomorphology of Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 36 pp. by Robert E. Landon PhD.

ROSS - 7 Climate of the Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 67 pp. by William E. Marlatt PhD.

ROSS - 8 Disease Vectors of the Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 21 pp. by William C. Marquardt PhD.

ROSS - 9 Surface Runoff and Snow Cover in Piceance Creek Basin. May 1973. 40 pp. by James R. Meiman PhD.

ROSS - 10 Cold-blooded Vertebrates of the Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 21 pp. by David Pettus PhD.

ROSS - 11 Water Quality in the Piceance Creek Basin, Rio Blanco and Garfield Counties Colorado. May 1973. 63 pp. by Charles G. Wilber PhD.

ROSS - 12 Impact of the Oil Shale Industry upon the Scenic Resources of the Piceance Creek Basin, Colorado. April 1974. 56 pp. by Hubert D. Burke.

ROSS - 13 Environmental Impact Analysis of Prototype Oil Shale Leases upon Wildlife in Colorado. May 1974. 79 pp. by Alexander T. Cringan PhD. and L. W. Carlson.

ROSS - 14 An Ecological Analysis of the Vegetation of the Piceance Basin, Colorado. August 1974. 19 pp. by Hugo Ferchau PhD.

ROSS - 15 Soils Impact Analysis. March 1974. 63 pp. by Charles J. Fox.

ROSS - 16 Impacts of the Oil Shale Industry upon Archaeology and History of the Piceance Basin. August 1974. 32 pp. by Calvin Jennings PhD.

ROSS - 17 Environmental Impact Analysis of Oil Shale Development on Recreation Resources of the Piceance Basin. July 1974. 72 pp. by Leonard K. Johnson and Howard R. Alden PhD.

ROSS - 18 Geologic Inventory and Impact Analysis. January 1974. 134 pp. by Robert E. Landon PhD.

ROSS - 19 The Impact of the Oil Shale Industry upon the Air Quality of the Piceance Basin, Rio Blanco and Garfield Counties Colorado. 8 pp. by William E. Marlatt PhD.

ROSS - 20 Blood-sucking Arthropods and Selected Diseases in the Piceance Basin, Rio Blanco and Garfield Counties Colorado. June 1974. 83 pp. by William C. Marquardt PhD.

ROSS - 21 Environmental Impact Assessment of Oil Shale Development on Surface Runoff. April 1974. 35 pp. by James R. Meiman PhD.

ROSS - 22 Infiltration Studies in the Piceance Basin, Colorado. June 1974. 124 pp. by James R. Meiman PhD.

ROSS - 23 Limnological Status of Streams in the Piceance Area. Summer 1973. June 1974. 50 pp. by Robert W. Pennak PhD.

ROSS - 24 Inventory and Impact Analysis of Amphibian and Reptilian Component. June 1974. 90 pp. by David Pettus PhD.

ROSS - 25 Inventory and Impact Analysis, Fishes of the Piceance Basin. July 1974. 22 pp. by David Pettus PhD.

ROSS - 26 Evaluation of the Oil Shale Industry upon the Water Quality of the Piceance Basin, Colorado. 1974. 129 pp. by Charles G. Wilber PhD.

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SUMMARY

The Piceance Basin contains the major oil shale deposit in Colorado. It lies in west central Colorado and covers about 1600 square miles. The White River bounds the Basin on the north and the Colorado River on the south. The river valleys that bound the Basin contain the towns of Meeker on the northeast, Rifle on the southeast, De Beque on the southwest, and Rangely on the northwest.

The primary study area is a shallow north-sloping bowl that sits on top of the Roan Plateau which is made up of the Green River geologic formation. The steeply rolling topography of the Basin surface is made up of the Evacuation Creek Member consisting of the light yellowish buff or whitish oil shales. These oil shales form the segments of the high cliffs which drop from the rim of the Plateau.

Classed as semiarid, the Basin has precipitation ranging from 12 to 24 inches, annually, depending upon location and elevation. Much of the precipitation occurs as snow between December and April. The heighth and orientation of mountain ranges control to a major extent the storm tracks in this region, as well as those generally occurring over western states. Winter-summer temperature extremes are wide (-40°F to 100°F). The rarity of severe cold air masses plus the dry air, and effective solar radiation, combine to produce comfortable mid-winter days even when air temperatures are fairly low. Summer days can be pleasant due to low relative humidity and sufficient air movement. Nights are effectively cooled by down-drafts from higher country.

Sagebrush, grasses, pinyon pines and juniper trees grow in the lower parts of the Basin; sagebrush, mountain shrubs and grasses, grow at higher elevations with clumps of Douglas fir and aspen scattered on north-facing slopes.

The high, colorful cliffs and deep canyons combine in patterns with the silver green of sage, the olive green of juniper, ochre of grasses and bright greens of shrubs and pinyon pine against a backdrop of awesome space, making this an area of great beauty. However, lying as it does between the superb scenery of the Rocky Mountains to the east and the canyonlands to the west it suffers by comparison. The Basin and the surrounding valleys support over 70 species of mammals including deer, black bear, elk, and mountain lions; bands of wild horses also roam the region. Over 250 species of birds are to be found here during certain seasons. Golden eagles circle on the rising air currents in the brilliant sun along the rims of the towering cliffs.

The few streams and beaver ponds are the primary fish habitat. For fishermen, there are limited opportunities for some backcountry stream fishing. At higher elevations these more remote streams and headwaters can be fished for native cut-throats as well as rainbow and brown trout.

A significant part of the Basin is under public ownership, with two approximately 5,000 acre tracts, i.e. Ca and Cb, leased to private corporations for oil shale development. On private lands, four more companies are currently active on the rims of the Basin. One of these companies is developing a plan for the production of dawsonite and nahcolite along with oil shale.

Presently, commercial production is not considered feasible for shales that produce less than 30 gallons of recovered oil per ton of shale. Plans under consideration include surface or strip mining; conventional underground mining, and a modified form of <u>in situ</u> mining.

Processing of shale for removal of oil may be accomplished through any one of several methods. Under each method, the shale is heated to 900°F, at which point hydrocarbons are converted to liquid or vapor and released. Each process must provide for disposal of spent shale, which expands about 25 percent when heated. Under the assumption of 30 gallons per ton, a plant producing 100,000 bbls. of oil per day would have to process l65,000 tons of shale daily. And some plans have even considered production of up to 4 million bbls. of oil per operating day.

One must envision enormous tonnages of spent shale and disposal problems of magnum dimensions. Also, availability of water looms as a major obstable -- 1.5 to 3 barrels of water will be needed for each barrel of shale oil produced. Furthermore, one can't ignore the limited water supply in the Rocky Mountain region and the probably need for diversion of water away from present users; nor can one easily bypass any of the potential adverse effects of all facets of oil shale production upon the environment. Finally, more people, more roads and accompanying machines, etc, will surely pollute air and water and may well have serious consequences upon the major wildlife species and lesser-known animals and plants.

Three levels of industrial development (to be realized by 1990) are under consideration: (l) Limited Economic Growth, about 250,000 to 400,000 bbls. of oil produced per day; (2) Moderate Expected Growth, 1,000,000 to 1,600,000 bbls. per day; and (3) Program of Accelerated Growth, 2,500,000 to 5,000,000 bbls. per day. Each increase in industrialization would bring added increments of environmental and social disruption.

None of the plans currently being considered would be a "mature industry", i.e. if a mature industry is defined as an industry that has passed through the experimental or prototype stage has made an irretrievable comitment of capital and natural resources to a commercially feasible technology.

If the decision were to be made to develop a mature oil shale industry in western Colorado, Thorne Ecological Institute believes that the industry developed should make a substantial contribution toward:

(1) Assuring reliability of energy supply;
(2) Achieving the lowest cost to society for energy;
(3) Avoiding economic and regional inequities;
(4) Safeguarding the quality of the environment; and
(5) Minimizing international problems due to energy.

Answers to questions concerning the development of a mature, coordinated oil shale industry, while very much needed at this time, cannot be answered by resource specialists or in a casual fashion in the context of an environmental inventory. The questions raised acquire a wider forum and careful sociopolitical consideration transcending immediate costs and benefits.

Environmental disruption is a price that must be paid for industrial development; the price is not only loss of the present salubrious environment, but certain lifestyles and options traditionally identified with the West will change. The most careful planning and disciplined efforts are needed to keep these costs within due bounds.

ENVIRONMENTAL INVENTORY, ANALYSIS AND IMPACT STUDY

I. THE ENVIRONMENTAL SETTING

The environment of the Piceance Basin and its surrounding corridors are discussed in this general report which offers a synopsis of 26 technical reports (ROSS 1 - 26), each of which gives a more detailed look at the area. The study area lies within an area having its four corners in the towns of Rangely, Meeker, Rifle and De Beque.

A. DESCRIPTIONS

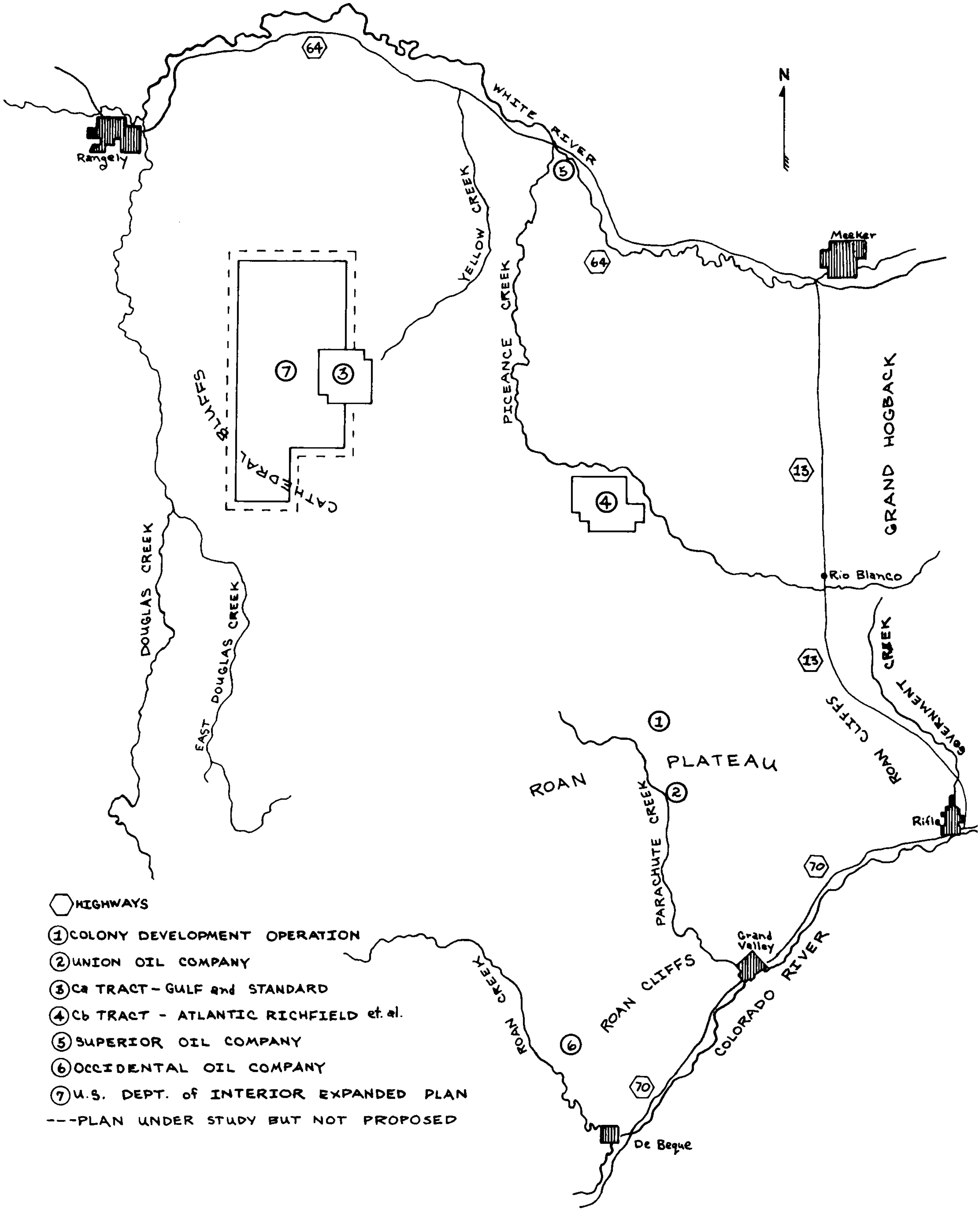
Located in an area of approximately 1600 square miles, the Piceance Basin lies in Rio Blanco and Garfield Counties in West Central Colorado. In a recent geological time this area was subjected to extreme vertical uplift. This resulted in a broad, shallow, northward-tilting bowl situated on top of an elevation known as the "Roan Plateau" (referred to herein as the Plateau).

The Plateau is bordered by stream valley corridors. Only a few drain the outward faces of the Plateau and these are short and have steep gradients. In contrast, Piceance and Yellow Creeks and their tributaries which drain the interior of the Basin are longer and have less gradient (Fig. 1).

Along the Colorado River, the south rim of the Roan Plateau ranges in elevation from 3000 to 3500 feet above the valley floor. High, almost perpendicular cliffs also dominate the east and west rims of the Plateau. The north rim is not so spectacular, partly because the 7000-foot elevation averages 2000 feet less than that along the south rim; and also because the valley floor is 500 feet higher at this location.

Basin vegetation, typical of this semi-arid region, is primarily pinyon-juniper, sagebrush, and mixed mountain shrubs; these types are commonly found in the Plateau and Great Basin regions. This vegetation has predominating silver-green or olive-green colors that shade into the yellow ochre colors of grass in summer and fall; these colors may mislead those used to vivid greens of humid regions into regarding the Basin as a "desert." However, in reality a mosaic of plant communities offer interesting scenic variation and also support a rich variety of mammals and birds. For example, Vories found 11 tree species, 53 shrub species and 349 herbaceous species in the Basin. Thirty of these species are "exotics" originating outside the North American Continent; they reflect disturbances and manipulations of vegetation by man.

FIGURE 1. LOCATION OF OIL-SHALE OPERATIONS



HIGHWAYS

1 COLONY DEVELOPMENT OPERATION

2 UNION OIL COMPANY

3 Ca TRACT - GULF and STANDARD

4 Cb TRACT - ATLANTIC RICHFIELD et. al.

5 SUPERIOR OIL COMPANY

6 OCCIDENTAL OIL COMPANY

7 U.S. DEPT. of INTERIOR EXPANDED PLAN

---PLAN UNDER STUDY BUT NOT PROPOSED

(p.1) A mosaic of plant communities offer interesting scenic variation and also support a rich variety of mammals and birds.

(p.3) The Basin is made up of the Green River Geologic Formation which was laid down in four layers. The youngest, the one on top, in the Evacuation Creek Member. Beneath this in order are: The Parachute Creek Member (oil bearing); Douglas Creek Member; and Garden Gulch Member.

The complex mosaic of vegetation apparently developed in response to: elevation; topography; microclimate; soils; adaptability of plants; utilization of plants by animals; and management by man (Vories 1974).

Precipitation here in the Basin increases with elevation and at higher elevations more of the precipitation comes in the form of snow (Marlatt,ROSS-7). Although there is a correlation between elevation and vegetation zonation, the direction of slope is most significant. Slopes facing north are cooler and more moist than those which face south and are exposed to the direct rays of the sun (Vories 1974).

1. The Piceance Basin

The Basin is made up of the Green River Formation which was laid down in Eocene time in four layers, (or members). The youngest, the one on top, is the Evacuation Creek Member. Beneath this in order are: the Parachute Creek Member (oil bearing); Douglas Creek Member; and Garden Gulch Member. The Evacuation Creek Member is made up of gray, red, and brown sandstones, gray and yellowish siltstones; and gray-brown sandy shale, with occasional thin beds of low-grade oil shale and marlstone. This layer covers the entire top of the plateau. Because of its sandy character, poorly developed stratification and relatively porous nature, it erodes into a hilly topography (Landon, ROSS - 6). However, from a distance the surface of the Basin appears to be a smooth, gentle dip because one is looking across the tops of the rounded hills.

Near the south rim of the Basin and at other points of high elevation clumps of Douglas fir and aspen grow on north-facing slopes where moisture is more available throughout the year. The north rim and lower portions of the Basin support stands of pinyon pine and juniper. Otherwise the Basin is generally covered by mountain shrubs such as serviceberry, mountain mahogany, oakbrush, snowberry, and sagebrush as well as grass. The brush reaches a height of about 15 feet on better sites; the pinyon pine and juniper rarely exceed 20 feet.

Soils support a good growth of vegetation in spite of their rocky appearance. Wind and water erosion have removed the surface soils so that in many places it appears that plants are growing out of a thin layer of shale fragments. When one removes this layer, soil is found mixed with weathered shale, often to a depth of several feet (Fox, ROSS - 4).

As on the sea or plains, vastness of the landscape provides a stage on which in summer, frequent storm clouds unfold a series of magnificent ephemeral views. Fleetingly present, but nevertheless an important component of this scene and the ecosystem, are the living creatures. In proper seasons hawks, eagles, or vultures soar along the rising air currents at the crest of the slopes. Grouse are sighted occasionally, and deer are seen frequently.

The Piceance Basin supports mainly pinyon-juniper or shrub habitats; each type is rich with food and cover. Thus, food, shelter, and the necessary "edge" is provided for large numbers and a wide variety of mammals and birds.

A total of 82 species of mammals either occur or have occurred in the Piceance Basin surrounding stream valleys. The list includes 1 marsupial (opossum) 5 shrews, 14 bats, 5 hares and rabbits, 33 rodents, 18 carnivores (wolves, cats, bears, mink-like animals), 5 even-toed ungulates (deer, elk) and the wild horse. Of these, the grizzly bear, gray wolf, black-footed ferret, and mountain sheep have disappeared from this region. Another 40 species are either rare or their status in the region is uncertain. The area also supports considerable numbers of domestic sheep and cattle (Cringan, ROSS - 3; Cringan and Carlson, ROSS - 13).

Mule deer are the most abundant wild mammals presently inhabiting the region. They generally inhabit the entire area during summer but in winter migrate to lower ranges below about 7000 feet.

Game Management Units that cover parts of the Piceance Basin show the highest total deer kill for the state; mean harvest was over 14,000 deer per year from 1956 to 1972. In 1962 an average of nine deer per square mile were taken by hunters.

