22--POPULATION GROWTH CONSTRAINED SYNTHETIC LIQUID FUEL IMPLEMENTATION SCENARIOS

By Barry L. Walton

One approach to limiting the impacts of synthetic fuels production in a region is to constrain the population growth rate of the community. This chapter describes the preparation of scenarios on this theme and presents several alternative scenarios.

Each synthetic fuels plant of building block size has a defined labor force associated with its construction and operation phases. The primary jobholders during these phases induce additional population in the area through secondary support employment and families. The effect of this induced population can be treated analytically by applying an appropriate population multiplier to the labor force of the primary industry. This process can be used to construct a population profile for each type of synthetic fuels building block plant. On the basis of these profiles, detailed scenarios projecting the population increases under given conditions of industrial development can be plotted for a given region. The method can be used to construct scenarios that are applicable to nearly any technology and relevant region.

To illustrate the procedure, the following pages contain a description of the steps involved in constructing a fuel production schedule for a region that is limited by a planned population growth rate. Sample scenarios are given that depict the effect of introducing, on a planned schedule, coal mining and coal liquefaction or methanol production in Campbell County, Wyoming, and oil shale development operations in

Garfield and Rio Blanco counties, Colorado. A multiplier of 6.5 was chosen for reasons explained in Chapters 12 and 23.

It is important to note that the profile for a 100,000 B/D (16,000 m^3/D) coal liquefaction plant is essentially identical to a 250 million cubic foot per day (23 million m^3/D) coal gasification plant. Thus, the method immediately possesses useful generality.

<u>Step One</u>: A population profile for each type of facility is prepared. Figure 22-1 shows the resulting population profiles for coal mines, coal syncrude, methanol, and oil shale building blocks. Sources of the data for the building block facilities are Chapters 4 and 6. The profiles in Figure 22-1 already include the effect of the population multiplier of 6.5 (assuming a constant population during each yearly interval). Aggregation of the work force and the associated population into the profile facilitates construction of the scenarios and yields reasonably realistic population profiles.

<u>Step Two</u>: The current population for the county or region is established from census data or by using population estimates from local government officials. For this study, the estimated 1975 populations for Campbell county, Wyoming (17,000), and for Garfield and Rio Blanco counties combined (23,500) were obtained from local planning officials.

<u>Step Three</u>: Annual growth rates of 2 percent, 5 percent and 10 percent compounded continuously were applied to the current population to determine a set of theoretical population growth trajectories for the appropriate region. Figures 22-2 through 22-10 show growth curves of 2 percent, 5 percent, and 10 percent annual growth for the two selected areas.

Step Four: Paper cut-outs of the building blocks from Figure 22-1 laid on the population graph made during Step Three enable rapid construction of the final aggregate population projection. Rearranging the cut-outs on the population growth graph allows any growth rate to be easily approximated. (Use of separate cut-outs of the construction and operating phases greatly aids in experimentation and in the drawing of the final profile.) Figures 22-2 through 22-7 show a number of alternatives for Campbell county, Wyoming, derived by this method; Figures 22-8 through 22-10 show a number of alternatives for Garfield and Rio Blanco counties in Colorado. Once the start-up date for each plant is determined for each scenario, the net fuel production schedule is fixed and can be calculated. The insets to each figure show the fuel production schedule and water consumption needs for each scenario that were obtained by using the fuel output and water requirement scaling factors from tables in Chapter 6.

The implications of these population growth constrained scenarios are reported in Chapter 23.

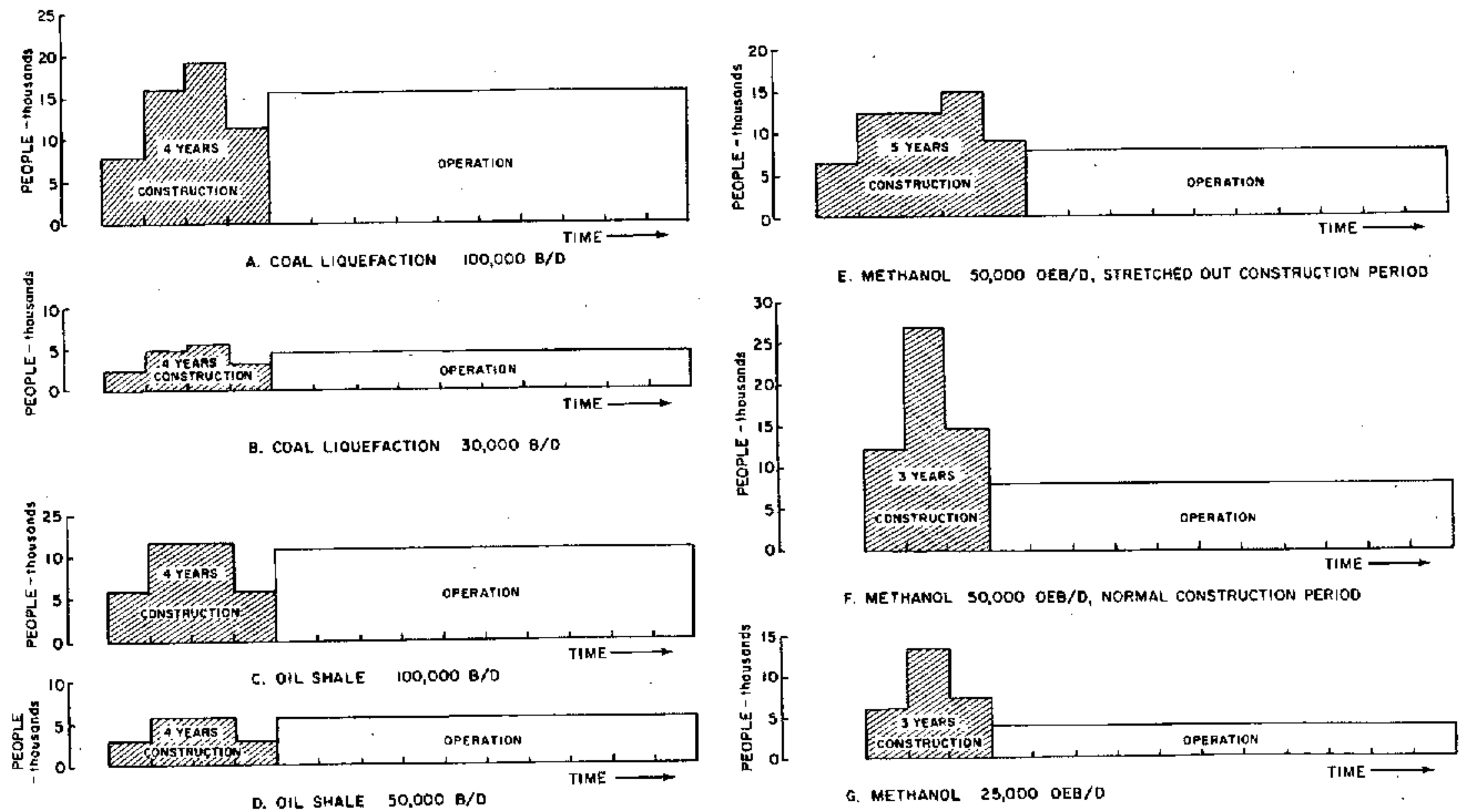

FIGURE 22-1. TOTAL POPULATION ASSOCIATED WITH INDIVIDUAL PLANT CONSTRUCTION AND OPERATION BUILDING BLOCKS. All building blocks include the mines that supply the plants. The actual labor force is multiplied by 6.5 to account for induced secondary employment and families. The data for these building blocks come from the scaling factors derived for the Maximum Credible Implementation Scenario.

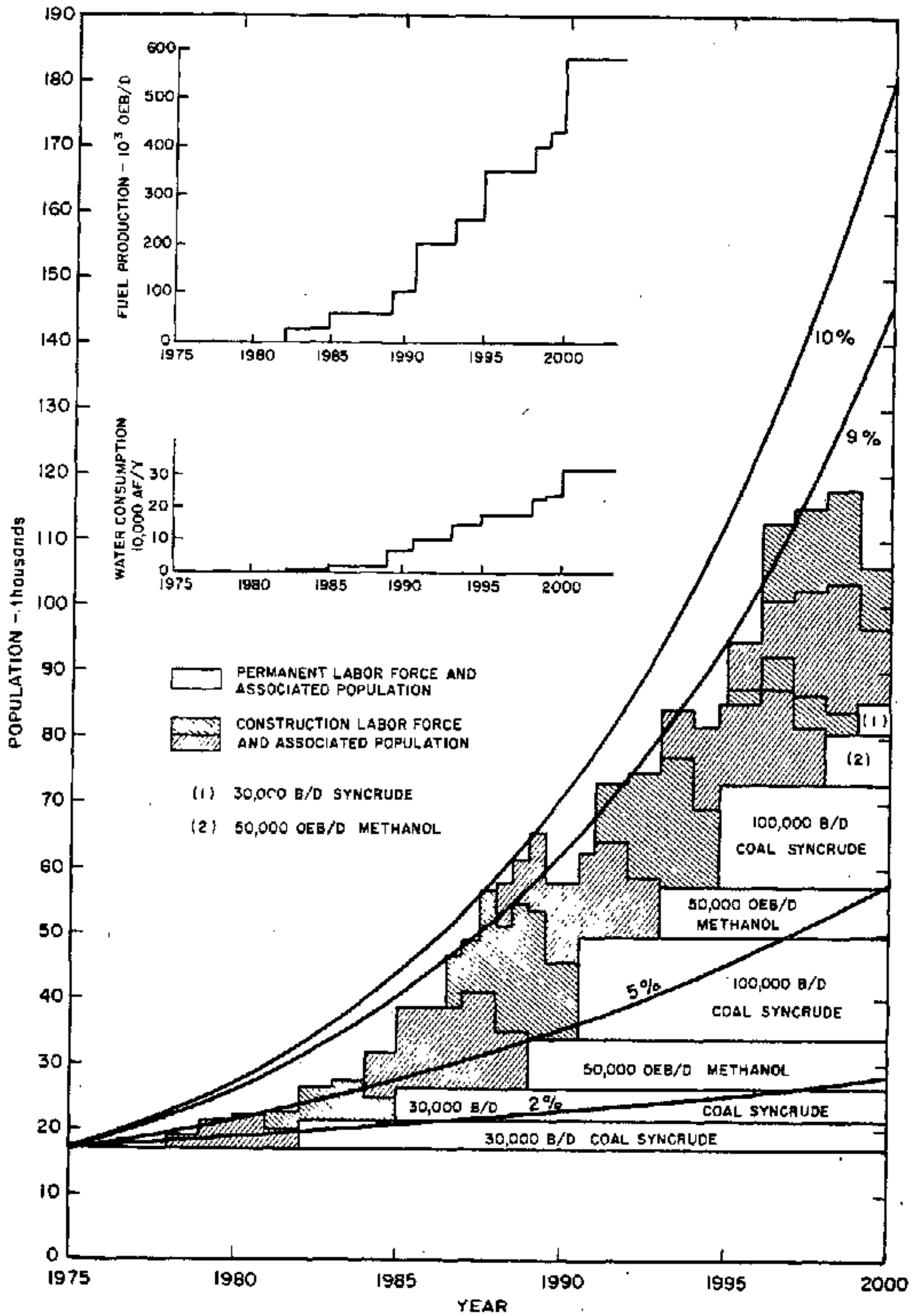

FIGURE 22-2. EFFECTS OF THE MAXIMUM CREDIBLE IMPLEMENTATION SCENARIO UPON POPULATION IN CAMPBELL COUNTY, WYOMING. Assumes that one quarter of all the Scenario's development in Wyoming occurs in Campbell County. This assumption is expected to be on the low side.

