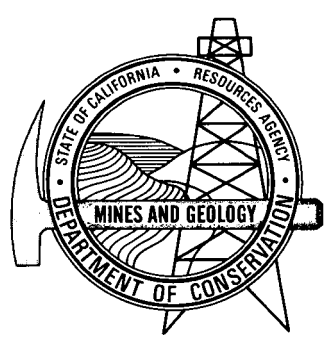
MINERAL LAND CLASSIFICATION: PORTLAND CEMENT CONCRETE-GRADE AGGREGATE IN THE SACRAMENTO-FAIRFIELD PRODUCTION-CONSUMPTION REGION

1988

CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

SPECIAL REPORT 156



DIVISION OF MINES AND GEOLOGY
JAMES F. DAVIS
STATE GEOLOGIST

SPECIAL REPORT 156

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1988

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FOREWORD

Special Report 156, "Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Sacramento-Fairfield Production-Consumption Region," is the first analysis of mineral resources in the Sacramento Valley to be developed by the California Department of Conservation, Division of Mines and Geology under authority of the Surface Mining and Reclamation Act of 1975 (SMARA). This classification is provided to the State Mining and Geology Board for transmittal to the local governments that regulate land use in this region, and for consideration of areas, if any, to be designated as regionally significant. SMARA was enacted by the State Legislature to assure mineral resource conservation and adequate mined land reclamation.

The Mining and Geology Board adopted guidelines in June 1978 to be employed by the Division in its mineral resource classification. This report was prepared in conformance with those directives. The undertaking is of great importance in economic geology because it deals with very specific mineral resource conservation issues in areas of intensive competing land use.

James F. Davis
State Geologist

PREFACE

Reserve tonnage data presented in this report was accurate as of November 1982. In January 1985 a preprint version of the report was circulated to lead agencies and made available to the public. Changes in reserves resulting from either the premature closure of mines active in 1985, or the permitting of new mines since that time, may have impacted forecasted depletion dates for the production-consumption region studied. However, the material presented and the fundamental conclusions of the report remain valid and useful.

David J. Beeby
Urban SMARA Program Manager

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EXECUTIVE SUMMARY

This report presents the results of the classification of aggregate resources by the Division of Mines and Geology (DMG) in the Sacramento-Fairfield Production-Consumption (P-C) Region. The primary goals of the study are :

1. To delineate, within the P-C region, all land containing sand and gravel deposits suitable for production as high-quality, Portland cement concrete (PCC) aggregate.
2. To calculate the quantity of the resources in these deposits that are on lands considered by the State to be available for possible aggregate production based upon evaluation of land uses.
3. To evaluate the adequacy of the current aggregate *reserves* (aggregate resources on land permitted for mining by local government) for meeting the future needs of the P-C region.

In the Sacramento-Fairfield area, as in any rapidly urbanizing area, it is important that land-use decisions are made with full recognition of the natural resources of the area. This is especially true when the resource in question is high-grade construction aggregate which is an indispensable building material and costly to transport.

The Sacramento-Fairfield area has been fortunate in that adequate quantities of low-cost, high-quality aggregate materials have been available locally. The total amount of these materials available in local deposits is limited, however, and with the rapid urbanization in the area, that amount is diminishing as active aggregate producers deplete their deposits and land containing suitable sand and gravel deposits is utilized for urban development. As an example, since 1980, access to over 139 million tons of PCC-grade aggregate east of Sacramento bordering the Highway 50 corridor has been irreversibly lost.

The loss of regionally significant mineral deposits to land uses that preclude mining is one of the problems that the California Surface Mining and Reclamation Act of 1975 (SMARA) was framed to address. SMARA mandates a two-phased mineral resource conservation process called classification-designation. Although the present report is concerned with the classification phase of this process, it is important to explain designation, if only briefly, so that the role of classification in the overall process can be understood.

Under SMARA, the State Mining and Geology Board (the Board) may designate areas within a P-C region that contain significant deposits of PCC-grade aggregate that may be needed to meet the region's future demand. The Board's decision to designate an area is based upon information in the classification report prepared by DMG after input from lead agencies and the public. Through designation, the Board provides formal recognition of regionally significant deposits of a resource, in this case aggregate material. The objective of the classification-designation process is to provide information on future resource availability to the urban population centers which depend upon it for future growth. This perspective will hopefully provide a context for land-use decisions by local government on which mineral resource availability is one of the pertinent factors being balanced with other considerations.

The DMG is responsible under SMARA for carrying out the classification phase of the classification-designation process. Classification normally entails six distinct but interrelated steps. In this particular study, a seventh step is included to provide additional data based on a hypothetical splitting of the P-C region. These seven steps are described below.

1. *Determination of Production-Consumption (P-C) Region Boundaries.* The boundaries of the P-C region are drawn along the limits of the marketing area of the active aggregate operations supplying the urban center under study. Included within the P-C region boundaries are all areas within the marketing area that have been identified as being urbanized or urbanizing by the State Office of Planning and Research (OPR), local lead agencies, or the Division of Mines and Geology.

2. *Establishment of Mineral Resource Zones (MRZ).* All lands considered to be urbanized or urbanizing by the OPR, local lead agencies, or the DMG are assigned Mineral Resource Zone classifications (MRZ-1, MRZ-2, MRZ-3, or MRZ-4) based upon a geologic appraisal of the aggregate resource potential of the land. This appraisal includes study of pertinent geologic reports and maps, field investigation and sampling at outcrops and active and inactive pits and quarries, and analysis of water-well logs and drill records.

3. *Identification of Available Aggregate Resource Areas as Sectors.* Lands containing significant deposits of PCC-grade sand and gravel (areas classified as MRZ-2 in step 2) are evaluated to determine whether or not current uses of these lands preclude possible future mining. Areas currently permitted for mining and areas found to have land uses compatible with possible future mining are considered available for mining. These sectors are delineated and described in detail. Sectors are thus distinguished because the State Geologist judges that they meet the criteria for availability established by the State Mining and Geology Board.

4. *Calculation of Resource Tonnages within Sectors.* Investigation and analysis of on-site conditions, measurement of the areal extent of deposits, drill-hole information, waste-material percentages, and deposit densities are used to calculate total tonnages of PCC-grade aggregate *reserves* (deposits in land owned or leased by an aggregate producer and permitted for mining by local government at the end of 1982) and *resources* (all deposits of PCC quality including the reserves) within each sector. Calculations reflect conditions of the deposits at the end of 1982.

5. *Forecast of 50-Year Needs and the Life Expectancy of Current Reserves.* The total tonnage of aggregate needed to satisfy demand in the P-C region over the next 50 years is estimated based on projected population over that period with the average annual per-capita rate of aggregate consumption from 1960-1980. Results of this forecast are used to determine the life expectancy of the P-C region's current reserves.

6. *Identification of Alternative Resources.* Alternative sources of aggregate to meet the forecasted 50-year demand are identified and their potential for meeting future needs of the region is briefly considered.

7. *Analysis of Reserves in Each of Two Halves of the P-C Region.* To determine whether or not the area west of West Sacramento would have adequate aggregate reserves for that area alone, the P-C region was divided into two parts, and the reserves and expected 50-year demand were calculated for each.

As with many forecasts of economic activity, the forecasts in this report should not be viewed as offering unqualified predictions of how the future will unfold. The forecasts of this report are based upon assumptions concerning the accuracy of the data base, and the continuation of the development trends of the past two decades into the five decades ahead.

The conclusions and forecasts of the February 11, 1985 preprint edition of this report have been modified herein to reflect new information concerning the availability of land for mining. This new information was provided by the Planning and Community Development Department of the County of Sacramento (See Appendix 2) on May 7, 1985. The Executive Summary Table No. 1 provides a summary of the sectors of the February 11, 1985 report that are now regarded as unavailable for mining. Executive Summary Table No. 2 summarizes the remaining available sectors in Sacramento County.

EXECUTIVE SUMMARY TABLE NO. 1. Sectors and resources that have been delineated by the State Geologist but which are no longer available for mining as of May, 1985.

SECTOR	UNAVAILABLE RESOURCES (Tons)	AREA (Acres)	WHY RESOURCES ARE UNAVAILABLE
E-1	13,700,000	299	Approved developments
F-8	4,700,000	91	Approved Industrial developments
F-9	7,400,000	169	Approved developments
F-10	4,500,000	82	Approved development under construction
G-1	12,200,000	401	Approved development
H-1	69,800,000	1,831	Existing development incompatible with mining
H-3	2,900,000	75	Approved development and construction
H-4	14,800,000	388	Approved development
TOTAL	130,000,000	3,546	

Of the 130 million tons of resources listed above, 12.2 million tons in Sector G-1 had been regarded as reserves.

EXECUTIVE SUMMARY TABLE 2. Sectors and resources mentioned in the May 7, 1985 letter from Sacramento County (Appendix 2) and retained as sectors available for mining in Sacramento County in accordance with criteria for availability provided by the State Mining and Geology Board.

SECTOR	AVAILABLE RESOURCES (Tons)	AREA (Acres)
E-2	3,400,000	74
E-3	6,000,000	132
F-1	7,400,000	143
F-2	4,100,000	79
F-3	15,300,000	277
F-4	4,500,000	87
F-5	5,000,000	228
F-6	38,900,000	752
F-7	10,500,000	253
F-9	*	210
F-11	66,300,000	1,281
F-12	15,300,000	370
G-1	17,900,000	587
G-2	7,500,000	242
H-2	11,000,000	289
I-1	3,400,000	125
I-2	6,700,000	188
I-3	12,500,000	348
I-4	2,500,000	94
I-5	5,700,000	160
I-6	5,500,000	152
SUBTOTALS	249,400,000	6,071
Parklands Resources		
J	43,700,000	1,154
K	66,500,000	1,691
L	26,100,000	1,141
SUBTOTALS	136,300,000	3,986
GRAND TOTALS	385,700,000	10,057

* Proprietary

Assuming, however, the correctness of our forecasts for the consumption of aggregate, the following conclusions were reached:

- The anticipated consumption of aggregate resources in the P-C region to the year 2033 is forecast to be 900 million tons, of which approximately 40 percent or 360 million tons must be of PCC quality.
- The total existing PCC reserves of 97 million tons is equal to the anticipated demands through most of 1990. Because many of the currently permitted properties are expected to be depleted by 1990, it is apparent that additional resource areas must be permitted for mining before 1990 if the needs are to be met from deposits in this region. The start-up time required for planning, permitting, and facility construction is such that local governments should take immediate action to ensure that aggregate material will be available to meet the needs of the very near future.
- Not all mines are expected to close in 1990. However, the production of the remaining mines will not be sufficient to meet the projected 50-year demand.
- About 97 million tons of permitted PCC-grade reserves exist in the P-C region. Of this total, 40 million tons occur along Cache Creek in Yolo County and 57 million tons occur within the American River Fan in Sacramento and Placer counties.
- In total, the 97 million tons of permitted PCC-grade aggregate reserves amount to 27% of the anticipated consumption of PCC aggregate during the next 50 years, and just 11% of the total anticipated consumption of all aggregate over the same period.
- The expected longevity of the existing PCC reserves is based upon the assumption that mining of these reserves will continue to be permitted until the reserves are depleted.

- Should the P-C region's 97 million tons of PCC reserves be used solely for concrete-grade aggregate, they would theoretically last until the year 2000. However, it can be expected that much of the PCC reserves will continue to be used for non-PCC applications.
- A total of 1.23 billion tons of aggregate resources (including reserves) has been identified within the Sacramento-Fairfield P-C Region. Of this total, 838 million tons occur along Cache Creek in Yolo County, and 394 million tons occur along the American River in Sacramento and Placer counties. Almost 140 million tons of the American River resources occur in dedicated parklands and are unlikely to be permitted for mining.
- Resources within the Cache Creek Channel (an area defined by Yolo County Ordinance) are in large part unavailable for mining as a result of legal restraints on mineral extraction below a defined thalweg elevation. Above the thalweg level, 29.7 million tons of reserves are present and tabulated in this report among the available resources. Below the thalweg level, 110.8 million tons of resources are present but are excluded from the tabulation of available resources. If the conditions of the ordinance were changed, additional resources could be made available for mining.
- The Sacramento-Fairfield P-C Region covers an area of 855 square miles, of which 78 square miles (9% of the total area) were classified MRZ-2. Only 43 square miles (5% of the total area) have been sectorized as having current land uses which do not preclude mining. Less than eight square miles of the sectorized areas are currently under mining permits.
- Rapid growth in the Sacramento-Fairfield P-C Region is annually eliminating many high-quality aggregate deposits from ever being mined. Just since 1980, lands south of the American River containing aggregate resources capable of providing a 22-year-supply to the entire region have been subdivided, developed, and otherwise lost to mining.

MINERAL LAND CLASSIFICATION: PORTLAND CEMENT CONCRETE-GRADE AGGREGATE IN THE SACRAMENTO-FAIRFIELD PRODUCTION-CONSUMPTION REGION

INTRODUCTION

In the Sacramento-Fairfield area (Figures 1 and 2), as in any rapidly urbanizing area, it is important that land-use decisions are made with full recognition of the natural resources of the area. This is especially true when the resource in question is high-grade construction aggregate used in Portland cement concrete (an indispensable building material and costly to transport).

The Sacramento-Fairfield area has been fortunate in having adequate quantities of low-cost, high-quality aggregate materials locally available. However, the amount of these materials available for future new development is limited. With the rapid urbanization in the area, the total available aggregate resource is diminishing as active producers deplete their deposits and land containing suitable sand and gravel deposits is utilized for urban development.

The loss of access to regionally significant mineral deposits as a result of land uses that preclude mining is one of the problems that the California Surface Mining and Reclamation Act of 1975 (SMARA) was framed to address. SMARA mandates a two-phased mineral resource conservation process called classification-designation. Although the present report is concerned with the classification phase of this process, it is important to explain designation here, if only briefly, so that the role of classification in the overall process can be understood.

Under SMARA, the State Mining and Geology Board (the Board) may designate certain mineral deposits as being regionally significant to satisfy future needs. The Board's decision to designate an area is based on information in the classification report prepared by the Division of Mines and Geology (DMG) and on input from lead agencies and the public. The objective of the classification-designation process is to establish an awareness of the availability of important resources to urban population centers through communications with the appropriate lead agencies regarding the presence, location, and significance of mineral deposits within their region.