Mountain lions roam generally throughout the Piceance Basin. However, mountain lions are intolerant of man and thus tend to inhabit the more rugged and remote areas. A bounty of $50.00 was paid by the State on mountain lions until 1956; since then lions have been protected and regulated as game animals. An estimated 6 to 10 mountain lions are taken by hunters each year in the Basin.

Black bears inhabit the Plateau along broken areas of the rims and in the northeast corner. A total population count may be estimated from the 20 to 30 bears killed by hunters each year.

From 200 to 300 elk live in the Basin region. Bobcats inhabit their chosen areas throughout the region. Herds of wild horses, now protected by federal statute graze and roam over the Yellow Creek Basin and in the areas above Cathedral Bluffs. An estimated total of more than 200 wild horses exist in several small bands, each led by a single stallion.

Most wild mammals would suffer if man's presence increased along with the direct harassment, industrial noises, lights, road traffic, and the subsequent loss of living- and food-producing space (Cringan and Carlson, ROSS - 13).

About 258 species of birds may be expected in the Plateau region and in surrounding valleys; some of these will occur very rarely. These include: 1 species of loon; 4 grebes; 1 cormorant; 6 herons; 26 waterfowl; 16 hawks, vultures, and eagles; 6 gallinaceous birds (grouse, pheasants); 4 cranes; coots and rails; 25 shorebirds; 11 gulls and terns; 4 pigeons; 1 cuckoo; 8 owls; 8 woodpeckers; 5 hummingbirds; 4 other non-passerines (non-perching birds); and 128 species of perching birds (swallows, warblers, jays, robins, crows, sparrows, etc.).

All birds are important elements of the ecosystem and also have great value for recreationists. Most birds are sensitive to noise, lights, and other disturbances resulting from the presence of man. A few, specifically the two species of eagles, probably will suffer because of invasion of their nesting areas. The rare and endangered peregrine falcon was seen in the area during these studies (Cringan, ROSS - 3; Cringan and Carlson, ROSS - 13).

2. <u>The Piceance Creek Valley</u>

Piceance and Yellow Creeks flow north and drain the Plateau surface into White River. Piceance Creek has a paved road along its course from Colorado Highway 13 at Rio Blanco to Colorado Highway 64 which runs along the White River. This road would carry most of the traffic from the lease sites unless added roads were constructed. The Piceance Creek scenic corridor is closely restricted by the low, rounded hills that support scattered growths of junipers and pinyon pines. In only a few places can an observer see more than a mile up or down the valley; but the view is pleasant to anyone that enjoys western ranch country. Nevertheless, one mile looks remarkably like another for the full length of Piceance Creek.

This valley is the corridor to oil shale lease sites Ca and Cb; and Piceance Creek near the valley mouth divides the holdings of the Superior Oil Company. This narrow valley would be highly vulnerable to the impacts of unplanned development.

3. <u>The White River Valley</u>

The White River Corridor lies between Meeker and Rangely. The valley floor is occupied by ranch headquarters, irrigated meadows, and fields; in places it widens to about three-fourths of a mile and is bordered by rounded hills that reach elevations of 400 to 600 feet.

(p.5) Piceance Creek at its junction with White River.

These hills support sagebrush and a scattering of juniper. Trees dot the landscape along the river, but they do not form an actual stream border. Reddish sandstone ledges break the uniform pattern of the rounded hills, but these ledges are too small and drab to be considered outstanding scenic resources. The most interesting views along this corridor are of ranches and livestock.

One important point noted, however, is the fact that expected incidence of urbanization (resulting from expanded activities) will have serious effects on the surrounding natural environment.

Along the White River corridor there is sufficient water and space to accomodate the new urbanization that would accompany commercial oil shale development. Because of urban sprawl, the surrounding ranching environment becomes vulnerable to the consequences of unregulated construction. In this instance a pretty ranching valley, now pleasant but not outstanding scenically, could become a very ugly valley filled with the clutter of boomtown development. This area is not unaccustomed to this; Rangely was a typical oil boomtown when it began, and the vestiges of the oil boom persist. Yet, the extent and rate of the expected developments are such that major disruption may be expected.

4. <u>The Colorado River Valley</u>

The Colorado River Valley which forms the southern border of the Basin is at a lower elevation, wider and deeper in relation to the cliffs bordering the valley. Numerous ranch headquarters, some industrial and mining operations, and three towns, Rifle, Grand Valley, and De Beque occupy the valley.

This corridor probably would not be greatly affected by the direct or on-site impacts related to an expanded oil shale industry. But, it would be highly vulnerable to a variety of indirect or off-site impacts such as clots of urbanization scattered along the valley, greatly increased numbers of houses, service facilities, and "quick buck" operations. The degradation would not be confined to the offending structures themselves, but because of the depth and shape of the canyon and prevailing climatic conditions, the emissions from the added buildings and traffic could create serious smog conditions in the Colorado River Valley (Marlatt, ROSS - 7 and - 19).

Parachute Creek which enters the Colorado River at Grand Valley is an important tributary and contributes to the scenic value of the Colorado River Valley in this stretch. It is about three-fourths of a mile wide on the canyon floor at Grand Valley narrowing gradually as it reaches about 13 miles back into the plateau. Colony Development

Operation and Union Oil Company developments are located at the head of this canyon.

The vegetation of the Colorado River Valley differs from that in the Basin in that there are groves of hardwood trees that follow the River. On the valley floor, where native vegetation has not been replaced with irrigated pastures or cropland, sagebrush and rabbit-brush are dominant except that greasewood predominates where soils are heavily alkaline.

5. Government Creek and Sheep Creek Valleys

Neither Government Creek nor Sheep Creek have more than a trickle in them except during snowmelt or following a rain. The east wall of the corridor--the Grand Hogback--is made up of geological debris of varicolored clays, sandstones, and shales. The west wall near Rifle, formed by the cliffs of the Plateau, is spectacular but views are somewhat restricted by the low, rounded canyon walls.

In places the narrow floor of the canyon has been preempted by power lines; five lines run along the valley in one place. Also, the highway runs north along Government Creek.

6. Douglas Creek and East Douglas Creek Valleys

Douglas Creek flows north into the White River at Rangely forming the north half of the western boundary of the Basin; the creek skirts the base of the Cathedral Bluffs.

The large and seemingly unseen space below Cathedral Bluffs leaves the Douglas Creek Corridor extremely vulnerable. Presumably because of its size, and because it is somewhat hidden, this space has been proposed as a disposal site for processed shale.

From some places along the Basin rim and from the air, Cathedral Bluffs and their spectacular beauty can be enjoyed. However, the bluffs can be seen but from very few places along the Douglas Creek road as they are hidden by the lower terraces formed by debris from the bluffs.

Some urban impact could be expected in the Douglas Creek valley from uncontrolled development that would reach south from Rangely, but this would not compare to that that could be expected east of Rangely in the White River valley. However, if an orderly growth occurred, the area at the foot of the Cathedral Bluffs contains sites that would make excellent estate-type building sites. The remainder of the Corridor is narrow and not very attractive for building.

7. The Roan Creek Valley

Similar to Douglas Creek, the upper portions of this corridor are on ranches closed to the public. The boundary line continues from East Douglas Creek over the top of the plateau and runs down Roan Creek.

This valley is primarily ranch land. The waters of Roan Creek are diverted for irrigation until the stream is dry in the lower reaches during summer.

B. SOME ECOLOGICAL INDICATORS

Of the streams in and around the Basin described above, only the Colorado and White Rivers and Parachute and Piceance Creeks offer sport fishing. Waters cool enough for trout and whitefish, the two species of interest to sportsmen, are limited to the eastern portion of the area and the higher elevations on the Plateau. Where the White River reaches the mouth of Piceance Creek there are few if any trout or whitefish. The Colorado River contains trout down to the vicinity of the village of Grand Valley at the mouth of Parachute Creek. Both the Colorado and White Rivers have warm-water species in their lower reaches.

In addition to their importance for recreation, fishes offer indicators of environmental change; they are more sensitive than any other organism. Many, if not most, changes in terrestrial habitats will also affect the aquatic environment. For example, construction and resulting soil disturbance will almost inevitably increase siltation in streams which tends to diminish light penetration and reduces primary productivity (photosynthetic activity of aquatic plants). The sediments may also reduce the availability of proper substrate required as habitat for bottom-dwelling organisms and as egg-deposition sites for fishes. Continued and increased erosion will invariably increase the load of dissolved solids in the streams. Typically this increased load causes degradation of water quality and reduces habitat suitability for fishes. Numerous other examples of how stream quality is affected by terrestrial actions could be cited. However, the point is that whatever happens on either land or in the stream usually affects the fish populations. Thus fishes may be considered as biological integrators of environmental dynamics.

The most conspicuous role of fishes in ecosystem function is their trophic function. Fishes, collectively, occupy all of the consumer levels in aquatic food chains. However, species most interesting to man, the trouts and whitefish, are secondary and tertiary consumers; thus, they are more apt to be affected by alterations of the environment than are species in the primary consumer level (Pettus, ROSS - 25).

One species of fish occurring in this region is a candidate for the rare and endangered species role. This is the Colorado River cut-throat trout (Salmo clarki pleuriticus) which occurs in tributaries of Parachute Creek, above the falls on the Plateau (Pettus, ROSS - 10 and ROSS - 25).

Reptiles and amphibians form a group of animals that are highly sensitive to change and therefore good indicators of environmental conditions. Together, reptiles and amphibians are called "herptiles."

Herptiles of the area are primarily insectivorous or predatory upon other vertebrates. None is herbivorous as an adult, but frog and toad tadpoles do utilize aquatic plants as the major component of their diets.

Tiger salamanders take a variety of animal prey, both during the aquatic larval stage and as terrestrial adults. Annelid worms, crustaceans and larval insects are the groups most utilized by the salamander larvae, while insects and annelid worms (earthworms) constitute the bulk of the adult's diet.

Toads and frogs of the study area are virtually restricted to a diet of arthropods. Due no doubt to their greater abundance, insects are the primary prey. However, at times of particular abundance, spiders will comprise over 50 percent of the intake of chorus-frogs. Further minor components of the anuran diet include millipedes, scorpions, ticks, isopods, and earthworms.

The food habits of two species of spiny lizards in Parachute Canyon have been studied in detail by Turner (1974). The two species, together with the short-horned lizard, are the most abundant representatives of this group in the study area. Like most other species of lizards the Sceloporus species are opportunistic feeders and are primarily insectivorous. The two species differ somewhat in their foraging habits and resultant prey selection. The larger species of spiny lizard tends to wait for prey to approach its resting site and will then consume them. About half of the prey of the smaller spring lizard is comprised of ants.

The other species of lizards are all largely insectivorous. The interesting, parthenogenetic (all female) species, the plateau whiptail belongs to a genus which is noted for a high degree of dietary dependence on termites.

Snakes of the area show considerable variation in dietary components. The most abundant species, the western garter snake takes fishes, salamanders, tadpoles, frogs, lizards, birds, mammals, earthworms, leeches and probably other animals. Its catholic tastes no doubt contribute to its abundance. This is the only species of snake that occurs at the upper elevations of the study area. All other species penetrate only the peripheral areas by following water courses. These latter species feed upon insects, frogs, lizards, birds and mammals. The gopher snake is considered particularly significant in this region because of its preference for rodents, particularly pocket gophers which can be serious pests by burrowing in irrigation ditches and causing leakage.

Taken collectively, the herptiles occupy feeding niches at the level of secondary and tertiary consumers. However, their roles in the trophic ecology of an ecosystem is more significant than their contribution to simple estimates of species diversity indices would suggest. Because they are cold-blooded, they are active only during the warmer seasons. Thus when primary productivity is greatest, these organisms are functional components of the animal community, actively contributing toward the cycling of materials and energy which helps maintain the stability of the ecosystem. However, in fall when primary productivity declines and temperatures fall, the herptiles enter dormancy and thus, in effect, become ecologically non-functional. In regions of severe seasonality, such as the Piceance Basin, the availability of such plastic organisms is especially important. The possibility of having a variable index of functional species diversity that can "track" changes in primary productivity without recruitment through reproduciton permits greater ecosystem stability. This is precisely the contribution made by herptiles (Pettus, ROSS - 24).

Ticks abound in all areas in season and mosquitoes are found along streams and irrigated meadows. In its annual list of reported diseases the Colorado Department of Health includes Colorado tick fever, equine encephalitis, Rocky Mountain spotted fever, tularemia, and bubonic plague as diseases that are transmitted by hematophagous or blood-sucking arthropods. Diseases of major concern for man in the western counties are Colorado tick fever, St. Louis encephalitis and tularemia. The reason for concern is that these diseases appear to be endemic in the western counties. The first known outbreak of St. Louis encephalitis in the Rocky Mountains occurred in Grand Junction, Mesa County, where there were about thirty confirmed human cases.

Diseases of importance to livestock and wildlife in Colorado include western equine encephalitis (a disease of both man and horses), vesicular stomatitis (a disease of cattle transmitted by several varieties of biting flies), and anaplasmosis (a disease of cattle transmitted by ticks). Veterinary reports indicate that western equine encephalitis and anaplasmosis are the most prevalent, and probably the most economically destructive, of the vectorborne veterinary diseases of Garfield County and outlying counties.

Mosquitoes occur in some areas of running water in large numbers, but they also were found in areas that have no running water and remarkably little standing water. They are particularly bad in the vicinity of the irrigated meadows along Piceance Creek. Mosquitoes appear to do well if only a small amount of water is present in these draws. This is not to imply that problems with mosquitoes would be confined to areas that have water, since it is known that some species can migrate several miles from breeding sites (Marquardt - ROSS - 8 and -20).

II. ANALYSIS OF PROBABLE IMPACTS

Assessment of possible consequences resulting from the Prototype Program was the primary intent of this study. Now that leases have been awarded, there are differences between the programs of the successful lessees and those programs set forth in the Prototype Program (site plans). For this reason, the following discussion of impacts related to all operational developments but in some instances does refer to specific locations.

A. IMPACTS FROM INDUSTRIAL INFRASTRUCTURE AND SUPPORT

1. Roads, Powerlines and Pipelines

A network of main access and service roads is needed for moving equipment and servicing installations. Some roads will be of a temporary type and used only occasionally but others will be paved 2-lane roads used by heavy traffic.

In rolling, strongly-sloping hilly land such as that of the Piceance Basin, a 2-lane road uses 6.66 acres of land per mile. A single-lane road in this type of terrain uses 4.24 acres (Fox, ROSS - 4). In addition to cutting and filling, which would permanently change the landform and cause soil erosion, the roads would contribute to increased vehicular death to wildlife. Merely bringing people, vehicles, lights, noise and associated disturbances into the area would result in serious impacts upon the more shy species. These additional roads would increase run-off potential and carelessness or accidental spills from vehicles carrying oil or chemicals would increase the potential for pollution.

The use of engineering methods that minimize cut and fill would help to minimize some of the impact. However, any impacts from road construction that occurred upon the soil would be irreversible and irretrievable. Impact of people and vehicles upon wildlife could be reduced if both the Bureau of Land Management and company security forces acted to reduce traffic (particularly off-road or minor road traffic) to the absolute minimum required for operation. Strict traffic regulations for paved roads over which oil or toxic materials were hauled also would help to mitigate impacts from roads. Surfacing of roads reduces dust and may be considered an environmental advantage. Newly constructed roads normally are kept open after their initial purpose has been fulfilled; this probably would extend the impact of roads considerably beyond the close of operations for oil shale removal and roads should be considered a permanent impact.

If present best environmental engineering practices are used, pipeline and powerline impacts should be both low and temporary -- existing only during oil shale operations.

2. Drill Sites and Off-road Travel

Sites for drilling core holes, test wells, etc., require about a 200-foot cleared-and-levelled platform. An acre is approximately 208 feet on a side, thus a core hole site utilizes a full acre. Some *in situ* processes may require as many as four drill holes per acre (Gentry and Bator 1974); this means that every square foot of the land surface on these sites would be cleared and levelled. Thus, some groups pressing for *in situ* mining may be underestimating the environmental-damage potential of *in situ* mining.

Underground mining also requires numerous drill holes as a guide to mining. These drill holes and the roads leading to them will use 4.24 acres per mile; this could result in considerable impact if careful measures are not employed to minimize damage from construction and if prompt restoration is not accomplished.

Off-road travel is a temptation for drivers of jeep-type vehicles; and almost everyone "cuts across" roadless areas at times. The difficulty on this plateau occurs from such usage leaving scars that last for decades.

3. Staging Areas

Each mining and processing operation probably will have a staging area at the nearest rail-siding and another on-site for unloading and storing supplies and equipment. These areas would vary in size from about 15 acres to 40 acres and probably would have gravel or blacktop pads, gasoline pumps, warehouses, and perhaps repair shops. Traditionally such areas are an eyesore and a source of noise from loading and unloading pipe and engines running. Potential impacts in these staging areas include runoff and attendant transport of pollution (Meiman, ROSS - 21).

Non-reflective surfaces on buildings and fences would reduce much of the scenic impact. Screening with vegetation could be used to hide the installation and would also act as a barrier to lights and noise. Excessive overhead lighting should be avoided. Catchment basins for runoff would minimize pollution.

4. Mine and Plant Structures

At the mine and the pyrolysis plant where oil is removed from shale, structures (for both pit and underground mines) would include: lift structures; compressor houses; change houses; storage piles or silos for crushed shale; upgrading plants; maintenance shops; tank farms; offices; parking lots and roadways connecting these structures. Heavy crushers and conveyor lines probably would be in the pit or in the mine but some secondary crushers might be located at the plant site.

The plant complex would occupy about 140 to 200 acres that had been levelled or covered with excavated rock from mine shafts or from overburden. This complex probably would be on a high ridge for best dissemination of stack emissions.

The refining plant would resemble a standard oil refinery but with a number of added structures, i.e. pyrolysis towers, which may number as many as twelve and probably would be taller than the highest towers of a refinery (USDI 1973b).

Because of the size of the plant complex and the amount of activity, the impact for most components would be severe. However, such impacts would be temporary; the plant could be removed and the area rehabilitated after the close of operations.

Impacts on soils and vegetation would be total under the connecting roads and the plant structures. Also, between roads and structures, where soil was not removed or buried, some damage from compaction could be expected (Fox, ROSS - 4 and - 15).

Runoff will be almost 100 percent from roofs and paved areas; this increases the probability of pollutants being washed onto surrounding vegetation (Meiman, ROSS - 21).