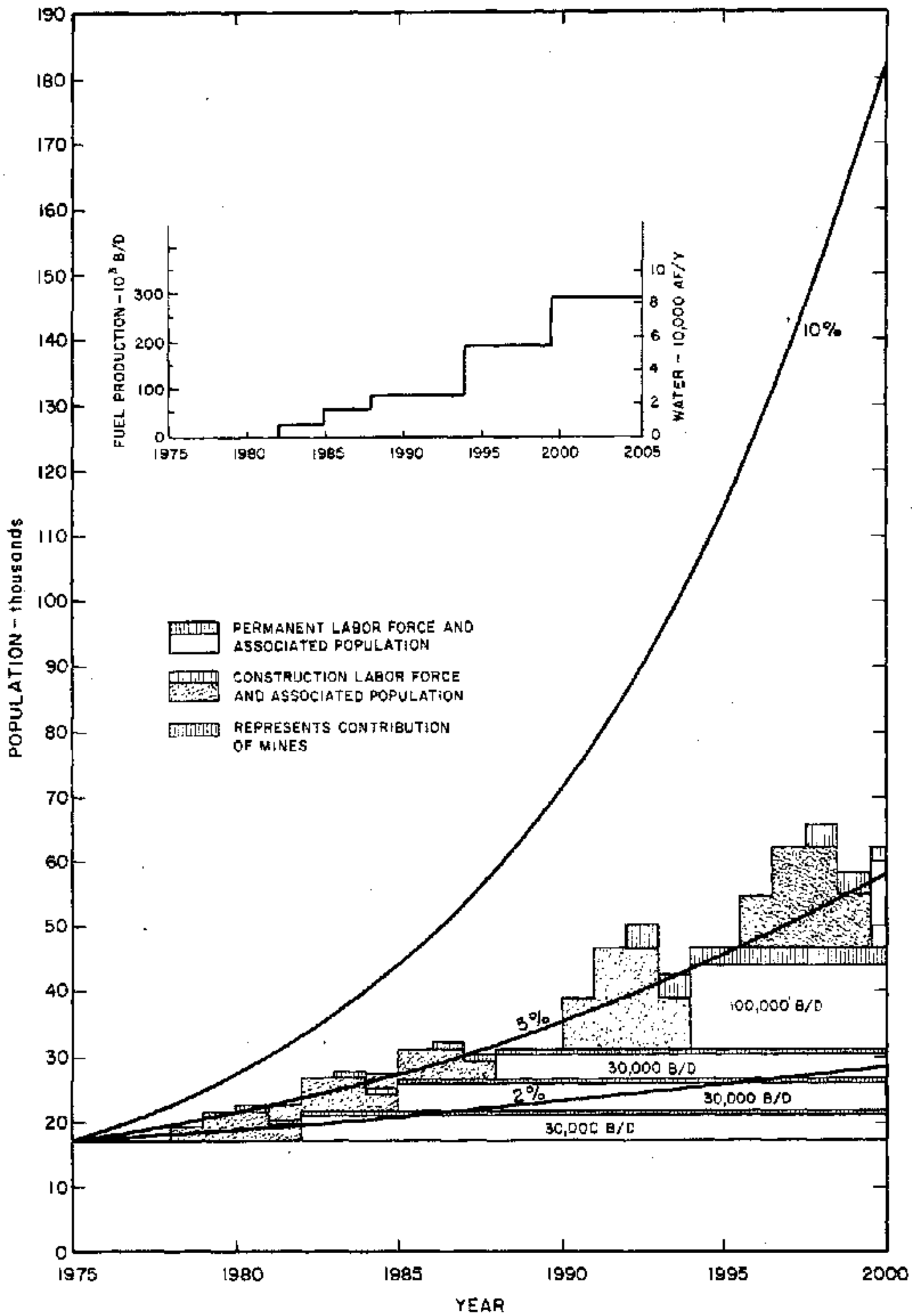

FIGURE 22-3. FIVE PERCENT CONSTRAINED POPULATION GROWTH RATE SCENARIO FOR CAMPBELL COUNTY, WYOMING ILLUSTRATED WITH COAL LIQUEFACTION PLANTS AND ASSOCIATED MINES. The larger sized plants cause rapid changes in population.

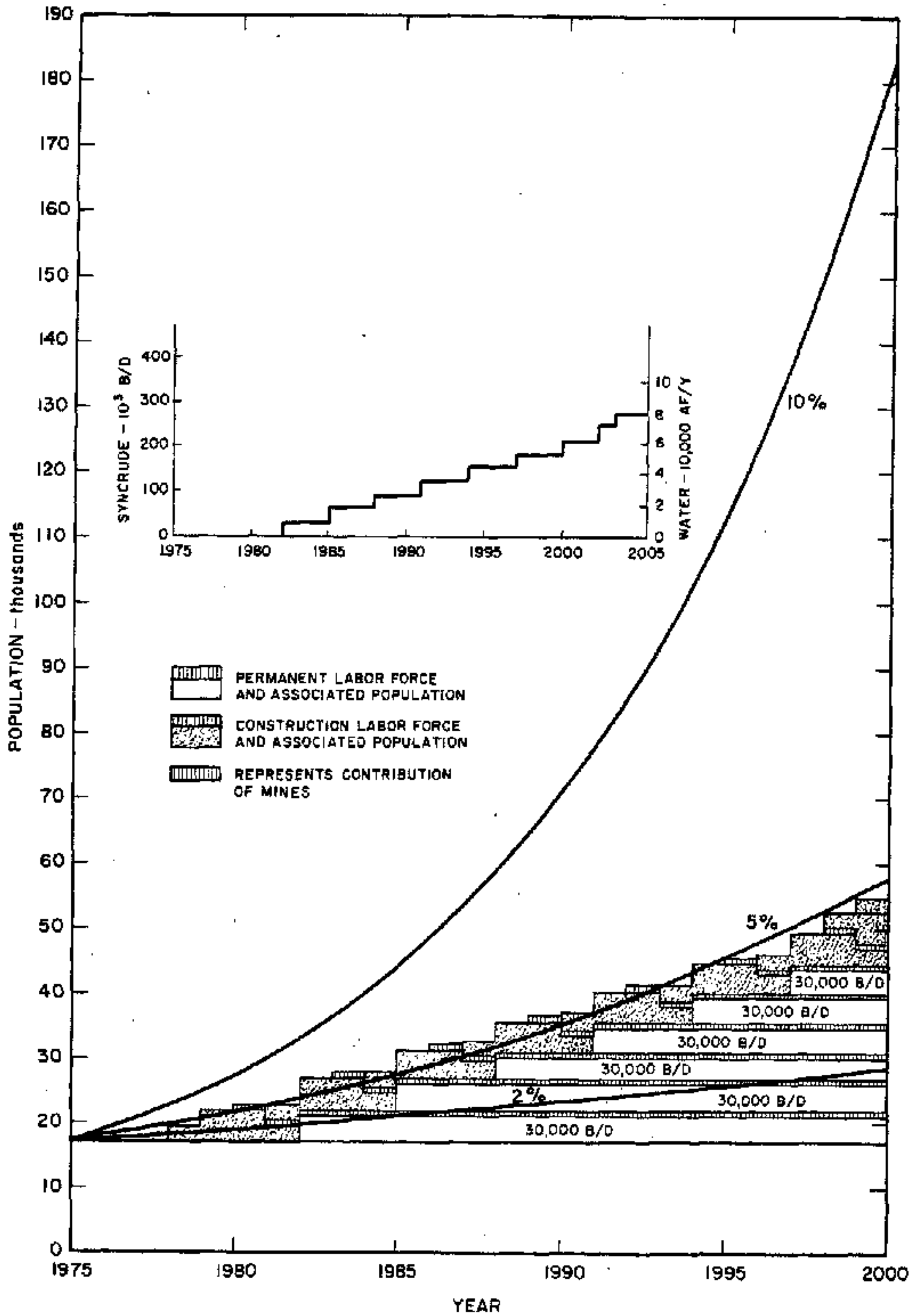

FIGURE 22-4. MODIFIED FIVE PERCENT CONSTRAINED POPULATION GROWTH SCENARIO FOR CAMPBELL COUNTY, WYOMING ILLUSTRATED WITH COAL LIQUEFACTION PLANTS AND ASSOCIATED MINES. By building only the smaller sized coal liquefaction plants, large fluctuations in population can be avoided

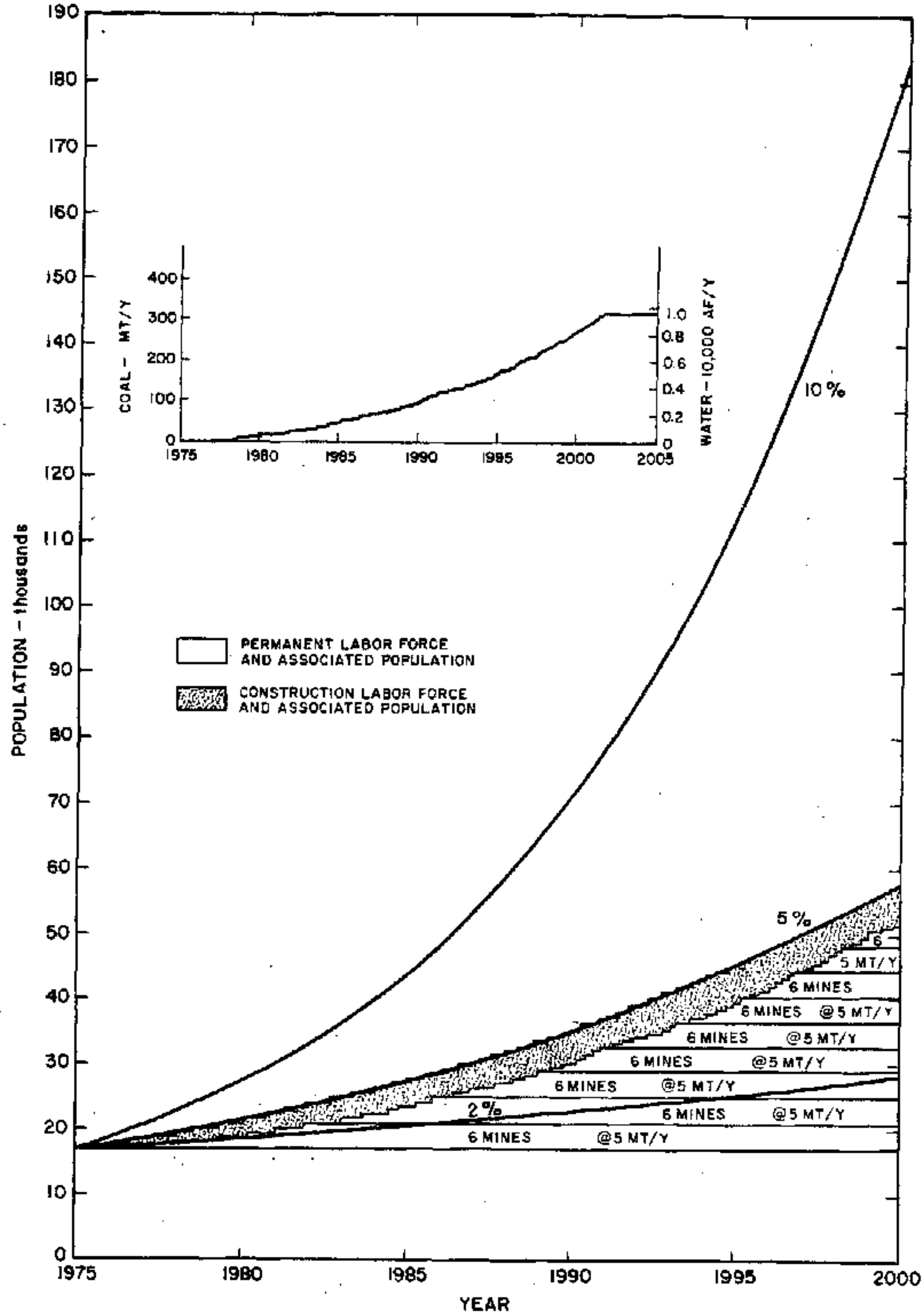

FIGURE 22-5. FIVE PERCENT CONSTRAINED POPULATION GROWTH SCENARIO FOR CAMPBELL COUNTY, WYOMING IN WHICH ONLY COAL MINES ARE DEVELOPED. Under these conditions growth in population can be made very smooth. By 2000, 54 mines, each producing 5 million tons/year, would be exporting 270 million tons of coal per year.

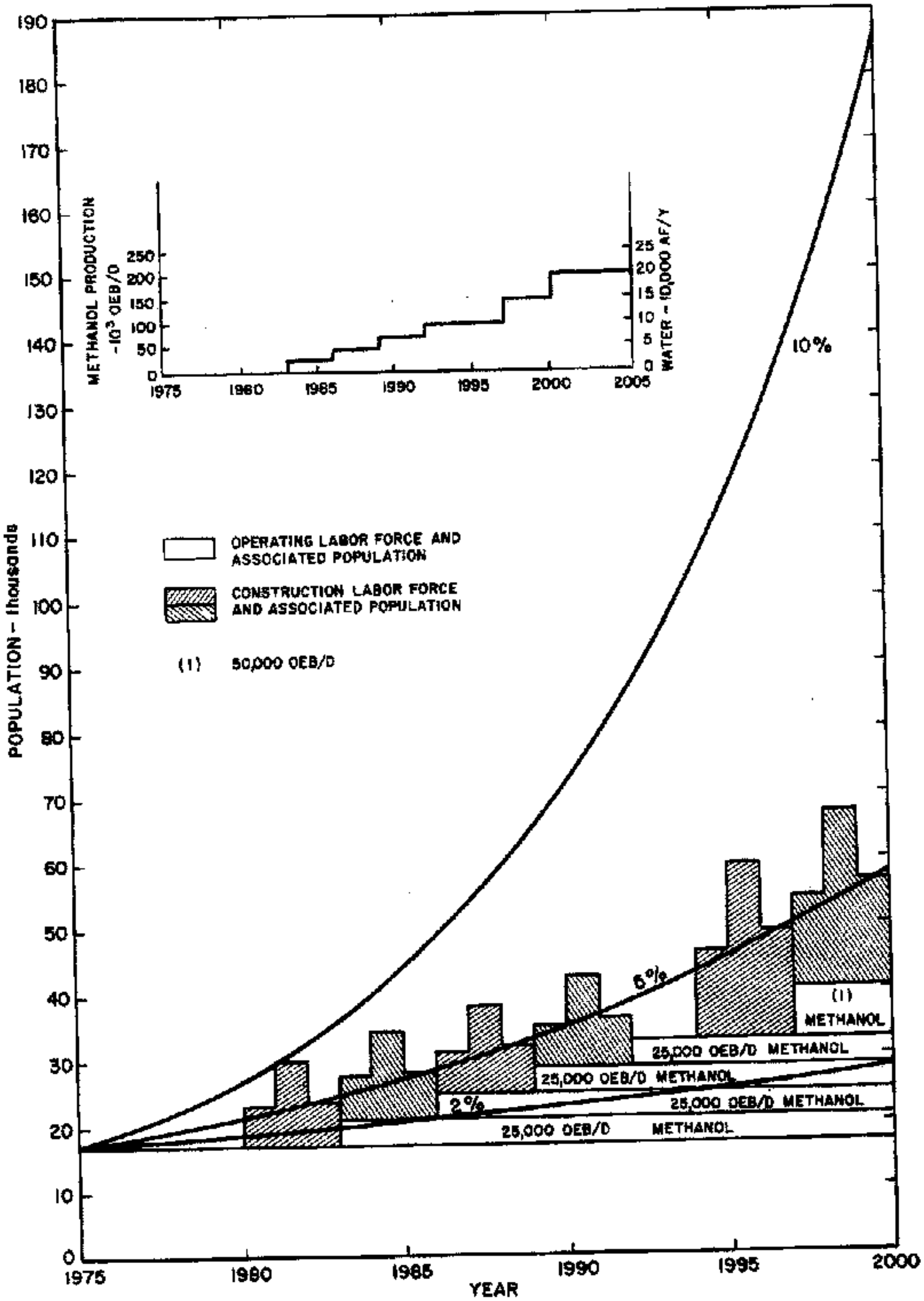

FIGURE 22-6. FIVE PERCENT CONSTRAINED POPULATION GROWTH SCENARIO FOR CAMPBELL COUNTY, WYOMING ILLUSTRATED WITH COAL TO METHANOL CONVERSION PLANTS. Severe fluctuations in population are apparent.