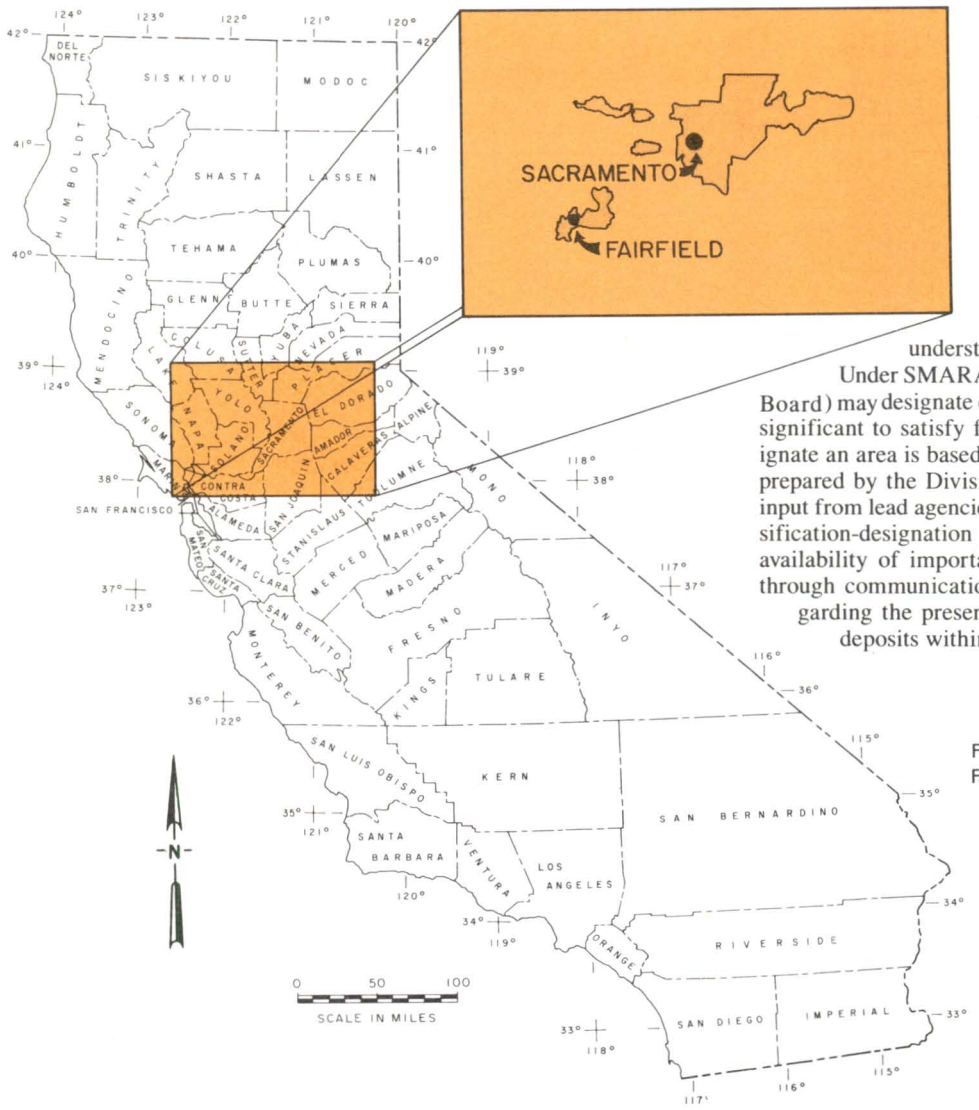

Figure 1. General location map of the Sacramento-Fairfield Production-Consumption Region.

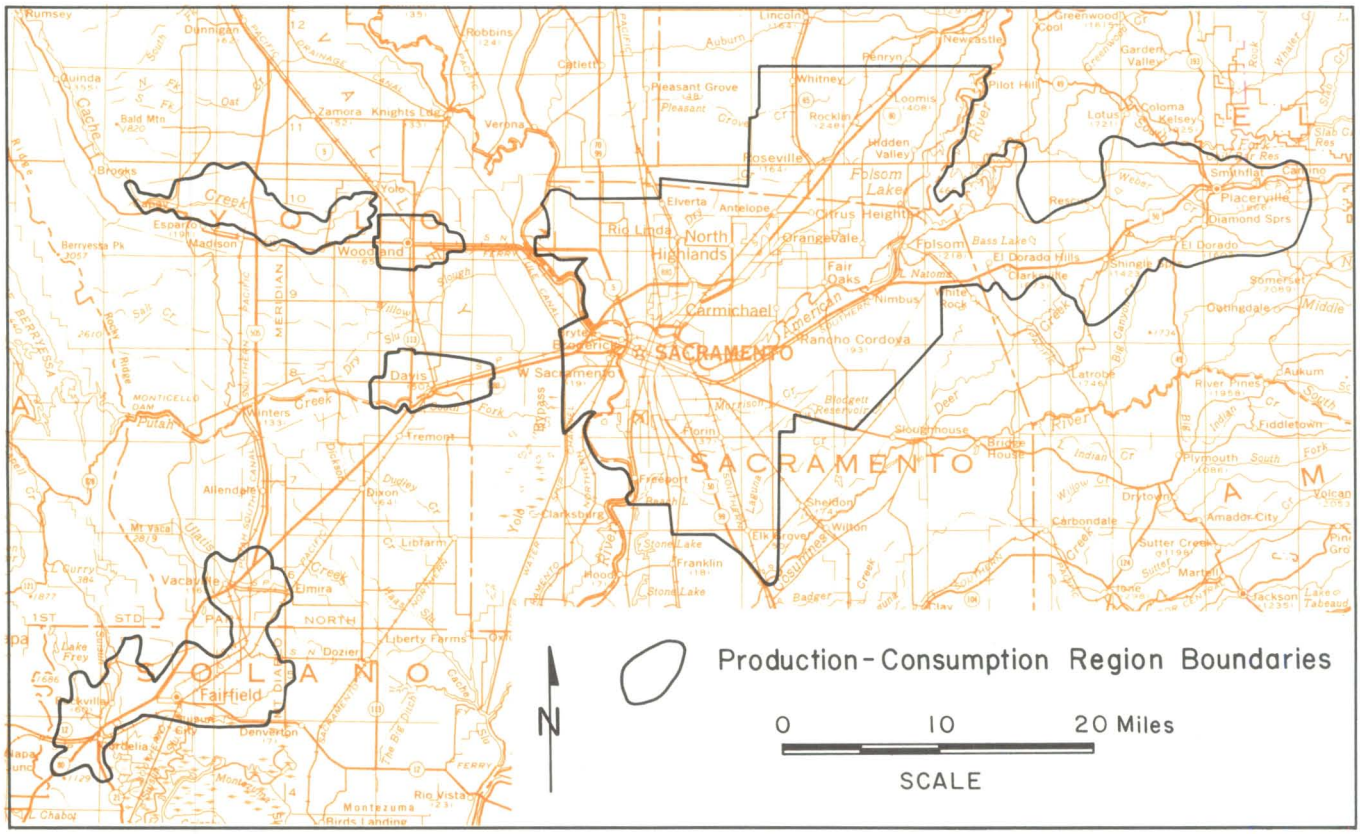

Figure 2. The Sacramento-Fairfield Production-Consumption Region boundaries.

Overview of Classification

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area alone, the P-C region was divided into two parts, and the reserves and expected 50-year demand were calculated for each.

Overview of Aggregate Uses

Sand, gravel, and crushed stone are "construction materials." These commodities, collectively referred to as aggregate, provide bulk and strength to Portland cement concrete, asphaltic concrete, and plaster, or stucco. Aggregate is also used as roadbase, subbase, railroad ballast, and fill. Aggregate normally provides from 80 to 100 percent of the material volume in the above uses.

Aggregate material is essential to the needs of a modern society. It is a resource of great importance to the economy of any metropolitan area.

During 1982, nearly 6.2 million tons of aggregate, an amount worth about $19 million, were mined from the Cache Creek and American River deposits in the Sacramento-Fairfield P-C Region. Nearly 95 percent of this amount was consumed within the P-C region. Approximately 40 percent of the aggregate produced from 1960 to 1982 was used as Portland cement concrete (PCC) aggregate (U.S. Bureau of Mines statistics). Enormous tonnages of high quality PCC-grade aggregate are used in concrete highways, dams, canals, airport runways, bridge abutments, foundations, buildings, and general construction.

In this aggregate resource classification study, special emphasis is given to aggregate that meets the specifications used in making Portland cement concrete (PCC). The material specifications for PCC-grade aggregate are more restrictive than the specifications that aggregate for other applications must meet. The restrictiveness of these specifications makes deposits acceptable for use as PCC aggregate the scarcest and most valuable aggregate resources in the Sacramento-Fairfield area. The aggregate produced from such deposits is commonly used for other purposes than concrete aggregate. Because PCC-grade aggregate is a versatile and important construction material, the future availability of this commodity is of significant concern for urban planning.

In past years, the population in the Sacramento-Fairfield area has been served by high-quality, relatively low-cost aggregate deposits from the Cache Creek and American River areas. However, the high-quality deposits are rapidly being depleted, and many of the potential sources already have been made inaccessible as a consequence of irreversible land uses that are incompatible with mining.

Rarely, even from the highest-grade deposits, is in-place aggregate raw material physically or chemically suited for every type of aggregate use. Every potential deposit must be tested to determine how much of its material can meet specifications for a particular use and what processing is required. Specifications for various uses of aggregate material have been established by several agencies, such as the U.S. Bureau of Reclamation, the U.S. Army Corps of Engineers, and the California Department of Transportation (Caltrans), to ensure that aggregate is satisfactory for specific uses. These agencies and other major consumers of concrete, test aggregate for acceptance by standard test procedures outlined by such organizations as the American Society for Testing Materials and the American Association of State Highway Officials.

Most aggregate specifications have been established to ensure the manufacture of strong, durable materials capable of withstanding the physical and chemical effects of weather and use. For example, specifications for Portland cement concrete and concrete products prohibit or limit the use of rock materials containing mineral substances such as gypsum, zeolites, pyrite, opal, chalcedony, chert, siliceous shale, volcanic glass, and some high-silica volcanic rocks. Gypsum lengthens the setting time of Portland cement, pyrite dissociates to yield sulfuric acid and iron oxide stain, and other substances contain silica in a form that reacts with alkali substances in the cement, resulting in cracks and "pop-outs."

Specifications also call for precise particle-size distributions in the various uses of aggregate. Aggregate is commonly classified into two general sizes: coarse aggregate and fine aggregate. Coarse aggregate is rock retained on a 3/8″ or a #4 U.S. sieve. Fine aggregate passes a 3/8″ sieve and is retained on a #200 U.S. sieve (a sieve with 200 weaves per inch). For some uses, such as asphalt paving, particle shape is specified. Caltrans' Standard Specifications (1981) require that at least 25 percent by weight of coarse aggregate (1/4 inch to 3/4 inch diameter) used as Class 2 aggregate base material shall be crushed particles. Furthermore, aggregate material used with bituminous binder to form sealing coats on road surfaces shall consist of at least 90 percent by weight of crushed particles. Crushed stone is preferable to natural gravel in asphaltic concrete because asphalt adheres better to broken surfaces than to rounded surfaces, and the interlocking of angular particles strengthens the asphaltic concrete and roadbase.

The preferred use of one aggregate material over another in construction practices depends not only on specification standards, but also on economic considerations. Alluvial gravel is preferred to crushed stone for Portland cement concrete aggregate because the rounded particles of alluvial sand and gravel result in a mix that is easier to work with than a mix composed of angular fragments. The workability of a mix consisting of Portland cement with crushed stone aggregate is improved by adding more sand and water. More cement must then be added to the mix to maintain concrete durability standards. At the present time, the additional cement amounts to about a quarter of a 94 pound sack per cubic yard of concrete at an additional cost of about $0.75 per yard of mix. Although more care is required in pouring and placing mix containing crushed stone, Portland cement concrete made with this aggregate is as satisfactory as that made with sand and gravel of comparable rock quality.

In the Sacramento-Fairfield area, PCC aggregate sells in bulk for about $4.00 per ton at the plant site (in late 1983). However, this selling price reflects only part of the costs to the consumer. Transport costs are a significant part of the final delivery price. In areas that lack nearby aggregate sources, the delivery charges alone may be greater than the sale price of the material at the plant site.

Background and Purpose

Urban expansion has been a major contributing factor to the loss of significant mineral resources in past years. In response to the problem of conflicting land use and the essential need for mineral products, the California State Legislature enacted the Surface Mining and Reclamation Act of 1975 (SMARA). SMARA requires the State Geologist to classify*, according to the presence or absence of significant mineral deposits, certain areas of the state which are subject to urban expansion or other irreversible land uses incompatible with mining. Urbanizing areas are identified by the State Office of Planning and Research (OPR). The boundaries of the areas are modified to reflect current land use through consultation with local lead agencies and selected on-site field inspection.

* *Classification* is the process of identification of lands containing significant mineral deposits based solely on geologic factors without regard for present land use or land ownership.

The State Mining and Geology Board, upon receipt of the classification information from the State Geologist, transmits the classification report to the appropriate lead agencies and makes it available to other interested parties. Upon receipt of the classification report, each lead agency must within twelve months develop and adopt mineral resource management policies to be incorporated in its general plan. These policies will:

1. Recognize the mineral classification information, including the classification maps, transmitted to it by the Board and include the classification maps in its general plan.
2. Emphasize the conservation and development of identified significant mineral deposits.

After receipt of mineral classification information from the State Geologist, the State Mining and Geology Board may designate specific geographic areas that contain mineral deposits of regional significance. Procedures for designation** of lands containing significant mineral deposits are specified in Section II.2 of the State Mining and Geology Board's "Guidelines for Classification and Designation of Mineral Lands," which is included as Part II of California Division of Mines and Geology Special Publication 51, "California Surface Mining and Reclamation Policies and Procedures" (1979). This publication is available from the Division of Mines and Geology free of charge.

The objective of the classification and designation process is to ensure, through appropriate lead agency policies and procedures, that raw material is available when needed and does not become inaccessible as a result of a lack of information during land-use decision-making actions.

The "Guidelines for Classification and Designation of Mineral Lands" were adopted by the State Mining and Geology Board on June 30, 1978. The purpose of the guidelines is to implement SMARA by providing direction to the State Geologist in carrying out mineral resource classification and to establish procedures by which the Board may designate mineral-bearing lands of statewide or regional significance. Section I.1.a of the guidelines requires that the State Geologist classify specified areas into *Mineral Resource Zones* (MRZ) or *Scientific Resource Zones* (SZ) as defined in Section I.2 of the guidelines. Although California has a wide range of mineral commodities within its borders, the Mining and Geology Board recognizes that construction materials (sand, gravel, and crushed stone) are produced regionally, are used in every urban area of the state, and require special classification data. Section I.3 of the guidelines requires that classification reports that pertain to deposits of construction materials include the following information: (1) the location and estimated total quantity of construction material that is geologically available for mining; (2) limits of the market (production-consumption) region which the potential resource would serve; and (3) an estimate of

** *Designation* is the formal recognition by the State Mining and Geology Board, after consultation with lead agencies and other interested parties, of areas containing mineral deposits of regional or statewide significance that should be considered for protection from land uses incompatible with mineral extraction. These deposits are deemed to be of prime importance in meeting the future needs of the region or the state.