Stack emissions might exert a major impact which would be temporary in nature and last only a few hours a day; perhaps a few days a month in some seasons. This potential impact must be seriously considered due to the nature of the Basin and the surrounding canyons and their temperature inversion patterns. Although individual plants may be operating well within legal limits, the inversion system could concentrate the combined outputs of several plants and raise air pollution to "shut down" levels. For this reason, emission problems cannot be studied successfully on an individual plant basis. Each proposed plant should be analyzed in relation to all other operations in the Basin, in relation to its location, and to the type and volume of emissions that it would contribute (Marlatt, ROSS - 7 and - 19).

In one sense, the scenic impact of a large complex sitting high on a ridge would be enormous. However, when considered within the total setting complex, the impacts would not be so great; all of the plants would be in remote areas and most of them would have to be sought out to be seen. Nonetheless, structures should be painted in non-reflective colors (Burke, ROSS - 12).

The impact of the structures on recreation would be reflected in lessened hunting opportunity for sportsmen (Johnson and Alden, ROSS - 17).

Traces of prehistoric man are found in the area. Because these people were hunters and gatherers rather than farmers and city builders it is easy to overlook and to destroy the fragile traces of their culture. These traces are not of the sort found at Mesa Verde and Taos; thus, many feel that they are not important. Actually, the reverse is true. The fragile nature of these traces must receive greater than ordinary care in their survey and protection because any loss is irreversible and irretrievable. Archaeological search should be done before any roads or structures are begun and should be continued to insure that industrial activities do not destroy information (Jennings, ROSS - 16).

Plant design should include adequate safeguards against polluted runoff reaching surface waters and provisions for total disassembly in mind. Apparently, the sample contract between the government and the lessee under the Prototype Program does require that worn-out equipment be removed. It provides that the government may purchase left-over equipment as needed, if the company doesn't want to move it. However, it appears that structures and equipment could be left by the company and would be removed at government expense (USDI 1973a).

5. Open Pit Mines

The only practicable locations for open pit mines are on the west side of the Basin, in the headwaters of Yellow Creek, where the oil-bearing shale is relatively near the surface. In this area the bottoms of the creeks rest on the hard oil shales of the Parachute Creek Members. The surrounding hills contain non-oil bearing sandstones, shales, and marlstones of the Evacuation Creek Member. This member, which averages 450 feet in thickness, would have to be removed as overburden.

The Prototype Program for Ca tract states that the pit would be graded to a 45^{o} slope on the sides. After 30 years of operation the pit would have a maximum depth of about 1400 feet and cover an estimated area of 1400 acres. When the pit became large enough to allow operating room at maximum depth (estimated to be about 16 years), both overburden and processed shale could be placed back into it (USDI 1973b).

Estimated surface area of the pit, at maximum, would be about 1400 acres; however, final size could be less than 1400 acres and depth could be reduced by carefully planned disposal of processed shale and overburden. The manner of replacement has not been specified. The way that the vertical steps on the pit sides and the roads are covered will have important implications on rehabilitation. Regardless of methods, etc , the impacts on landform would be great and would remain so.

Impact of the pit upon soils would be severe, irreversible, and irretrievable because of surface removal over the 1400-acre area. It would be difficult to minimize this impact by removal and storage of topsoil because of the rocky nature of these soils. However, the surface soil should be saved and replaced on the material that fills the pit. These soils vary greatly with slope, exposure, and aspect; during removal, storage, and replacement operations these factors should be considered because of their probable influence upon site rehabilitation (Fox, ROSS - 15) (Ward, Saluson, and Dix 1974) (Wymore and Striffler 1974).

An open pit would have a major influence on the hydrologic regime of the streams that it intersects. At maximum, the disturbed area proposed in the Prototype Plan would intercept or absorb runoff from a watershed of approximately 22 square miles. Runoff on the disturbed area would be trapped in the pit and thus would reduce peak storm runoff (Meiman, ROSS - 21).

During construction and operation, dust and fumes from vehicles, crushers, conveyors and similar equipment would cause a moderate negative impact. The extent will depend upon the design and efficiency with which the environmental plan is administered. At the close of operations there should be no existing impact on air quality.

Vegetation would be removed along with the overburden when the pit was dug. Revegetation processes could not be started in the pit area until over 16 years had elapsed. In this semiarid region with extremes of heat and cold plus desiccating winds, vegetation is more complex as to water and insolation relationships than in more humid regions. Species composition and density can change drastically within a few feet because of either aspect or slope, or both (Ferchau, ROSS - 14) (Vories 1974).

Revegetation of the pit area is the responsibility of another Study Group. They state that successful restoration of the environment will require close attention to composition and density patterns of the plant species now present. Furthermore, the tree-and-shrub overstory and the shrub-and-herb understory must be restored in a manner somewhat resembling their current state. Research on this should be established in the area because microclimate and elevation have a strong influence on plants on this locality. The seeding of overburden and processed shale to grass is only a temporary measure; it should be considered as no more than a first and perhaps only a preparatory step in rehabilitation (Terwilliger, Cook and Sims 1974).

The mining companies should develop environmental plans for selective planting designed for the actual soil type, elevation, slope and aspect of the area being rehabilitated. The effects of slope and aspect upon vegetation should be considered while shaping of the land progresses during rehabilitation operations.

Of the on-site wildlife, mammals and birds would suffer most from loss of habitat. However, reptiles, primarily lizards, also would be deprived of habitat during construction and operation. Some animal life would return after operations ceased, but a restoration of habitat to something resembling the present condition would be necessary if the present native species were to be restored in the post-operation period.

After mining and processing, the soluble oil shale elements become more subject to leaching. Furthermore, additional materials, such as blasting powders, processing compounds, etc, would be introduced into the pit during operations. If allowed to collect in the pit, a number of these could seep into and pollute the ground water (Wilber, ROSS - 26).

Ground-water studies also are the responsibility of another group but ground-water quality is of interest here because polluted ground water might possibly reach the surface in the vicinity of the pit or perhaps well downstream. An additional problem is that an open pit over 1000 feet deep may lower the ground-water table over a relatively large area, thus drying up springs and denying water to wildlife. Stream biology is not a serious factor here because Yellow Creek is dry most of the time except near the mouth where it is fed by salt springs. It is devoid of most aquatic life except the salt-tolerant blackfly (Pennak, ROSS - 23). Any added pollutants to Yellow Creek, however, would be transferred to the White River.

The present environment contains ticks that are capable of transmitting Rocky Mountain spotted fever, equine encephalitis and other diseases of man and animals. The partial or total removal of vegetation would be a minor improvement in the disease vector problem because ticks would also be reduced in numbers or eliminated (Marquardt, ROSS - 20).

Scenically the pit will exert high negative impact, but the area is not visible from a public road; anyone viewing it would have to seek for it. Activities in and near the pit might reduce deer hunter success over a radius of 5 miles. But, on the positive side the pit itself may become a point of interest (Burke, ROSS - 2 and - 12) (Johnson and Alden, ROSS - 17).

Archaeologically there should be very little impact if the area is adequately surveyed for signs of past human activity before earth-moving work begins and if all portable artifacts are properly mapped, cataloged, and removed (Jennings, ROSS - 16). In some areas it may be desirable for an archaeologist to examine the removal of the surface layer of the overburden during operations to insure that traces of former human endeavor in the region be preserved.

The primary impact from overburden would result from the burying of several hundred acres of vegetation, soil, and wildlife habitat. There could also be an additional operational impact because an area so buried could not be developed as an open pit mine, although this would not necessarily prohibit development of an underground mine (Landon, ROSS - 18).

Lean shales (i.e. those assaying less than 30 gallons per ton) would be stockpiled for possible future processing (U.S. Dept. Interior 1973b). No estimate of the amount or grade of lean shale is presently available. Under the Prototype Plan it appears that about 600 acres of storage space could be filled to an average heighth of 108 feet, thus offering space for about 65,880 acre feet. Presumably the height of this storage pile could be increased above the stated figure because unprocessed shale stacks well. However, if lean shale occurs in larger quantities than expected, additional land will be required for storage. The lean shales would not be crushed but would be in the mine-run sizes that have good stacking characteristics. However, this shale from the mine, containing fresh fractures and fines, would provide a source of dust and leachable materials (Landon, ROSS - 18) (Wilber, ROSS - 26).

If economic conditions were not favorable for processing, this lean shale (a pile of yellowish-white rock) could remain in place for generations. It cannot be considered "temporary" unless there are plans for its use in the forseeable future. The primary impact would be the burying of about 600 acres of vegetation, soil and wildlife habitat. Geologically this rounded "hill" of lean shale would resemble many natural hills.

Piles of lean shale have high potential for impact both upon air quality (as a source of dust) and upon water quality (as a source of leachates). Because of size, light color, and probability of remaining into the post-operation period, this lean shale could become the greatest scenic impact of the operation with one exception; i.e. if processed shale is deposited in Douglas Creek.

Because it is considered temporary, rehabilitation plans have not been indicated for this lean shale pile; nevertheless, plans call for use of only the shale yielding 30 gal. per ton and over. The amount of shale yielding less than 30 gal. per ton has not been established; if the lean shale were to approach 50 percent of the total oil shale, then the lean shale pile would be enormous. If a substantial portion of the shale were to be under, let us say 20 gals. per ton, the pile probably would become a permanent feature of the landscape due to low economic potential. On the other hand, in underground mining, lean shale would be left undisturbed underground.

6. Processed Shale Disposal

Under the Prototype Plan, processed shale would be disposed of in the Douglas Creek valley. The lessee mining plan for Ca tract does not consider use of this area. However, an expanded plan being studied by the Department of Interior still plans on disposal in Douglas Creek, therefore, discussions of this report are based on the assumption of Douglas Creek as a possible disposal site (USDI 1974).

A 100,000 bbl. per day operation would produce 118,000 tons of processed shale per day, or 1.3 billion tons in 30 years. Storage requirements would range from 860,000 to 1 million acre-feet if the shale were dry or near-dry; and 657,000 to 700,000 acre feet would be needed if it were slurried. If the industry continued until the lease area were mined out, 4.6 billion tons, or 2.5 million acre feet, of processed shale would require disposal space (Landon, ROSS - 6 and - 18).

Two methods of processed shale disposal are suggested in the Prototype Program (U.S. Dept. Interior, 1973 Vol. III; pp. III-40 and III-43): (1) This scheme would utilize six canyons in the Douglas Creek drainage basin for all of the processed shale produced. (2) The second scheme would utilize some of the six canyons over a period of 16 years; then processed shale would be disposed of in the mined-out areas of the open pit, presumably, along with overburden also being disposed of there at that time (Fig. 2).

The six canyons offering a total storage space of 704,960 acre feet (see Table 1) could contain all of the processed shale produced in 30 years if it were slurried. This space appears to be inadequate. If mining continued until the 5,000-acre lease were mined out, these canyons would provide less than one-third of the needed space (Landon, ROSS - 18).

The alternate plan, utilizing the same canyons for a 16-year period would require about 530,000 acre-feet of storage space for dry or near-dry shale or 370,000 acre-feet for slurried shale. Several combinations of the six canyons could furnish adequate storage space for the 16-year period (Landon, ROSS - 18).

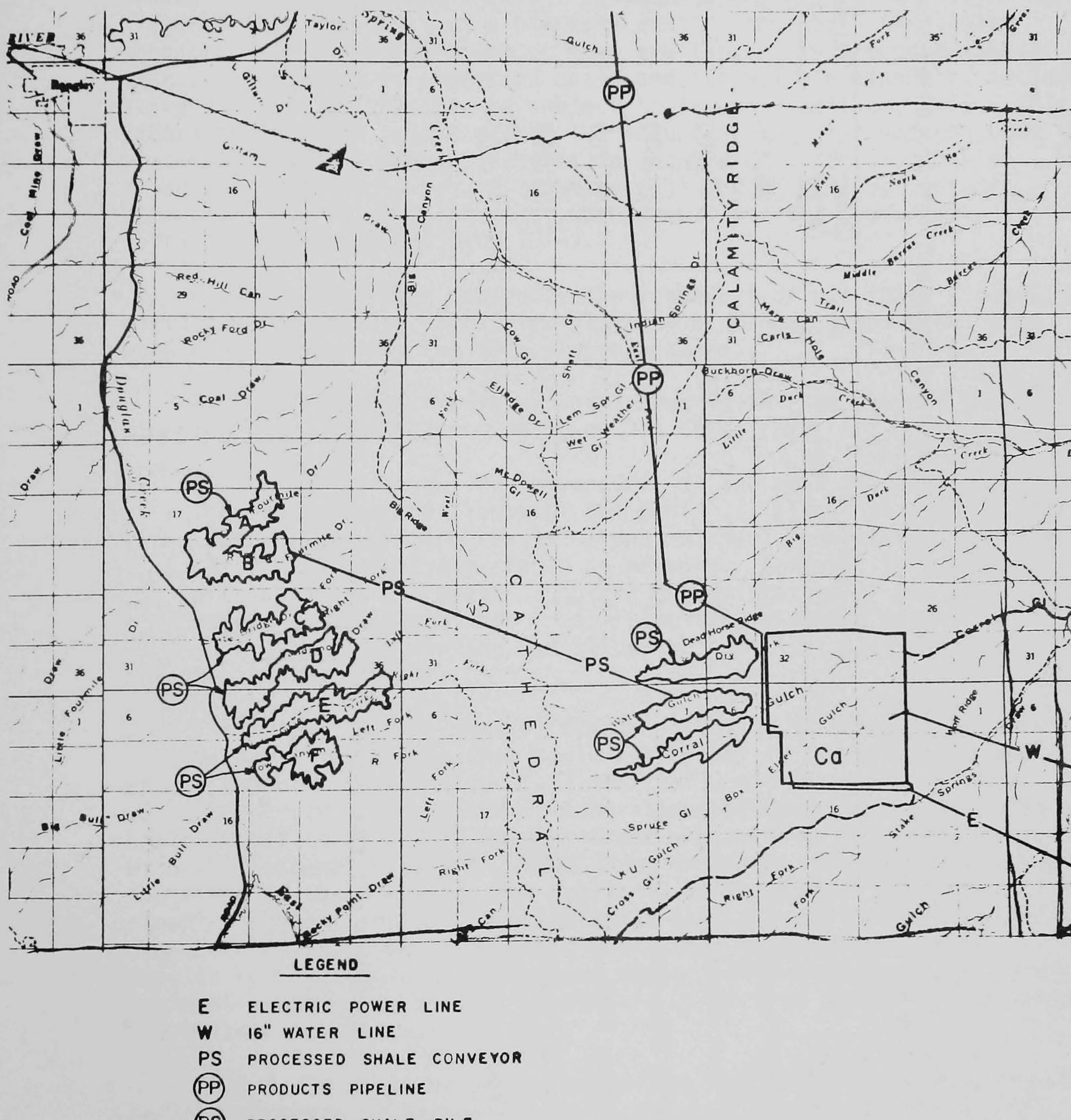


Figure 2.--Proposed shale disposal sites

Table 1. Features of six canyons in the Douglas Creek drainage proposed for processed shale disposal (Landon, ROSS - 18).

Canyon	Ave. Depth (Ft.)	Area Acres[1]	Capacity (Acre-ft.)	Stream Course (Ft.)
A. Left Fork-Fourmile Draw	164	600	98,400	11,000
B. Right Fork-Fourmile Draw	210	580	121,800	10,000
C. State Bridge Draw	150	800	120,000	10,000
D. Vandamore Draw	139	1,020	141,780	12,400
E. Philadelphia Creek	173	760	131,480	18,000
F. Cow Creek	183	500	91,500	7,000

1. All lands here are off the leased sites.

Impacts of processed shale would depend to some extent upon which process was used. For example, the waste product of the TOSCO II process is a material resembling coal dust. On the other hand, the process developed at Anvil Points produces a waste product resembling clinkers that weather into a blackish dust. Thus, both the basic characteristics and the enormous mass are factors in processed-shale impact. Furthermore, processed shale and its soluble minerals, including heavy deposits of salt may be subject to leaching (Wilber, ROSS - 26). Laboratory studies indicate that the amount of leaching depends upon the process. TOSCO II process results in about one-percent leachable material. This would amount to between 45 and 52 million tons of leachable material each year at 100,000 bbl. per day production (Striffler, Weymore and Berg 1974).

Environmental loss caused by the residue from oil-shale processing would be irreversible, irretrievable, and of magnum proportions even when considering only the 30-year projections.

This proposed oil-shale disposal area is an area subject to mass slumping. Schumm and Olson (1974, p. 27) state that

> "... areas of landslide susceptibility and past major slides are located around the flanks of the basin ... along Cathedral Bluffs. These slides are the result of past climatic conditions, and the cliffs are relatively stable at present. However, if during extraction of oil shale or during rehabilitation of the area water is introduced into these relatively unstable areas, the possibility of creating new slides or reactivating old ones is substantial."

The probability of massive stream pollution is apparent both in the leachable substances that would be present in the processed shale and in the high probability of slides that would damage or destroy containment structures which in turn allow polluted water and processed shale itself to flow into Douglas Creek and on into the White River. With the "escape" clause (U.S.Dept.Interior Lease Form Sec.7,(a)(ii)(C)(d) contained in the contract, the public would be charged with the cost of stopping a major source of pollution to the Colorado River. Emergency dams, or perhaps a permanent dam, would have to be placed across Douglas Creek to hold the processed shale. Diversion structures also would be required to by-pass unpolluted water from Douglas Creek around the defense structure.

Over 4,000 acres of soil, vegetation, and wildlife habitat would be lost permanently because it is doubtful if the southwest-facing slopes of this processed-shale debris could be revegetated successfully at this altitude. At the altitude of this proposed disposal, rainfall is lowest and evapotranspiration is highest.

(p.23) Corral gulch is typical of the areas where processed shale would be deposited.

The extreme impact of this great mass of processed shale located in an unstable area immediately above Douglas Creek, the city of Rangely, and a part of the Colorado River system (with its salt already causing international problems) is of unmanageable proportions. There is no plausible effective mitigation for an impact of this magnitude. *Processed shale should not be deposited in the Douglas Creek area.*

The Prototype Program offered no alternative to deposition of processed shale in the Douglas Creek drainage. Because of the unacceptably severe impacts probable in Douglas Creek the Thorne study team examined alternative disposal sites on the plateau near Ca tract, including Water Gulch, Box Elder Gulches and Corral Gulch. A combination of Water Gulch (capacity 52,490 acre-feet) and the two Box Elder Gulches (capacity 132,000 acre-feet) probably would supply adequate storage space. Because it is at too high an elevation to permit use of a gravity line from the assumed plant site, Water Gulch would not be suitable for the disposal of slurried shale. Slurried shale would require only about 70 percent of the space needed for dry compacted shale.