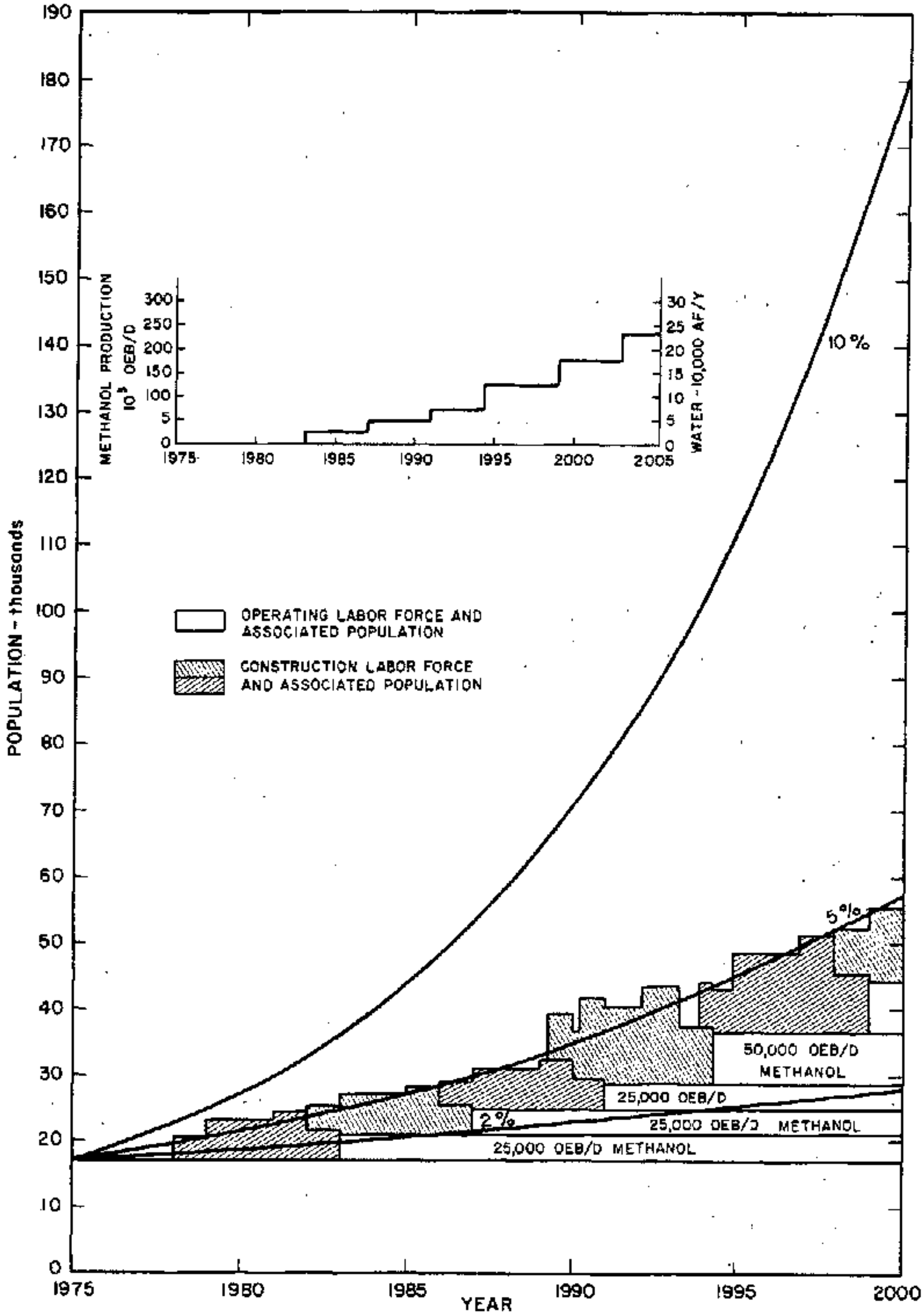

FIGURE 22-7. FIVE PERCENT CONSTRAINED POPULATION GROWTH SCENARIO FOR CAMPBELL COUNTY, WYOMING ILLUSTRATED WITH COAL TO METHANOL CONVERSION PLANTS WITH EXTENDED (5 YEAR) CONSTRUCTION PERIODS. By extending the construction time, the fluctuations in growth can be avoided.

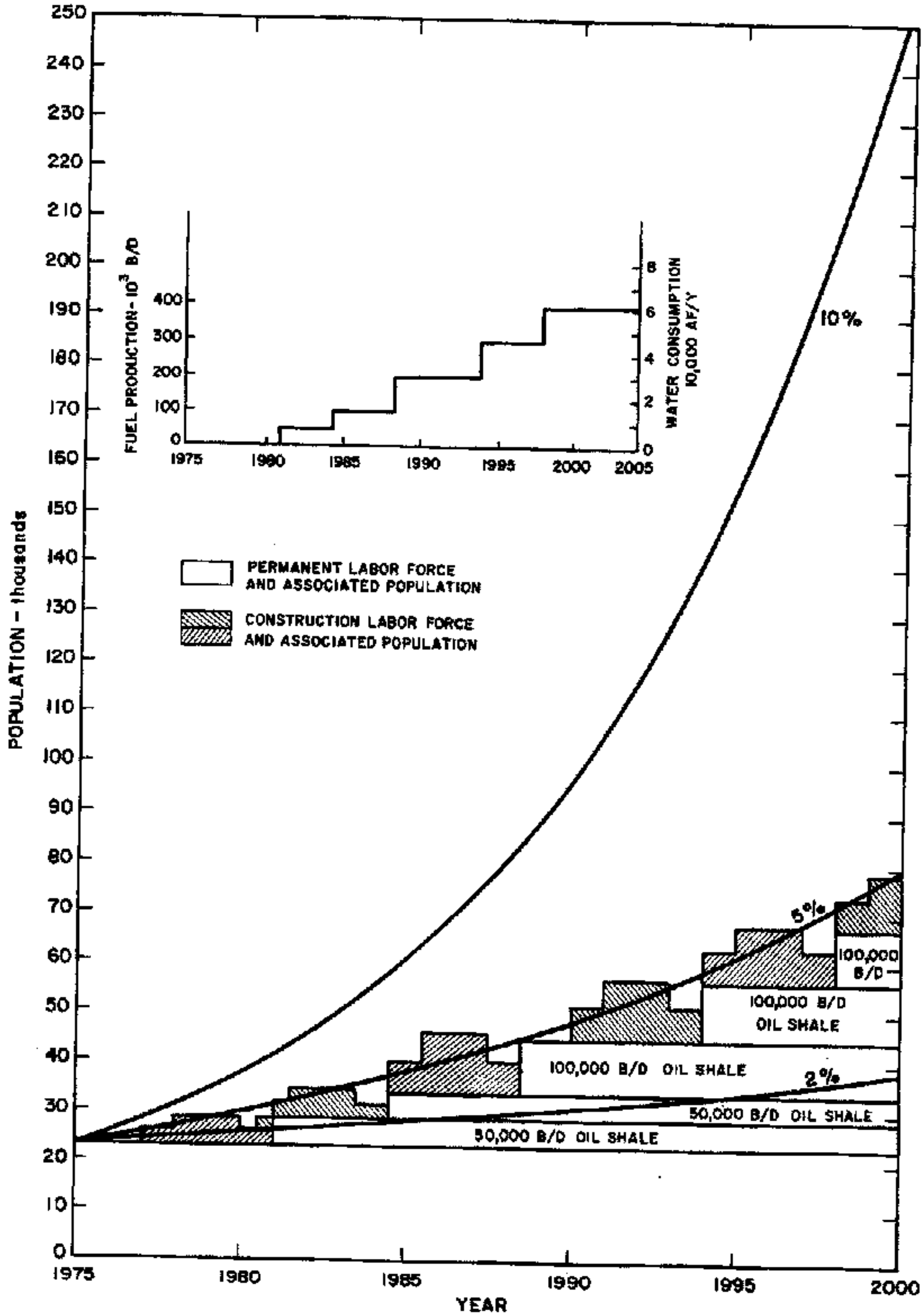

FIGURE 22-8. FIVE PERCENT CONSTRAINED POPULATION GROWTH SCENARIO FOR OIL SHALE DEVELOPMENT IN GARFIELD AND RIO BLANCO COUNTIES, COLORADO

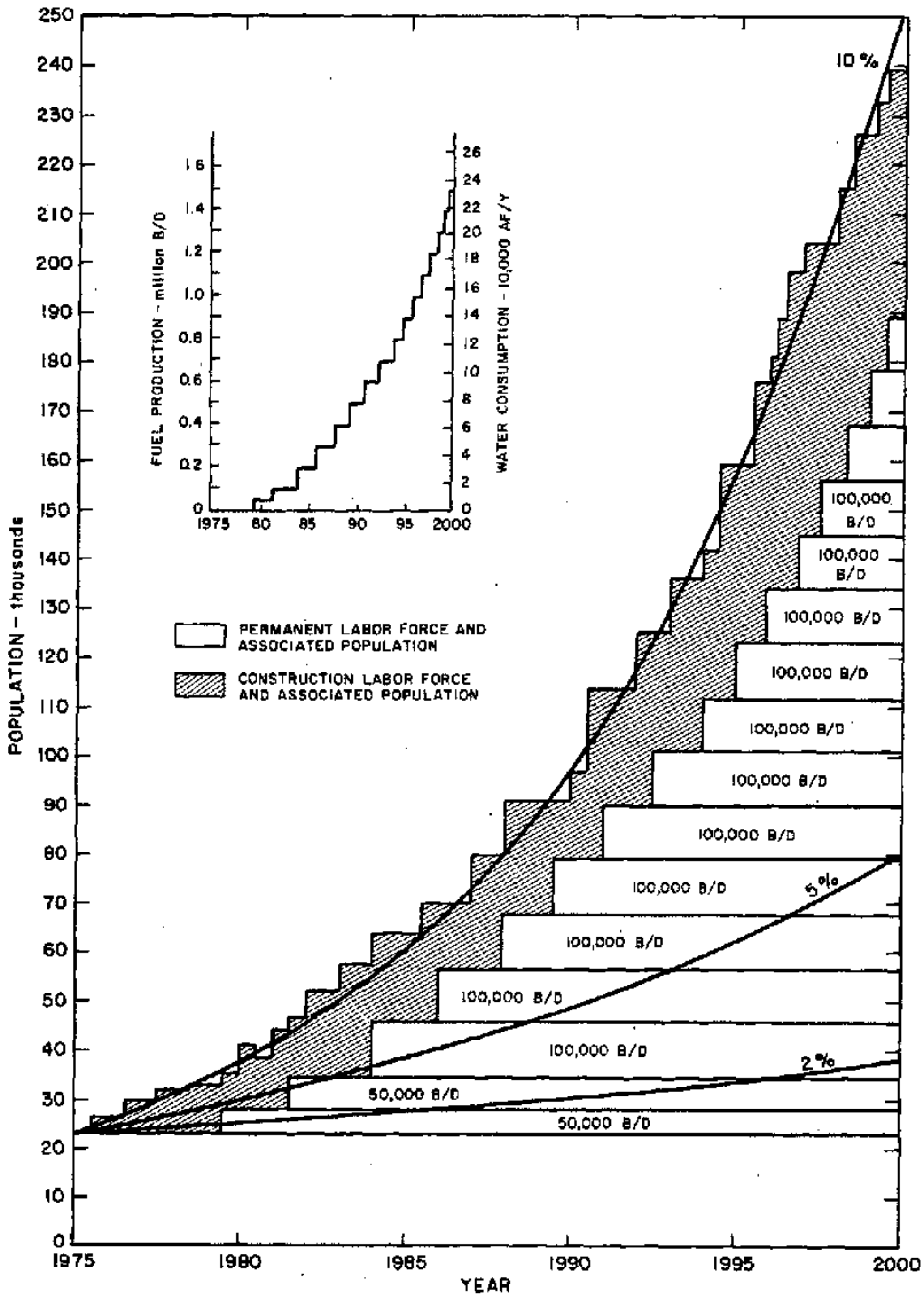

FIGURE 22-9. TEN PERCENT CONSTRAINED POPULATION GROWTH SCENARIO FOR OIL SHALE DEVELOPMENT IN GARFIELD AND RIO BLANCO COUNTIES, COLORADO