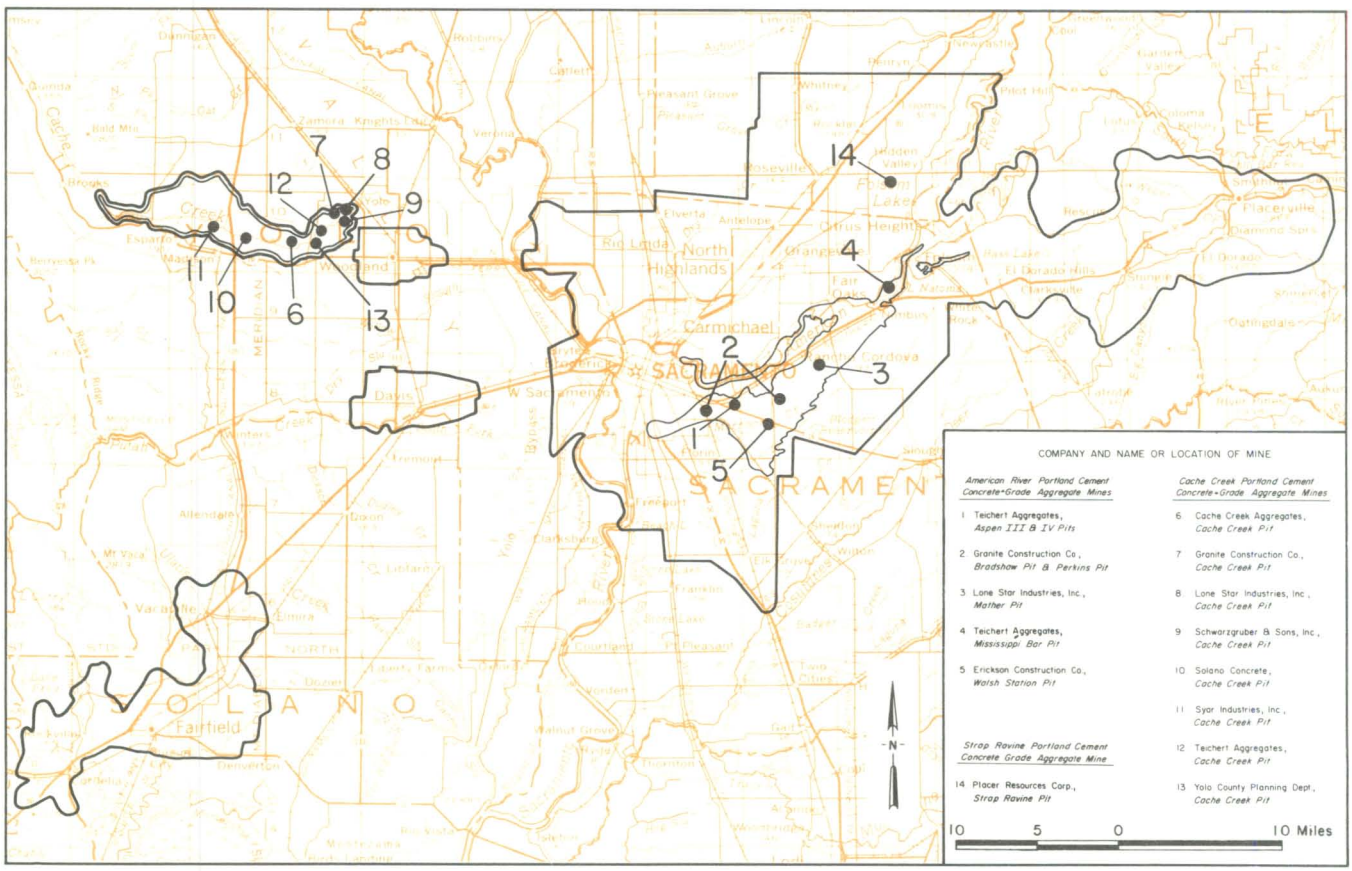


Figure 3. Map of the Sacramento-Fairfield Production-Consumption Region showing locations of currently permitted PCC-grade aggregate quarries.

the total quantity of material that will be needed to supply the requirements of the consumption region for the next 50 years. This information will assist the State Mining and Geology Board in determining the statewide or regional significance of these types of deposits.

The Mineral Land Classification of the Sacramento-Fairfield Production-Consumption Region was initiated in 1981 by the State Geologist. Included in the project area are parts of Sacramento, Solano, Yolo, El Dorado, and Placer counties. Portland cement concrete-grade aggregate resources of the area were selected for initial classification.

Each aggregate deposit was evaluated separately, and then considered as part of a single production-consumption (P-C) region established on the basis of existing aggregate consumption patterns. The Sacramento-Fairfield marketing region is served by two production districts with overlapping market regions, the Cache Creek production district and the American River production district.

DETERMINATION OF THE SACRAMENTO-FAIRFIELD P-C REGION

To evaluate the significance of a mineral resource, it is necessary to know where the mineral commodity is produced and where it is consumed. Mineral commodities like the borate produced from southern California deposits have a worldwide market area and, therefore, worldwide significance. On the other hand, low unit-value bulk commodities, such as sand and gravel and crushed stone, are marketed regionally and have a significance that is measured on a regional level.

PCC-Grade Aggregate Production Districts

The initial focus of this classification study was on the Sacramento area. The work began by defining the production-consumption (P-C) region for this large metropolitan area. Subsequently, it was learned that the aggregate needs of the Sacramento area are being met by aggregate produced in the nearby American River area and in the Cache Creek area, which lies about 25 miles west of Sacramento. These two areas were identified as the two major production districts serving the study area. (A *production district* typically contains one or more mining operations of competing companies mining from a single deposit.) A total of 16 pits were found to be producing PCC-grade aggregate in these two production districts (Figure 3).

The staff next defined the marketing areas of these two production districts (Figure 4). Transportation costs are critical in determining the marketability of an aggregate deposit and are therefore considered important in determining the common marketing area of the two production districts.

Transportation Rates

Because aggregate is a low-value, high-bulk weight commodity, a major part of the cost of aggregate to the consumer is for transportation. The increased aggregate costs to the consumer due to transport charges can be seen using Fairfield as an example. Twenty-four tons of PCC aggregate mined and processed at Cache Creek for a price of $4.00 per ton at the plant and delivered to Fairfield by truck (a distance of 45 miles) would cost the consumer a minimum of $7.66 per ton, including $3.66 per ton for transport charges. Additional labor and fuel surcharges could significantly increase the costs to the consumer. The final delivery price would be at least 90 percent more than the selling price at the plant. As a consequence of transportation costs, an important factor in determining the marketing region of an aggregate plant is the distance its product can be hauled and still be sold at a competitive price.

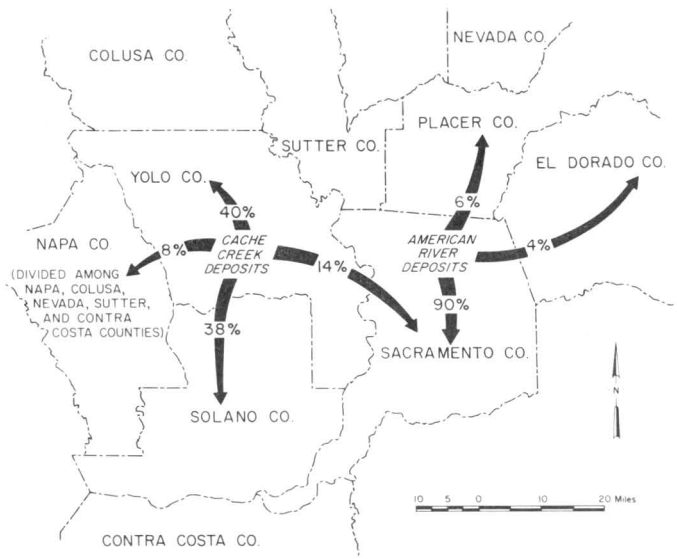


Figure 4. American River and Cache Creek aggregate marketing distribution patterns, generalized over the past decade.

Rocklin's situation provides an example of how the extent of a plant's marketing region is defined by transportation costs. In Rocklin, aggregate supplied by American River operators is in direct competition with aggregate supplied by Bear River operators. Each production area yields PCC aggregate, and each area is roughly equidistant from Rocklin. As a result, aggregate prices in Rocklin are very competitive and the precise location of the P-C region boundary is hazy and difficult to define. We have placed the boundary north of Rocklin to ensure that the P-C region incorporates an area within which at least 90 percent of the total American River production is consumed.

All aggregate marketed in the Sacramento-Fairfield P-C Region is transported by truck. Minimum rates for independent aggregate truckers are set by the California Public Utilities Commission and are called "Minimum Rate Tariffs" (MRT). These rates vary with geographic area, the number of truck axles, and whether the trucking is done on weekdays, Saturdays, Sundays, or holidays. The Minimum Rate Tariff for the study area is MRT-7A, which lists the minimum hourly rates and minimum distance rates that have been established for northern California.

For aggregate truck transport in the study area, the current minimum hourly rates established by MRT-7A range from $28.40 per hour for a two-axle truck to $35.90 per hour for a five-axle truck. MRT-7A also specifies minimum distance rates for aggregate hauling. In the Sacramento-Fairfield area, the minimum

rate for a distance of 40 miles or less is $3.25 per ton hauled. The minimum hourly rate or the minimum distance rate, whichever is larger, may be charged to the consumer. In addition to the above base rates, a 22.5 percent fuel surcharge on the cost of fuel required to deliver the aggregate to the consumer may also be applied. Truckers in the Sacramento-Fairfield area commonly charge a larger amount than specified in MRT-7A, providing the charge is mutually agreed upon by the trucker and the shipper (California Public Utilities Commission, 1979).

P-C Region Boundaries

P-C region boundaries were drawn so that they encompass all major urbanizing areas (with a population of 10,000 or more), and associated areas projected for future urbanization within the marketing areas of the American River and Cache Creek production districts.

Maps supplied by the State Office of Planning and Research (OPR) served to identify urbanized and urbanizing areas within the Sacramento-Fairfield area. These maps are part of a series issued by the Office of Planning and Research in July 1975 entitled "Urban Expansion Map of California." The generalized maps were published at a scale of 1:500,000 (1 inch equals approximately 8 miles) and show "Existing Urban - 1970" and "Projected Urban - 1990" areas.

The "existing urban" areas shown on the OPR maps represent the *urbanized* areas used as the basis for the land classification maps developed during the present study; the "projected urban" areas are the *urbanizing* areas. Because the OPR maps were produced several years ago, the boundaries shown on the maps were modified to reflect current conditions. This was accomplished by contacting local lead agencies (usually planning departments) to determine where urbanization is anticipated to occur in the next 10 to 30 years, and by on-site examination to determine where urbanization has occurred since the OPR maps were issued. The modified urban and urbanizing area boundaries are shown on Figure 5.

The P-C region boundaries were drawn to include these "urban" or "urbanizing" areas as well as a number of areas containing active aggregate mines and significant mineral deposits that lie outside of the urbanizing boundaries. These deposits were included in the P-C region because they constitute a significant part of the aggregate supply for the greater Sacramento metropolitan area.

The resulting Sacramento-Fairfield P-C Region incorporates the greater Sacramento metropolitan area, including Roseville, Placerville, Elk Grove, and West Sacramento, as well as the Fairfield-Vacaville, Davis, and Woodland areas and the Cache Creek area.

The 16 aggregate pits that produce PCC aggregate in the P-C region operate within the jurisdictional boundaries of six lead agencies (Table 1).

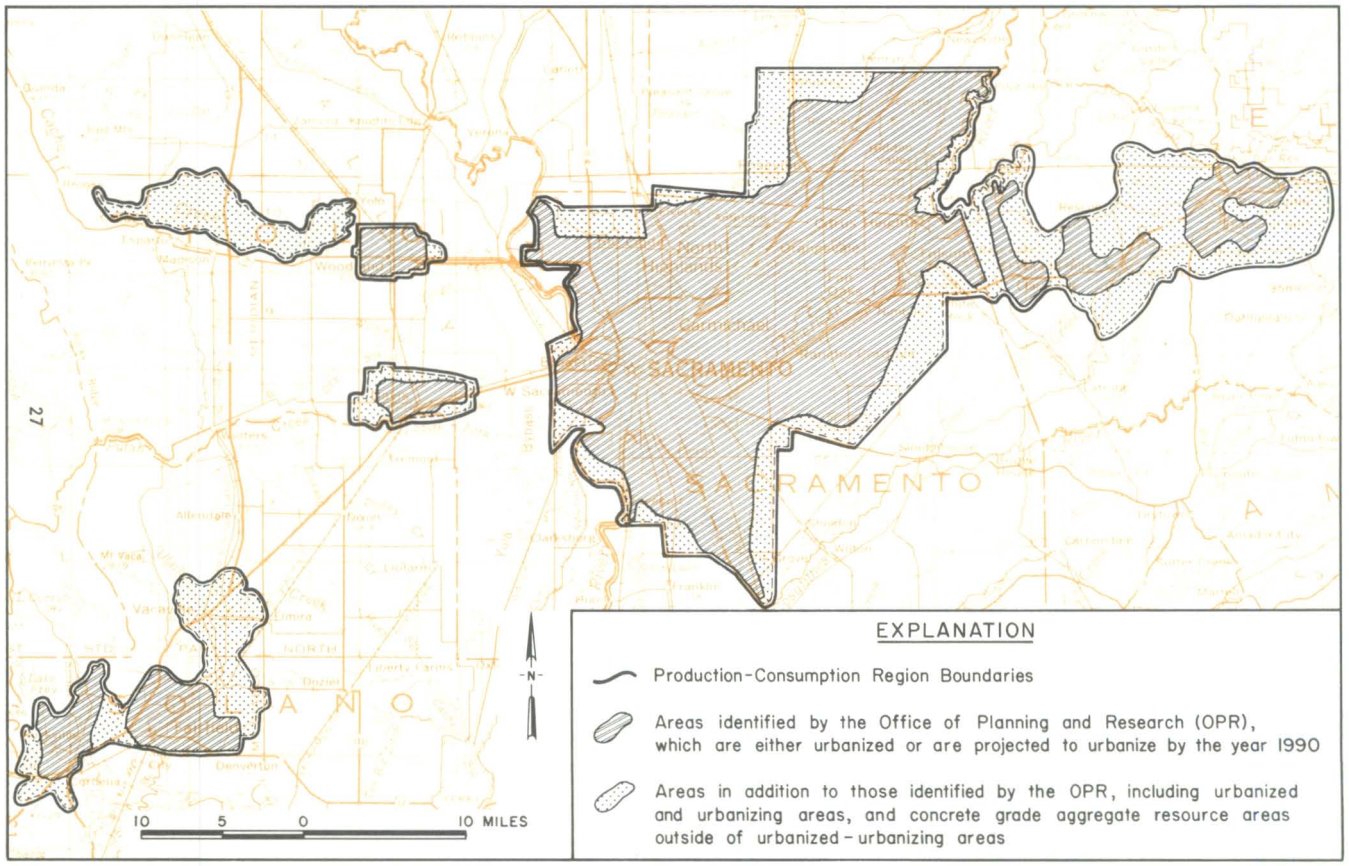


Figure 5. Urbanizing areas and urban areas of the Sacramento-Fairfield Production-Consumption Region.

ESTABLISHMENT OF MINERAL RESOURCE ZONES

The DMG has classified land in the Sacramento-Fairfield P-C Region according to the presence or absence of significant PCC-grade aggregate deposits. The land classification is presented in the form of Mineral Resource Zones (MRZ). Directions for the identification of Mineral Resource Zones are set forth in DMG's Special Publication 51 in the section entitled "Guidelines for Classification and Designation of Mineral Lands" (Division of Mines and Geology, 1979).

The guidelines for establishing the Mineral Resource Zones are as follows:

MRZ-1 Areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence. This zone shall be applied where well-developed lines of reasoning, based upon economic-geologic principles and adequate data, demonstrate that the likelihood for occurrence of significant mineral deposits is nil or slight.

MRZ-2 Areas where adequate information indicates that significant mineral deposits are present, or where it is judged that a high likelihood for their presence exists. This zone shall be applied to known mineral deposits or where well-developed lines of reasoning, based upon economic-geologic principles and adequate data, demonstrate that the likelihood for occurrence of significant mineral deposits is high.

MRZ-3 Areas containing mineral deposits, the significance of which cannot be evaluated from available data.

MRZ-4 Areas where available information is inadequate for assignment to any other Mineral Resource Zone.

Mineral Resource Zones in the Sacramento-Fairfield P-C Region are presented on 36 U.S. Geological Survey topographic maps that accompany this report (Plates 1-36). Figure 6 shows the quadrangles that cover the Sacramento-Fairfield area.