Overburden stacks better; thus about 510 acres would be available in Water Gulch for overburden as compared to only about 290 acres for processed shale. Average depth of overburden here would be about 180 feet but it could be stacked to 300 feet. Dry Fork would have 580 acres of space available for overburden (Landon, ROSS - 18).

With this alternative, a total of about 1700 acres would be buried; soils, vegetation, and animal habitat would be destroyed. Large piles of processed shale, if left uncovered by soil, may affect microclimate and local inversion patterns; the possible extent of these effects is still unknown.

Processed shale deposits on the Plateau would affect runoff and pollution in a way similar to results of such deposits in the Douglas Creek area except that on the Plateau there would be sufficient opportunity for adequate checking before leachates could reach a major drainage.

Fugitive dust and fumes from hauling and spreading vehicles would affect air quality in plant and mine areas during construction and mining operations. The hot shale may effect snow melt and cause convection currents which might serve as boosters that would help lift stack emissions to higher levels than normal (Marlatt, ROSS - 7).

The filling of valleys with processed shale on the Plateau would be a permanent change in landform, ... but the scenic impact would have to be sought out to be seen. Otherwise the principal impacts would be from potential toxic materials and surface characteristics of the shale piles. The toxic threat can be reduced if catchment basins of adequate size are installed. However, these basins cannot be protected by spillways because spillways would release polluted water. The catchment basins must be big enough to catch and hold all of the rainfall from the area that it drains until it evaporates. The dams must be designed to hold for a century with but minimum maintenance.

Physical and biological characteristics of the processed shale are so unlike the soil material that has developed here that restoration of the vegetation is highly improbable unless the shale piles are covered with stockpiled soil. Terwilliger, Cook and Sims (1974) state that:

> "The soil and subsoil should be at least 18 to 24 inches in depth to store surplus moisture for plant growth during more arid periods ..."

They further suggest that careful attention be paid to the proportions of clay, sand, gravel and organic matter in the topsoil material. In the Piceance Basin the gravel fraction of the soil would be replaced with shale shards. A cover of grasses and some shrubs can be established on the shale, but the survival of such plantings has not been proven; furthermore, their ability to spread and become established communities has not been tested.

7. <u>Industrial Activities and Water Quality (Wilber, ROSS-11, 1973; ROSS-26)</u>

Water quality is a vexing and continuing problem. Careful studies of probable modifications that may take place upon development for commercial oil shale production need to be made in advance of development in order to provide assurance of maintaining water quality and also to seek the most economic means of preserving water quality.

The leaching of strongly alkaline materials from raw shale storage piles and from spent-shale dumps could pose serious problems for surface waters of the basin. With the exception of Yellow Creek, most of the surface waters have pH values near neutrality. Leachable components from oil shale could upset the pH balance of the surface waters as they exist (Wilber, ROSS - 11 and - 26) (Prien, Nevens and Hollingshead 1970).

A major concern for water quality in the Colorado River centers around the total load of dissolved inorganic salts. Already the Colorado River carries over 700 parts per million of salts by the time it reaches diversion points for Los Angeles and other lower basin cities; that amount is 200 ppm saltier than the U.S. Public Health Service accepts for potable water. Any added salt would worsen an already critical situation. Yet development of oil shale would bring billions of tons of shale to the surface where it would be in raw and processed shale piles.

In addition, there are extensive beds of saltwater in the shale which must be removed before mining can be done. A recent release by the Colorado Department of Natural Resources (Ficke, Weeks and Welder 1973) offers data from well drillings that give cause for concern with respect to dewatering of mining sites and the possible use of underground water for industrial processes. For example, well No. 36 located between Enoch Gulch and Big Jimmie Gulch about a mile north of the Cb lease area has water with a specific conductance of 20,000 micromhos per centimeter; this value is equivalent to a little over 11,000 ppm sodium chloride. Other wells on the Cb area have waters of the following salinity:

Well No.	Conductance (Umhos)	NaCl (ppm)
16	5,500	3,000
24	22,000	13,000
4	20,000	11,000
14	over 20,000	over 11,000

Saline waters may be classified as follows:

Slightly saline 1,000 to 3,000 ppm; Moderate 3,000 to 10,000; Very saline 10,000 to 35,000 and over 35,000 ppm is brine (Wilber, ROSS - 11 and - 26).

On lease site Ca three wells have water with a specific conductance of 2,500-3,000 umhos -- equivelant to about 5,100 ppm sodium chloride. Well No. 20 has a conductance of 12,000 umhos or about 7,000 ppm salinity.

In addition to high salinity, many of the wells produce hot water; well No. 44 produced water as hot as 50°C (122°F) at depths of 915 m (3,000 ft.) (Ficke, Weeks and Welder 1974).

Sodium chloride and bicarbonate of soda are the dominant ions in the water. At less than 300 m (1,000 ft.) in depth, water has less than 1,000 ppm of salts; at depths below 600 m (2,000 ft.) water becomes saline (Ficke, Weeks and Welder 1974).

8. Water Diversion Systems and Catchment Basins

Essentially all oil shale installations would need diversion dams and by-pass systems to catch unpolluted waters from drainages above the installations, by-pass the water around, under, or through the installations, and return it to channels below in its original condition. These dams would be of proper sizes to meet applicable needs; i.e. catch and hold the design storm with no overflow.

By-pass systems also must be of proper sizes that will empty diversion dam reservoirs rapidly enough to maintain the reservoir catch-capacity; otherwise a series of storms could cause an overflow.

Catch basins would be necessary below every potential pollution source. These also must be large enough to catch all of the runoff without a spillway. An added problem must be faced in the construction of catchment basins; i.e. these basins must depend upon evaporation to empty. During mining operations they can be pumped and the water reused; after operations cease, evaporation alone must be depended upon. Therefore, an adequate catch basin must catch and hold all the runoff from a particular polluted area for an entire season. Catch basins at higher elevations must be proportionately larger because of greater precipitation and lower temperatures. Also, normal evaporation rates cannot be used in computations because of the probability that an oily surface layer would inhibit evaporation.

In the areas occupied by dams and reservoirs of the diversion system the impacts would result in total loss of soil, vegetation, and habitat. However, there might be some small temporary gain where reservoirs had small permanent pools that might provide water for wildlife. Catchment basins below potential pollution sources would cause similar losses to soil, vegetation, and habitat and the water in them probably would be unfit or perhaps dangerous for wildlife.

The most serious potential is that of "accidental" loss of pollution into stream channels. The overall record of industry has not been good in this respect and the mining industry's record is particularly bad. Some procedure should be worked out whereby the State of Colorado has the power to review the design of these structures and approve or disapprove of their adequacy.

Mine and plant structures may be dismantled at close of operations, but restraining structures related to processed-shale disposal areas must be built to last for a century or more, without maintenance. This will be difficult in an area subject to heavy movement of debris and even mass slumping.

9. <u>Allocation of Water</u>

There would be a consumptive use of approximately 1-3 barrels of water for each barrel of oil produced. To this must be added the water needed for the added population and supporting industries (Prien, Nevens, Culbertson and Hollingshead 1970). Proponents of oil shale development claim that there is adequate water for their needs. Opponents say that with purchase and development of added storage the developers might obtain enough water. However, the costs of displacement in irrigation and disruption of other values such as recreation would be too high and too severe; permanent damage to the State could be expected. Study of the water-availability problem by both sides has been fragmented and accomplished without sufficient regard to all pertinent factors. There is no reason to believe that each study was not honestly designed and implemented. Yet, each of the studies was limited as to scope and objectives; there is no clear picture of the pressures that oil shale development will place upon water resources and, just as important, no indication of how this pressure will impinge upon other users of the same water. Opposite views continue to be presented and could end in law suits in which the courts, forced to depend upon insufficient studies, may decide the issue on purely legal grounds to the detriment of the economic, social, and environmental interests of the region and the State.

10. Emissions and Air Quality

The circulation of air within the Piceance Basin poses a particularly difficult analysis problem. Studies of local circulations such as mountain and valley breezes, interactions between local and large synoptic flow, and even the large-scale wind patterns require much more detailed study than customarily available in mountainous regions.

Prevailing winds are from the southwest and west-southwest throughout the year. Wind occurs from the north or northeast for an average of only 10-15 percent of the time. It appears that the local wind circulation which would control transport and diffusion characteristics of the Basin are strongly influenced by local topographic features and the coupling and uncoupling of surface flow and the synoptic gradient flow.

At night, as heat is lost from the higher elevations, cold air tends to drain down into the valleys and lower depressions. As the cold air pools in the valleys and lowlands, inversions are formed in these areas which restrict the dispersion of smoke or other pollution held within the boundary layer. Height of inversion is dependent upon the depth and duration of drainage air, the topography of the area, and the surface thermal features (Marlatt, ROSS - 7).

Most of the companies are spending substantial sums on the study of air quality and air movement conditions in relation to their proposed processing plants. Because all plants will emit into a common air reservoir, study of the Basin, as a whole, is needed.

In this environmental analysis some study was conducted on the potential synergistic effects of three proposed developments Ca, Cb; and the Superior Oil Company. From this study it appears that only two or three processing plants would exhaust the capacity of the Basin to dispose of stack emissions (Marlatt, ROSS - 19).

Although this study used both topographic and mathematical models and the results checked, there still are no answers to such questions as: (a) How will the three plants studied (Ca, Cb and Superior) affect Colony and Union's air problem in Parachute Creek Canyon? (b) Assuming a southerly wind, how will Colony and Union affect these three plants? (c) How will Occidental -- located on the southwest rim affect the air quality of the Basin? (d) What would be the effect of emission from coal developments to the north and west upon the Basin? (3) What would be the effect if an expanded industry (such as the one being studied by the U.S. Dept. of Interior) were superimposed upon plants already under consideration. (f) In addition to the plants, what would be the effect of each of the above situations when added to the emissions from dwelling houses, satellite industries, and transportation, etc, that would accompany each? (g) Finally, considering the known direction of air flow, how much will the total emission output from the Piceance Basin affect the air quality of Denver and other Front Range communities?

11. Mine Dewatering

The Piceance Basin in underlain by some aquifers that contain fresh water and others that are highly saline. About 2.5 million acre feet of water are present under the central part of the Basin (USDI, Vol. I, p. II-140, 1973b). Thus, mines in the center of the Basin would have to be dewatered. The aquifers may be highly permeable; if so, virtually the entire water body might need to be pumped before shale could be mined. The shallower-lying waters are less saline and could be stored for use in later operations. Saltwater presumably would be stored separately; it also could be used for some purposes or it could be desalted.

Impacts from water would start in the construction period when water was removed to allow mining. Just how much water will have to be pumped and how it will be used or stored is unknown. This storage problem was overlooked in the EIS (Environmental Impact Study) of the Prototype Program. The reservoirs may add some positive impacts by providing water for wildlife and waterfowl. The saltwater reservoirs would be a perpetual threat to salinity levels of the Colorado River. Presumably, these saltwater reservoirs would begin to dry up at close of operations leaving salt bogs and finally salted areas of several hundreds or thousands of acres. Until vegetation is established on these areas they could become the source of salt-laden dust clouds that would damage vegetation on adjacent areas.

Any salt resulting from desalting should be disposed of commercially, if possible, or replaced in dry areas of the mine. Saltwater reservoirs should be constructed to hold the maximum saltwater plus the maximum designed storm without use of a spillway; any spillover would have disastrous effects upon the saline levels and aquatic ecosystems of White River, Green River, and Colorado River, in turn.

Some of the uncertainties that occur in relation to water are: (a) How much fresh water would have to be pumped? (b) How much storage would be required for fresh water? (c) How much saltwater storage would be the environmental consequences of the loss of animal habitat and loss in animal movement alternatives? (e) What would be the environmental consequences of surface storage of such a quantity of salt? (f) What is the potential threat to the salt levels of the Colorado River? (g) What would be the effects of the reservoirs on stream flow?

Runoff and streamflow were not within the scope of this study but a determination of infiltration rates was made which contribute basic information to storm runoff calculations (Meiman, ROSS - 9 and - 22). There are a number of important environmental questions that need study in relation to rainfall, snowcover and possible flooding.

12. Rate of Development

Just as a tree may bend and recover under pressure but will snap if the pressure is applied too rapidly, an integrated environment is also a living organism that may be permanently damaged by sudden pressures, shifts, and accelerated rates of growth. The Environmental Study of which this Environmental Inventory Analysis and Impact Study is a part, presumably was to be done to provide direction to oil shale development.

However, the pressure of circumstances from outside the region, and the nation have combined to accelerate development. Because of this acceleration the results of studies are often developed too late to be included in plans with the result that important environmental factors are often overlooked. Two questions remain unanswered in this circumstance. The first, what rates of development would be really feasible and second, what would be the environmental consequences of various rates of development?

13. Linkages with Other Energy Sources

Oil shale is but one of the prime energy sources in the Rocky Mountain Region. Coal is abundant, has a higher efficiency of energy output, has well tested production procedures, and could be put into reliable production very quickly.

Uranium has a number of uncertainties of its own but may be capable of eclipsing coal and shale in bo t efficiency and volume of energy production. A number of studies have been made in relation to each and also studies have been made of the alternate energy sources (Ford Foundation 1974). There has been no coordinated study of all of the variables in relation to oil shale in western Colorado.

Because full development of any one energy source may preclude development of the others, uncertainty as to high-level policy may impede development or lead to investments that might prove disastrous. It is possible that the best solution would be a reasonable level of development for all energy sources from which a higher level of production could be attained quickly in case of national need. The results or costs of any combination now are uncertain because the general problem has not been studied adequately. A proposed study to make the above evalution is outlined in section VI, herein.

B. RELATING IMPACTS TO THE VIABILITY OF THE EXISTING ENVIRONMENT

1. Rare and Endangered Species

This study has identified three species of plants (Vories 1974) and one species of fish (Pettus, ROSS - 10 and ROSS - 24) that may be rare and endangered.

No one has questioned the authenticity of these identifications. For example, some taxonomists are inclined to give species rank to hybrids or to genetic variations; others tend to lump such individuals into a single species. Or, a species may be rare in a cerain area (e.g. the Piceance Basin) simply because it is on the edge of its range. This same species may be plentiful within its range.

It must be understood that if candidates for rare and endangered species classification are ignored, there may be serious biological and genetic loss. On the other hand, giving the rare and endangered classification to species not really entitled to it may result in unnecessary expenditures.

2. How Much is Enough?

Somewhat parallel to the uncertainty about rare-and-endangered species is an uncertainty that occurs in all biological studies. Environmental monitoring and other studies are being required that are overly-expensive, overlapping, and biologically unsound (USDI 1973a). For example, adequate evidence exists to verify that Yellow Creek is too salty for any aquatic biota except blackfly larvae (Pennack, ROSS - 23). Yet, further study is required by the Department of the Interior lease.

Another example of such uncertainties is the requirement for bi-monthly sampling (U.S.D.I. 1973a, p. V-52) and the requirements for sampling patterns and intensity (Millert 1974a and b). The result of these requirements is that lessees are spending hundreds of thousands of dollars on data that may be either inadequate or perhaps overdone.

The above shortcomings could be corrected and a better approach to environmental problems obtained if legislation in the State of Colorado were to establish a single scientific entity that would be mandated to review the need for information, coordinate scientific investigations relating to control of environment and to provide guidelines for uniform monitoring. For example, in the biological sciences a body could say with authority, "Further study of the aquatic biology of Yellow Creek is not needed for monitoring purposes;" of that: "The construction of additional lists of vascular plants is unnecessary but perhaps more work should be done on lichens."

The lack of clear guidelines and uniformity contribute heavily to the distrust that industry's people have for the ecological aspects of industrial development. When there is a competent and objective entity that has the responsibility for review of the scientific aspects of the environmental monitoring and can officially state: "This is needed" and "That is not needed" and "Just this much is enough" -- then acceptance of ecological principles by industry should be greatly enhanced.

3. Inundation without Representation!

Residents at the community and regional levels and State leaders are asking: "How can we cope with the added population and the industrial complex that is inundating the region?" Decisions are made by multinational companies in New York, Houston, or Los Angeles and by federal agencies in Washington that completely change the region and residents of the region are not informed of what is going on, or even asked to contribute input for decision-making purposes.

The companies are interested primarily in the tracts that they own or lease. The federal agencies responsibility stops at the edge of federal lands. Both make decisions without the State's approval; yet the State must live with these decisions and pay for social and environmental consequences of the actions.

Plans for "assistance" and "prior taxation" are available but they are not adequate for "boom" conditions. One Wyoming man, interviewed on a Cheyenne TV program, suggested that a head tax be paid to the State for each new company employee hired. His contention was that such a tax could be passed on to the ultimate consumer in distant urban areas who rightfully should pay the bill.

Perhaps such remedies are drastic but at present there seems to be nothing that promises to protect the oil shale region from the problems of inundation that are occurring in neighboring Wyoming.

III. THE CONSEQUENCES OF OIL SHALE DEVELOPMENT ON THE SIX TRACTS NOW BEING CONSIDERED FOR DEVELOPMENT

A. DESIGN ALTERNATIVES ON THE SIX TRACTS

There are presently six oil-shale-development enterprises either on the rim or within the Piceance Basin (Fig. 1). Of these, the Ca and Cb tracts which comprise the USDI's Prototype Program to date are within the Basin. In addition, there are four private enterprises on the rim of the Basin; mostly on private land, these are briefly described:

1. Ca tract (Gulf Oil Company and Standard Oil Company (Indiana)).

Two alternate mining plans have been developed for mining tract Ca. The first is a combination plan using surface mining where the overburden is thin and underground mining where it is thick. Standard room-and-pillar mining would be used for the underground mine.

The TOSCO II process of oil removal is being considered. In this process, raw shale is first crushed to minus 1/2 inch particle size. It is then heated by hot ceramic balls in a rotating retort in a continuous process. The spent shale and balls then move by gravity, the balls going back to the heating furnace, the spent shale to the disposal pile. Oil is removed as vapor and goes to the upgrading plant.

The open pit mine probably would be the largest source of environmental impact. The shale disposal areas also would be heavily impacted. Stack emissions from this site may combine with those of Cb and Superior. It is not known whether emissions from Occidental would cover this area. There is a prevailing southwest wind which makes it a possibility. (Gulf Oil Company 1974 a and b.)