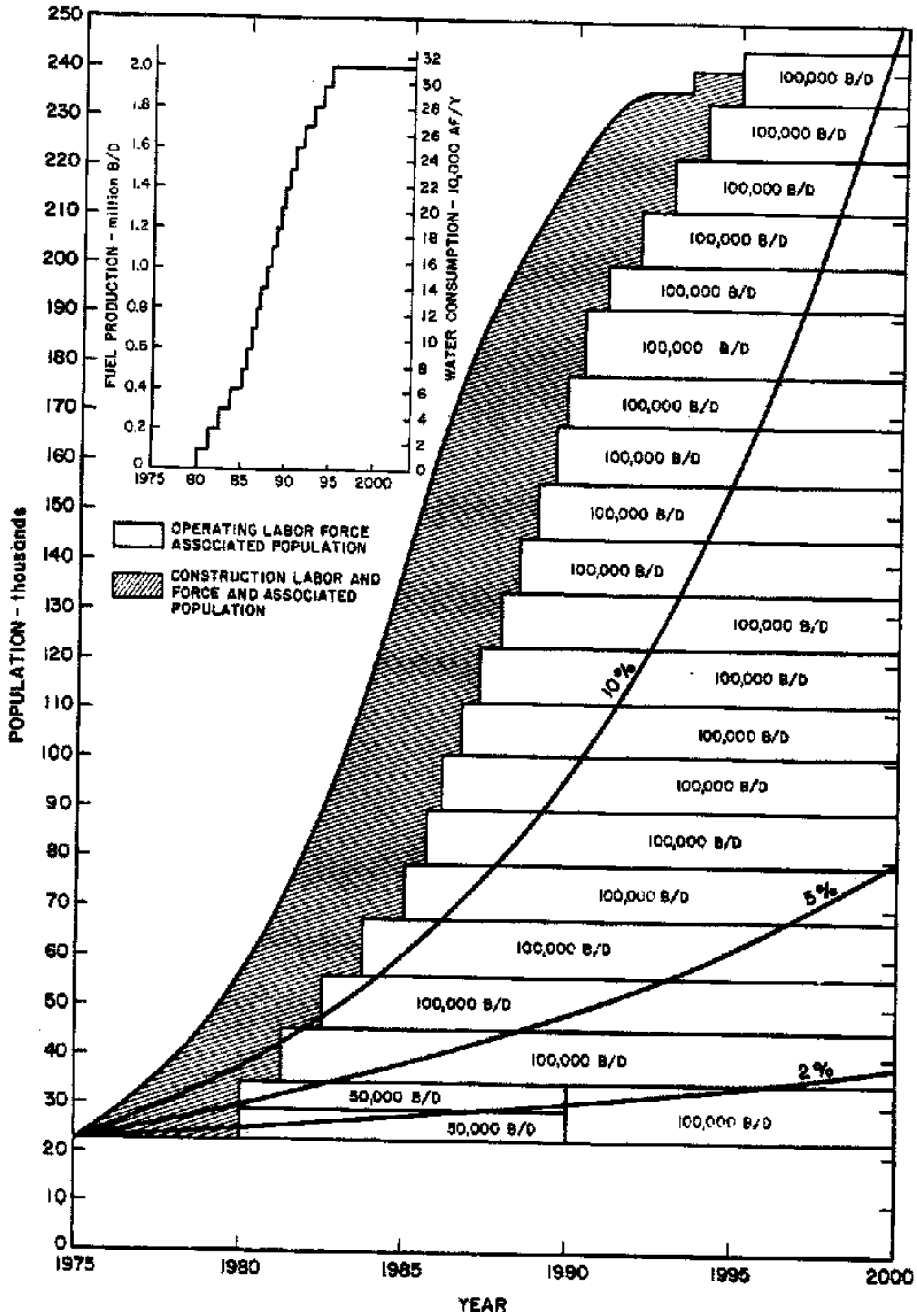

FIGURE 22-10. MAXIMUM CREDIBLE IMPLEMENTATION SCENARIO FOR OIL SHALE DEVELOPMENT IN GARFIELD AND RIO BLANCO COUNTIES, COLORADO. The resulting annual population growth rate is about 17 percent.

23--COMPARATIVE IMPACTS OF CONTROLLED AND UNCONTROLLED URBANIZATION

By Peter D. Miller

A. Introduction

Growth and prosperity have traditionally been linked. As human groups move beyond bare subsistence and begin to produce more than they consume the surplus creates a form of wealth. Specialization of labor, industrial organization, and technological efficiency increase productivity and thus support larger populations. The capacity to generate new wealth, built into the process of growth, soon becomes dependent on growth. New products and new ways of generating demand are harnessed to the engine of growth. Jobs, firms, and entire industries become bound up with more and more growth. Annual increases in gross national products and national incomes are registered in the confident belief that they mean a better standard of living for all. Yet many observers now doubt whether the traditional alliance of growth and prosperity is still viable.

Critics of growth have made three kinds of arguments that merit the attention of anyone contemplating the prospect of more growth. The first is that "spaceship earth" has certain natural limits--of resources, of carrying capacity, of the necessities of life--that are rapidly being approached at present rates of depletion. While the capacity to generate wealth has indeed been increased by growth, so the second argument goes, control of the means of production has concentrated this wealth in a few hands, leaving many in poverty. The third argument is that social costs, negative externalities, spillover effects, and other unanticipated consequences of growth have polluted air, water, and land to such an extent as to make life unlivable.[1] None of these ideas is particularly new. Malthus, the first prophet of overpopulation, was preoccupied with natural limits. Inequitable distributions of wealth resulting from control of the means of production were, of course, a major concern of Marx and his followers. Externalities were first identified by the economist Alfred Marshall. If these ideas have acquired more cogency in recent years, it is because the effects they point to are visible on a local as well as the global level.

The following analysis focuses on the comparative impacts of two levels of growth on two specific areas, the Powder River Basin of Wyoming and the Piceance Basin of Colorado. The dynamics of growth are described in such a way, however, that they can be generalized to other areas. With appropriate modifications for technological variables, the analysis is applicable to large-scale energy production, mining, and industrial development in general.

B. Impact of the Maximum Credible Level of Synthetic Fuel Production

The "maximum credible" (described in Chapter 6) case describes the situation in which real-world constraints other than technical and physical limits are absent. It is the level of synthetic fuels production that would be achieved if labor could be attracted in sufficient numbers, if there are no obvious bottlenecks in the supply of steel, pipe, and other materials, if there were no obvious shortage of capital, if deliveries of "walking draglines," to scoop up strippable coal were assured as soon as they were needed, if residents of the coal mining regions and their elected representatives had no objections to the industrialization plan, if there were no lawsuits by environmenalists, ranchers, Indians, or anyone else who could be adversely affected in fact by the Federal Coal Leasing Program, and if world energy prices remained stable for the foreseeable future. The maximum credible case is thus by no means to be construed as a prediction, but rather as a theoretical upper limit to the level of production. Other factors, as we shall see below, begin to constrain development of synthetic fuels long before the theoretical upper limit is reached.

1. Population

Figure 22-2 in the previous chapter shows the population that would be generated in Campbell County, Wyoming, from coal liquefaction plants, methanol plants, and coal mines just sufficient to fuel them (captive mines only), according to the maximum credible level of production. In Figure 22-1, it is assumed that Campbell County would produce one fourth of the synthetic crude oil produced in Wyoming, probably a low figure. The present population of 17,000 would double by 1985, triple by 1988, and increase by a factor of 7 before the end of the century. Population density in the county, now 3.5 people per square mile (0.74 people per km^2), would be 20 to 25 (7.7 to 9.7 people per km^2). Compared to that, the current annual rate of 5.5 percent in the county and Gillette's 7 percent seems leisurely. Since the county is experiencing great difficulty in keeping up with the growth that has already occurred, it would undoubtedly experience even greater difficulty in the maximum credible case. It is evident that the major increments of growth come from the construction of coal liquefaction and methanol plants. The operating labor force and associated population for a 100,000-B/D (16,000 m^3/D) coal liquefaction plant are also substantial.

Figure 22-2 shows steep peaks and valleys for coal-related employment. This in part results because data are presented on a year-by-year basis, while in fact employment would be added and would taper off more gradually. However, even if the data were presented on a daily basis, peaks and valleys would still exist, only with rounded corners. In short, there would be severe discontinuities in the local economy and the fortunes of the county would swing up and down in response to the fortunes of the coal mining industry. With extremely large units of production, it is almost impossible to avoid such instability.

2. Housing

According to the 1970 census, Campbell County ranked second highest in Wyoming in the proportion of its housing containing one or more persons per room--14 percent. This proportion has probably gone up in the intervening five years. Nevertheless, if the same ratio of dwelling units to population (3.4) were maintained for future years, the maximum credible case would require the construction of 5000 additional housing units by 1985, 10,000 by 1988, and 30,000 by the end of the century. Failure to meet these requirements would result in additional real estate speculation and extremely high rents, probably on a scale that would drive out those who did not own property and whose wages did not compensate for these increases. Campbell County's 1970 median rent of $140 a month was already the highest in the state. Rents have gone up by a factor of 2 or 3 with a 5-mile (8 km) radius of Gillette during the last 5 years, according to the Campbell County Planning Department. The actual limits of local growth would probably be reached well before synthetic fuels production attained a small fraction of its maximum technically-credible level.

3. Age Distribution and Schools

If present trends continued, the age distribution of the incoming population would be younger than average. In 1970, Campbell County had the highest proportion of under-18 population in Wyoming, 42 percent. Its school-age population (5 to 18 years of age) was about 30 percent of the total in 1970, and has risen since then to about one-third the total population. If that proportion remained no more than one-third, the number of school children in 1988 would be equivalent to the county's present total population, in the maximum credible case. The school population alone would be a medium-sized town of 40,000 by the end of the century. Classroom expenditures and school personnel salary expenditures would be quite large.

4. Public Expenditures

Total county governmental expenditures, using the correlation developed by the Bureau of Reclamation,[2] would be over $10 million a year in 1985, $16 million a year by 1988, and $38 million a year (constant 1970 dollars) by the end of the century. Per capita expenditures, currently $260, would rise to about $290 in 1985, $310 in 1988, and $320 by the end of the century (constant 1970 dollars). If 1970 proportions were maintained, about half would go to schools, an eighth for highways, one-twelfth for public welfare and public health, and the rest for other expenses. These expenditures would be a bare minimum, inasmuch as the raw data from which the correlation between population and expenditures was developed came from counties that had delayed necessary expenditures as long as possible. Unless tax structures were overhauled, the bulk of these public expenditures would be financed by old and new individual residents and/or by future generations through long-term debt obligations. The maximum credible case of synthetic fuels production, then, would impose substantial, perhaps insurmountable burdens on local government.

C. Development Constrained by a 5 Percent Annual Growth Rate

Relationships between the global trends mentioned above and local impacts have been brought home to the American people in recent years. Natural limits are readily understandable to anyone who has waited in a gasoline line, paid high prices for groceries, or had a well run dry. When local taxes go up as the natural resources of a region are extracted, inequitable income distribution becomes a topic of concern. Moreover, the crowding, tension, and other conditions of boomtown growth provide ample evidence of the unfortunate by-products of rapid urbanization. These considerations suggest that the largest possible scale of development may not always be equivalent to the best scale of development for all concerned.

To meet these concerns, we have treated local rates of population growth as a factor that might constrain industrial development. Just as there are limits to what can be done with available materials and technology, there are limits to how fast a region can grow without impairing a decent quality of life. In many cases, these limits are imposed by the courts or the political process, and so they vary according to the tolerance of affected interest-groups. In other cases, these limits are breached at a cost that often appears in hindsight to have been too great to pay. At that point, costly remedial measures may have to be taken. Although planners disagree on what an optimum growth rate might be in theory, they sense that it is not large.* A planner in one rural western county said he considered growth rates between 1 and 2 percent a year to be ideal. Some planners have referred to a 5 percent annual growth rate as "hyper-urbanization." There is no magic number that can guide all development planners in all circumstances; however, an approximate indication can be drawn from the experience of cities, towns, and counties that viewed their growth rates as excessive.

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*The annual growth rate, r, is derived from the formula $P_2 = P_1(1 + r)^n$ where P_1 is the population at the beginning of the time period, P_2 is the population at tne end of the time period, and n is the number of years in the time period.

Santa Clara County, California (San Jose), which is generally conceded to be an example of the unfortunate consequences of uncontrolled development, grew at an annual rate of 5 percent between 1960 and 1970. Santa Barbara and Riverside Counties, two other fast-growth areas of California, added population at the rate of more than 4 percent a year. Boulder, Colorado, another example of what many consider "runaway growth," increased its population every year at a rate approaching 6 percent. In Phoenix, Arizona, and Albuquerque, New Mexico, two cities of the Southwest where local growth has become a major public concern, the rates were under 3 percent. Thus it seems reasonable to select 5 percent additional growth per year as an upper limit of the rate communities can tolerate. Few would consider such a figure ideal, as many adverse impacts appear well below that rate, but almost all would agree that annual growth rates exceeding 5 percent impose severe burdens on community institutions, services, and resources. By using such a figure hypothetically as a constraint on development, we do not mean to suggest that population can be limited by law or regulation. Instead, our intention is to show the consequences of controlling growth on the basis of population (by whatever means society deems acceptable), contrasted with the impact of development constrained only by technical and physical factors.