Mineral Resource Zones within the Sacramento-Fairfield P-C Region were established on the basis of an aggregate appraisal that included the following tasks for assessing the quantity, quality, and extent of the aggregate deposits:

1. Examination and compilation of relevant geologic maps, aerial photos, geologic literature, aggregate industry data (some of which is proprietary) and aggregate engineering test data.
2. Interviews with aggregate operators, company geologists, consultants, and university faculty.
3. Compilation and analysis of subsurface well-log data and drilling records.
4. Field investigation of active and depleted aggregate quarries.
5. Field investigations combined with a petrologic examination of untested surficial aggregate deposits.

In this study, an understanding of geologic formations was particularly helpful in the delineation of MRZ, because most alluvial formations in the Sacramento-Fairfield area are similar in lithology throughout their extent. In some instances, however, physical differences in rocks within a formation made it necessary to assign more than one MRZ category to a single formation. An example of this is provided in the classification of the Riverbank Formation. Most of the PCC-grade aggregate produced in Sacramento County comes from this formation; however, it does

TABLE 1. Lead agencies located within the boundaries of the Sacramento-Fairfield P-C Region.

AGENCIES	
COUNTIES	CITIES
El Dorado	Placerville
Placer*	Lincoln Rocklin Roseville*
Sacramento*	Folsom* Sacramento*
Solano	Fairfield Vacaville Suisun
Yolo*	Woodland Davis

* Lead agencies within the Sacramento-Fairfield P-C area that contain aggregate which meets Portland cement concrete specifications.

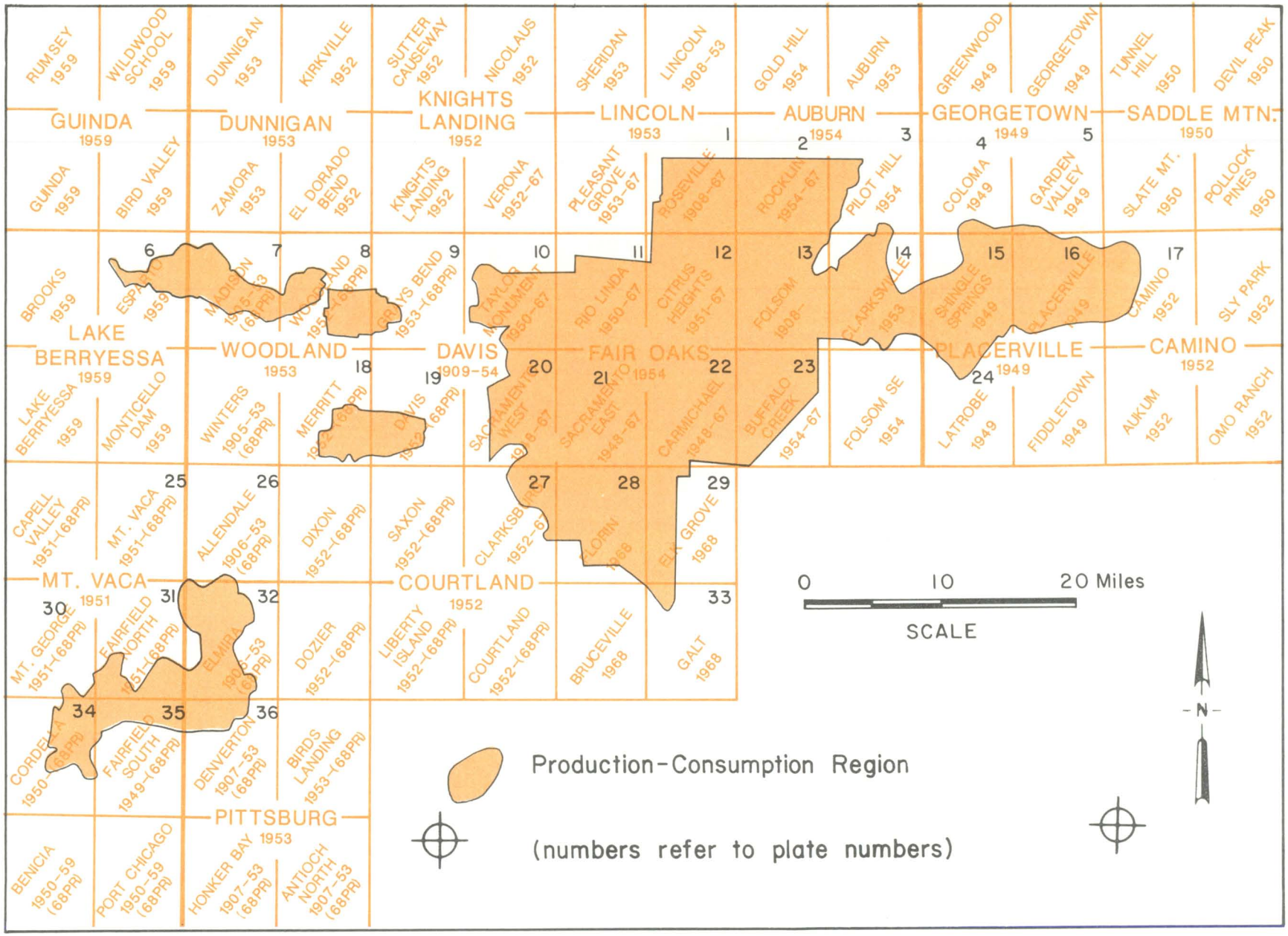


Figure 6. Index map of the U.S. Geological Survey quadrangles covering the Sacramento-Fairfield Production-Consumption Region.

not contain consistently high-grade aggregate throughout its extent. In some areas, the presence of friable rock, clay lenses, and excessive amounts of silica-iron cemented hardpan results in rock that does not meet PCC aggregate specifications. Because of major lithologic changes within the formation, some parts of the Riverbank Formation have been classified MRZ-1, other parts MRZ-2, and still other parts MRZ-3.

Areas Classified as MRZ-1

Areas classified as MRZ-1 were judged on the basis of available data to have little likelihood of containing significant deposits of PCC-grade aggregate. Deposits that have excessive amounts of clay, silt, organic matter, absorptive rock, alkali-reactive rock, platy rock, or soft rock are unsuitable for use in PCC aggregate; areas containing such deposits are classified MRZ-1. Most areas in the Sacramento-Fairfield P-C Region that are classified as MRZ-1 are underlain by alluvial material judged to contain too much clay, silt, and decomposed rock for use as aggregate in concrete.

Areas Classified as MRZ-2

Four areas within the Sacramento-Fairfield P-C Region are classified MRZ-2 (see Figure 7). These are areas for which data indicate that there is a high likelihood that significant deposits of PCC-grade aggregate exist.

SMARA guidelines set forth two requirements to be used to determine if land should be classified MRZ-2:

1. The deposit must be composed of material that is suitable as a marketable commodity.
2. The deposit must meet threshold value. The projected value (gross selling price) of the deposit, based on the value of the first marketable product, must be at least $6,700,000 (5 million 1978 dollars).

Areas classified MRZ-2 in the Sacramento-Fairfield P-C Region are underlain by Cenozoic river channel and floodplain deposits. These deposits are the primary source of PCC aggregate production in the P-C region.

The MRZ-2 alluvial deposits within the Sacramento-Fairfield P-C Region were formed during the Quaternary and Tertiary periods when mountain streams carried large volumes of sand, gravel, and cobbles into the Sacramento Valley. The abrupt decrease in slope gradient as streams entered the flat valley caused a decrease in stream transporting energy which resulted in sediment deposition, and the creation of alluvial fans. This is a normal fluvial transport process and includes periods of high stream energy during periodic flood stages.

Areas classified MRZ-2 contain aggregate resources that either are proven PCC-grade or have a high likelihood to be PCC-grade aggregate. Much of the aggregate in the MRZ-2 areas has not been identified as PCC-grade aggregate through formal engineering tests. Aggregate deposits in untested, unproven areas identified as MRZ-2 are believed to contain PCC-grade aggregate for the following reasons:

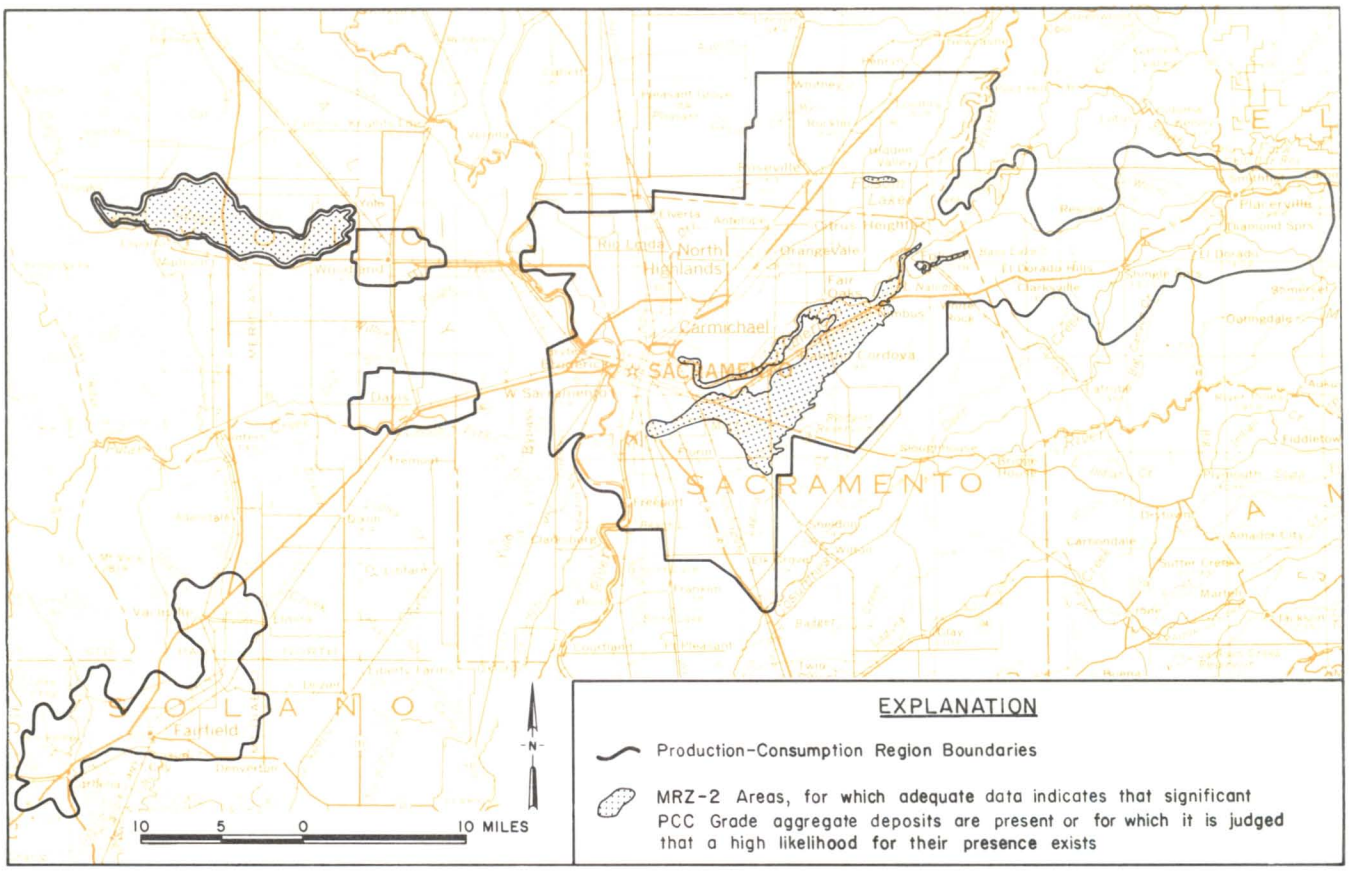


Figure 7. Map showing MRZ-2 areas in the study region.

- The aggregate in unproven areas is similar in age and lithology, and was deposited under similar geologic conditions, as that of the proven PCC aggregate.
- Extrapolation as a basis for determining the PCC quality of an unproven deposit was used only when the unproven deposit was a lateral extension of an alluvial formation from which PCC aggregate had been produced.

CACHE CREEK DEPOSITS

The Cache Creek MRZ-2 area extends along Cache Creek from the town of Capay to the town of Yolo as shown on Figure 7. Eight aggregate companies currently have permits to mine in this area (see Figure 3).

The Cache Creek MRZ-2 deposits consist of alluvium derived from the Coast Ranges to the northwest. This alluvium is predominantly composed of interbedded lenses of metamorphic and sedimentary rock fragments. The median clast size along the active Cache Creek channel is roughly 3/8″. Nearly all of the channel aggregate is minus 3″ in size.[1] Floodplain deposits found at depth throughout the area contain clay and silt deposited as the creek periodically overflowed its banks. All of the PCC-grade aggregate mined from these MRZ-2 deposits come from Quaternary river channel deposits. Unproven terrace deposits that are located away from the active Cache Creek channel are mantled and interlayered at depth by deleterious floodplain clay and silt. Qualitative test data concerning these older terrace deposits are not available; however, they have been classified MRZ-2 because the following evidence strongly suggests that these buried terrace deposits contain PCC-grade aggregate:

- In general, the farther away the aggregate deposit is from the active Cache Creek channel, the older the aggregate is and the more probable that weathering processes have diminished the quality. The existing MRZ-2 Cache Creek deposits are believed to contain rock clasts that are young enough to have avoided extensive in-place weathering.
- The proven PCC-grade deposits located near the active Cache Creek channel and the unproven, untested, older terrace deposits were deposited under similar geologic conditions.
- Field observations indicate that thick aggregate strata within the lower Cache Creek basin are laterally continuous. Strata containing unproven aggregate resources — located in older terraces away from the Cache Creek channel — appear to be lateral extensions of strata near the Cache Creek channel that contain proven PCC-grade aggregate.
- The proven PCC-grade aggregate material along the active Cache Creek channel and the older, unproven, untested MRZ-2 aggregate resources have a common source area.
- Through field examinations, the lithology and character of proven PCC aggregate appear to be similar to the lithology and character of the unproven off-channel aggregate terrace deposits that have been classified MRZ-2.

AMERICAN RIVER DEPOSITS

American River PCC-grade aggregate deposits are present in three MRZ-2 areas north, south, and east of the Sacramento metropolitan region as shown on Figure 7. Four aggregate companies currently have permits to mine in seven localities within the large MRZ-2 area south of the American River (see Figure 3).

All the PCC-grade aggregate in the MRZ-2 deposits comes from the Riverbank Formation, the Modesto Formation, Holocene river channel deposits, and durable dredge tailings. These units were all derived from the Sierra Nevada Range to the east and are predominantly composed of interbedded lenses of granitic and metamorphic rock clasts.

Areas in the American River region were classified MRZ-2 if they met the following criteria:

1. The area had been tested and proven to contain minable PCC-grade aggregate; or
2. The area had not been tested and proven to contain minable PCC-grade aggregate, but:
   - The deposits contain aggregate material that was formed under depositional conditions similar to those of proven PCC-grade aggregate deposits in a nearby tested area. The similarity of depositional conditions is confirmed by evidence of ages of deposition, lithologies, and river depositional patterns.
   - The deposits contain materials which petrologically prove to have engineering and textural characteristics similar to those of proven PCC-grade aggregate in nearby areas.
   - The deposits are composed of aggregate which was deposited during the last 1 million years or so. Material deposited during this time span has not undergone extensive in-place weathering.

Riverbank and Modesto Formations.