2. Cb tract (Ashland Oil Inc., Atlantic Richfield Company, The Oil Shale Corporation, and Shell Oil Company).

This development would use underground room-and-pillar mining and the TOSCO II process.

The major environmental impact from this operation may be saltwater. The tract lies over the saltwater aquifer and if this water has to be removed to provide for mining, surface storage would be a considerable threat. As with other operations, the spent shale deposits would be enormous and would be a serious impact. (Atlantic Richfield Company *et al* 1974 a and b.)

3. Colony Development Operation

Colony is on the south rim of the Basin in the headwaters of Parachute Creek which drains into the Colorado River. Several years of experimental work have been completed on-site and the planning of a 66,000 bbl. per day commercial plant is under way. Conventional room-and-pillar mining and the TOSCO II process will be used here (Colony 1974).

Aside from environmental impacts common to all plants, the major environmental threat from this operation is the potential for air pollution from the retorting operation. Inversion layers in Parachute Creek Canyon are such that even plant operation at legal-emission levels may produce heavy accumulations of air pollution. Following extensive environmental studies, Colony relocated both their plant and the processed-shale pile to achieve maximum environmental protection. The site for the plant, originally planned for Parachute Creek Canyon, was changed to a high point west of the canyon to obtain dissemination of stack gases above the inversion layer. Placement of the processed shale on the Plateau moved this environmental impact from the critically-needed winter wildlife range and scenic area to an area of relatively plentiful summer range and low scenic impact. However, an added threat, which is the result of moving the plant to the divide, would be the access road which can cause severe damage to scenic values and wildlife habitat if not carefully located and properly constructed.

4. Union Oil Company of California

Union is also located along Parachute Creek. They have done experimental mining and oil production since World War II. In the early 1950's they built a 50-ton per day experimental plant at the mouth of East Fork of Parachute Creek. Union uses a Steam Gas Recirculation SGR process. By 1980 they plan completion of a commercial 50,000 bbl. per day plant located in the canyon at the confluence of Parachute Creek and East Fork.

Union claims that this retorting process produces a decarbonized shale of a color and texture similar to the natural terrain, thus permitting normal temperature, water retention, and mulching conditions (Hartley and Hopkins 1974).

The major environmental threats from this operation appear to be from stack emissions and processed-shale disposal. With the plant in the canyon, even very tall stacks may fail to carry emissions above the inversion layer. There also is the threat of combined emissions from both the Colony plant at the head of the canyon and the Union plant down in the canyon. With both plants complying fully with emission standards, the accumulation of gases in the canyon might reach shut-down levels during periods of temperature inversion.

Depositing processed shale in portions of Parachute Creek Canyon and its tributaries would damage scenic values in the canyon and also destroy critical winter habitat for deer, carnivores and perhaps for eagles and hawks. Furthermore, because of the extensive watershed above these canyons in some areas, the possibility of flooding and the creation of a mud-flow down the main stream of Parachute Creek canyon cannot be easily dismissed.

5. Occidental Petroleum Corporation

Occidental is operating on the southwest rim of the basin on lands draining into Roan Creek and thence into the Colorado River. Here, they have developed a modified in situ process, the "Garratt System," which consists of three basic steps:

> "(1) A limited amount of conventional mining; (2) blasting of the overlying oil shale to form the retort; and (3) retorting in place, normally using air and underground combustion ... . The mining step creates the void in the form of a room underlying and/or overlying the oil shale zone to be retorted. The rock mined is conveyed to the surface, where it can be stacked and vegetated or added to other mined shale and retorted. The second step in the process consists of drilling vertical holes ... loading these holes with ANFO explosive ... so that the rock, as it breaks, spreads out to fill the entire volume; that is both the volume of the room and the volume of the rock before blasting. Finally connections are made to both top and bottom and retorting is carried out. Air is circulated downward through the rock pile, combustion is initiated at the top with the aid of an outside fuel source for a matter of hours." The shale releases the oil which drains to the bottom of the retort where it is collected and pumped into storage (Ridley 1974).

This system would utilize the low-grade shales as well as the richer ones and would leave the bulk of the processed shale underground; however, the shale that was mined (to provide retorting space) would have to be disposed of or be retorted in which case the spent-shale problem still would exist to some extent. Disruption of underground aquifers or toxic leaching perhaps would be no greater and might be less than conventional mining; this should be investigated.

One serious environmental threat comes from the need to introduce air and heat into the top of each underground retort. Apparently, this would require a drilling platform or some type of installation on almost every acre. Although this method is less damaging than surface mining, perhaps overall it would be more damaging to surface values than conventional underground mining.

6. The Superior Oil Company

Superior is located on the north rim of the Basin at the mouth of Piceance Creek where they are initiating a process in which nahcolite, dawsonite, and oil shale can be recovered in one integrated operation. Removal of these minerals provides sufficient space for processed shale to be deposited in the mine. Conventional room-and-pillar mining would be used.

Weichman (1974) states that: "Pilot mining operations beginning in 1974 and concentrating initially on high nahcolite zones, could deliver as much as 5,000 tons per day of nahcolite to the surface in 1974. Five thousand tons of nahcolite per day would free over 94,500 tons per day of 1% sulfur, western coal for production of clean energy. This is the equivalent of about 326,000 barrels of oil per day available as clean energy as early as 1975."

The principal environmental threats of the Superior operation appear to be twofold: stack emissions; and potential pollution of the White River. Located at the low point in the Basin, Superior's stack emissions might add to emissions from tracts Ca and Cb, thus causing a shut-down situation even when all three plants were operating under applicable requirements.

Here, at the Superior location the threat to the White River exists because so little space is available for catchbasins. Location of basins near the mouth of Piceance Creek would make them subject to flooding which could cause an overflow and wash pollution into the river.

B. COMMON ENVIRONMENTAL PROBLEMS OF THE SIX ENTERPRISES

While in Section II general environmental impacts were discussed in the broad context of any oil shale development, it is desirable at this point to present briefly the impacts related to developments now under way.

1. Mine Dewatering

Production of water in the course of mining operations and its disposal are recognized in the Final Environmental Statement, Vol. I, pp 1-73 to I-75 (U.S. Dept. Interior 1973) which generally describes these problems but offers few solutions. On page I-75, saline water encountered in mining is proposed for use in the disposal of processed shale. However, saline waters could be encountered even before processing of shale was started; their disposal during the construction period would cause problems because they could neither be discharged into a surface stream nor into an aquifer bearing potable water (Landon, ROSS - 18).

Reservoirs for impoundment of saltwater must be large enough to hold all arriving water until evaporation can empty them; this will probably leave a salt flat with a salt bog at the lowest point. Such reservoirs will pose long-term hazards to the environment. Another hazard is possible if salt is placed in processed shale; i.e. capillary action sometimes brings salt to the surface. Where this happens, plant growth would be inhibited. Both saltwater reservoirs and salted shale piles also could subject surrounding areas to environmental hazards; winds could blow the salt over other areas of the Plateau.

It now appears that enterprises on the rims of the Basin may not be as severely affected by saltwater as those within because saline waters are concentrated near the center of the basin (USDI 1973b, Vol I p. II-52). The Superior operation which would produce nahcolite and dawsonite in addition to oil shale would extract and use the salt in their process.

The fragmented approach now being used for the development of oil shale on the present six enterprise operations is currently inadequte to cope with the salt problem. To protect against environmental loss, a carefully integrated study and disposal program is needed to deal with this environmental hazard. This fragmented approach also may be adversely affecting the solution of a common problem -- how to profitably use underground water reserves.

2. Lowering the Water Table

A corollary to the problem of mine-produced water is the lowering of water tables and the resulting effects on nearby lakes and streams. In areas of high permeability, such as the leached zone and also in zones of fracturing, lowering of the water table could occur over a considerable expanse of surrounding terrain (Landon, ROSS - 6 and - 18).

The profitable use of the underground water reserves is being examined in a cooperative effort by the U.S. Geological Survey and the State of Colorado (Ficke, Weeks, and Welder 1974). This study should be expanded to more fully determine the amount, character, and location of the water and the location and size of the reservoirs needed to contain the water until it can be used. Some consideration should be given as to whether salt water reservoirs, if emptied by use, could be flushed by having fresh water pumped into them and this water used in processing.

The study of surface water and water rights is outside of the scope of this study. However, the production, transport, diversion and application of water have environmental implications that should be examined carefully as a single interconnected problem. Historically, water rights have been considered almost exclusively as a legal problem; to a lesser extent they have been viewed as a social problem.

3. Air Quality

Air quality is an overlapping problem for the six enterprises with the possible exception of Occidental which is isolated in the Roan Creek drainage. Colony and Union stack emissions will both drain into Parachute Creek Canyon and on into the Colorado River Valley. Both Ca and Cb will contribute aerial emissions that will flow down the valleys of Piceance and Yellow Creeks to the Superior plant and on down the White River Valley. In the above circumstances, courts may be asked to decide on matters for which no data-base for sound judgement has been established.

Rather than describing impacts in general terms we may use the synthesis of Table 2 to discuss problems associated with oil shale developments.

Table 2. Problems Associated with Oil Shale Development on Ca and Cb Tracts.

Components	Construction (Time)	Operation (Time)	Rehabilitation (Time)	Post-Operation (Time)
I_1				
Ecological:				
Physical	Changes in: (1) Land form (2) Water regimen	(1) Land form (2) Water regimen	(1) Land form (2) Water regimen	
Biological Vegetation	(1) Destroyed (2) Damaged	(1) Destroyed (2) Damaged (3) Loss of vigor	(1) Reestablishment of cover. 30-yr. period.	(1) Secondary Succession (2) Recovery of vigor 50 to 100 year period. (3) Recovery to present composition improbable.
Animal	(1) Destroyed (2) Decimated (3) Dislocated (4) Loss of habitat	(1) Destroyed (2) Decimated (3) Dislocated (4) Loss of habitat	(1) Habitat partially restored. (2) Populations partially restored. 1 to 10 year period	(1) Habitat stabilized. (2) Full restoration of populations highly improbable.
I_2 Hydrologic System				100 years
Water Availability	(1) Mine dewatering (2) Obtaining process water (3) Diversion of surface water (4) Water storage (5) Control of salt water	(1) Mine dewatering (2) Obtaining process water (3) Diversion of surface water (4) Water storage (5) Control of salt water (6) Control of polluted water	(1) Diversion of surface water (2) Control of salt water (3) Control of polluted water	(1) Diversion of surface water (2) Control of salt water (3) Control of polluted water 500 > years.
I_3				
Water Quality	(1) Leaching of salts (2) Silt from construction activities. (3) Salt from dewatering.	(1) Toxic materials from raw shale (2) Salt from dewatering (3) Pollution from activity areas. (4) Silt from construction areas.	(1) Toxic materials from over-burden, raw shale, and processed shale piles. (2) Silt from earth moving (3) Salt in surface system from previous dewatering (4) Pollution from activity areas.	(1) Toxic materials from over-burden, processed shale piles. 500 > years. (2) Salt from previous dewatering 500 > years. (3) Pollution from abandoned pollution check dams 100 years.

Table 2. (Cont.)

Components	Construction	Operation	Rehabilitation	Post-Operation
I_4 Air Quality and Meteorology	(1) Fugitive dust from construction (2) Emissions from working equipment. (3) Emission from increased housing and vehicle traffic.	(1) Fugitive dust from mine if open pit. (2) Stack emissions from plant (3) Emissions from housing and vehicle traffic. (4) Dust from processed shale piles.		
I_5 Local Climatic Changes	(1) Effects from salt water reservoirs. (2) Effects from fresh water reservoirs (shoreline only).	(1) Heat islands or hot spots from processing plants and processed shale deposits. (2) Islands of early snow melt induced by dust from processed shale deposits. (3) Local winter fog from evaporation of moisture from processed shale piles. (4) Effects from salt water reservoirs (shoreline only). (5) Effects from fresh water reservoirs (shoreline only).	(1) Islands of early snow melt. (2) Effects from fresh water reservoirs (shoreline only). (3) Effects from salt water reservoirs (shoreline only).	(1) Effects from salt water reservoirs (shoreline only). (2) Effects from fresh water reservoirs (shoreline only).
I_6 Recreation	(1) Opens new access roads for hunters. (2) Fresh and salt water reservoirs will provide added habitat for water birds and fish. (3) Activities at construction sites will cause moderate displacement of deer, some birds. (4) Major impact is from increased human presence. (5) (With max. development the operation itself may become a recreational interest point).	(1) Local increase in population will increase hunting pressure. (2) Year-long access may introduce snowmobiles. (3) Fresh and salt water reservoirs would introduce boating, fishing and waterfowl hunting. (4) Increased access may introduce recreational horseback riding. (5) Heavy hunting pressure.		
I_7 Surface Water Availability	(1) Fresh water reservoirs from mine dewatering. (2) Salt water reservoirs from mine dewatering.	(1) Fresh water reservoirs from mine dewatering. (2) Salt water reservoirs from mine dewatering.	(1) Water may be rediverted from these reservoirs to other reservoirs for other uses. (2) Salt water reservoirs will lease to be replenished.	(1) Fresh water Reservoirs may be allowed to dry up. (2) Salt water reservoirs may become first salt bogs and later salt flats.

Table 2. (Cont.)

Components	Construction	Operation	Rehabilitation	Post-Operation
I_8				
Social Population	Large influx of construction workers. "Overurbanization"	Large influx operating personnel and families.	Possibility of declining population, with mature industry.	Emigration of the more mobile population.
Community Organization Education Health Associations	Trailer communities. Problem of public health. School demand		Suburban expansion. Rise in welfare and support.	Suburban development. Rise in welfare and support. Need for centralized planning.
Spatial Umbilical Services	Waste disposal problems. Social disruption. Degradation of environment. Blight Law enforcement problems.	Transportation and attendant problems (construction, air quality). Community cohesion disrupted. Lack of quiet and solitude	Public transportation systems. Solid waste for communities. Community degradation. Lack of esthetic integration.	Public transportation systems. Solid waste for communities. Breakdown of existing social structure. Change in "image" of the West/ Blight in surrounding environment.
I_9				
Economy Employment	Shifting employment basis. "Easy money". Hardship on local labor market.	Shifting employment basis. "Easy money". Hardship on local labor market.	Potential for widespread unemployment. Reduction of industrial productivity.	Potential for widespread unemploy. Reduction of industrial productiv.
Housing	Make-shift arrangements. Trailers.	Beginning conversion to permanent housing. Boom + bust developments, fore-closure, etc.	Slums. Appalachia syndrome.	Ghost town.
Finance/Capital	Influx of capital, increased purchasing power. Inundation of local market.	Influx of capital, increased purchasing power. Cut-throat competition.	Potential of drastic losses. Request for State and Federal aid.	Potential of drastic losses. Request for State and Federal aid.
Tax Basis	Lag in tax basis.	Increased tax basis for new services.	Welfare burden. Tax delinquencies.	Welfare burden.
I_{10}				
Land Management				
Land Use Patterns	Speculative land purchase.	Speculative land purchases.	Speculative land purchases.	Perhaps "bust" needed intervention.
Recreation (See other table)				
Agriculture	Loss of production.	Loss of production.	Partial return. New types of agricultural activity.	Partial return. New types of agricultural activity.
Shrub Land	Loss of recreational potential.	Loss of recreational potential.	Increased recreational potential.	Increased recreational potential.
Wildlife	Major disruption from industrial activities + large presence of population.	Major disruption from industrial activities + large presence of population.	Difficult to achieve in new habitat.	Loss of hunting.

IV. ALTERNATIVE GROWTH OPTIONS

A. SOME TENTATIVE TYPES OF GROWTH

The thrust of the energy program described previously is primarily based upon an experimental effort the success of which may open further options for even more intensive commercial exploitation. It has already been emphasized that future developments in oil shale exploitation will be dependent both on a host of endogenous circumstances integral to the region and the industry and on a series of exogenous factors: i.e. the result of larger social policies; either continuous energy demands or curtailment of consumption; further environmental trade-offs; alternative energy sources and technologies, etc.

When assessing and evaluating regional oil shale impact, one must face the vexing problems of estimating both experimental and mature industry consequences, direct and indirect effects, and the overall complex interrelationship of natural environment and surroundings upon the human community. In the previous pages, a framework of impact analyses has been offered. At this point, these projected impacts must be linked with a series of alternative growth options. In essence, one needs to see the magnitude, intensity, or severity of expected impacts under a variety of development options that range from rapid growth to perhaps no further growth.

A recapitulation of the major linkages in oil shale development and the generation of environmental consequences may help provide an appropriate framework for examination of the variety of impacts under different growth options.

Figure 3 summarizes key factors of an oil shale industry. Here, one can see how the surrounding environment (both natural and human) is affected by three essential aspects of an oil shale industry: (a) Construction activities (the creation of infrastructure); (b) the industrial operation; and (c) the metabolism of the industry (industrial output). These activities produce new situations which through ecological transformations and expanded human activities can produce long-range environmental consequences and significant alterations upon the original character of the region (once again, exogenous factors will have cumulative effects on the rate and extent of these expected changes).