Although economic growth is usually defined as increased per capita output, such a measure is not useful in small towns and surrounding regions because of the difficulties of disaggregation and because these are not self-sufficient economic entities. Growth is conceptualized here as urbanization and is measured by increases in population. Economic growth and urban growth are of course highly correlated, but the definition used here does not assume growth is tied to increased per capita output or to net welfare.[3]

1. <u>Smooth Growth Rates as a Mathematical Approximation</u>

Rates of population growth are not always uniform from year to year. In reality they may vary a great deal, and a compound annual average taken between two points in time smooths out these differences. For example, a town could grow rapidly at 10 percent a year for 5 years, then slow down to 0.25 percent for the next 5 years, and still finish out the 10-year period with a 5 percent annual growth rate overall. If continuity and stability were of any value to the townspeople, this would hardly be a desirable state of affairs. If they sought to maximize these values, they would try to add no more than a fixed percentage to their number every year, apportioning new residents over time as evenly as possible. In practice, of course, they could not always attain this ideal. However, a smooth rate of growth represents a reasonable objective, given the available alternatives. Hence the use of a constant growth rate as a possible constraint on development is realistic.

2. <u>Selection of Base Year</u>

The projection of growth rates into the future is sensitive to the base year chosen. It makes a great deal of difference whether a given constraint might start in 1960, 1965, 1970, or 1975. The smaller the population base, the smaller the number of people added by fixed percentage increases. For any period when population is increasing, earlier base years will tend to depress future values, while later base years will elevate future values. Gillette, Wyoming, for example, numbered 3600 people in 1960, 7200 in 1970, and was estimated by the county planner to contain 11,000 people in 1975. If the base year of 1960 were selected, and 5 percent a year were added to its population then, it would gain fewer than 2300 people in 10 years. The same growth rate and the same time period applied to the 1975 population adds nearly 7000 people. Therefore we have selected the current year's population as the starting point for all projections, even though growth rates may have exceeded 5 percent in previous years.

3. Selection of Geographical Base

Future values are also sensitive to the geographical base chosen. Larger geographical units, with more people in them to start with, can accommodate larger numbers of additional people than can smaller geographical units with fewer people, assuming equal growth rates. Five thousand new people added to Detroit would hardly be noticed, but the same number added to Gillette create substantial problems. Three principles governed selection of the geographical base:

- Since social impacts are often obscured when the nation as a whole or even the Northern Great Plains as a whole is examined, it was necessary to narrow the focus to where visible impacts actually take place--where people live, work, shop, play, or pass the time of day.

- A commuting distance between home and work of more than 35 miles (56 km) was considered impractical for the vast majority. In a similar problem involving selection of the boundaries of a regional housing market, Sternlieb et al., found that 86 percent of the commuters sampled lived within 35 miles (56 km) of their place of work.[4] The quality and layout of roads were examined in deciding how far people might live from where they work. Existing towns within 35 miles (56 km) from the place of work were considered the most likely areas of new settlement.

- A geographical base could have been selected by including all the area within a 35 mile (56 km) radius of adjacent places of work. Populations for the parts of counties included in such a circle could then have been estimated from known population densities. For the sake of administrative simplicity, however, counties were used as the geographical base. The county is the planning unit that would have to react to impacts that occur, and counties have been selected so as to be broadly inclusive of the vast majority of immigrants. Growth rates would not be identical in every part of a county (unless immigrants happened to settle proportionally in exactly the same places as older residents). Instead, existing towns could be expected to capture a greater proportion of new residents than their present proportion of older residents. Gillette, Wyoming, for example, had slightly more than half of Campbell County's population in 1970. Its "capture rate" of new residents will, however, probably be at least 80 percent. At that rate, if the county grows at 5 percent a year, Gillette will grow at about 7 percent a year. This pattern would pertain to all counties in which the "capture rate" of towns will exceed their present population share, as is generally the case in the West. Figure 23-1 illustrates this pattern. The use of a county-wide average growth rate thus tends to underestimate impacts on towns.

4. Employment-to-Total-Population Multipliers

Labor requirements for the coal mines, oil shale mines, and synthetic fuels production facilities have been derived from industry sources and are explained in Chapter 4. The ratio of total population

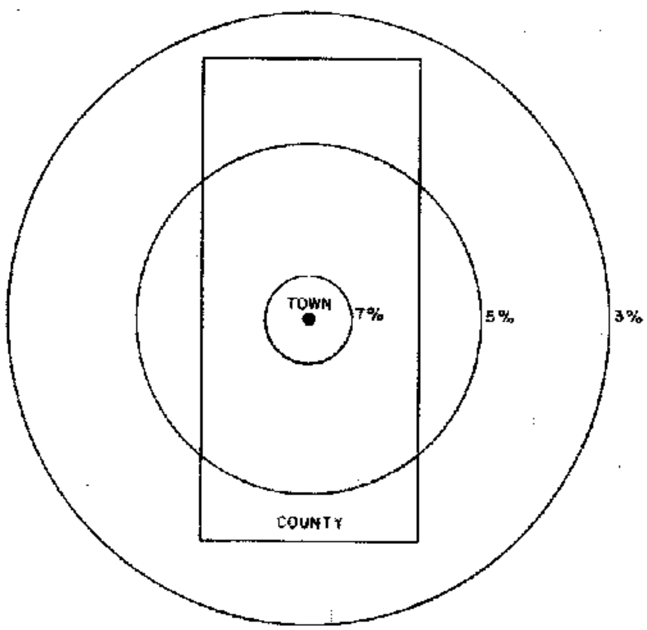

FIGURE 23-1. GROWTH RATES ARE HIGHEST NEAR THE CENTER OF ACTIVITY AND FALL OFF WITH DISTANCE. The radii shown are for purposes of illustration only; actual radii depend strongly upon the actual location.

to size of the labor force, known as the population multiplier, is usually derived from an "export base model" in which various assumptions are made about the dynamics of the local economy and demographic characteristics of immigrants. The export base model assumes that basic industrial employment generates additional services and related secondary employment. Urban growth rates are assumed to be more or less thoroughly determined by expansion of the industrial (export) base. It is not always clear, however, that the cause-and-effect relationship proceeds only one way. The efficiency of the local service industries and of local public management in fact often determines the rate of "basic" industrial growth.[5] The model also assumes that sufficient labor is available and can be attracted to the town at whatever wages it may be necessary to pay. If the export base model is relied on for precise population predictions, its assumptions about the direction of causality and the likelihood of attracting labor are likely to yield inaccuracies. If it is used only to compare two hypothetical growth rates, as it is here, the oversimplifications are relatively harmless. The multiplier is the product of two numbers: locally generated secondary employment, and average family size. If 2.6 indirect local jobs are necessary for every industrial job, and if average family size is 2.5, the multiplier will be 6.5. Figure 23-2 shows schematically the basis for population multipliers. Total population added can then be estimated by multiplying the industrial labor force by this number.

For precise predictions of future population, several refinements are possible. An input-output model of the regional economy could be constructed, and direct employment, secondary employment, and multipliers could be calculated for each industry. Multipliers vary according to the size of the community because larger towns and cities already have some existing capacity to provide needed public and private services. Smaller towns, on the other hand, have less capacity to start

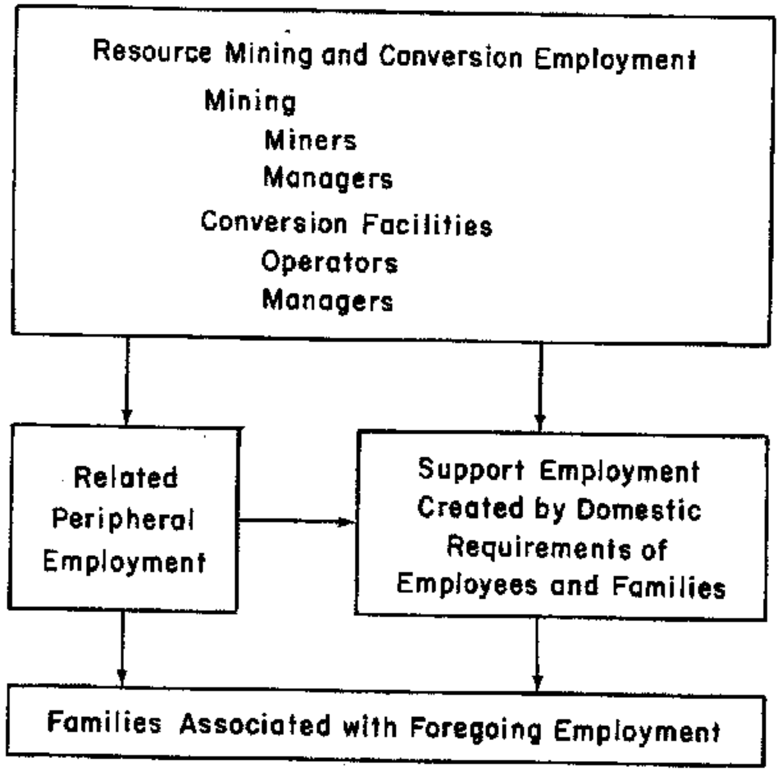

FIGURE 23-2. BASIS OF POPULATION MULTIPLIER CONCEPT

with and therefore require greater additional secondary employment. Since the propensity to shop locally affects the size of the multiplier, distance from major trade centers could be taken into account in selecting an accurate predictive value. A lower multiplier could be used for the construction labor force than for the operating labor force, on the assumption that fewer construction workers will bring their families. Finally, labor force participation rates may be broken down by age and sex to allow for varying demographic characteristics of immigrants. A model incorporating these and other elements has been constructed for the U.S. Department of Agriculture.[6]

Our purpose here, however, is not to predict total population resulting from all industries but to compare the impacts of two hypothetical levels of development in mining and synthetic liquid fuels production only. These two hypothetical levels of development are constrained in one case by technical and physical factors only, and in the other case by a 5 percent annual growth in population. Neither of these constraints will be the operative limits in real life. A multiplier of 6.5 has been selected for the Powder River Basin of Wyoming and the Piceance Basin of Colorado. Because towns in those regions are presently small, and because mining and manufacturing usually have large multipliers, there is good reason to believe that a multiplier of 6.5 underestimates actual added population. The likeliest sort of error in such an analysis, then, would be to understate the severity of local impacts that could be expected to occur.

D. A 5 Percent Annual Growth Rate in Campbell County

If Campbell County added 5 percent a year to its population in the future, its growth rate would approximately duplicate what it has experienced in the past 5 years (1970-1975). Figure 22-3 depicts an attempt to fit a combination of small and large coal liquefaction plants, along with associated coal mines, under a 5 percent growth curve. Phased to minimize discontinuities, the population profile still exhibits minor jumps during years of peak labor force in the construction of the small liquefaction plants. Major peaks and valleys appear after 1990, when construction of the large liquefaction plants would begin. Even limiting production capacity to 300,000 B/D (48,000 m^3/D) by the end of the century, the necessary facilities still could not be accommodated within a 5 percent growth rate, as the figure shows. Further study of Figure 22-3 reveals that a 5 percent growth rate is practically incompatible with construction of the extremely large, 100,000 B/D (16,000 m^3/D) liquefaction plants. One would have to wait until 1990 to begin construction of such a facility (doing nothing until then) to keep additional population within the 5 percent growth constraint.

1. <u>The Alternative of Building Smaller Plants</u>

Figure 22-4 (Chapter 22) depicts an alternative that smoothes out the rate of development considerably--building relatively small (30,000-B/D or 4800 m^3/D capacity) liquefaction plants only. This would create a 210,000-B/D (34,000 m^3/D) capacity by the year 2000, compared with a 290,000-B/D (46,000 m^3/D) capacity in the case of both large and small plants, and compared with a 400,000-B/D (64,000 m^3/D) capacity in the maximum credible case. Although the growth rate depicted by Figure 22-4 would actually be closer to 6 than to 5 percent until after 1990, employment would not be subject to massive increases and declines. Instead, it would rise more or less steadily if start-up construction of succeeding plants were phased to coincide with final year construction of preceding plants.

Assuming that housing in Campbell County would become neither more nor less crowded than it is at present (i.e., that the ratio of dwelling units to people would be constant), necessary additions to the housing stock would be substantial although not nearly as large as those required by the maximum credible case. As population rose in a 5 percent growth rate from its present 17,000 to about 57,000 by the end of the century, additional (cumulative) housing requirements would be as follows: 1700 by 1980, 4300 by 1985, 6400 by 1990, and 12,000 by 2000. While these requirements are certainly modest compared to those of the maximum credible case, they would still mean adding between 400 and 500 new dwelling units a year, a substantial effort for a small or medium-sized town. In practice, a large proportion of these would be mobile homes, and some additional crowding would result from any shortfall in the provision of housing.

Assuming the school-age population remained one-third of the total, the county school system would have to absorb nearly the equivalent of its 1970 pupil population by 1980, under the 5 percent a year growth constraint. There would be 7500 pupils in 1980, more than 10,000 in 1985, 12,500 in 1990, and more than 19,000 by the end of the century. Demands for classroom space, teachers, and administrative capacity would rise accordingly. In contrast with the maximum credible case, increased requirements would be steadier, more predictable, and approximately half the size. However, the increase would still be substantial in the near-term when financing would be the most difficult to obtain, and some crowding, double sessions, increased pupil-teacher ratios, etc., could be expected if construction and organizational development fell behind schedule. Although impacts would not be of the same order as those in the maximum credible case, they could still be characterized as moderately severe.