The Riverbank and Modesto formations are major geologic units in the broad mid-Pleistocene alluvial plain known as the Victor Plain. This broad plain of low relief occupies the central portion of Sacramento County from Elk Grove north to the Sacramento-Placer County line. Throughout the Pleistocene, the ancestral American River has progressively advanced northwest to its present position. Frequently shifting its course, the American River cut across the Victor Plain and produced a maze of truncated buried channels that are laterally and vertically discontinuous. As the ancestral American River migrated north, it left progressively older, stranded alluvial terraces to the south of the present American River channel (Shlemon, 1967). Subsequent erosion has reworked and smoothed these slightly elevated terraces of low relief. Although the Riverbank and Modesto formations contain large deposits of PCC-grade aggregate, not all the material within these formations is of PCC quality. Delineation of PCC-grade aggregate within untested areas of these formations was based upon extrapolation of available geologic information, well-log records, producer records and interviews. Aggregate sizes in the undisturbed portions of the Riverbank and Modesto formations vary from 20 to 25 percent fine aggregate and 75 to 80 percent coarse aggregate by volume. Only that part of the Riverbank and Modesto formations south of the American River and north of Gerber Road has been classified MRZ-2.

Holocene River Channel Deposits.

Holocene river channel deposits that lie within the present bed of the American River have been classified MRZ-2. These deposits are similar in character to sediments of the Riverbank Formation. Aggregate in these deposits grade from nearly 90 percent fine aggregate in the western area to about 40 percent fine aggregate in the eastern area.

1. Klein, I.E. and Goldman, H.B., 1958, Sand and gravel resources of Cache Creek, Yolo County, California: California Journal of Mines and Geology, vol. 54, no. 2.

Dredge Tailings.

Durable dredge tailings derived from Holocene channel deposits, and the Modesto and Riverbank formations have been classified MRZ-2. Gold dredges operated intermittently in the lower American River area from 1878 to 1962. Of the 27 square miles of dredge tailings in the Sacramento-Folsom area, only a few square miles have been classified MRZ-2. This is because the quality of the dredge tailings is unpredictable. The dredging operations were not restricted to any specific geologic formation but wandered about the Sacramento-Folsom area following the auriferous gravels to depths as great as 90 feet. As a consequence of these operations, high quality aggregate in the Riverbank and Modesto formations was commonly blended to varying degrees with older, poor-quality aggregate of underlying formations. Only areas in which dredge tailings are currently being mined for PCC-grade aggregate, areas where the geologic data indicates that there is a high likelihood for the existence of PCC-grade aggregate, or areas for which reliable tests indicate that tailings meet PCC specifications are classified MRZ-2.

STRAP RAVINE DEPOSIT

The Strap Ravine MRZ-2 area is located just east of Roseville in Placer County (see Plate 38). Placer Resources Corporation has a permit to mine in this area.

The Strap Ravine MRZ-2 deposit consists of Tertiary arkosic sand and gravel derived from the quartz-diorite Rocklin pluton. This alluvium lies in a shallow, gently westward-dipping ravine cut into the Rocklin pluton. Approximately 70 percent of the Strap Ravine alluvium is fine aggregate. Most of the Strap Ravine deposit was dredged for gold from 1934 to 1942. The dredged material averages about 20 to 25 feet in thickness.

Areas Classified as MRZ-3

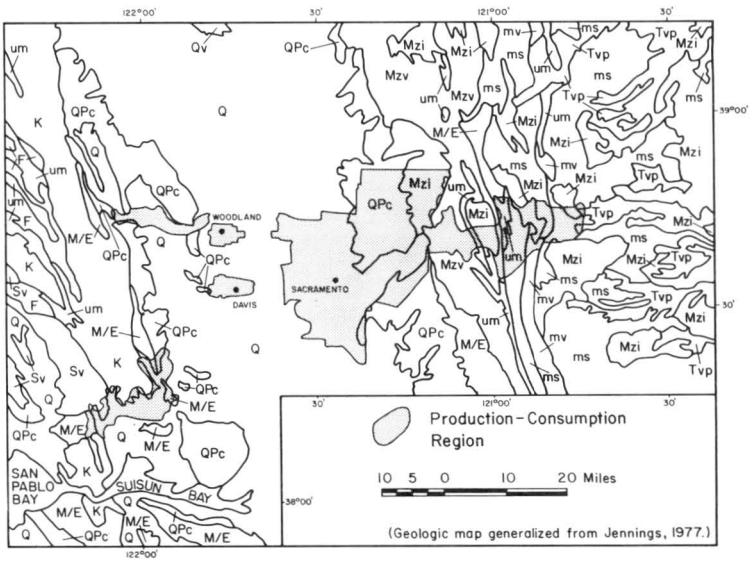
Areas classified as MRZ-3 are those containing aggregate deposits, the significance of which cannot be evaluated from available data. Sedimentary, metamorphic, and igneous rock types are included in this category. Positive indications in the geologic literature and petrologic field examination that shows a rock unit to contain abundant, hard, durable material without excessive amounts of deleterious materials are necessary for a rock unit to be considered a suitable candidate for an MRZ-3 classification. Additional information regarding the quality of material in these areas could either upgrade the classification to MRZ-2 or downgrade the classification to MRZ-1. Many of the areas classified as MRZ-3 are located in hilly or mountainous terrain. These areas include rocks of the Sonoma Volcanics, Putnam Peak Basalt, and the Great Valley Sequence, all of which are located in the Fairfield-Vacaville area; and volcanic rocks, metamorphic rocks, and granodioritic rocks which are located in the Sacramento-Placerville area. Other MRZ-3 areas are located in the Sacramento Valley and are composed of Tertiary alluvial sediments. Stratigraphic relationships of these units are shown on Figures 8-11.

Areas Classified as MRZ-4

Areas classified MRZ-4 are those areas for which available information is lacking or incomplete for assignment into the other MRZ categories. Areas classified MRZ-4 in the Sacramento-Fairfield P-C Region are areas where thick overlying soil layers offer poor rock exposures or are areas where the accessibility is poor, and for which available geologic data is incomplete.

Ultramafic rocks trending northeast to southwest in the Sierra Nevada foothills contain MRZ-4 areas overlying highly altered, badly fractured serpentine bodies that would normally be classified MRZ-1. Other ultramafic rock areas classified MRZ-4 contain massive, quite durable bodies of greenstone, periodotite, and serpentine that would normally be classified MRZ-3. However, the available geologic maps do not distinguish the massive from the fractured rock units. As a consequence, all ultramafic bodies are classified MRZ-4.

Other areas classified MRZ-4 include Quaternary landslide deposits in the hilly terrain of the Fairfield-Vacaville area. These deposits vary greatly in thickness and areal extent, commonly concealing many acres of underlying rock, the physical properties of which have not been determined.



		SEDIMENTARY ROCKS	VOLCANIC ROCKS	PLUTONIC ROCKS
CENOZOIC	QUATERNARY	Q, Alluvium, stream, terrace deposits, unconsolidated marine and non-marine sediments.	Qv, Sutter Buttes, composed of volcanic and pyroclastic rocks.	
		QPc, Pliocene and Pleistocene sandstone, shale and conglomerate deposits, loosely consolidated.		
	TERTIARY		Sv, Sonoma Volcanics, volcanic flows and pyroclastic deposits.	
		M/E, Miocene and Eocene age shale, sandstone, conglomerate and minor limestone deposits.		
			Tvp, Tertiary pyroclastic and volcanic mudflow deposits.	
PALEOZOIC MESOZOIC		K, Great Valley Sequence, rocks of marine sandstone, shale and conglomerate.	Mzv, Undivided Mesozoic volcanic and metavolcanic rocks. Andesite, rhyolite, greenstone and volcanic breccia is strongly metamorphosed in the Production-Consumption Region.	Mzi, Mesozoic granite, granodiorite, gabbro and diorite.
		F, Franciscan Complex, Cretaceous and Jurassic age sandstone, shale, chert and conglomerate.		um, Ultramafic rocks, includes mostly serpentine with minor inclusions of peridotite, diabase and gabbro.
			mv, Undivided metavolcanic rocks of Pre-Cretaceous age. Includes greenstone tuff and dacite. Strongly metamorphosed.	
		ms, Metasediments, includes slate, shale, sandstone, conglomerate, chert, phyllite, schist and quartzite. Mesozoic to Paleozoic in age.		

Figure 8. Generalized geology of the Sacramento-Fairfield Production-Consumption Region.

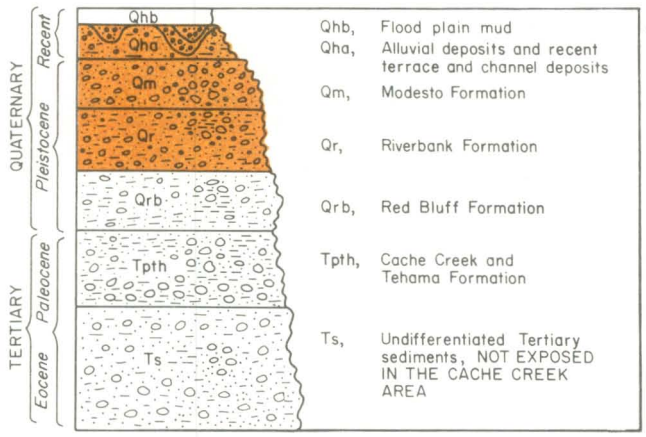


Figure 9. Generalized columnar section of the Cache Creek study area.

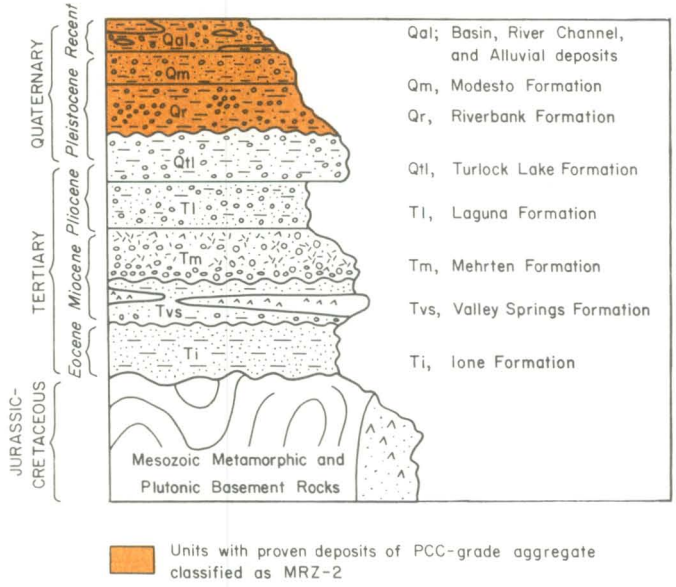


Figure 10. Generalized columnar section of the Sacramento study area.

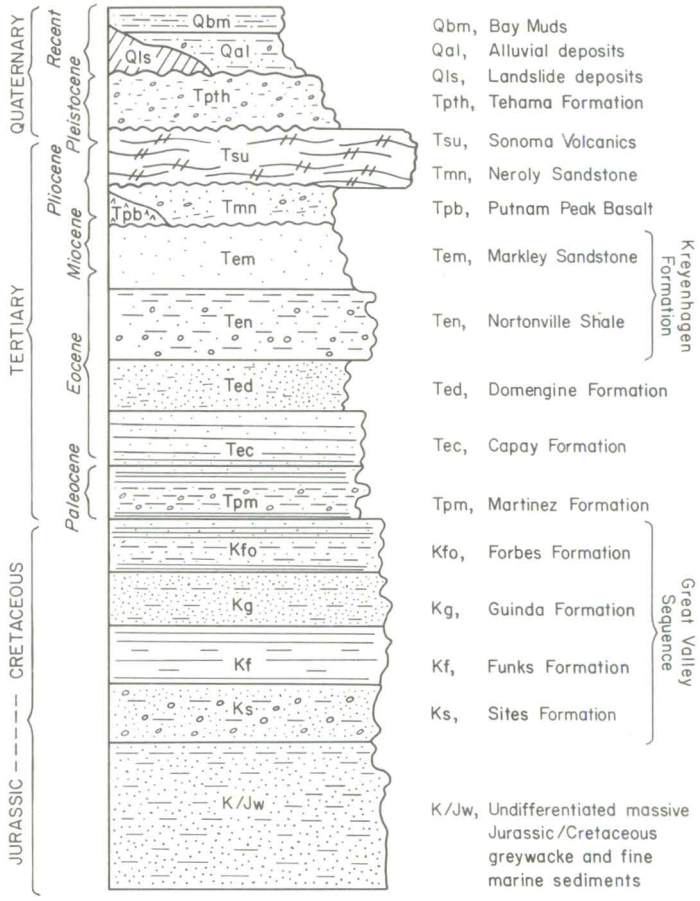


Figure 11. Generalized columnar section of the Fairfield study area.

EVALUATION OF PCC AGGREGATE IN THE SACRAMENTO-FAIRFIELD P-C REGION

An assessment of aggregate resources in the Sacramento-Fairfield P-C Region is presented in this section of the report. The assessment was conducted on the basis of a quantitative evaluation of available economically minable aggregate resources classified MRZ-2.

Concepts Used in Identifying Available Aggregate Resource Areas

The State Geologist is responsible for calculating aggregate resources for those areas classified as MRZ-2. Recognizing that there are lands within MRZ-2 areas that have already been urbanized and that therefore have a limited opportunity for mineral resource conservation and extraction, the State Geologist has limited the calculation of aggregate resource tonnages to portions of MRZ-2 areas that have not been urbanized.

For purposes of classification, incompatible uses are urbanized lands containing improvements of high cost, such as high-density residential developments, intensive industrial developments, commercial developments, and major public facilities (see Appendix 1, Interim Criteria for Sectorization of MRZ-2 Areas for Aggregate). Compatible uses are nonurbanized land comprised of very low density residential land (approximately one unit or less per ten acres), recreational land that does not have high-cost improvements, agricultural land, silvicultural land, grazing land, and open space.

For this report, the determination of which MRZ-2 land is nonurbanized was based upon conditions of the land at the time of the study (February 1982 through November 1983). The use of the land was determined by the author after consultations with lead agencies, reference to aerial photographs and photo-revised topographic maps, and field reconnaissance.

SECTORS

Sectors are areas that have been classified as MRZ-2 by the State Geologist, and that are deemed to be available for mining based upon criteria for availability provided by the State Mining and Geology Board.

A sector is an area within which the geometrical configuration of the deposit is sufficiently regular to permit reliable calculation of the tonnage of the mineral resource present. For example, sector boundaries would be established between that part of a natural deposit formed on a fan, and that part within the confines of an adjacent modern stream channel and its floodplain. Mineral land classification, which is done without regard for current land use, results in a delineation of the resource areas on maps, but this by itself does very little to put into perspective the resource base that is available to meet the future needs of a region. Sectors have been employed to focus the attention of land planners and local governments on just those areas that remain accessible for mineral extraction. The State Geologist calculates the available resources of each sector and identifies the amount of remaining resources that have been permitted for mining. These latter resources are termed reserves. The resources present in other (non-sectorized) MRZ-2 resource areas are not calculated because they are regarded as unavailable.

The calculated reserves and resources of all the sectors of a region are compared with the State Geologist's forecast of the 50-year needs of a region for the mineral resources. The comparison of regional needs with the available reserves and resources provides the opportunity to focus attention on the mineral resource issues confronting the region; *viz.* the need to plan carefully for the use of any lands containing mineral resources, and the need to consider the permitting of additional mining operations in the region as currently mined deposits are depleted.

Each sector meets or exceeds the Board's threshold values for deposits of significant size, and each sector may be considered for designation as an area of regional or statewide significance by the State Mining and Geology Board pursuant to Section 2790 SMARA. Areas that have not been sectorized by the State Geologist are not considered for designation by the Board.