Although Figure 3 illustrates many direct and indirect effects, the important point is that oil-shale development will change the entire regional system (i.e. social, economic, and environmental). The search for a new equilibrium (i.e. the result of new ecological, social, economic, etc, conditions), inevitably leads to a consideration

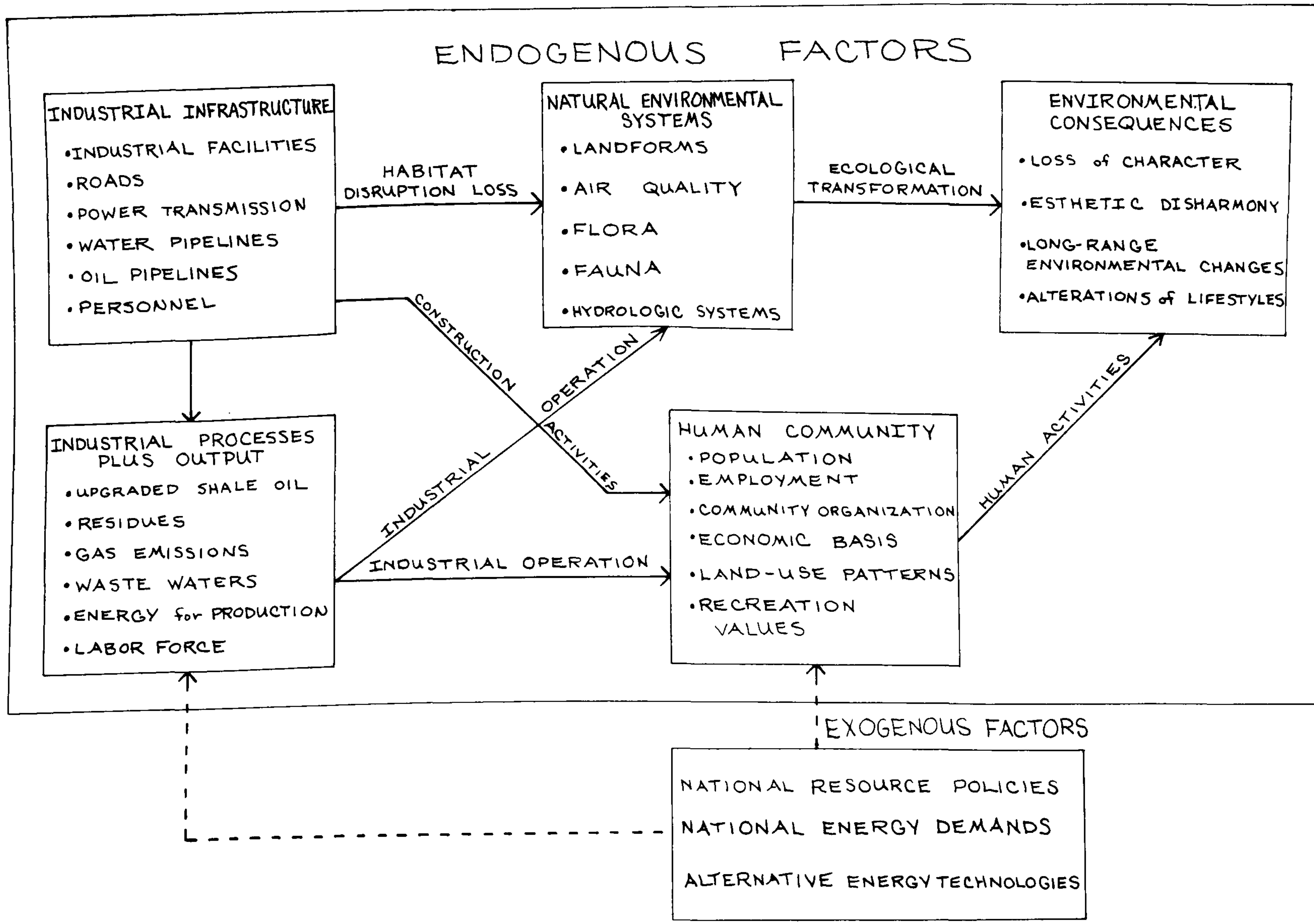


FIGURE 3. KEY ENVIRONMENTAL RELATIONSHIPS

of larger policy options concerning desired goals for the area, for the State, or the nation. Thus, the ultimate examination of environmental effects will depend on such broader questions as: who will be the beneficiary (local-regional-national); problems of equity; competing demands among various users; possible legal conflicts; and a whole series of social issues resulting from the disparities between energy demands and the environmental quest for preserving water, air, wildlife and the cultural artifacts as well as maintaining a salubrious and unique environment for recreation and human enjoyment.

The above discussion may help narrow the options for oil-shale development in the region. First, the present program may continue essentially as experimental with limited commercial development. Second, it may wither away after awhile, especially if the economic viability of the program is threatened or other technologies and breakthroughs make oil-shale development unattractive. Third, other options, especially full-speed development, may become generally acceptable as national and international events make oil shale exploitation a necessary alternative.

Therefore, to generalize the long-range environmental consequences of oil-shale development, we need to bring forward a series of greater options and examine in their context some projected effects. From a variety of documents, proposals, memos, and the general literature three broad options seem to emerge: See also: (Ford Foundation 1974).

1. Program of Accelerated Growth (PAG)
2. Moderately Expected Growth option (MEG)
3. Limited Energy Growth option (LEG)

Before discussing in more detail the general dimension of these three broad options, it is important that their largely speculative character and qualifying parameters be emphasized. One of the most difficult problems is the elusive nature of both the quantitative dimensions and the wide margins in <u>expected</u>, <u>hoped for</u>, or <u>desired</u> oil-shale output. This elusiveness is compounded by the inability to provide estimates of oil-shale output as one moves from the near-term effects to the long-term effects and consequences of the various growth options (i.e. PAG, MEG, and LEG).

With these reservations in mind, the following discussion will provide a framework for examining the potential environmental effects in the three growth options. Figure 4 summarizes the three envelopes of potential developments in the three growth options.

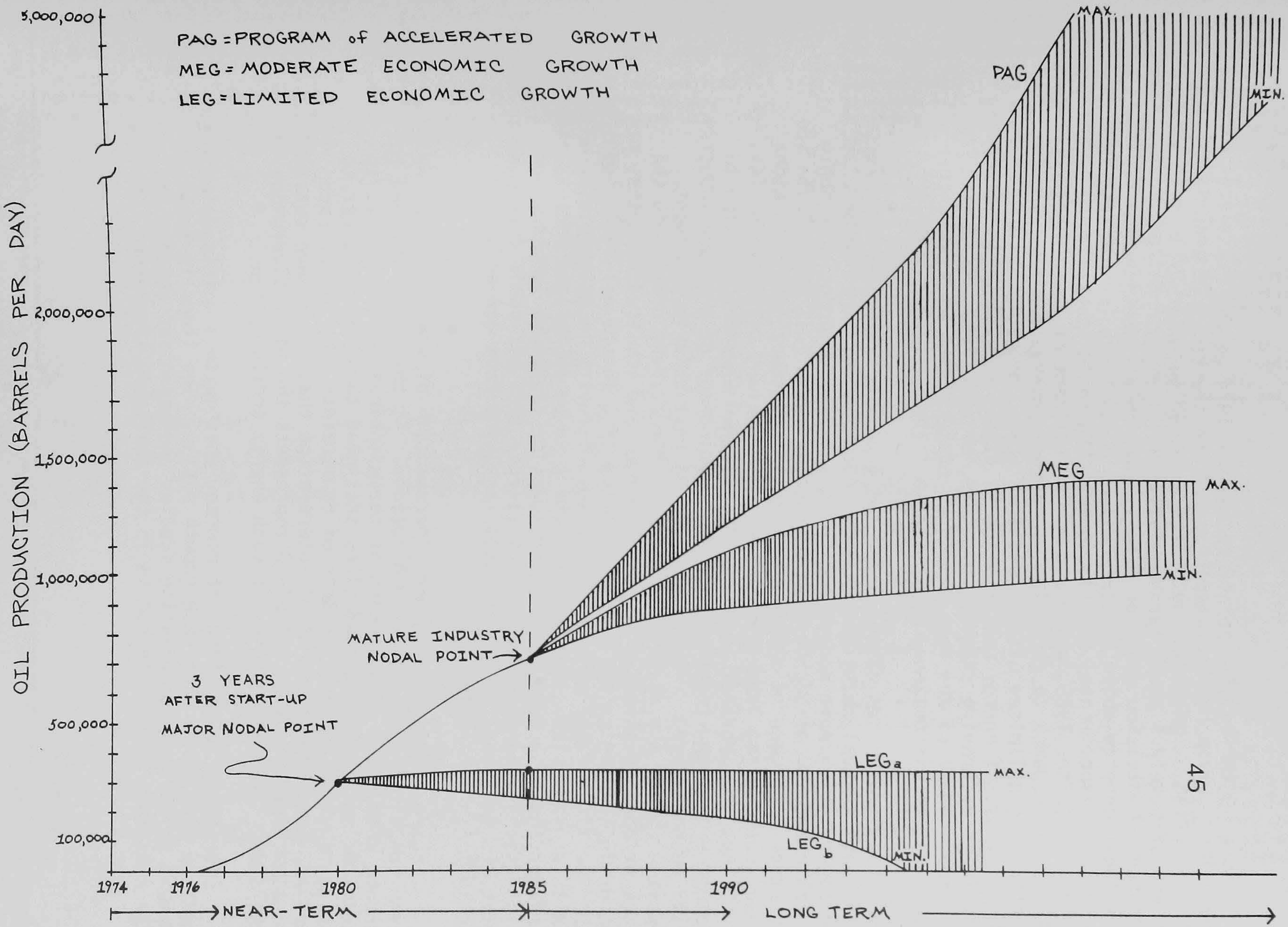


FIGURE 4. THREE GROWTH OPTIONS BEING CONSIDERED

As a beginning time point, we may use 1974 as the first year of operation. Given the Prototype Program and the required lead-time for operation, significant output is expected to occur by late 1976; in approximately 3 years (around 1979-1980) a major nodal point is reached. A decision could be made at this point, whether or not the oil-shale program would be continued on a low track (perhaps continue only on an experimental basis); so that LEG could stabliize over the long-term (after 1985, which assumes curtailment of energy demand). LEG, as a response to condition of energy conservation may continue as a limited oil-shale output (LEGa, or as low as 250,000 bbl./d); or, if energy conservation is highly successful, or alternative sources provide cheaper solutions, or a decision is reached that the environment of the region must be protected at all costs, then LEG might be discontinued and phased out (LEGb).

Final direction of the other two growth options (PAG and MEG) also have a nodal point about 1985. A commitment might be made to follow either a more moderate oil-shale-expansion program or begin a crash program of accelerated development with full speed ahead and relative disregard of many environmental considerations. In either case, considering lead-time and larger questions of social policy, by 1985 another important nodal point is reached when the decision to commit effort and resources for the development of a mature industry will be considered. This last point is particularly important, because one of the major criticisms of the current program is the lack of consideration of the vast changes and ramifications that may occur in the region due to the presence of a mature oil-shale industry. The question of the effects of a mature industry is raised later on in this discussion. However, the point to be emphasized here is that independent of growth option, the question of mature industry and its effects transcends the direct effects from oil-shale development with its indirect "ripple" effects resulting from new economic activity in the region.

Figure 4 provides a general perspective of some probable, or even conceivable, energy-growth options. At this point we need to become more aware of what each of these options implies: i.e. in terms of more specific conditions that need to be met in order to pursue a given option; the sets of constraints that hinder each option; and, some elements of intervention that may remove constraints on a particular option. Table 3 represents the major diversions of the items introduced above for each energy growth option.

It should be realized, of course, that quite a multitude of items must be considered with each growth option. The items in Table 3 derive primarily from existing studies and expressed concern and are the ones most often referred to in the available literature. At the

Table 3. A Synopsis of Crucial Development Dimensions for Three Broad Energy Growth Options

	Dimensions	Conditions	Constraints	Interventions
PAG Program of Accelerated Growth	High growth, "Project Independence" by 1990 2,500,000 to 5,000,000 bbls/day Public land by 1985 125,000 acres.	1. Additional leasing of public oil shale lands to private industry (42,000 acres +) 2. Economic incentives and risk removal conditions for industry. 3. Building of new dams and reservoirs in Northwest Colorado to serve industry. 4. Weakening air-pollution control laws in Colorado.	1. Limited capital because of low-profit expectations and long-term tie-up of money. 2. Limited availability of oil-shale land (since 80% is federally owned. 3. Low oil prices. 4. Lack of engineering talent and skilled workers. 5. Rising material and labor costs. 6. Increasing delays in necessary equipment. 7. Shortages of material, especially steel. 8. Water Rights. 9. Exogenous factors (price fluctuation, alternate technologies, resource policies, etc.). 10. Lead time. 11. Industry structure.	1. Guaranteed price for oil 2. Additional leasing of public lands. 3. Removal of EIS 4. Land exchanges between private and federal. 5. Additional water supplies (transfer from agriculture, weather modification, etc.). 6. Tax incentives. 7. Levying of tariffs and quotas, financial assistance, cost sharing, guaranteed loans. 8. Accelerate R.& D. especially for in situ processing. 9. Establish a centralized system for information and coordination. 10. New industrial structure (centralized, coordinated, subsidized, etc.). 11. Legislation for off-site disposal.
MEG Moderate Expected Growth	Expanded but controlled by 1990 1,000.000 to 1,600,000 bbls/day Public land by 1985 83,000 acres.	1. Some additional leasing of land (28,000 acres). 2. Some economic help, but limited 3. Available water, perhaps some transfers. 4. Variances for air quality.	1. Limited capital because of low-profit expectations and long-term tie-up of money. 2. Low oil prices. 3. Some shortage of engineering skills. 4. Rising material and labor costs. 5. Some delay in equipment. 6. Some steel shortage. 7. Water rights less than in PAG. 8. Exogenous factors still apply. 9. Lead time. 10. Industrial structure. problems great.	All, but #10 above and perhaps some of #3 above.
LEG Limited Economic Growth	Limited Prototype 250,000 bbls/day by 1990 400,000 750,000 bbls/day Public Land by 1985 55,000 acres.	1. Limited leasing of land (12,000 acres) 2. No particular economic help to industry 3. Available water 4. Existing air quality standards	1. Low oil prices can be absorbed. 2. Rising material and labor costs. 3. Delays in equipment still a problem. 4. Some steel shortage. 5. Exogenous factors greater because of experimental nature of development. 6. Uncertainty in lead time.	More R.& D. badly needed. Also need price floor, low interest loans, accelerated depreciation and some added federal land leased.

same time, one should be particularly alerted to two dimensions, specifically outlined in each option, namely production levels and amounts of public land leased.

To supplement the general outlook for each growth option outlined in Table 4, one can make a preliminary evaluation of environmental consequences. While the references made are primarily based on findings concerning the present program (LEG), it may be advantageous to extend the remarks and speculate about consequences for more rapid oil shale development. Table 4 summarizes baseline conditions and expected changes for various systems under each growth option. Data can be calculated for some dimensions, but for others only some broad qualitative statements may be possible at this time.

Generally, these data (Table 4) indicate the rather obvious observation; higher development increases the possibility of "boom-and-bust" growth, thus leading to serious questions of growth management and severe environmental perturbations. Yet, such a statement should not go unchallenged, especially if one considers that an accelerated program of oil shale development coupled with strategic interventions and coordination, has the advantages of economy of scale and concerted action. It still remains true, however, that any attempt to accelerate the oil shale development program will involve new risks for environmental quality. Furthermore, strategic uncertainty increases with each extension of the "time" horizon. Risk and uncertainty, therefore, are inherent in any long-range estimation: this is especially true for larger interventions, and the possibility of irreversible damages to a fragile environment also increase with a lengthened "time" horizon.

Keeping these background considerations in mind, we may now examine some potential developments by building three alternative scenarios. The scenarios or "future histories" are offered primarily as a means for stretching the imagination and as a form of questioning the assumptions behind each energy-growth option, especially as they relate to environmental consequences.

B. SOME BROAD SCENARIOS OF OIL SHALE DEVELOPMENT

The energy crisis became part of the social reality in the winter of 1973; concerted programs were proposed to correct the apparent unbalances between supply and demand. Simply stated, the restoration of energy balance can be achieved either through an increase of supply (including supply alternatives) or through a limiting of the demand (especially through energy conservation).

Table 4. Baseline Conditions and Changes Anticipated for Various Components of the Ecosystem in the Piceance Basin as the Result of Oil Shale Development

Component	Indicators	Units of Change	Changes Anticipated at Three Levels: Low Track (LEG)	Middle Track (6-Plants MEG)	Hi Track (PAG)
Physical					
Land form	Volume of earth excavated or deposited causing change.	Dimensions	Low impact	15 sq. mi. major change.	110 sq. mi. major change.
Soils	Soil removed, buried or mixed.	Acres	" "	15 sq. mi. removed or buried.	110 sq. mi. removed or buried.
Meteorology-Air Quality	Gaseous composition	Concentrations and time.	" "	Heavy pollution in areas of concentration Parachute Creek, Colo. R. & White R.	Serious pollution in river valleys surrounding Basin
Surface Run-off	Infiltration Rate	Cm. per hr.	10 cm per hr.	2 cm per hr. on affected areas.	2 cm per hr. on affected areas.
Biological					
Deer	Population	Animal numbers	20-60 thousand	10-25% reduction	Greatly reduced (irreversible)
Large carnivores	"	" "	No Change	Moderately reduced	Greatly reduced (irreversible)
Other mammals	"	Animal occurrence	" "	Small reduction	Moderate reduction
Reptiles	"	" "	" "	Small reduction	Moderate reduction
Raptors	"	Numbers	" "	" "	" "
Other Birds	"	Occurrence	" "	" "	" "
Disease Vectors	Habitat Area	Habitat Area	" "	" "	" "
Aquatic ecosystems	Species Occurrence	Species occurrence	" "	" "	" "
Fish	Population	Population	" "	" "	" "
Vegetation	Species density and composition.	Species density and composition.	" "	Major change 15 sq. mi.	Major change over 110 sq. mi.
Social					
Aesthetics	Characteristic Natural landscape.	Line, form, color, texture, and light value.	No change	Low	Low
Recreation	Number of participants.	Number of participants.	" "	Large increase.	Large increase.
History and Archeology	Presence of artifacts.	Number of sites damaged or destroyed.	" "	" "	" "
Socio-demographic	Population	Number of persons by 1990	Added oil shale pop. 60,700.	Add. oil shale pop. 112,700.	Add. oil shale pop. 148,000.
	Land Use pattern	Acres in specific use	Some change.	Significant change.	Overurbanization
Economic	Employment	Number employed (temp.& perm.)	26,400	49,000	64,400
	Housing	Dwellings	Perm.8,700-temp.15,200	Perm.32,300-temp.16,700	Perm.42.500-temp.21,900
	Tax Basis	Dollars/yr.	Federal 541 million State 86 million Local 132 million	Large increase	Quite large increase.

Oil shale development can be seen both as a response to this general quest for providing energy and as part of a search for oil sources that are independent of the vagaries of international politics. If, then, we see oil shale as part of the broader energy picture, it is apparent that its development and environmental consequences will depend on the restoration of the balance between supply and demand through a recognition of such constraints as: (1) Supply; and (2) Demand.

Supply	Demand
Overall resource limitations.	Population growth.
Technological limitations.	General economic growth and affluence.
Economic-and-tax policies.	The extent to which economic activity is energy-consumptive.
Distribution problems.	Amount of energy wasted.
Ecological limitations.	The extent to which lifestyles are, or are becoming, energy-consumptive.