Using information from Reference 2, public expenditures in Campbell County in constant 1970 dollars would total $6.7 million a year in 1980, $9.4 million a year in 1985, $11 million in 1990, and $18 million in the year 2000. Major spending differences between the growth-constrained case and the maximum credible case would only begin to show up after 1985. Prior to 1985 (in the hypothetical cases depicted in Figures 22-2 and 22-4, population growth would advance fairly steadily in both cases. The discontinuous growth exhibited by the maximum credible case would yield no benefits in reduced expenditures because the county would only have to gear up again for resumed growth after momentary declines. Thus its expenditures in all likelihood would not decline along with temporary losses of population, but would continue to climb for several years after any leveling-off in growth rate. After 1985, annual expenditures in the growth-constrained case would be about half the annual expenditures in the maximum credible case. On a per capita basis, county expenditures would rise from $262 currently to $290 in 1980, $295 in 1985, $300 in 1990, and $310 in 2000

270 million tons (240 billion kg) of coal a year by the year 2000. The labor force and associated population in coal mining alone is so small that it would allow local and state officials much greater regulatory flexibility in choosing appropriate growth rates. While conversion facilities are not practical below a certain size and level of employment, coal mines are practical to operate in a variety of sizes. A more than adequate amount of coal extraction is compatible with growth rates generally regarded as manageable.

3. The Alternative of a Longer Construction Period

One characteristic of coal liquefaction and methanol plants that makes them difficult to adapt to a small town is their short construction period. With a short, say, three-year construction period, the distribution of work throughout time is typically uneven: moderate levels of effort during the first and third years, intensive level of effort during the second year. This unevenness is probably unavoidable during a short construction period because some allowances must always be made for start-up time, recruiting a large work force, and proper sequencing of the installations of parts of the plant. Figure 22-6 depicts a possible construction and operation schedule for four small (25,000 OE B/D or 4000 OE m^3/D) and two large (50,000 OE B/D or 8000 OE m^3/D) methanol plants. This schedule can almost be accommodated within a 5 percent annual growth constraint, except for the peak year of construction effort. This feature clearly creates sharp jumps and drops in the demand for labor and hence in associated population. A region subject to this instability would require either a highly mobile labor force or some other source of local employment to take up the slack during periods of lesser coal-related employment.

The incentives for a firm to minimize the construction period are clear. A plant under construction is tying up capital nonproductively, to experience some impacts associated with oil-shale development in later years after highway access from the resource development sites was improved. It has been excluded from the unit of analysis considered here, however, on the basis of principles described above: (1) Rio Blanco and Garfield Counties are small enough in population and in land area to form a coherent planning unit that would show the effects of proposed development. Yet they are not so small that those effects would be distorted. Their land area is 6300 square miles (16,000 km^2) compared with 4800 in Campbell County, Wyoming. Adding Mesa County (Grand Junction) would create a land area too large to behave as a unit; (2) The only heavy-duty route between Grand Junction and places of oil-shale employment follows a zig-zag course northeast for 60 miles, then 20 miles to the northwest. A daily 160-mile (260 km) round trip would be intolerable for almost everyone. A slightly more direct route exists, but it is now only a dirt road in parts and would only cut about 10 miles from the one-way commuting distance even if it were improved; (3) In accordance with the objective of analyzing the implications of growth for administrative units, Rio Blanco and Garfield Counties have been selected as the geographical base. Piceance Creek is about in the center of this two-county area, and the layout of roads in the region also makes this area a logical unit for the analysis of local impacts.

The maximum credible level of oil-shale mining and retorting would require an annual rate of population growth of between 16 and 19 percent between 1975 and 1990, after which growth would level off. Population would grow almost tenfold during the first 15 years. As Figure 22-10 shows, the population of the two counties would climb to 56,000 in 1980, 135,000 in 1985, 220,000 in 1990, and level off to 245,000 in 1995.

This population would not be distributed evenly over the vast land area of the two counties. The presence of the White River and Routt National Forests in the eastern portion of the two counties would credible level of oil shale production would lead to the sacrifice of "option values" for land use, that is, the implementation of decisions whose consequences might be irreversible.

F. Oil Shale Development Constrained by a 5 Percent Annual Growth Rate--Piceance Basin

Figure 22-8 shows the extent of oil shale development possible within an annual growth rate of 5 percent. In contrast to the maximum credible case, population would rise gradually from its current 23,500 to 28,000 in 1980, 41,000 in 1985, 52,000 in 1990, 65,000 in 1995, and 79,000 by the end of the century. Daily capacity for crude oil production would be 400,000 barrels (64,000 m^3/D) one-fifth of the capacity hypothesized for the maximum case. Instead of boomtowns of 50,000 people by 1990, cities closest to places of oil shale employment would number only about 10,000 inhabitants. Reduced population pressures would allow for needed planning of residential development so that mobile home sites and other settlements could be located with least damage to environmental values and amenities. Due to the shortage of suitable residential land, however, some real estate speculation and competing land uses could still be expected. The strain on local governmental fiscal capacity would be substantial, particularly in the area of schools and roads, but not nearly as severe as in the maximum case. For those services whose cost rises steeply with geographical dispersion, practically no economies of scale would be realized. Even if immigrants settled predominantly in the existing towns of Rangely, Meeker, Rifle, and Glenwood Springs, those towns themselves are separated from one another by large distances. Rangely, for example, is 78 miles (130 km) away from Meeker, and Meeker is another 67 miles (110 km) from Glenwood Springs. Thus needed public expenditures for those services would continue to rise throughout the entire course of require large urban concentrations, and these simply do not exist near the coal fields. Thus while the present population base is numerically adequate to accommodate such an industry, it is not distributed in ways that are immediately useful to the industry.

Related to the low degree of urbanization, Appalachia has been deficient in the social institutions necessary to manage an industrial economy. County governments in the coal-producing regions undertaxed productive resources and so never received a fair share of the region's wealth. As a result they were unable to finance needed services such as education, road-building, utilities, planning, and so forth. The capacity to deliver services adaptable to an urban environment has never developed in Appalachia, partly because these were not needed by a population traditionally reliant on kinship as the source of mutual aid, and partly out of distrust of government in general. New industries have not been attracted to Appalachia because the region either chose not to or failed to develop this institutional and service capacity. As far as a new industry such as synthetic fuels is concerned, then, the region is really no better adapted to urbanization and industrialization than is the sparsely populated Powder River Basin.

In Appalachia, constraints besides the size of the population base are of the greatest significance. Bitterness on the part of many people in the region toward the coal mining industry has flared up in recent years in acts of industrial sabotage costing millions of dollars.[6] In less dramatic ways, grass-roots organizations like Miners for Democracy and Appalachian Coalition Against Strip Mining have questioned the wisdom of industry domination of their region and have begun to attract a following in Congress and in state legislatures. The United Mine Workers of America has begun to take a much tougher bargaining stance than did previous union leadership. The collective bargaining agreements of December 1974 brought coal miners nearer to wage parity with other to size of the labor force, known as the population multiplier, is usually derived from an "export base model" in which various assumptions are made about the dynamics of the local economy and demographic characteristics of immigrants. The export base model assumes that basic industrial employment generates additional services and related secondary employment. Urban growth rates are assumed to be more or less thoroughly determined by expansion of the industrial (export) base. It is not always clear, however, that the cause-and-effect relationship proceeds only one way. The efficiency of the local service industries and of local public management in fact often determines the rate of "basic" industrial growth.[5] The model also assumes that sufficient labor is available and can be attracted to the town at whatever wages it may be necessary to pay. If the export base model is relied on for precise population predictions, its assumptions about the direction of causality and the likelihood of attracting labor are likely to yield inaccuracies. If it is used only to compare two hypothetical growth rates, as it is here, the oversimplifications are relatively harmless. The multiplier is the product of two numbers: locally generated secondary employment, and average family size. If 2.6 indirect local jobs are necessary for every industrial job, and if average family size is 2.5, the multiplier will be 6.5. Figure 23-2 shows schematically the basis for population multipliers. Total population added can then be estimated by multiplying the industrial labor force by this number.

For precise predictions of future population, several refinements are possible. An input-output model of the regional economy could be constructed, and direct employment, secondary employment, and multipliers could be calculated for each industry. Multipliers vary according to the size of the community because larger towns and cities already have some existing capacity to provide needed public and private services. Smaller towns, on the other hand, have less capacity to start

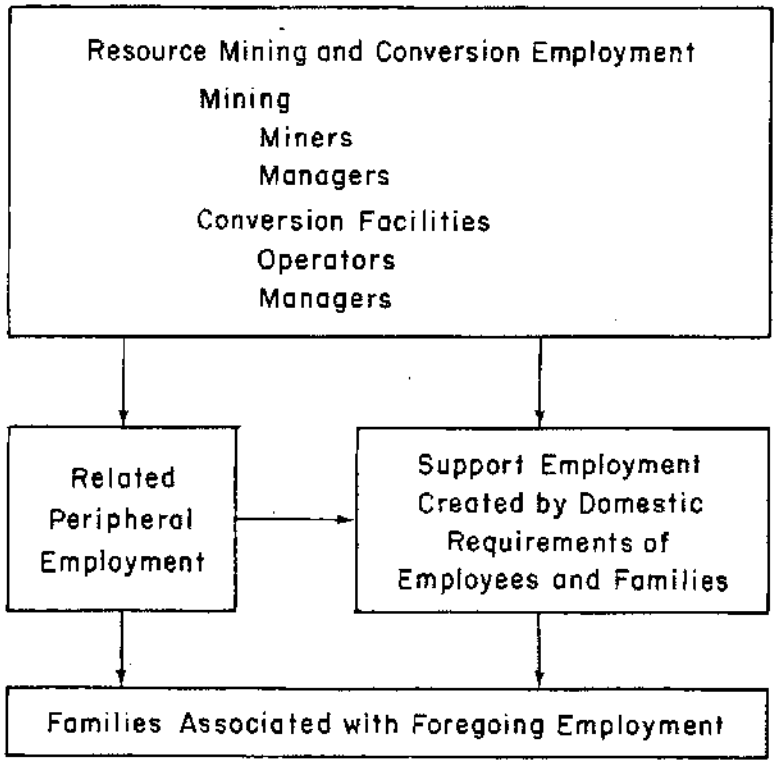

FIGURE 23-2. BASIS OF POPULATION MULTIPLIER CONCEPT

with and therefore require greater additional secondary employment. Since the propensity to shop locally affects the size of the multiplier, distance from major trade centers could be taken into account in selecting an accurate predictive value. A lower multiplier could be used for the construction labor force than for the operating labor force, on the assumption that fewer construction workers will bring their families. Finally, labor force participation rates may be broken down by age and sex to allow for varying demographic characteristics of immigrants. A model incorporating these and other elements has been constructed for the U.S. Department of Agriculture.[6]

Our purpose here, however, is not to predict total population resulting from all industries but to compare the impacts of two hypothetical levels of development in mining and synthetic liquid fuels production only. These two hypothetical levels of development are constrained in one case by technical and physical factors only, and in the other case by a 5 percent annual growth in population. Neither of these constraints will be the operative limits in real life. A multiplier of 6.5 has been selected for the Powder River Basin of Wyoming and the Piceance Basin of Colorado. Because towns in those regions are presently small, and because mining and manufacturing usually have large multipliers, there is good reason to believe that a multiplier of 6.5 underestimates actual added population. The likeliest sort of error in such an analysis, then, would be to understate the severity of local impacts that could be expected to occur.

D. A 5 Percent Annual Growth Rate in Campbell County

If Campbell County added 5 percent a year to its population in the future, its growth rate would approximately duplicate what it has experienced in the past 5 years (1970-1975). Figure 22-3 depicts an attempt to fit a combination of small and large coal liquefaction plants, along with associated coal mines, under a 5 percent growth curve. Phased to minimize discontinuities, the population profile still exhibits minor jumps during years of peak labor force in the construction of the small liquefaction plants. Major peaks and valleys appear after 1990, when construction of the large liquefaction plants would begin. Even limiting production capacity to 300,000 B/D (48,000 m^3/D) by the end of the century, the necessary facilities still could not be accommodated within a 5 percent growth rate, as the figure shows. Further study of Figure 22-3 reveals that a 5 percent growth rate is practically incompatible with construction of the extremely large, 100,000 B/D (16,000 m^3/D) liquefaction plants. One would have to wait until 1990 to begin construction of such a facility (doing nothing until then) to keep additional population within the 5 percent growth constraint.

1. The Alternative of Building Smaller Plants

Figure 22-4 (Chapter 22) depicts an alternative that smoothes out the rate of development considerably--building relatively small (30,000-B/D or 4800 m^3/D capacity) liquefaction plants only. This would create a 210,000-B/D (34,000 m^3/D) capacity by the year 2000, compared with a 290,000-B/D (46,000 m^3/D) capacity in the case of both large and small plants, and compared with a 400,000-B/D (64,000 m^3/D) capacity in the maximum credible case. Although the growth rate depicted by Figure 22-4 would actually be closer to 6 than to 5 percent until after 1990, employment would not be subject to massive increases and declines. Instead, it would rise more or less steadily if start-up construction of succeeding plants were phased to coincide with final year construction of preceding plants.

Assuming that housing in Campbell County would become neither more nor less crowded than it is at present (i.e., that the ratio of dwelling units to people would be constant), necessary additions to the housing stock would be substantial although not nearly as large as those required by the maximum credible case. As population rose in a 5 percent growth rate from its present 17,000 to about 57,000 by the end of the century, additional (cumulative) housing requirements would be as follows: 1700 by 1980, 4300 by 1985, 6400 by 1990, and 12,000 by 2000. While these requirements are certainly modest compared to those of the maximum credible case, they would still mean adding between 400 and 500 new dwelling units a year, a substantial effort for a small or medium-sized town. In practice, a large proportion of these would be mobile homes, and some additional crowding would result from any shortfall in the provision of housing.