Although the classification by the State Geologist and the designation by the Board are actions explicitly provided for by SMARA, and although the results of such actions yield reports that must be acted upon by affected local governments, the sectorization and sector maps do not of themselves carry with them specific obligations imposed on local governments by SMARA.

The sector maps and the resource base calculations, however, contain the essential facts that are needed to focus the attention of planners on the mineral availability problems and the alternative solutions to meet the mineral resource needs of the region. Without the sector maps and the accompanying calculations, the primary objectives of SMARA could not be achieved.

Because the Board's criteria for sectorization focus on the apparent suitability of the land for mining and do not take into account commitments that may have been made to restrict the accessibility of some of the sectors for mining, it is possible that the available resource base as calculated by the State Geologist may be overestimated and the problems confronting local government may be understated. Considering these possibilities, it becomes important for local governments to carefully review the sectors and the associated estimates of resources to ensure that previously unrevealed problems are not overlooked and that planning decisions are made using a correct perspective on available resources.

RESOURCE SECTORS WITHIN PARKS

Dedicated parklands are recognized as having special status. Resource sectors within parks have therefore been treated as a special class of sectors, and the quantifications of the resources in them are presented separately in Table 4.

Calculation of Available Resources

RESERVES AND RESOURCES

In this report, *reserves* are estimates of tonnages of aggregate that have been determined to be acceptable for commercial use, that exist within properties owned or leased by aggregate producing companies, and for which permits have been granted to allow mining and processing of the material. *Resources* include *reserves* as well as all similar potentially usable aggregate materials that may be mined in the future, but for which no permit allowing mining has been granted, or for which marketability has not been established.

FACTORS CONSIDERED IN CALCULATIONS

The resource estimates given here are limited to those PCC-grade aggregate resources present in resource sectors, which are, as explained in the previous section, the nonurbanized portions of the areas classified MRZ-2. The 13 resource sectors defined in this study are shown on the sector maps (Plates 37, 38 and 39) that accompany this report. The sectors are identified by the letters A through M on the sector maps and in the sector descriptions that follow.

The following factors were used to determine the areal extent and tonnage of PCC-grade aggregate resources within the 13 sectors.

1. Sector resource tonnage estimates were based on measurements taken from base maps that have a scale of 1:24,000.
2. Even in proven PCC-grade aggregate deposits, a small percentage of the aggregate cannot be used in concrete and is referred to in this study as "waste." Waste includes pit-run waste and production waste. The waste factors for untested sector areas were estimated using data from water-well logs and idealized cross sections. Known waste percentages were often extrapolated to deposits in untested sector areas from proven, nearby PCC-grade deposits.
3. Thicknesses of PCC-grade deposits were determined by water-well log data, geologic literature and interviews with knowledgeable aggregate professionals.
4. Setback considerations, adopted from lead agency mining ordinances, were used in determining the areal limits of sectors that border areas not available for mining.

In the following sector descriptions, each sector is identified by a letter. Many sectors are subdivided into numbered subsectors to recognize differences in geology and the county mining ordinance setbacks from existing freeways, canals, bridges, dams, major powerlines, and major pipelines. These criteria allowed for the calculation of more realistic resource tonnages.

Resource Sector Descriptions

The total area of the resource sectors in the Sacramento-Fairfield P-C Region is 43 square miles, of which, about 7.9 square miles are currently permitted for mining and 6.2 square miles are within dedicated parklands. The aggregate resources in these sectors consist of Tertiary and Quaternary alluvial sediments. Inasmuch as these sectors are MRZ-2 areas, they are either areas where proven PCC-grade aggregate resources are known to exist or areas where there is a high likelihood that PCC-grade aggregate resources exist. The estimated total of PCC-grade aggregate resources in these sectors is 1.2 billion tons (136 million of which is in dedicated parklands). As of November 1982, 97 million tons of these resources qualified as reserves.

The resource sectors are described below in the following order. The sectors in the Cache Creek Area (Sectors A through D) are described first. They are followed by the sectors in the American River area (Sectors E through L) and the Strap Ravine area (Sector M). The sectors that are in parklands along the American River (Sectors J, K, and L) are treated under a separate heading following the descriptions of the other American River sectors.

CACHE CREEK SECTORS

Four sectors in the lower Cache Creek basin (see Plate 37) contain deposits of PCC-grade aggregate. These four sectors together cover a total of 27 square miles. Past and current mining operations have been limited to areas in and bordering the active Cache Creek

TABLE 2. Cache Creek resource calculations; Sectors A through D.

GENERAL FORMULA USED TO CALCULATE AGGREGATE TONNAGES

Total Sector Tonnage = # Acres per Sector x Minable Aggregate Thickness in Feet x Percentage of Usable Aggregate Minus Waste x Density* in Tons per Acre-Foot

Density* = $\frac{43{,}560\ ft^2}{acre} \times \frac{1\ yard^3}{27\ ft^3} \times \frac{1.65\ tons}{yard^3} = \frac{2662\ tons}{acre\text{-}foot}$

SECTOR	AREA IN ACRES		MINABLE AGGREGATE THICKNESS		PERCENTAGE OF USABLE AGGREGATE MINUS WASTE		DENSITY IN TONS PER ACRE-FOOT		TONNAGE (ROUNDED TO 100,000 TONS)
A									
A-1	752	x	15′	x	80%	x	2662	=	24,000,000
A-2*	3,828	x	30′	x	80%	x	2662	=	244,600,000
A-2**	1,130	x	8′	x	80%	x	2662	=	19,300,000
A-3	224	x	20′	x	75%	x	2662	=	8,900,000
A-4	70	x	20′	x	75%	x	2662	=	2,800,000
TOTAL	6,004								299,600,000
B									
B-1	811	x	30′	x	75%	x	2662	=	48,600,000
B-2	1,340	x	30′	x	75%	x	2662	=	80,300,000
B-3	79	x	25′	x	75%	x	2662	=	3,900,000
B-4	145	x	25′	x	75%	x	2662	=	7,200,000
B-5	79	x	25′	x	75%	x	2662	=	3,900,000
B-6	633	x	30′	x	75%	x	2662	=	37,900,000
B-7	372	x	15′	x	75%	x	2662	=	11,100,000
TOTAL	3,459								192,900,000
C	3,207	x	30′	x	75%	x	2662	=	192,100,000
C**	299	x	3′	x	75%	x	2662	=	1,800,000
TOTAL	3,506								193,900,000
D									
D-1*	12	x	10′	x	80%	x	2662	=	300,000
D-1**	615	x	2′	x	80%	x	2662	=	2,600,000
D-2*	2,693	x	25′	x	75%	x	2662	=	134,400,000
D-2**	748	x	4′	x	75%	x	2662	=	6,000,000
D-3	53	x	25′	x	75%	x	2662	=	2,600,000
D-4	112	x	25′	x	75%	x	2662	=	5,600,000
TOTAL	4,233								151,500,000

TOTAL ALL CACHE CREEK SECTORIZED AREAS A-D = 17,202 Acres or 26.9 sq. mi.

TOTAL ALL CACHE CREEK PCC RESOURCES = 837,900,000 TONS

* outside legal Cache Creek channel ** within legal Cache Creek channel

channel. Formal aggregate engineering tests conducted in the channel areas prove the aggregate mined meets and exceeds PCC specifications. Seven operators process PCC aggregate from sectors A, C, and D (see Plate 37 for operator names and pit locations). The Yolo County Mining Ordinance (Chapter 3 of Title 10, Yolo County Code) prohibits mining below the theoretical thalweg within the legally defined channel of Cache Creek. This prohibition eliminates 110,800,000 tons of otherwise available PCC-grade aggregate resources from consideration in sectors A-2, C, D-1, and D-2. Resource sector tonnages cited herein reflect the requirements of the Yolo County Code and do not include material below the theoretical thalweg. As of November 1982, the estimated total tonnage of PCC aggregate resources in the four Cache Creek sectors is 838 million tons (Table 2), of which 40 million tons qualify as reserves. Specific reserve totals on a sector-by-sector basis are not listed for this production district to avoid revealing proprietary data.

A density of 2,662 tons/acre-foot (1.65 tons/cubic yard) was used to calculate all of the aggregate resources in the Cache Creek sectors. This density figure was determined by averaging density figures reported by seven aggregate operators along Cache Creek.

Waste percentages by volume vary from sector to sector and in some cases from subsector to subsector. Sectors within the Cache Creek channel have a much smaller percentage of waste than do sectors away from the active channel. Stream-flow action has washed away much of the clay and silt in the active channel. In contrast, sectors away from the channel commonly contain a high percentage of floodplain clay and silt. When this percentage of clay and silt exceeds 25 percent by volume (pit-run waste) in the Cache Creek area, the deposit no longer qualifies for MRZ-2 classification, and hence is not sectorized.

Sector A

Sector A consists of 6,004 acres (of which 1,130 acres are within the legally defined Cache Creek channel) at the southern end of Capay Valley where Cache Creek enters the Sacramento Valley and deposits alluvium on top of Pliocene sedimentary rocks. Average minable aggregate thickness ranges from 8 feet to 30 feet. Estimated waste varies from 20 to 25 percent by volume. The estimated total of PCC-grade resources in Sector A is 299,600,000 tons.

A-1: Subsector A-1 consists of 752 acres along the creek channel. Exposed aggregate bars are common in this subsector. Water-well log data show that minable aggregate occurs to a maximum depth of 17 feet. An average minable aggregate thickness of 15 feet and a waste factor of 20 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector A-1 is Quaternary alluvium. The estimated total PCC resource is 24,000,000 tons.

A-2: Subsector A-2 consists of 4,958 acres along and adjacent to the Cache Creek channel; 1130 acres of this subsector are within the legally defined Cache Creek channel. This subsector is bordered on the east by the Interstate 505 freeway. In subsector areas along the active channel, proven PCC-grade aggregate exceeds 50 feet in thickness but only 8 feet lie above the theoretical thalweg. Large exposed bars of aggregate are found along Cache Creek in this subsector. Well-log data indicate that between 20 and 55 feet of minable aggregate lies beneath 10 to 15 feet of soil and clay overburden in areas away from the active channel. An average minable aggregate thickness of 30 feet (3 feet within the legal channel) and an average waste factor of 20 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector A-2 is Quaternary alluvium. Syar Industries is currently mining PCC aggregate in this subsector. The estimated total PCC aggregate resource is 263,900,000 tons.

A-3: Subsector A-3 consists of 224 acres. Well-log data indicate that a clay-soil mantle up to 15 feet thick caps an estimated 20 feet of minable aggregate. An average minable aggregate thickness of 20 feet and a 25 percent waste factor were used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector A-3 is Quaternary alluvium. The estimated total PCC aggregate resource is 8,900,000 tons.

A-4: Subsector A-4 consists of 70 acres that lie to the south of the Winters Canal. A 12- to 18-foot thick, soil-clay overburden layer blankets an estimated 20-foot thickness of minable aggregate in this subsector. An estimated waste factor of 25 percent was used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector A-4 is Pleistocene alluvium. The estimated total PCC aggregate resource is 2,800,000 tons.

Sector B

Sector B consists of 3,459 acres and lies just to the north of and parallel to Cache Creek along a 6-mile long belt that is roughly a mile wide. Well-log data extrapolated from nearby areas is adequate for resource calculations in Sector B. Average minable aggregate ranges from 15 feet to 30 feet in thickness. Waste is estimated at 25 percent by volume. The estimated total PCC-grade aggregate resource in Sector B is 192,900,000 tons.

B-1 & B-2:
Subsector B-1 consists of 811 acres and subsector B-2 consists of 1,340 acres. Available well-log data indicate that within these subsectors the thickness of soil/clay overburden ranges from 4 feet to 32 feet. Minable aggregate thickness ranges from about 20 to 50 feet. An estimated average minable aggregate thickness of 30 feet and an average waste factor of 25 percent were used to calculate the total tonnage of PCC-grade aggregate in each subsector. All the minable aggregate in Subsectors B-1 and B-2 is Quaternary alluvium. The estimated total PCC resource in Subsector B-1 is 48,600,000 tons and the estimated total PCC resource for Subsector B-2 is 80,300,000 tons.

B-3, B-4, & B-5:
Subsectors B-3, B-4, and B-5 combined cover only 303 acres and are clustered in a relatively small area just to the north of Cache Creek near Interstate 505. Well-log data indicate that the soil-clay overburden thickness varies from 7 feet to 12 feet and that the minable aggregate thickness varies from 20 feet to 60 feet. An average minable aggregate thickness of 25 feet and an average waste factor of 25 percent were used to calculate the total tonnage of PCC-grade aggregate in each area. All the minable aggregate in Subsectors B-3, B-4, and B-5 is Quaternary alluvium. The estimated PCC resource for Subsector B-3 is 3,900,000 tons; for Subsector B-4 is 7,200,000 tons; and for Subsector B-5 is 3,900,000 tons.

B-6: Subsector B-6 consists of 633 acres. Data from water-well logs in this subsector indicate that approximately 20 feet of clay and soil overburden cover the aggregate. An estimated average minable thickness of 30 feet and an average waste factor of 25 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector B-6 is Pleistocene alluvium. The estimated total PCC aggregate resource is 37,900,000 tons.

B-7: Subsector B-7 consists of 372 acres. Based on the available water-well log data for this subsector, it is believed that the minable aggregate is overlain by a layer of soil and clay 6 to 15 feet thick. An estimated average minable aggregate thickness of 15 feet and an average estimated waste factor of 25 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector B-7 is Pleistocene alluvium. The estimated total PCC aggregate resource is 11,100,000 tons.

Sector C

Sector C consists of 3,506 acres (of which 299 acres are within the legally defined Cache Creek channel) bordered on the west by the Interstate Highway 505 and on the east by Weggers Airport. Abundant aggregate test data, good quarry exposures, and well-log records provide a high confidence level for the aggregate resource tonnage estimate in Sector C. The aggregate is covered by a variable thickness of overburden that ranges from naught to 27 feet. Lenses of deleterious floodplain deposits of clay and silt are common in the aggregate. An average minable aggregate thickness of 30 feet (3 feet within the legal channel above the theoretical thalweg) and an average waste-factor of 25 percent were used to calculate the total tonnage of PCC-grade aggregate in Sector C. All the minable aggregate in Sector C is Quaternary alluvium. The Solano Concrete Company and Cache Creek Aggregates have permits to mine aggregate in Sector C (see Plate 38). The estimated total PCC aggregate resource is 193,900,000 tons.

Sector D

Sector D contains 4,233 acres (of which 1,363 acres are within the legally defined Cache Creek channel) in a 6-mile long area that encompasses the active Cache Creek channel from Moore Dam on the west to the eastern border of the Cache Creek MRZ-2 boundary. Abundant well-log records, good quarry-exposures, and extensive aggregate test data in quarries neighboring the active Cache Creek channel provide a high confidence level for the aggregate resource tonnage estimate in Sector D. The estimated total for the PCC-grade resources in Sector D is 151,600,000 tons. Sector D is divided into four subsectors for descriptive purposes.

D-1: Subsector D-1 consists of 627 acres (615 acres of which are within the legally defined Cache Creek channel) and includes the active Cache Creek channel from Moore Dam on the west to Stevens Bridge on the east. This subsector is where Cache Creek has cut a narrow "U"-shaped trough through the sub-PCC-grade alluvium of the Dunnigan Hills. An estimated average minable aggregate thickness of 10 feet (2 feet within the legal channel above the theoretical thalweg) and an average waste factor of 20 percent by volume were used to calculate the total tonnage of PCC-grade aggregate in this subsector. The estimated total aggregate resource is 2,900,000 tons.