The problem of "energy needed to produce additional energy" must be considered during any analyses of options, potential solutions, or environmental consequences. As stated above, it is necessary to talk about net energy as contrasted to gross energy (the products of oil shale). There are indications that oil shale development on a grand scale, in addition to major environmental disruptions, may have significant secondary effects through the high consumption of energy required for its production (on top of other ancillary supporting infrastructures; notably, dams and reservoirs).

As an introduction to three brief scenarios (LEG, MEG, and PAG) of potential developments we may use Figure 5 which summarizes the major dimensions of the attempts to generate "future histories" under different assumptions of diverse policies to be followed. This figure can be completed by filling in the series of impacts and consequences presented under various headings above. However, it is important to concentrate on some probable, possible, or plausible environmental consequences as a result of oil shale development under each of the major energy-growth options outlined above. The scenarios that follow are a composite of the various studies incorporated in the main ROSS Report and an extrapolation of potential effects based primarily on data, information, and references from the Prototype Program.

1. Scenario Alpha (Low Economic Growth)

This scenario assumes that present trends of limited economic growth (LEG) will stabilize and continue more or less the same, but with continuous emphasis upon: comprehensive planning requirements;

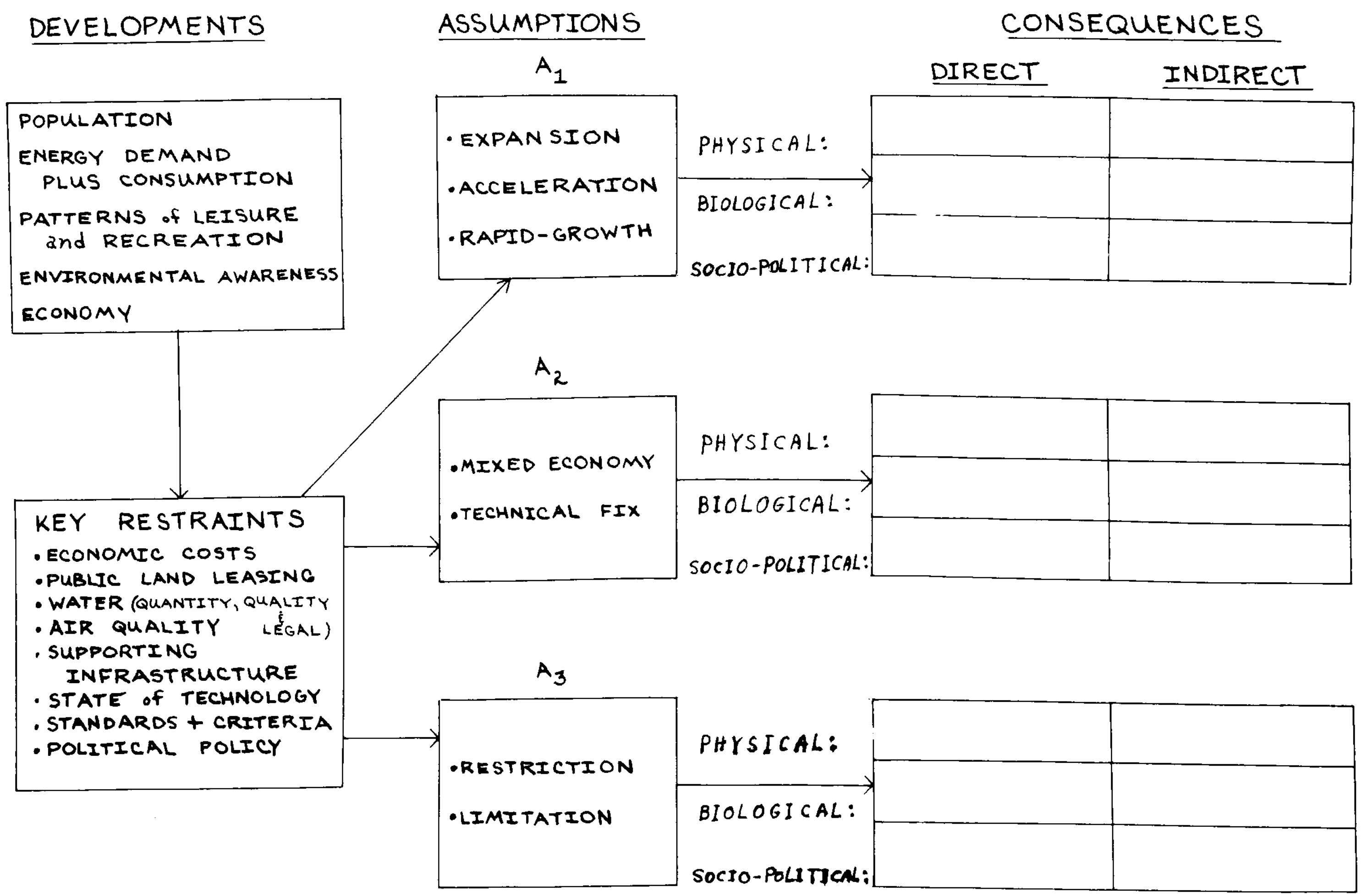


FIGURE 5. ENVIRONMENTAL DIMENSIONS of ALTERNATE ENERGY DECISIONS

strict enforcement of environmental guidelines; accentuation of quality-of-life dimensions; similar measures of continuous environmental awareness and involvement.

Strong energy-conservation measures will be providing a breather from continuous demands for more energy. At this same time, solar energy will become a more viable energy alternative; also the increased efficiency of heating and cooling units, especially in the arid West, will provide significant savings of conventional fuel. Despite "ups" and "downs" in the international scene, there is a guaranteed flow of imported oil. At the same time, the completion of the Alaska pipeline coupled with the discovery of new off-shore oil fields, will have kept the price of oil steady, and for a few years, even lower.

Population growth will have stabilized, while mandatory new standards for thermal insulation of houses has increased heating efficiency. For economic and lifestyle reasons, condominiums will be more prevalent and the assorted energy savings accruing from centralized services will be in evidence. A "steady-state" economy is now widely discussed and governmental efforts seem to support frugality.

However, the need for revitalizing western Colorado still makes it imperative to develop a basic oil shale industry of around 400,000 bbls/day capacity. This permits a modest investment and limited leasing of land, while also providing an expanded tax base for a small population increase; furthermore, it retards out-migration of younger people by offering increased local employment.

By 1990 this relatively small oil shale operation is continued primarily to provide fuel for Colorado industry; thus it will create an autonomy of fuel resource for the State.

The environmental consequences of such a program have already been described. There probably would be some disruption but no great decrease of the deer herd. Scenic values would have been somewhat decreased in scattered locations because of present experimental work, but mostly this would be only temporary.

Some damage to archaeological values would result from exploratory roads, trails, and drill-sites. Air pollution would remain within legal bounds except for some problems which might arise, especially during inversions, from two plants at the head of Parachute Creek Canyon. There would be little or no threat to water quality from operations on private land; however, some problems may arise from saltwater on the lease sites.

2. Scenario Beta (Moderate Economic Growth)

Because of rising unemployment and the need for moderate economic growth (MEG), a deliberate decision will be made to encourage, through appropriate mechanisms, oil shale production; but some control will be maintained over speculative developments.

After a dramatic dip, the birth rate will rise to a modest annual increase of 1 percent, which will provide some additional demand for housing. The housing demand is also accentuated by a significant increase in construction activities, following the drop in inflation rate. Demand for energy, although not increasing in geometric rate, remains high; this high demand is also the result of energy-consumptive lifestyles in the increased urban agglomeration of the nation. Technological breakthroughs are still lagging and a relatively high price of oil in the international market attracts investors and capital to oil shale ventures.

With a production of approximately 1,200,000 bbls/day, some major operations are needed in western Colorado in order to generate such an output. Environmental guidelines still are maintained, but standards are relaxed, especially in terms of air-quality criteria. Water has been transferred from agriculture to industry through a series of legal interpretations and significant inroads are made upon the "rights" of agriculture under the concept of "beneficial use." While the salinity of the Colorado River remains a problem, new facilities for controlling salt-load are established through contributions from the oil shale industry.

Under these circumstances, environmental degradation becomes inevitable as a result of the transition.

The six plants, ranging up to a production of about 1.5 million bbls. per day, probably would require enough water to strain present sources. Some reservoirs might be necessary. Reservoirs to hold mine-produced water might occupy about 20 to 30 square miles of land. Shale piles would change the land surface of another 10 to 20 square miles. The more timid forms of wildlife would become very scarce and the deer herd would suffer from lack of winter habitat buried to some extent beneath reservoirs and shale piles. Current damage to water quality probably would remain low, but the threat to water quality would increase greatly. Air quality standards would be exceeded in Parachute Creek Canyon to Grand Valley, and down the Colorado River. Also, accumulations of polluted air would build up near the mouth of Yellow and Piceance Creeks and flow up and down the White River Valley with diurnal change in temperature. Blight would occur from social impacts and would be a serious threat to local governments; quality of life would degrade in the corridors surrounding the Basin because of lack of centralized controls. This threat would be met by the State and by local governments to the limit of their ability, but this ability would be severely limited by lack of funds. The limited levels of production would not provide adequate planning and control funds.

3. Scenario Gamma (PAG)

A new international confrontation sets the stage for a vigorous program of accelerated growth (PAG) and "Energy Independence." The rationing of fossil-fuel exports to the U.S. and the need for energy for fertilizer (following international food riots and crop failures in the Midwest) make large investments in oil shale industry more attractive. NEPA (National Environmental Protection Agency) has been watered down by Congress, especially through a recall of the provision for preparation of EIS (Environmental Impact Statements). The State has also lowered air and water quality standards, as many industries prefer to establish subsidiaries elsewhere, especially across the border.

The national population is also showing a new baby-boom following the low rates of the middle 70's. The U.S. has decided to become the bread-basket of the world, but it tries to strike a balance through a diversified tapping of varied export markets.

The oil shale industry is encouraged by guaranteed oil prices, purchase agreements, low-interest loans, accelerated depreciation, increased depletion allowances, investment tax credits, royalty reduction, and other specific subsidies; the industry is booming, reaching by 1990 an output of 4,500,000 bbls/day. Investments in the oil shale industry have closed options in other energy industries, especially in solar energy where only a hardy band of pioneers and naturalists are to be found.

The massive investment in oil shale attracts talent and facilitates further technological breakthroughs, especially for *in situ* operations. An air of boom-and-bust permeates western Colorado, where a deliberate choice has been made to develop economically, while retaining other parts of the State in a relatively pristine condition for recreational enjoyment.

Under these circumstances, the Federal Government probably will label the western slope of Colorado an "Accelerated Development Area" (ADA) and officially wash its hands of all social and environmental consequences of their decision to go ahead full speed.

Such a designation and development thrust can be seen as a national commitment to promote energy self-sufficiency. That this may be a possibility can be seen in parallel problems, such as in the case of the state of Montana. An extreme example of the strong sentiments of a segment of the population concerning the exploitive character of development can be seen by an editorial in the High Country News, July 19, 1974, a portion of which reads as follows:

> Four words, just four words, pretty well sum up how the exploiters of Eastern Montana's coal fields look at the social and economic problems which will face the people of the area.
>
> "That's your problem, gentlemen."
>
> Those were the words spoken by the director of the environmental system's study firm brought in by the Montana Power Co. consortium to make possible "the best for Montana."
>
> That was the way J.H. Wright, Westinghouse Environmental Systems Department director, answered a question as to how Colstrip school district could be expected to find the money to finance an exploded school population brought about by the construction of four massive power generating plants.
>
> "That's your problem, gentlemen."
>
> Despite all the pretty pictures painted of how much money is going to flow into the area, how much economic bustling and hustling there's going to be, when it got down to the hard facts of social and economic impact and who was going to pay for it, the answer was clear.
>
> "That's your problem, gentlemen."

This scenario (PAG) brings forward most of the feared characteristics of "Boomtown" development. The strains from such explosive growth can be already seen in various communities in the western U.S. that are facing rapid growth from such expanding activities as coal development. In a typical "Boomtown" there is a dangerous lag between the ever-expanding needs of the community (result primarily of the high population influx) and the proper development of a viable tax base. The exploitative character of development is not conducive to long-range planning and the individualist "bust" atmosphere does not promote centralization and concerted policy option.

As elaborated in previous tables, under such conditions all aspects of life in and around "Boomtown" are characterized by helter-skelter developments and are continuously under the imminent danger of social breakdown. More concretely, extrapolating from present trends, in some rapidly-expanding communities in other parts of western America, one may discern the profile and lifestyle of the future "PAG-Community" (boomtown). The salubrious clean air and open environment begin disappearing as air inversions and smog become a more frequent occurrence. Whatever surplus water may have existed for agriculture begins to disappear, thus increasing problems of salinity and toxic loads. The demand for construction materials for housing and roads dots the countryside with the unsightly excavations of sand and gravel pits. The effects on wildlife are dramatic; crawling urbanization, new transportation networks and noise drive the limited animal population away. All in all, the very environment that has come to be known as the "Wide-open West" and the land of the "Big Sky" begins to close down and loses the very attractiveness that in earlier years brought many urban refugees from other parts of the country.

Under such circumstances the ramifications on both the social structure and the cultural life of the community can be severe and long-lasting. The alteration in land use promotes not only removal of crop production areas but also encourages land speculation that results in land prices soaring and private lands passing into corporate hands. Housing becomes impossible to find, with a large portion of the population living in trailers while motels are overtaxed, forcing the renting of units in eight-hour shifts. Inevitable traffic jams that result from long-range commuting over long distances become the order of the day, with all the attendant problems of a highly mobile (and increasingly denser) population. Similarly, other transportation facilities, such as the small local airports, are overtaxed and unable to handle increasing passenger and cargo traffic.

More severe and far-reaching, however, are the impacts and consequences on the social structure and the people of "Boomtown." Despite the need for laborers, job turnover as well as absenteeism are high as a result of social problems in the community. Many high school students tend to drop out of school as they are lured by high industry wages, while local retailers face the problem of staffing unattractive, low-paying positions. In the context of a highly-mobile, heterogeneous, young population, cleavages with old-timers increase bitterness on local issues, all of which results in the loss of the earlier tranquil way of life. Increased suicide attempts, higher divorce rates, crime, and drunkeness become for many the obvious character traits of the new community. All of these attributes reinforce the prevailing feeling of a fast, exploitative type of town that exudes despair and a sense of loss over the future of a community that is drifting away from a natural environment and from the "western way" of life. The West, for many, is again won by a new invasion of people who stand, at least in many respects, at some distance from the cherished values of a quiet, shared, more leisurely community lifestyle.

Perhaps the case of "Boomtown" may be overstated; after the initial shock of a transitional phase, some communities may adapt to a changing environment. The question that is being asked is not whether communities and people can adjust to new environments and social conditions, but whether the short-range gains may eventually be overcome by the long-range consequences that result from the loss of a unique way of life that is a source of satisfaction and purposeful quest for many citizens of the nation.

V. AN ALTERNATE PROGRAM OF DEVELOPMENT -- SPECULATING ON A MATURE INDUSTRY

A. REQUIREMENTS FOR A VIABLE MATURE INDUSTRY

After analyzing and discussing an ongoing program of oil shale development and pointing out impacts, deficiencies and potential long-range ramifications, eventually the questions of what should be done and the policies to be followed have to be faced. The Ford Foundation report "Exploring Energy Choices" (Ford Foundation 1974, p. 10) outlines five major objectives which also can be used in the present situation, with appropriate adjustments for the particular conditions of oil shale production. In the form of questions these objectives become a test which any proposed energy program should meet. In essence, then, do proposals made in relation to oil shale development make a substantial contribution toward:

(1) Assuring reliability of energy supply?
(2) Achieving the lowest cost to society for energy?
(3) Avoiding economic and regional inequities?
(4) Safeguarding the quality of the environment? and
(5) Minimizing international problems due to energy?

All of the above must be considered in order to achieve a balanced solution for any one, thus all of the questions must be considered.

It would be almost impossible to embark upon a detailed examination of these questions without devoting large sections to broader questions of national policies of energy self-sufficiency, social objectives of equitable distribution of resources, of environmental costs, and of the perennial quest for achieving short-term gains as contrasted to long-term enhancement and productivity. Rather than entering into a complicated discussion of such broad questions, two points need to be emphasized in the context of the present analysis of a program of oil shale development for the State of Colorado:

1. The first is the interlocking character of each of the above questions and the interdependence of answers to these questions which are but a part of a complex but interrelated program that brings together national benefits, international independence, local advantages, and some balance or tradeoffs between economic, social and ecological benefits and costs.

2. The second point is consideration of the consequences for the State and the "ripple effects" that arise from the creation of a <u>mature</u> oil shale industry. A mature industry would have a more permanent presence and a more expanded scope of operation, and attendant impacts from other supporting economic activities, industries, etc.,

including consequences from the "multiplier effect;" this last needs some elaboration. Generally, the location of new (especially large) industrial activity in small localities or the rural hinterland is often accompanied by sudden, rapid, and sometimes traumatic changes in the natural environment and in the life of surrounding communities. In addition to vast changes resulting from massive capital influx, new values, attitudes, and patterns of behavior are introduced. Old social structures are altered and traditional and established patterns of community life and employment are disrupted. The establishment of a mature industry provides the impetus for the emergence of an industrial-commercial complex that includes, in addition to the energy plants, transportation companies, material and supplies, commercial businesses, and service enterprises. Thus, new industrial activities whether or not they primarily serve local markets, will have an initial multiplier effect. New local demands created by both the energy-industry and by the purchasing power of the labor force will call into being new occupational opportunities. An interrelated linkage of reactions and changes would occur, stemming from an increasingly complex network of economic activities, and the interaction of an expanding and more diversified population. In such a situation, environmental impacts are magnified, social disruption and undesirable effects in community life would increase(Figure 6).

The role of the mature industry, therefore, becomes a critical ingredient in the discussion of probable or plausible environmental consequences of oil shale development in Colorado. However, before proceeding any further a mature industry should be defined.

The Prototype Programs did not discuss the probable environmental impact of a mature oil shale industry. The Institute of Ecology Critique of the Prototype Program pointed to this omission but did not itself define a mature industry. However, the critique contains quotations from the courts decision in the case of "Scientists Institute for Public Information Inc., vs. Atomic Energy Commission et al. 5 ERC 1418 (DC Cir 1973)." The court used the following statements in speaking of a mature industry: (underlining added). "To wait until a technology attains the state of complete commercial feasibility ...,.... Technological advances are therefore capital investments, as such once brought to a state of commercial feasibility the investment in their development acts to compel their application. Once there has been an irretrievable commitment of resources in the technology development stage ... . To what extent are irretrievable commitments being made ...? How severe will be the environmental effects if the technology does prove commercially feasible." (Fletcher and Baldwin, 1973).