Assuming the school-age population remained one-third of the total, the county school system would have to absorb nearly the equivalent of its 1970 pupil population by 1980, under the 5 percent a year growth constraint. There would be 7500 pupils in 1980, more than 10,000 in 1985, 12,500 in 1990, and more than 19,000 by the end of the century. Demands for classroom space, teachers, and administrative capacity would rise accordingly. In contrast with the maximum credible case, increased requirements would be steadier, more predictable, and approximately half the size. However, the increase would still be substantial in the near-term when financing would be the most difficult to obtain, and some crowding, double sessions, increased pupil-teacher ratios, etc., could be expected if construction and organizational development fell behind schedule. Although impacts would not be of the same order as those in the maximum credible case, they could still be characterized as moderately severe.

Using information from Reference 2, public expenditures in Campbell County in constant 1970 dollars would total $6.7 million a year in 1980, $9.4 million a year in 1985, $11 million in 1990, and $18 million in the year 2000. Major spending differences between the growth-constrained case and the maximum credible case would only begin to show up after 1985. Prior to 1985 (in the hypothetical cases depicted in Figures 22-2 and 22-4, population growth would advance fairly steadily in both cases. The discontinuous growth exhibited by the maximum credible case would yield no benefits in reduced expenditures because the county would only have to gear up again for resumed growth after momentary declines. Thus its expenditures in all likelihood would not decline along with temporary losses of population, but would continue to climb for several years after any leveling-off in growth rate. After 1985, annual expenditures in the growth-constrained case would be about half the annual expenditures in the maximum credible case. On a per capita basis, county expenditures would rise from $262 currently to $290 in 1980, $295 in 1985, $300 in 1990, and $310 in 2000 (constant 1970 dollars). Differences between these values and comparable values associated with the maximum credible case are of the order of only a few dollars. Individual tax burdens in the maximum credible case would be only slightly higher than those in the growth-constrained case. Because much greater numbers of people would be paying the slightly higher taxes, the differences between the two tax rates would tend to be minimized. As far as local governmental capacity is concerned, the chief advantage of the growth-constrained case would be to allow the county to defer necessary expenditures for a longer time. Slower growth would provide more flexibility and would help prevent the formation of crises such as have occurred in the recent past.

2. The Alternative of Exporting Coal from the Region

Some local and state officials have occasionally expressed a preference for a policy of having coal extracted and transported elsewhere to be processed. The advantage of the "strip it and ship it" philosophy, for these officials, is that mining activities in themselves would not disrupt the region as much as would be combination of mining and conversion to synthetic fuels at the site. The most disturbing impacts, as noted above, come from construction of extremely large industrial facilities in a relatively short span of time. Moreover, the permanent labor forces associated with liquefaction and methanol plants are only slightly less than the peak-year construction labor forces. Thus large numbers of people would be required both to build and to operate these facilities. Compared with these numbers, the labor force and associated population brought about by coal mining alone would be small. Figure 22-5 shows that a growth rate of only 2 percent a year would be compatible with extraction of about 90 million tons (8.1 billion kg) of coal a year by the year 2000. Constrained only by a 5 percent a year growth in population, Campbell County could mine

270 million tons (240 billion kg) of coal a year by the year 2000. The labor force and associated population in coal mining alone is so small that it would allow local and state officials much greater regulatory flexibility in choosing appropriate growth rates. While conversion facilities are not practical below a certain size and level of employment, coal mines are practical to operate in a variety of sizes. A more than adequate amount of coal extraction is compatible with growth rates generally regarded as manageable.

3. The Alternative of a Longer Construction Period

One characteristic of coal liquefaction and methanol plants that makes them difficult to adapt to a small town is their short construction period. With a short, say, three-year construction period, the distribution of work throughout time is typically uneven: moderate levels of effort during the first and third years, intensive level of effort during the second year. This unevenness is probably unavoidable during a short construction period because some allowances must always be made for start-up time, recruiting a large work force, and proper sequencing of the installations of parts of the plant. Figure 22-6 depicts a possible construction and operation schedule for four small (25,000 OE B/D or 4000 OE m^3/D) and two large (50,000 OE B/D or 8000 OE m^3/D) methanol plants. This schedule can almost be accommodated within a 5 percent annual growth constraint, except for the peak year of construction effort. This feature clearly creates sharp jumps and drops in the demand for labor and hence in associated population. A region subject to this instability would require either a highly mobile labor force or some other source of local employment to take up the slack during periods of lesser coal-related employment.

The incentives for a firm to minimize the construction period are clear. A plant under construction is tying up capital nonproductively, and meanwhile there is interest to pay on borrowings to finance construction (unless sufficient equity financing is available). The incentives for the public to have the construction period lengthened are equally clear. As Figure 22-7 shows, it is possible to smooth out the rate of population growth considerably by substituting a 5-year for a 3-year construction period. Periods of unemployment are reduced almost to zero, and the only period of very sharply rising demand for labor occurs at the onset of construction of the first large methanol plant. This stability brings obvious advantages to public officials, who can plan for the expansion of services, housing, etc., more readily when growth is steady than when there are violent upswings and downswings.

E. The Maximum Credible Level of Oil-Shale Mining and Retorting--Piceance Basin

Fewer alternatives are available in oil-shale development than in coal development because it is not practical to retort oil shale (extract crude oil from shale rock) far from the site where it is mined. Transportation of oil shale over long distances could not possibly compete economically with transportation of the crude oil product (after upgrading) through pipelines. Oil shale must be mined and retorted at the site or not at all. Thus the option of developing a relatively simple mining operation without an associated industrial complex does not exist.

Abundant deposits of oil shale are found in the Piceance Basin, a remote area of the Rocky Mountains' Western Slope, located in Rio Blanco and Garfield Counties, Colorado. The two counties currently have a combined population of 23,500 (1975 local planners' estimates). About half this number live in four towns: Meeker and Rangely in Rio Blanco County, and Rifle and Glenwood Springs in Garfield County. Grand Junction, to the south, is presently a major population center and could be expected to experience some impacts associated with oil-shale development in later years after highway access from the resource development sites was improved. It has been excluded from the unit of analysis considered here, however, on the basis of principles described above: (1) Rio Blanco and Garfield Counties are small enough in population and in land area to form a coherent planning unit that would show the effects of proposed development. Yet they are not so small that those effects would be distorted. Their land area is 6300 square miles (16,000 km^2) compared with 4800 in Campbell County, Wyoming. Adding Mesa County (Grand Junction) would create a land area too large to behave as a unit; (2) The only heavy-duty route between Grand Junction and places of oil-shale employment follows a zig-zag course northeast for 60 miles, then 20 miles to the northwest. A daily 160-mile (260 km) round trip would be intolerable for almost everyone. A slightly more direct route exists, but it is now only a dirt road in parts and would only cut about 10 miles from the one-way commuting distance even if it were improved; (3) In accordance with the objective of analyzing the implications of growth for administrative units, Rio Blanco and Garfield Counties have been selected as the geographical base. Piceance Creek is about in the center of this two-county area, and the layout of roads in the region also makes this area a logical unit for the analysis of local impacts.

The maximum credible level of oil-shale mining and retorting would require an annual rate of population growth of between 16 and 19 percent between 1975 and 1990, after which growth would level off. Population would grow almost tenfold during the first 15 years. As Figure 22-10 shows, the population of the two counties would climb to 56,000 in 1980, 135,000 in 1985, 220,000 in 1990, and level off to 245,000 in 1995.

This population would not be distributed evenly over the vast land area of the two counties. The presence of the White River and Routt National Forests in the eastern portion of the two counties would preclude residential development in about 1000 square miles (2600 km^2). Steep canyon sides and higher elevations would also be unsuitable for residential development. The only land remaining would be along broad valleys and upland plateaus. Much of this would be restricted as well because of lack of access by road. Areas classed as suitable for residential settlement by a recent study made up only 7 percent of the area of Garfield County, and 17 percent of Rio Blanco County.[7] Since oil shale lands in the Piceance Basin were included in the classification, the actual proportions would be somewhat less. Existing towns would likely absorb the bulk of the increased population, with the remainder absorbed along existing transportation routes. The only other Colorado county to have undergone industrialization recently, Pueblo County, has 82 percent of its population living in urbanized areas. As an indicator of expected urban population in Rio Blanco and Garfield Counties, this proportion is probably low; nevertheless it would yield an urbanized population of 176,000 in 1990. Rifle and Meeker, closest to the oil shale sites, could well become cities of 50,000 or 60,000 people.

Such sudden increases in population would strain every social and institutional resource in the region. Mobile homes would be strung out along every canyon and river valley, the Colorado River would receive urban waste water, schools would be vastly overcrowded or nonexistent, public expenditures would soar faster than population, and services would be unable to catch up with growth. Real estate speculation would become a major industry, while tourism, which grew during the 1960s, would probably decline. Labor turnover would probably be high. Competition for scarce land in valleys and upland plateaus would pit residential development against recreation, farming, transportation, tourism and other interests seeking to use the same land. If the oil shale industry were developed to its maximum possible extent, opportunities for diversification of the local economy would decline. The maximum credible level of oil shale production would lead to the sacrifice of "option values" for land use, that is, the implementation of decisions whose consequences might be irreversible.

F. Oil Shale Development Constrained by a 5 Percent Annual Growth Rate--Piceance Basin

Figure 22-8 shows the extent of oil shale development possible within an annual growth rate of 5 percent. In contrast to the maximum credible case, population would rise gradually from its current 23,500 to 28,000 in 1980, 41,000 in 1985, 52,000 in 1990, 65,000 in 1995, and 79,000 by the end of the century. Daily capacity for crude oil production would be 400,000 barrels (64,000 m^3/D) one-fifth of the capacity hypothesized for the maximum case. Instead of boomtowns of 50,000 people by 1990, cities closest to places of oil shale employment would number only about 10,000 inhabitants. Reduced population pressures would allow for needed planning of residential development so that mobile home sites and other settlements could be located with least damage to environmental values and amenities. Due to the shortage of suitable residential land, however, some real estate speculation and competing land uses could still be expected. The strain on local governmental fiscal capacity would be substantial, particularly in the area of schools and roads, but not nearly as severe as in the maximum case. For those services whose cost rises steeply with geographical dispersion, practically no economies of scale would be realized. Even if immigrants settled predominantly in the existing towns of Rangely, Meeker, Rifle, and Glenwood Springs, those towns themselves are separated from one another by large distances. Rangely, for example, is 78 miles (130 km) away from Meeker, and Meeker is another 67 miles (110 km) from Glenwood Springs. Thus needed public expenditures for those services would continue to rise throughout the entire course of growth. These expenditures would be small compared with those required by the maximum level of development.

Unlike Campbell County, Wyoming, Rio Blanco and Garfield Counties, Colorado, have not experienced boomtown growth rates recently. Garfield County's growth rate between 1960 and 1970 was 2 percent a year, and Rio Blanco County lost population in that decade. A growth rate of even as little as 5 percent a year would be a big jump, while a growth rate of 16 to 19 percent annually would be extremely high. This lack of comparable experience would undoubtedly handicap the western Colorado counties in adapting to rapid industrial and urban growth.

G. Implications for Appalachia

The coal mining regions of Appalachia currently have a much larger population base than the resource-rich regions of the West. Eastern Kentucky, southern West Virginia, and southwestern Virginia still have substantial reserves of bituminous coal averaging 10,000 to 12,000 Btu per lb (23 MJ/kg to 28 MJ/kg) and a labor force experienced in the techniques of coal mining. The Big Sandy Area Development District, a 5-county region of eastern Kentucky, contains 143,000 people (1972 local planners' estimate). The 5 counties--Floyd, Johnson, Magoffin, Martin, and Pike--form a land area of 1979 square miles (5100 km^2), less than half the area of Campbell County, Wyoming. It would appear that a population base of that size could more easily absorb the growth induced by a synthetic fuels industry than Campbell County could. Before reaching such a conclusion, however, it should be noted that the present population is overwhelmingly rural. Only 10 percent live in towns of more than 2000, and only 15 percent live in towns of any size at all. Coal mining in Appalachia has traditionally coexisted with a predominantly rural culture. A synthetic fuels industry, on the other hand, would require large urban concentrations, and these simply do not exist near the coal fields. Thus while the present population base is numerically adequate to accommodate such an industry, it is not distributed in ways that are immediately useful to the industry.

Related to the low degree of urbanization, Appalachia has been deficient in the social institutions necessary to manage an industrial economy. County governments in the coal-producing regions undertaxed productive resources and so never received a fair share of the region's wealth. As a result they were unable to finance needed services such as education, road-building, utilities, planning, and so forth. The capacity to deliver services adaptable to an urban environment has never developed in Appalachia, partly because these were not needed by a population traditionally reliant on kinship as the source of mutual aid, and partly out of distrust of government in general. New industries have not been attracted to Appalachia because the region either chose not to or failed to develop this institutional and service capacity. As far as a new industry such as synthetic fuels is concerned, then, the region is really no better adapted to urbanization and industrialization than is the sparsely populated Powder River Basin.