D-2: Subsector D-2 consists of 3,441 acres (of which 748 acres are within the legally defined Cache Creek channel) bordered by Road 94B on the west and the MRZ-2 boundary line on the east. Overburden in this area ranges from 25 feet to naught in the active channel. Minable aggregate thickness varies from 10 feet to nearly 80 feet. An average estimated minable thickness of 25 feet (4 feet within the legal channel above the theoretical thalweg) and an average waste factor of 25 percent by volume were used to calculate the total tonnage of PCC-grade aggregate in this area. All the minable aggregate in Subsector D-2 is Quaternary alluvium. Teichert Aggregates, Granite Construction Company, Schwarzgruber and Sons, Lone Star Industries, and the County of Yolo currently mine PCC-grade aggregate in this subsector (see Plate 38). The estimated total PCC aggregate resource is 140,500,000 tons.

D-3 & D-4:
Subsector D-3 (53 acres) and Subsector D-4 (112 acres) both have an estimated soil and clay overburden thickness of 14 to 18 feet. Data from water-well logs provide a high confidence level for the resource estimates for these subsectors. An average estimated minable aggregate thickness of 25 feet and an average waste factor of 25 percent by volume were used to calculate the total tonnages of PCC-grade aggregate in these subsectors. All the minable aggregate for these subsectors is Pleistocene alluvium. The estimated total PCC aggregate resource for Subsector D-3 is 2,600,000 tons. The estimated total resource for Subsector D-4 is 5,600,000 tons.

AMERICAN RIVER SECTORS

American River PCC-grade aggregate resources are composed of four kinds of river alluvium: Holocene-channel sand and gravel deposits in the American River; low-relief, Quaternary terrace alluvium bordering the American River channel; Plio-Pleistocene terrace alluvium in sector areas away from the American River channel; and Tertiary arkosic sand and gravel deposits to the east of Roseville.

The alluvium in and bordering the American River has similar aggregate characteristics. This is because all alluvium in and bordering the American River sectors was derived from a common source, the Sierra Nevada to the east. The four kinds of alluvium from the American River have been actively mined for PCC-grade aggregate in the study area. Sectors J, K, and L contain Holocene sand and gravel alluvium in both the American River channel and the slightly elevated, Quaternary alluvial terrace deposits that border the active American River channel. Sectors F, G, H, and I contain the alluvial Pleistocene Riverbank Formation derived from the ancestral American River. Sector E contains dredged American River channel alluvium of Plio-Pleistocene age. Sector M contains arkosic alluvium of Tertiary age derived from the ancestral Strap Ravine Creek.

Two density figures were used to calculate the aggregate tonnages in the Strap Ravine, American River, and the American River Parkway sectors: one density for in-place aggregate and one density for dredge tailings. A density of 2,759 tons/acre-foot (1.71 tons/cubic yard) was used to calculate in-place aggregate of the Riverbank, Modesto, and Holocene formations for Sectors F, I, G, J, and for Subsectors K-1 and K-2. A density of 2,178 tons/acre-foot (1.35 tons/cubic yard) was used to calculate total tonnages of dredged aggregate in sectors E, G, H, and Subsector K-3.

The nine American River and American River Parkway sectors cover about 16 square miles and are estimated to contain approximately 394 million tons of PCC-grade aggregate (Tables 3 and 4). There are three active aggregate producers in Sector F, one in Sector G, one in Sector L and one in Sector M (see Plate 38 for operator names and mine locations).

In the sector descriptions that follow, Sectors J, K, and L occur within dedicated parklands of the American River Parkway. Because of this special status, they are treated under a separate heading and presented separately in Table 4.

Subsectors E-1, F-8, F-10, H-1, H-3, H-4, and parts of F-9 and G-1, which were identified in the February 11, 1985 preprint edition of this report have been deleted to reflect new information concerning availability of land for mining. This new information was provided by the Planning and Community Development Department of the County of Sacramento (see Appendix 2) on May 7, 1985. To avoid possible confusion, remaining subsectors have not been renamed.

Sector E

Sector E consists of 206 acres of dredge tailings that range in thickness from roughly 30 feet to about 80 feet. An average minable aggregate thickness of 30 feet was estimated for Sector E. Aggregate test data prove these tailings meet PCC specifications. These dredge tailings contain a higher percentage of softer, porous aggregate than do recent channel deposits in the American River and an estimated waste factor of 30 percent was used to calculate tonnages. The estimated total PCC-grade aggregate resource in Sector E is 9,400,000 tons. For descriptive purposes Sector E is divided into two subsectors, E-2 and E-3.

E-1: Deleted

E-2: Subsector E-2 consists of 74 acres located just south of Blue Ravine Road. An estimated average minable thickness of 30 feet and an estimated average waste factor of 30 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector E-2 is dredged Plio-Pleistocene alluvium, and the estimated total PCC aggregate resource is 3,400,000 tons.

E-3: Subsector E-3 consists of 132 acres located just south and east of Blue Ravine Road. An estimated average minable thickness of 30 feet for these tailings and an estimated average waste factor of 30 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. All the minable aggregate in Subsector E-2 is dredged Plio-Pleistocene alluvium. The estimated total PCC aggregate resource is 6,000,000 tons.

Sector F

Sector F, the largest sector in the American River area, consists of 3,680 acres. Granite Construction Co., Teichert Aggregates and Erickson Construction Co. have current mining permits in Sector F. Gravel pits within Sector F currently provide over 80 percent of the total annual aggregate production for Sacramento County (see Plate 38 for pit names and locations). The data base for Sector F ranges from good to excellent, with abundant water-well logs, engineering test results for aggregate, and exposed pit cuts for most of the area. A clay and soil overburden thickness varies from 4 feet to 33 feet in this sector. Average thicknesses of minable aggregate range from 10 feet to 25 feet. Beneath the minable aggregate is a 10 foot to 35 foot thick layer of clay and silt. Aggregate below this clay and silt layer has never been mined, and test data for quality of these deep deposits is lacking. Minable PCC-grade aggregate is currently restricted to the top 50 feet in Sector F. The average waste factor ranges from 20 percent to 25 percent and was applied to subsectors of Sector F for calculation purposes. The estimated total resource tonnage for the sector is 167,300,000 tons. For descriptive purposes, Sector F is subdivided into 9 subsectors.

F-1 & F-2:
Subsector F-1 consists of 143 acres and F-2 consists of 79 acres. Water-well log data and quarry exposures indicate that there is a 20- to 35-foot thickness of minable aggregate covered by a 5- to 30-foot soil-clay overburden in Subsectors F-1 and F-2. An average estimated overburden thickness of 10 feet, an average estimated waste factor of 25 percent, and an average estimated minable deposit thickness of 25 feet were used to calculate the total tonnage of PCC-grade aggregate in these subsectors. All the minable aggregate in Subsectors F-1 and F-2 is alluvium of the Riverbank Formation. The estimated total PCC aggregate resource is 7,400,000 tons for Subsector F-1 and 4,100,000 tons for Subsector F-2.

F-3: Subsector F-3 consists of 277 acres. Aggregate test data, observation of pit exposures and water-well log data indicate an average estimated minable aggregate thickness of 25 feet. An estimated waste factor of 20 percent was used to calculate the total tonnage for this subsector. All of the minable aggregate in Subsector F-3 is alluvium of the Riverbank Formation. Teichert Aggregates has a permit to mine PCC aggregate in this subsector. The estimated total PCC aggregate resource in this subsector is 15,300,000 tons.

F-4: Subsector F-4 consists of 87 acres. Water-well log data, observation of surrounding pit exposures indicate an average estimated minable aggregate thickness of 25 feet. An estimated waste factor of 25 percent was used to calculate the total tonnage in this subsector. All the minable aggregate in this subsector is alluvium of the Riverbank Formation, and the estimated total PCC aggregate resource is 4,500,000 tons.

F-5: Subsector F-5 consists of 228 acres. All the minable aggregate in this subsector is alluvium of the Riverbank Formation. Granite Construction Company has a permit to mine aggregate in this subsector, however, nearly 90 percent of the resources are mined out. It was learned from field studies and company personnel that (as of November 1982) approximately 5 million tons of PCC aggregate resource remained in this subsector.

F-6: Subsector F-6 consists of 752 acres. From water-well log data and observation of surrounding pit exposures, Subsector F-6 is estimated to have an average thickness of 25 feet of minable aggregate, and an estimated waste factor of 25 percent. All of the minable aggregate in this subsector is alluvium of the Riverbank Formation. Erickson Construction Company has a permit to mine aggregate in the northeast corner of this subsector. The estimated total PCC aggregate resource in this subsector is 38,900,000 tons.

F-7: Subsector F-7 consists of 253 acres. Observations of pit exposures, water-well log data indicate an estimated average thickness of 20 feet of minable aggregate. An estimated waste factor of 25 percent was used to calculate the total tonnage. Overburden is believed to vary in thickness from 4 to 12 feet and all of the minable aggregate in this subsector is alluvium of the Riverbank Formation. Teichert Aggregates has mined PCC aggregate in this subsector. The estimated remaining PCC aggregate resource in this subsector is 10.500,000 tons.

F-8: Deleted

TABLE 3. American River resource calculations; Sectors E through I and M.

GENERAL FORMULA USED TO CALCULATE AGGREGATE TONNAGE

Total Sector Tonnage	=	# Acres per Sector	x	Minable Aggregate Thickness in Feet	x	Percentage of Usable Aggregate Minus Waste	x	Density* in Tons per Acre-Foot
*In-Place Aggregate Density	=	$\frac{43{,}560\ ft^2}{acre}$	x	$\frac{yard^3}{27\ ft^3}$	x	$\frac{1.71\ tons}{yard^3}$	=	$\frac{2759\ tons}{acre\text{-}foot}$
*Dredge Tailing Density	=	$\frac{43{,}560\ ft^2}{acre}$	x	$\frac{yard^3}{27\ ft^3}$	x	$\frac{1.35\ tons}{yard^3}$	=	$\frac{2178\ tons}{acre\text{-}foot}$

SECTOR	AREA IN ACRES	x	MINABLE AGGREGATE THICKNESS	x	PERCENTAGE OF USABLE AGGREGATE MINUS WASTE	x	DENSITY IN TONS PER ACRE FOOT	=	TONNAGE (ROUNDED TO 100,000 TONS)
E									
E-2	74	x	30′	x	70%	x	2,178	=	3,400,000
E-3	132	x	30′	x	70%	x	2,178	=	6,000,000
TOTAL	206								9,400,000
F									
F-1	143	x	25′	x	75%	x	2,759	=	7,400,000
F-2	79	x	25′	x	75%	x	2,759	=	4,100,000
F-3	277	x	25′	x	80%	x	2,759	=	15,300,000
F-4	87	x	25′	x	75%	x	2,759	=	4,500,000
F-5	228	x	10′	x	75%	x	2,759	=	5,000,000
F-6	752	x	25′	x	75%	x	2,759	=	38,900,000
F-7	253	x	20′	x	75%	x	2,759	=	10,500,000
F-9	210	x	**	x	**	x	**	=	**
F-11	1,281	x	25′	x	75%	x	2,759	=	66,300,000
F-12	370	x	20′	x	75%	x	2,759	=	15,300,000
TOTAL	3,680								167,300,000
G									
G1	587	x	20′	x	70%	x	2,178	=	17,900,000
G-2	242	x	15′	x	75%	x	2,759	=	7,500,000
TOTAL	829								25,400,000
H									
H-2	289	x	25′	x	70%	x	2178	=	11,000,000
H-5	56	x	10′	x	70%	x	2178	=	900,000
TOTAL	345								11,900,000
I									
I-1	125	x	15′	x	65%	x	2759	=	3,400,000
I-2	188	x	20′	x	65%	x	2759	=	6,700,000
I-3	348	x	20′	x	65%	x	2759	=	12,500,000
I-4	94	x	15′	x	65%	x	2759	=	2,500,000
I-5	160	x	20′	x	65%	x	2759	=	5,700,000
I-6	152	x	20′	x	65%	x	2759	=	5,500,000
TOTAL	1,067								36,300,000
M									
M-1	136	x	25′	x	80%	x	2178	=	5,900,000
M-2	25	x	20′	x	80%	x	2178	=	900,000
M-3	5	x	15′	x	80%	x	2178	=	100,000
TOTAL	166								6,900,000

TOTAL AREA FOR SECTORS E through I and M = 6,293 acres or 9.8 square miles

TOTAL PCC RESOURCES = 257,200,000 TONS

** Data for Sector F-9 is proprietary since all resources within the Sector are reserves. Reserve totals shown in Table 5 include those contained in Sector F-9.

TABLE 4. American River Parkway resource calculations; Sectors J through L.

GENERAL FORMULA USED TO CALCULATE AGGREGATE TONNAGE

Total Sector Tonnage = # Acres Per Sector x Minable Aggregate Thickness in Feet x Percentage of Usable Aggregate Minus Waste x Density* in Tons per Acre-Foot

* In-Place Aggregate Density = $\frac{43{,}560\ ft^2}{acre} \times \frac{yard^3}{27\ ft^3} \times \frac{1.71\ tons}{yard^3} = \frac{2759\ tons}{acre\text{-}foot}$

* Dredge Tailing Density = $\frac{43{,}560\ ft^2}{acre} \times \frac{yard^3}{27\ ft^3} \times \frac{1.35\ tons}{yard^3} = \frac{2178\ tons}{acre\text{-}foot}$

SECTOR	AREA IN ACRES	x	MINABLE AGGREGATE THICKNESS	x	PERCENTAGE OF USABLE AGGREGATE MINUS WASTE	x	DENSITY IN TONS PER ACRE-FOOT	=	TONNAGE (ROUNDED TO 100,000 TONS)
J									
J-1	283	x	15′	x	75%	x	2,759	=	8,800,000
J-2	97	x	15′	x	75%	x	2,759	=	3,000,000
J-3	117	x	20′	x	75%	x	2,759	=	4,800,000
J-4	64	x	20′	x	75%	x	2,759	=	2,600,000
J-5	593	x	20′	x	75%	x	2,759	=	24,500,000
TOTAL	1,154								43,700,000
K									
K-1	1,169	x	20′	x	75%	x	2,759	=	48,400,000
K-2	129	x	20′	x	75%	x	2,759	=	5,300,000
K-3	393	x	20′	x	75%	x	2,178	=	12,800,000
TOTAL	1,691								66,500,000
L	1,141	x	15′	x	70%	x	2,178	=	26,100,000
TOTAL AREA FOR SECTORS J-L = 3,986 ACRES							TOTAL PCC RESOURCES	=	136,300,000 TONS

F-9: Subsector F-9 consists of 210 acres of minable aggregate of the Riverbank Formation. The entire subsector has been permitted for mining to the Granite Construction Company, so all resources are considered to be reserves. Consequently, specific data on this subsector is proprietary. The reserves contained within subsector F-9 are included in Table 5, which shows a resource summary for the entire P-C region.

F-10: Deleted

F-11 & F-12:
Subsectors F-11 and F-12 together consist of 1,651 acres. Based on the available water-well log data, aggregate test data, and field studies, Subsector F-11 has an average thickness of 25 feet of minable aggregate. Subsector F-12 has an average thickness of 20 feet of minable aggregate. An estimated waste factor of 25 percent was used to calculate the tonnages for subsectors F-11 and F-12. All of the minable aggregate in these subsectors is alluvium of the Riverbank Formation. The estimated total PCC aggregate resource for Subsector F-11 is 66,300,000 tons and for Subsector F-12 it is 15,300,000 tons.