It appears that the court has provided a definition of a mature industry. It is an industry that has passed through the experimental or prototype stage and has made an irretrievable commitment of capital

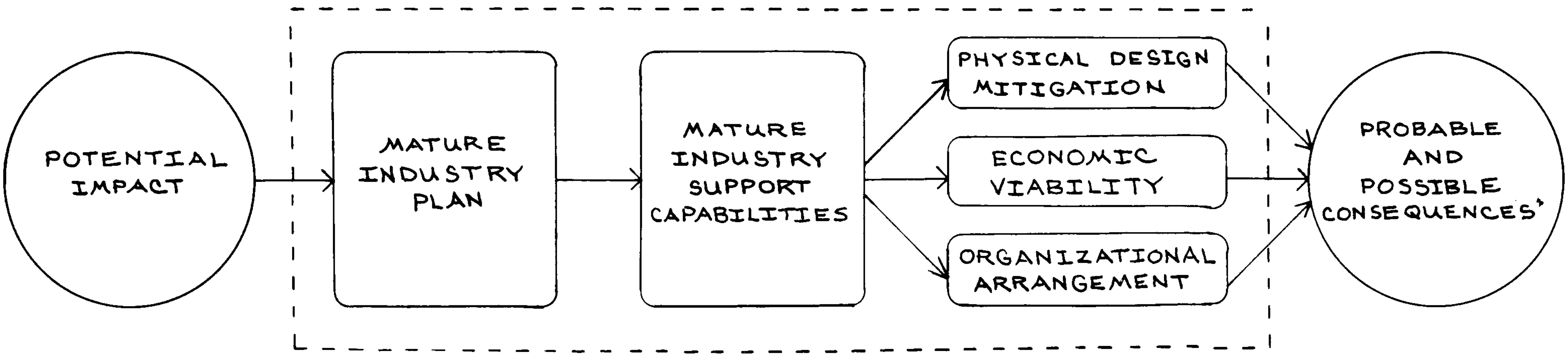


FIGURE 6. ALLEVIATION OR MITIGATION THROUGH "ALTERNATE PROGRAM"

and natural resources to a commercially feasible technology leading eventually to the possible sequence of economic and social events outlined above.

B. A MATURE OIL SHALE INDUSTRY -- AN ALTERNATE PROGRAM

1. The Present Alternatives

If the court's definition of a mature industry is accepted, a mature oil shale industry lies beyond the full development of the 6-point operation. It also lies beyond the accelerated growth program now under study by the U.S. Department of the Interior. Although this accelerated program envisions strip mining an area of 90 sq. miles it cannot meet the definition of a mature technology. A program of this scale at the present stage of technology is clearly premature in the sense of the above definition.

The Final Environmental Statement I - III, p. 607 generally agrees with this for it states "The combined output from private and public holdings would reach 650,000 barrels daily by 1985" and "Present estimates of the ultimate production from a mature industry is from 3 to 5 million barrels of shale oil per day."

In order to discuss further the role of mature industry in accentuating environmental impacts in the region, one should recall the range of options and probable effects outlined in the three "scenarios" of section IV. But one may also start from the assumption of no further growth to a program of rapid development in order to clearly understand the potential of a mature industry. More specifically:

Zero Economic Growth - The area is already past this point because the six plants are already under way. Such an alternative can be retained for comparison, however, and for examining pre-industry and post-development conditions.

Limited Economic Growth - The 6-plant alternative. It fails to meet mature standards because it is experimental and no commercially feasible method has been tested and accepted, so far.

Proposed Accelerated Growth - A U.S. Dept. Interior plan currently under study but not recommended as yet. This is a "premature" alternative because no commercially-feasible technique has been developed. At the same time, such development may lock-out more favorable energy options, including combinations of oil shale and coal.

All in all, the present plans discussed seem to vary widely between experimental conditions and accelerated development, with no clear and orderly way for a process of industrial maturation and appropriate economic infrastructure for maximizing opportunities for the region, while minimizing major disruptions through appropriate mitigating measures. It is beyond the scope of the present exposition to outline the specific sequence of such a development and its effects, but at least a number of remarks and questions that follow may help in establishing the general framework of a viable alternative of orderly growth and development.

2. Designing Viable Alternatives

Efforts to organize viable oil shale development where benefits are maximized and costs are minimized within a well-conceived mature industry context should consider such requirements as:

(a.) To assist in assuring a reliable energy supply in the event of a major crisis, the effort must be in the 3 to 5 million barrels per day range of production to assure a significant quantity of oil.

(b.) To assist in achieving the lowest cost to society for energy, the effort must be organized to provide unified economic, environmental, and social planning and control. It should be of a nature that can use and test the most promising mining and processing techniques, applying and testing each and using each where it fits best. Also, this effort should utilize the shale to well below the present 30-gal. per ton economic limit because the present hi-grading policy provides energy for this generation but may greatly increase the cost to the next generations that would have to mine all low-grade shale in the face of the barriers formed by the present hi-grading effort. This effort should have sufficient capital available to maintain it in the face of admitted immaturity because commercially feasible technologies have not yet been developed (at the same time in the face of inflationary tendencies and wide economic fluctuations the industry must have economic reserves and organizational capability to sustain short-term setbacks). A centralized research effort should accompany operations on a step-by-step basis; such research should deal with the improving and testing of all mining, manufacturing, and transporting processes and integrating of improvements back into the operation.

(c.) To avoid economic and regional inequities, the effort must be organized in a manner that will allow the people of the oil shale region and of the State of Colorado to have a significant influence upon the industrial and environmental decisions that affect their lives. The effort must be such that capital could and would be channelled back into the producing region, thus giving capital in exchange for the exported resources in addition to the wages, etc, which exist even under the most "colonial" types of operation. To maintain the economic stability of the region and prevent the "boom and bust" syndrome typical of exploitive operations, the effort not only must provide volume to satisfy the energy requirement but it must also provide diverstiy to allow for the continuity of viable communities if technological breakthrough or other cause removes the need for shale oil for energy. Yet, beyond local equity, the fact should be recognized that national demands may require some sacrifices on the part of local communities (one may think here of an "Energy Reclamation Act" similar to past efforts of the nation for regional development where national support has been given to regional benefit).

(d.) Proper safeguarding of the environment would require that the effort be organized on a scale similar in size and scope to that existing for achievement of products. The effort should be large enough to treat the Piceance Basin as a single environmental unit. (One that could treat management of the deer herd, and other animal populations, as a single problem rather than a separate problem for a number of enterprises). A single EIS study should be considered in which all environmental components and their interactions are considered on an equable basis. An environmental research effort closely integrated with research on mining and processing would be needed to evaluate the results that proposed changes in mining and processing practices would have on the environment. Economy of scale should be sufficient to provide for a centralized air-quality-control system that can meet and maintain Colorado and national control standards. Environmental protection also would provide for centralized water utilization plans. Land rehabilitation, including nurseries for native shrubs and replanting programs geared to the entire basin would be needed for restoration of the present or an equable cover.

(e.) The oil shale industry alone may have but little influence upon international problems. It might be good planning however, if the designed effort were provided with a reserve capacity that would allow accelerated production in time of national emergency, especially where resource independence may be a cornerstone for pursuing certain political objectives, or for avoiding blackmail that might be attempted to force political solutions. The plan should provide for this emergency expansion without undue stress on the industrial base of the country or upon local economic, social or environmental values.

Answers to questions of a coordinated oil shale (and even broader energy) development, while very much needed at this time cannot be answered by resource specialists or in a casual fashion in the context of an environmental inventory. The questions raised require a wider public forum and careful socio-political considerations transcending immediate costs and benefits. Yet, it is important to at least raise such questions because ultimately any evaluative scheme must bring together economic efficiency, organizational effectiveness, environmental protection, and social equity through a decision-making process that considers:

short-term	vs	long-term trade-offs
immediate gains	vs	long-range enhancement
primary	vs	secondary effects
tangible	vs	intangible benefits
desirable	vs	undesirable impacts
growth	vs	stability
integration	vs	diversity.

Following are only some of the problems that arise from pursuing any project or program where a two-fold planned-change effort is to be made:

1. How to balance in an equitable manner costs and benefits?
2. How to make appropriate transitions to new states without unacceptable disruption to all systems?

Thus, the questions that follow must once again be read in the context of the above points that tend to underline the key argument, namely that environmental impacts and resource considerations acquire meaning and importance through social valuation and political trade-offs. Among others, the following questions are relevant here:

1. Should a firm commitment of capital and resources be made to develop a mature oil shale industry?

2. How is an organization of "optimum" size achieved and continued?

3. Who should make the decisions as to overall energy development and appropriate organizational arrangements?

4. Because land is divided between federal and a number of private ownerships, how can control of lands be obtained for a centralized type of operation required?

5. How can access to various techniques and industrial processes be obtained and further technological breakthroughs be encouraged?

6. What are some of the necessary interlocking steps required in order to obtain the coordinated research effort described above?

7. By what means will the views of the state of Colorado and the people of the oil shale region be received and incorporated into decisions affecting their lives?

8. What corrective mechanisms and feedback channels should exist to monitor effective performance, achievement of goals, and alert planners, practitioners and publics as to bottlenecks and negative spillovers?

9. What are the policies required for restoration and rehabilitation of disturbed environments and what resource commitments are to be made in order to achieve equitable distribution of costs throughout the State, region and the Nation?

VI. RECOMMENDATIONS FOR FURTHER RESEARCH AND ACTION

A number of recommendations have been offered not only throughout the previous section of this document, but also throughout the various technical papers listed in Form of the Report (pp. vi, vii, viii). The comments in the following pages tend to highlight some major points and conclusions elicited from the specialized studies of the present effort and from more general impressions on the broad questions raised on oil shale development. A note of caution is necessary in a document that attempts to describe future environments and handle questions of strategic and technological uncertainty: conclusions must be relatively indefinite and recommendations tentative.

Although individual agencies have various regulating authorities, the State of Colorado lacks the institutional arrangement by which it can make an overall evaluation of projects such as oil shale or coal development or oil shale, coal and uranium development as a whole.

An Energy Policy Board is needed for the State of Colorado that has three primary functions and the authority to:

(1) Review all of the plans and proposals relating to the production and transmission of energy in Colorado.

(2) Assess the probable consequences of the proposed actions upon the people and the environment of Colorado.

(3) Recommend to appropriate State authority approval, disapproval, or additional study of points in question.

This Energy Policy Board should have two standing committees, one a policy committee and the other a technical committee.

The Policy Committee would handle affairs in the political realm, e.g. social impacts, land use, tax base, etc.

The Technical Committee would provide, or obtain by contract, competent technical reviews of proposed plans, monitor ongoing programs, and require or sponsor research needed for State decision making.

Some specific problems relating to oil shale and the environment are given as examples.

1. What will be the combined effect of the Union and Colony operations on air quality of Parachute Creek Canyon and the Colorado River Valley below; or as mentioned above, of the three operations (located in the Basin) upon White River Valley?

2. What will be the consequences of the three enterprises (in the Basin) upon the social structure of the Meeker-White River-Rangely area? How will both Union and Colony affect Grand Valley?

3. Should one company be allowed to go ahead without making provision for its social impacts and gain a competitive advantage over other companies that have spent time and funds in planning to alleviate social disruption?

4. One of the ways in which unnecessary studies can be avoided is for some agency of State Government to have the authority to say "This is adequate." For example, sufficient study has already been done to certify that Yellow Creek is so salty that the only aquatic fauna are blackfly larvae. Yet, companies are being required to restudy the Yellow Creek aquatic ecosystem. Also, Piceance Creek and White River have been given sufficient study for sound statistically-significant conclusions to be made concerning some aspects of their condition. Here again, studies are being required starting from point zero. There is now no place where this information is accumulated and evaluated, and no one who can authorize study to cease on Yellow Creek, or to say "So much is known for Piceance Creek, additional studies may be built upon this existing information."

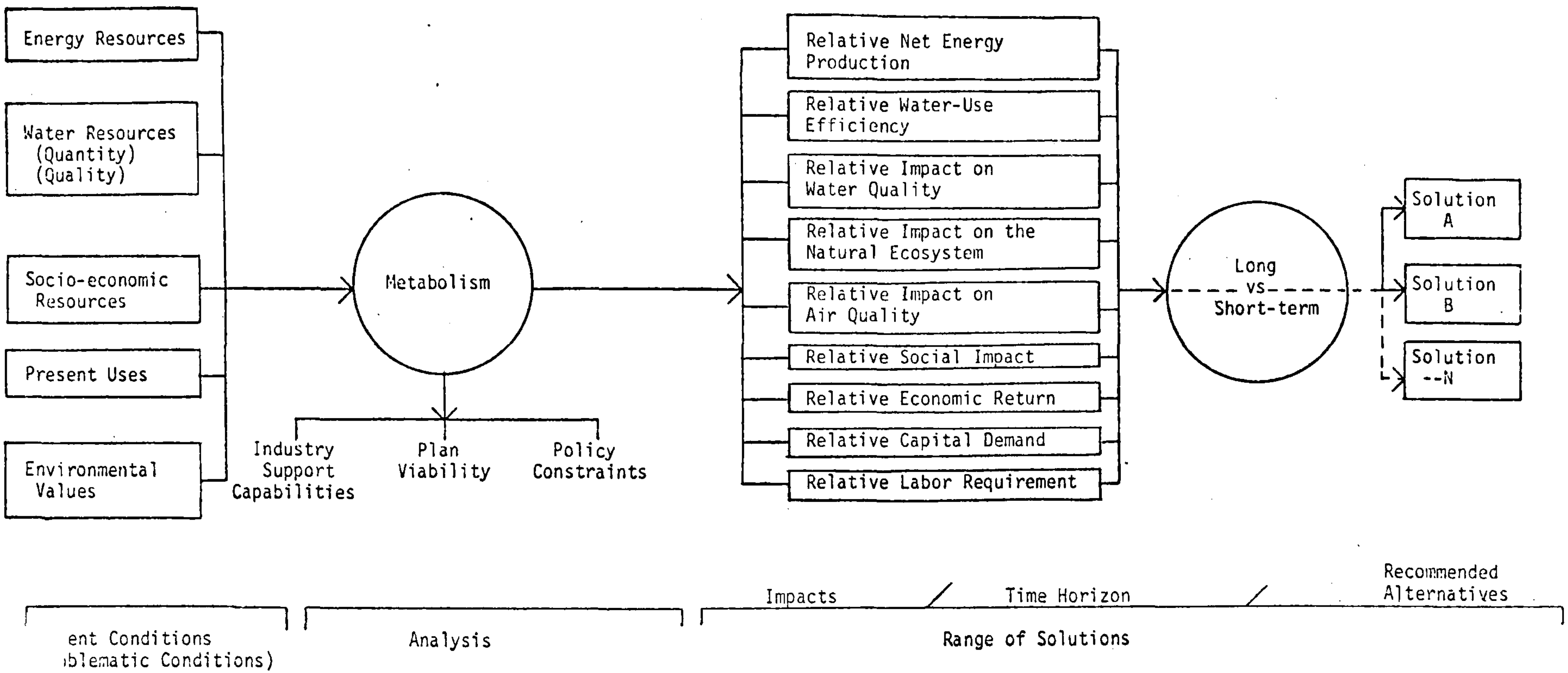
5. No one has carefully evaluated the energy option for oil shale plus coal plus uranium development. Presently coal development is more advanced than oil shale and may remain so for the foreseeable future.

Before a comprehensive plan for development of energy in Colorado can be developed a study is needed that will evaluate the effects of alternate decisions. Such a study is diagrammed in Figure 7.

6. There needs to be research into the effects of regional development on air quality. For example, what will the regional production of oil from shale plus power from coal do to the air in Denver? Prevailing winds are toward Denver. Prevailing practice is to place plants on high ridges with high stacks to "disperse emissions" (boost them toward Denver). What will be the combined effects of the emissions on Front Range communities given the intervening topography and prevailing air currents and imposing these emissions, if they exist, upon the present locally produced-smog belts?

7. As a basis for the studies outlined above, and as a means of focusing the present information on the most pressing problems, an environmental problem analysis is needed to look carefully at the energy and environmental problems of Colorado; this will test their validity and place them in perspective. This should be financed by the federal government because of the national energy implications.

Figure 7. **Analysis of Energy Development Alternatives in the Rocky Mountain Region**



One means might be by E.P.A. through the State's Department of Natural Resources.

Once the problems are placed in perspective, a series of carefully designed studies should be authorized. These could be contracted, hopefully to existing institutions of the Rocky Mountain Region, who could be expected to have more than an immediate commercial interest in the subject.

8. Ecological studies setting the environmental baseline are now made by each enterprise. Companies may hire the best qualified scientists to do the studies but frequently they do the coordinating and interpreting of the studies. The studies are often fragmented with, for example, one consultant being hired to study soils and another vegetation, and the one is not even told who the other is, to say nothing of attaining the coordination needed. Interpretation would tend to bend the results of such study to company policy and may be held suspect on that point.

Baseline studies should be done by a contractor working for the State, establishing an equable base for all enterprises. Individual enterprises should be responsible for their own impact studies because some impacts would relate to proprietary processes etc. These should be reviewed by the State in relation to the state-established baseline. These reviews should be held confidential, but would be the basis for State approval. However, no variance from State law or regulation should be granted in secret.

9. Often, environmental studies can be too expensive and too time consuming. This costs companies too much for environmental studies, especially on costs resulting from operational delay and erosion of potential gains from inflation and increased material costs. Present practice is for each enterprise to evaluate the base environmental conditions on its holdings and the impact of its operation upon them independent of the influence of other enterprises. The companies cannot be expected to do otherwise but this leaves a serious gap in the study of the accumulative effects of two or more enterprises. For example, both lessees in the Prototype Program must estimate the effects of their respective programs upon the White River, yet no one is studying the effects of both lessees plus the Superior Oil Company upon the River. There is a serious need for a series of carefully designed studies in the common and accumulative effects of the various aspects of energy development in Colorado.

Environmental disruption is a price that must be paid for industrial development; the price is not only loss of the present salubrious environment, but certain lifestyles and options traditionally identified with the West will change. The most careful planning and disciplined efforts are needed to keep these costs within due bounds.

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