In Appalachia, constraints besides the size of the population base are of the greatest significance. Bitterness on the part of many people in the region toward the coal mining industry has flared up in recent years in acts of industrial sabotage costing millions of dollars.[8] In less dramatic ways, grass-roots organizations like Miners for Democracy and Appalachian Coalition Against Strip Mining have questioned the wisdom of industry domination of their region and have begun to attract a following in Congress and in state legislatures. The United Mine Workers of America has begun to take a much tougher bargaining stance than did previous union leadership. The collective bargaining agreements of December 1974 brought coal miners nearer to wage parity with other industrial workers than previous negotiations had even attempted to do. The greater productivity of the coal mines has increased the amounts generated for the union's health and welfare fund by the tonnage royalty. Also, the greater educational attainment and lesser age of the new labor force make workers less tolerant of unnecessarily low safety standards and working conditions. These factors are probably more important considerations on the part of the mining industry as to the location of synthetic fuels facilities than are demographic factors.

H. Implications for Southern Illinois

Judging by demographic and geophysical characteristics, southern Illinois would appear to be less disrupted by the growth of a synthetic fuels industry than the other regions would. In contrast to the sparsely populated West, southern Illinois has a large enough population base to accommodate industrial growth without sustaining a large percentage impact. In contrast to Appalachia, it is not isolated by geographical and cultural factors from modern industrial society. The 6-county area of Franklin, Jefferson, Perry, St. Clair, Washington, and Williamson Counties comprise a land area of 3112 square miles (8100 km^2), somewhat smaller than Campbell County, Wyoming, in size. Their total population, however, is 437,500, large enough to absorb a new labor force and associated population without severe stress. Unlike Appalachia's population, it is concentrated in urban areas in a way that makes it accessible to industrial employers. In only 1 of the 6 counties is the population predominantly rural--Washington County, with 78 percent of residents in rural places. St. Clair County's population is overwhelmingly urban (83 percent) due to the presence of East St. Louis. The other 4 counties have a rural-urban mix of about half and half. Thus the urbanized base necessary for industrial growth is substantially already in place.

The necessity for large numbers of immigrants to the area would be lessened by the prevalence of higher-than-average unemployment rates. Rates ranged from 3.9 percent in Washington County to 6.8 percent in Franklin County in 1970. Even if renewed coal mining activity in the past 5 years has employed some of these people, a large amount of unemployment in neighboring cities has probably persisted. St. Louis, Missouri, had 16,000 unemployed persons in 1970; Evansville, Indiana, had 2700 unemployed persons.[6] Some proportion of Chicago's 64,000 unemployed might also be attracted to employment in southern Illinois.

Southern Illinois has an established coal mining industry. The 6-county region produced 37 million tons (33 billion kg) of coal from 20 operating mines in 1972, more than half of the total coal production in Illinois in that year. Two billion tons (1.8 trillion kg) of strippable reserves and 19 billion tons (17 trillion kg) of deep reserves remain in the region. The coal has a heating value of 11,000-12,000 Btu per pound (26 MJ/kg to 28 MJ/kt), about midway between that of Powder River Basin coal and Appalachian coal. Southern Illinois has a relatively diversified set of service industries, and access to a large urban center, St. Louis, for many industrial needs. Existing service industries and governmental capacity should therefore reduce requirements for additional population, relative to the other resource-rich regions.

In southern Illinois agriculture has a relatively higher value than in Appalachia, or than ranching and farming in the resource regions of the West. Agriculture would undoubtedly be disturbed by large-scale surface mining operations, to some extent. This impact, however, would be mitigated by the following factors:

(1) The reclamation potential of southern Illinois farmland is greater than that of either the arid western regions or Appalachia. (See Chapters 13 and 15.) Its superiority over the arid West is that rainfall can be expected to be adequate to stabilize and restore the land. Its

superiority over Appalachia is due to the fact that the county consists of flatlands and rolling hills rather than steeply contoured slopes.

(2) Surface mining in southern Illinois could actually improve agricultural productivity because it would break up the subsurface impervious soil layer, or hardpan, that prevents adequate drainage.

(3) Custom and practice in southern Illinois indicate that agriculture and coal mining can coexist more readily than in the other resource-rich regions. Many coal miners have traditionally worked their own farms in addition to being employed at mining. The proportion of farm operators (as defined by the 1970 Census) who worked 100 days or more per year off the farm was more than half for the region, while the statewide figure was one-third. While the discipline of a large industrial workplace might not be compatible with such dual employment, the mining activity itself clearly is.

Southern Illinois also derives some advantages from being close to eastern and midwestern energy markets, Ohio River and Mississippi River barge transportation routes, and a major rail terminus from the West. Compared to the other regions discussed, it is well located for domestic energy production.

I. Summary

In assessing the impact of development, we usually apply the concept of damage, reversible or irreversible, only to the natural environment. Certain actions can cause irreversible environmental damage; for example, radioactive wastes contamination and the extinction of rare species are examples of irreversible consequences of human action. Whether environmental consequences are long-lasting or not depends on human ability to regulate development in accordance with environmental standards. Similarly, adverse social consequences are controllable by concerted effort and proper planning.

The foregoing analysis has suggested that adverse social impacts could be mitigated by the following actions:

- Building smaller plants (conversion facilities).
- Exporting coal.
- Phasing employment buildups and layoffs so as to minimize labor shortages and unemployment.
- Pay-as-you-grow system of public finance to avert tax lag.
- Fair valuation of all taxable productive wealth.
- Governmental-industry cooperation in community-building.
- Rational land use policy for agricultural, range, industrial, residential, and recreational uses.
- Full public participation in decision-making affecting fundamental values and interests.
- Diversification of local economies.
- A system for compensating involuntary displacees.
- Adequate reclamation of land.

It has been shown that the consequences of a 5 percent annual growth rate are far less severe for communities than production at the maximum theoretical level would be. The dynamics of growth at the theoretical upper limit of synthetic fuels production would probably cause lasting damage in the form of costs payable by future generations, cycles of boom and bust, massive disturbances of land, rapid, perhaps unwanted change in living conditions, and narrowing of options. A 5 percent growth rate would allow time for needed planning and development of public services and amenities. The job of community-building, in short, would be brought within the range of possibility by such a constraint.

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Appendix C

PROJECTIONS OF CASH FLOW FOR THE PETROLEUM AND GAS INDUSTRY

The following gives financial accounting relationships used to derive cash flow for the petroleum and gas industry, summarized from Hass, Stone and Mitchell,[8] Appendix B and Table 3-4.

<u>Assets</u>

$$TA(t) = TA(t-1) + \Delta CA(t) + \Delta OA(t) + INV(t) - DEP(t)$$

where

- t = year
- $TA(t)$ = total assets in year t.
- $\Delta CA(t)$ = change in cash assets $(CA(t))$ from the previous year.
- $\Delta OA(t)$ = change in other assets $(OA(t))$ from the previous year.
- $INV(t)$ = investment in year t.
- $DEP(t)$ = depreciation on total assets in year t.

and

$$CA(t) = a\ TA(t) \qquad a = 0.32$$

$$DEP(t) = d\ TA(t-1) \qquad d = 0.064$$

$$OA(t) = \emptyset\ TA(t) \qquad \emptyset = 0.08$$

then

$$TA(t) = \frac{(1-a-\emptyset-d)\ TA(t-1) + INV(t)}{1-a-\emptyset}$$

$$TA(t) = \frac{0.54\ TA(t-1) + INV(t)}{0.60}$$

Appendix C

PROJECTIONS OF CASH FLOW FOR
THE PETROLEUM AND GAS INDUSTRY

Table A-5 (concluded)

- Credit agency borrowing

Sources: Historical. Federal Reserve Bulletin, Total New Issues table under Federally Sponsored Credit Agencies, various issues.

Projections. Credit agency borrowing is taken from the New York Stock Exchange study over the 1975-1985 period and extrapolated to year 2000.

- State and local borrowing

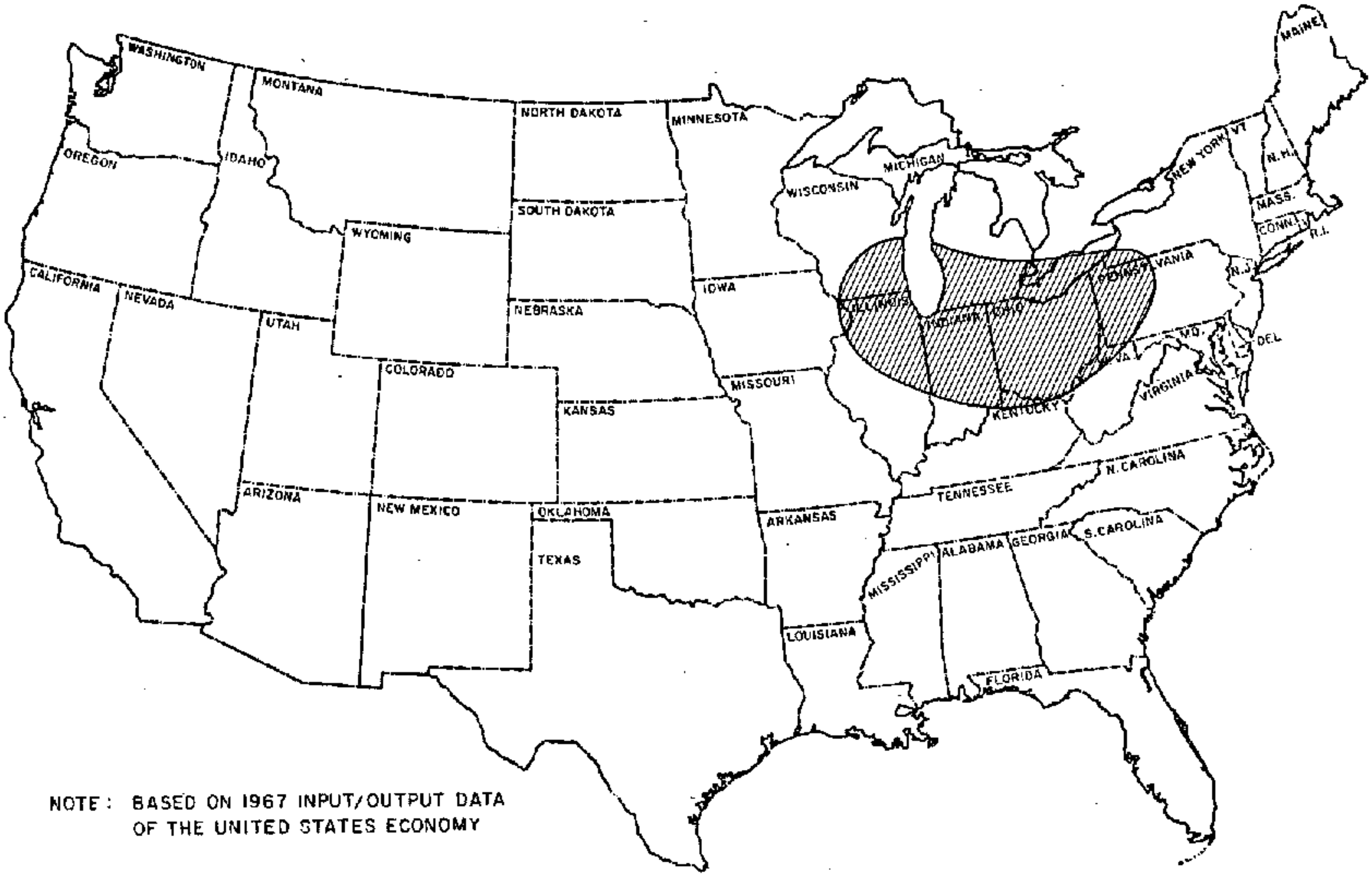
†State and local borrowing is equivalent to state and local surplus or deficit in the Survey of Current Business.

Sources: Historical. Survey of Current Business, National Income and Product, Table 14, various issues.

Projections. These projections are taken from the New York Stock Exchange study for the 1975-1985 period and extrapolated to 2000.

Appendix B

PROJECTIONS OF CAPITAL INVESTMENT IN THE OIL AND GAS INDUSTRY



NOTE : BASED ON 1967 INPUT/OUTPUT DATA
OF THE UNITED STATES ECONOMY

FIGURE II-2. PRIMARY CONCENTRATION OF MAJOR INDUSTRIAL SECTORS EXPECTED TO SUPPLY THE COAL AND OIL SHALE INDUSTRY

Appendix A

ESTIMATION OF DEMAND FOR WALKING DRAGLINES

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/7-76-004B	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE IMPACTS OF SYNTHETIC LIQUID FUEL DEVELOPMENT-- Automotive Market Volume II		5. REPORT DATE July 1976
		6. PERFORMING ORGANIZATION CODE EGU 3505
7. AUTHOR(S) E.M. Dickson, R.V. Steele, E.E. Hughes, B. L. Walton, R.A. Zink, P.D. Miller, J.W. Ryan, P.B. Simmon, B. R. Holt, R. K. White, E. C. Harvey, R. C R. Cooper, D. F. Phillips, W. C. Stoneman		8. PERFORMING ORGANIZATION REPORT NO. EGU 3505
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16. ABSTRACT

This study assesses the impacts of the development of synthetic liquid fuels from coal and oil shale; the fuels considered are synthetic crude oils from coal and oil shale and methanol from coal. Key issues examined in detail are the technology and all of its resource requirements, net energy analyses of the technological options, a maximum credible implementation schedule, legal mechanisms for access to coal and oil shale resources, financing of a synthetic liquid fuels industry, decision making in the petroleum industry, government incentive policies, local and national economic impacts, environmental effects of strip mining, urbanization of rural areas, air pollution control, water resources and their availability, and population growth and boom town effects in previously rural areas.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
coal	boom towns	synthetic fuels technology	
oil shale	water resources	net energy analysis	
synthetic fuels	strip mining		
methanol	control technology		
air pollution	incentive policies		
environmental impact			
economic impacts			

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