Sector G

Sector G consists of 829 acres. The northern 70 percent of Sector G is dredged alluvium of the Riverbank Formation and has been labeled Subsector G-1. The southern 30 percent of Sector G is undredged alluvium of the Riverbank Formation and has been labeled Subsector G-2. Lone Star Industries, Inc., has a permit to mine aggregate within Subsectors G-1 and G-2. The estimated remaining PCC aggregate resource tonnage is 25,400,000 tons (as of May 1985).

G-1: Subsector G-1 consists of 587 acres of dredged alluvium. Water-well log data, field studies and observation of pit exposures indicate there is an average minable aggregate thickness of 20 feet. An average waste factor of 30 percent by volume was used to calculate tonnage. The estimated remaining PCC aggregate resource in this subsector is 17,900,000 tons (as of May 1985).

G-2: Subsector G-2 consists of 242 acres of undredged alluvium. Water-well log data, field studies and observation of pit exposures indicate there is an average minable aggregate thickness of 15 feet. An average waste factor of 25 percent by volume was used to calculate tonnage.

The estimated remaining PCC-aggregate resource in this subsector is 7,500,000 tons (as of March 1984).

Sector H

Sector H consists of 345 acres of dredged Plio-Pleistocene alluvial gravel. The average estimated minable aggregate thickness ranges from 10 feet to 25 feet, and the waste is judged to be 30 percent. The total estimated resource tonnage is 11,900,000 tons. Sector H is subdivided into two subsectors, H-2 and H-5.

H-1: Deleted.

H-2: Subsector H-2 consists of 289 acres. Water-well logs and field studies indicate that there is an estimated 25-foot thickness of minable aggregate with an estimated waste factor of 30 percent in this subsector. All of the minable dredge tailings in this subsector are alluvium of the Riverbank and Laguna formations. The estimated total PCC-aggregate resource for Subsector H-2 is 11,000,000 tons.

H-3: Deleted

H-4: Deleted

H-5: Subsector H-5 consists of 388 acres north of Highway 50. In Subsector H-5, where aggregate is currently being extracted by Teichert Aggregates, there remains an estimated average minable aggregate thickness of 10 feet. An estimated waste factor of 30 percent was used to calculate tonnages. All the minable aggregate for Subsector H-5 is dredged alluvium of the Modesto, Riverbank, and probably Laguna formations. The total estimated PCC-aggregate resource for Subsector H-5 is 900,000 tons.

Sector I

Sector I consists of 1,067 acres. Geologic data from nearby water wells and field studies indicate that the aggregate within Sector I has a high likelihood of satisfying PCC specifications even though specific aggregate engineering test data is lacking. Because rock-quality data was extrapolated as far as 2 miles from proven PCC-aggregate deposits a slightly higher estimated waste factor of 35 percent by volume was used to calculate tonnages in this sector. The estimated total PCC-aggregate resource for Sector I is 36,300,000 tons. Sector I is divided into six subsectors, I-1 through I-6.

I-1, I-2, I-3, I-4, I-5, & I-6:

Subsectors I-1, I-2, I-3, I-4, I-5, and I-6 together consist of 1,067 acres. Well-log data indicate that average minable aggregate thicknesses vary from 15 feet in Subsectors I-1 and I-4 to 20 feet in Subsectors I-2, I-3, I-5, and I-6. An estimated waste factor of 35 percent was used to calculate tonnages for all six subsectors and all of the minable aggregate for these subsectors is alluvium of the Riverbank Formation. The estimated total PCC-aggregate resource for Subsector I-1 is 3,400,000 tons; for Subsector I-2 it is 6,700,000 tons; for Subsector I-3, 12,500,000 tons; for Subsector I-4, 2,500,000 tons; for Subsector I-5, 5,700,000 tons; and for Subsector I-6, 5,500,000 tons.

Sector M

Sector M consists of 166 acres along Strap Ravine (see Plate 38). Much of Sector M has been dredged. Sector areas bordering the dredge tailings contain PCC-grade aggregate that is covered by 2 to 8 feet of overburden. Pit and dredge tailing exposures and extensive aggregate test data provide a high confidence level for the aggregate resource tonnage estimate in Sector M. Aggregate varies in thickness from 15 feet to over 80 feet. Average estimated minable aggregate thicknesses range from 15 feet to 25 feet, and waste is estimated to be 20 percent by volume. The estimated total PCC aggregate resource in Sector M is 6,900,000 tons.

TABLE 5. A summary of the Sacramento-Fairfield P-C Region resource estimations.

Resource Area	Sector	Area (Acres)	PCC-Grade Reserves (Tons)	Resources (Tons)
Cache Creek Area	A	6,004	*	299,600,000
	B	3,459	0	192,900,000
	C	3,506	*	193,900,000
	D	4,233	*	151,500,000
	Subtotal	17,202	40,000,000	837,900,000
American River	E	206	0	9,400,000
	F	3,680	*	167,300,000
	G	829	*	25,400,000
	H	345	0	11,900,000
	I	1,067	0	36,300,000
	M	166	*	6,900,000
	Subtotal	6,293	55,000,000	257,200,000
American River Parkway	J	1,154	0	43,700,000
	K	1,691	0	66,500,000
	L	1,141	2,000,000	26,100,000
	Subtotal	3,986	2,000,000	136,300,000
TOTAL SECTOR AREA = 27,481 acres or 42.9 square miles			TOTAL RESERVES = 97,000,000 TONS	TOTAL RESOURCES = 1,231,400,000 TONS

* Proprietary

M-1:

Subsector M-1 consists of 136 acres along Strap Ravine and is underlain by Tertiary arkosic alluvium. Exposed dredge tailings and undisturbed alluvium range in thickness from 20 feet in portions to over 80 feet near the western border of Subsector M-1. An estimated average minable thickness of 25 feet and an estimated waste factor of 15 percent by volume were used to calculate the total tonnage of PCC-grade aggregate in this subsector. Placer Resources Corporation has a permit to mine aggregate in the eastern portion of this subsector. The estimated total PCC aggregate resource is 5,900,000 tons.

M-2 & M-3:

Subsectors M-2 and M-3 together consist of 30 acres and are underlain by Tertiary arkosic alluvium. An average estimated minable aggregate thickness of 20 feet and an estimated waste factor of 20 percent were used to calculate the tonnage of PCC-grade aggregate in Subsector M-2. An average estimated minable aggregate thickness of 15 feet and an estimated waste factor of 20 percent were used to calculate the tonnage of PCC-grade aggregate for Subsector M-3. The estimated total PCC aggregate resource is 900,000 tons for Subsector M-2, and 100,000 tons for Subsector M-3.

RESOURCE SECTORS WITHIN PARKS

Dedicated parklands are recognized as having a special status. Resource sectors within parks have therefore been treated as a special class of sectors, and the quantifications of the resources in them are presented separately in Table 4. Sectors J, K, and L are located entirely within the American River Parkway. These sectors lie in a narrow 19-mile-long belt that runs along the American River from Cal Expo to the City of Folsom (see Plate 38). With the exception of a single area in Sector L where dredge tailings are mined for PCC aggregate, these three sectors are currently excluded from mining under lead agency guidelines specified in the American River Parkway Plan. Sacramento County, in a letter dated May 7, 1985 (see Appendix 2), states ". . . we are confident that no mining would be permitted in the future in these sectors." Two sand and gravel mining operations are currently permitted in the American River Parkway outside of the sector boundaries. However, these operations produce plaster sand and fill material and have not been proven to contain PCC-grade aggregate. The available data, coupled with an extensive former mining history provides a high confidence level that the aggregate within the American River Parkway sectors meets PCC-grade specifications.

Sector J

Sector J consists of 1,154 acres and extends for 8 miles along the American River from the Cal Expo area to the footbridge at Goethe Park. This sector contains aggregate composed of Quaternary floodplain-terrace and river-bar channel deposits. For descriptive purposes, Sector J is divided into five subsectors, J-1 through J-5.

J-1 & J-2:

Subsectors J-1 and J-2 together consist of 380 acres and are underlain by Holocene floodplain-terrace and channel alluvium. Geologic data from field observations and water-well log data indicate that there is an average estimated minable aggregate thickness of 15 feet and an estimated waste factor of 25 percent for these two subsectors. The estimated total PCC-aggregate resource for Subsector J-1 is 8,800,000 tons; for Subsector J-2 it is 3,000,000 tons.

J-3, J-4, & J-5:

Subsectors J-3, J-4, and J-5 together consist of 774 acres and are underlain by Quaternary floodplain-terrace-alluvium, and river-bar channel-alluvium of the Modesto Formation. Observation of pit exposures, water-well log data, and exposed river bars indicate that there is an average estimated minable aggregate thickness of 20 feet for these three sectors. An estimated waste factor of 25 percent by volume was used to calculate tonnages. Past mining activity and aggregate test data for areas in Subsector J-5 prove that PCC-quality aggregate exists within these three subsectors. The estimated total PCC-aggregate resource for Subsector J-3 is 4,800,000 tons; for Subsector J-4 it is 2,600,000 tons; and for Subsector J-5 it is 24,500,000 tons.

Sector K

Sector K consists of 1,691 acres. This sector extends along the American River from the footbridge at Goethe Park to Nimbus Dam. Aggregate mining has occurred in this sector in the past, and abundant proven PCC-grade aggregate remains.

K-1, K-2, & K-3:

Subsectors K-1, K-2, and K-3 together consist of 1,691 acres. Sector K is underlain by alluvium and dredge tailings of the Modesto, Riverbank, and Quaternary formations. Based on observations of dredge tailings and channel material, an estimated average minable aggregate thickness of 20 feet and an estimated waste factor of 25 percent were used to calculate tonnages. The estimated total tonnage for PCC-grade aggregate resources in Sector K is 48,400,000 tons; for Subsector K-2 it is 5,300,000 tons; and for Subsector K-3 it is 12,800,000 tons.

Sector L

Sector L consists of 1,141 acres of dredge tailings and Holocene river channel aggregate deposits. The dredge tailings consist of alluvium of the Riverbank, Modesto, and Quaternary-channel formations. Current aggregate mining in the Mississippi Bar area by Teichert Aggregates is permitted by State Department of Parks and Recreation. Waste is judged to be 30 percent by volume, and minable aggregate thickness is estimated to be 15 feet. The estimated total PCC grade-aggregate resource in Sector L is 26,100,000 tons. The estimated remaining PCC-aggregate resource in this subsector is 7,500,000 tons (as of March 1984).

ESTIMATED 50-YEAR CONSUMPTION OF AGGREGATE

Basis of 50-Year Forecasts

The State Mining and Geology Board, as specified in its "Guidelines for Classification and Designation of Mineral Land" (Part II of Division of Mines and Geology Special Publication 51), requires that mineral land classification reports for regions containing construction materials classified MRZ-2 include "An estimate of the total quantity of each such construction material that will be needed to supply the requirements of both the county and the marketing region in which it occurs for the next 50 years. The marketing region is defined as the area within which such material, including aggregate, is usually mined and marketed. The amount of each construction material mineral resource needed for the next 50 years shall be projected using past consumption rates adjusted for anticipated changes in market conditions and mining technology." In the "Guidelines" the Board also specifies that these estimates be reviewed periodically (every 10 years or less).

Fifty-year forecasts of PCC-grade-aggregate needs in the Sacramento-Fairfield P-C Region were made on the basis of reported aggregate-production records during the years 1960-1980. For the purposes of this study, it was assumed that nearly all PCC-grade aggregate produced in the Sacramento-Fairfield area will be consumed in the study area[1] and that imports of PCC-aggregate from outside the study area are insignificant.

1. Nearly 95 percent of all aggregate produced in the Sacramento-Fairfield P-C Region is consumed within the P-C region boundaries.

Correlations Between Aggregate Production and Consumption

Past studies of aggregate marketing regions in California have shown that there is a strong correlation between the amount of aggregate produced and the population in a given aggregate production-consumption area. On this basis, aggregate production and population figures in the Sacramento-Fairfield P-C Region were correlated for the years 1960 through 1980. Correlations between the annual aggregate production records and the population statistics were used to obtain per-capital consumption rates of aggregate in the study area. The historical aggregate production data in the study area was obtained from mining records of the U.S. Department of the Interior, Bureau of Mines (1960 to 1980). The historical population data for the Sacramento-Fairfield area were taken from the 1980 census data published by the U.S. Bureau of the Census (1982).

The average per-capita consumption rate in the Sacramento-Fairfield P-C Region is 10.2 tons of aggregate per year over the 20-year period from 1960 to 1980 (see Table 6 and Figure 12). Due to the erratic variations in aggregate production from year to year, a three-year moving average of the annual aggregate production was used in conjunction with population statistics to compute the per-capital consumption rates for the P-C region (Figure 13). The high consumption rates in the Sacramento-Fairfield area are characteristic of aggregate marketing regions in which the

TABLE 6. Total P-C region per-capita consumption.

Year	Total American River Production (Tons)	90%** of Cache Creek Production (Tons)	Total Production (Tons)	Total P-C Region Population	Per-Capita Consumption (Tons/ Person/Yr.)
1960	4,308,000	1,301,000	5,609,000	488,000	11.5
1961	5,346,000	1,387,000	6,733,000	515,000	13.1
1962	4,123,000	1,375,000	5,498,000	542,000	10.1
1963	4,679,000*	1,384,000*	6,063,000*	569,000	10.7
1964	5,234,000	1,392,000	6,626,000	596,000	11.1
1965	7,009,000	1,815,000	8,824,000	662,000	13.3
1966	4,965,000	1,753,000	6,718,000	649,000	10.4
1967	5,023,000	1,816,000	6,839,000	676,000	10.1
1968	5,529,000	1,913,000	7,442,000	703,000	10.6
1969	6,387,000	1,933,000	8,320,000	730,000	11.4
1970	5,673,000	2,258,000	7,931,000	756,000	10.5
1971	5,644,000	1,825,000	7,469,000	782,000	9.6
1972	5,836,000	2,354,000	8,190,000	807,000	10.1
1973	4,476,000	3,476,000	7,952,000	832,000	9.6
1974	5,616,000	2,546,000	8,162,000	858,000	9.5
1975	4,422,000	2,207,000	6,629,000	883,000	7.5
1976	4,067,000	2,313,000	6,380,000	908,000	7.0
1977	4,780,000	2,920,000	7,700,000	934,000	8.2
1978	6,205,000	3,106,000	9,311,000	959,000	9.7
1979	7,499,000	4,028,000	11,527,000	984,000	11.7
1980	6,484,000	3,107,000	9,591,000	1,010,000	9.5

AVERAGE P-C REGION PER-CAPITA CONSUMPTION = 10.2 TONS/PERSON/YEAR

* Production data for 1963 is unavailable — these production figures were averaged from 1962 and 1964 production figures and used in Figure 12.

** Roughly 10% of Cache Creek's annual aggregate production is exported outside of the Sacramento-Fairfield P-C Region.

overall population density is relatively low and the rate of urban development is high. A high consumption rate probably will be maintained within a P-C region such as the Sacramento-Fairfield P-C Region until the onset of urban maturity, then it will decrease and eventually drop to a general maintenance level. Urban maturity is the point in the development of an area at which construction materials are used primarily to maintain what has already been developed, rather than to provide for further development.

Projected Population and Per-Capita Consumption to the Year 2033

A simple linear regression of the historical aggregate production and population statistics was conducted to forecast basic trends in the per-capita consumption rate of aggregate within the Sacramento-Fairfield area to the year 2033. The total aggregate needs of the study area to the year 2033 were calculated on the basis of two factors: (1) a projected average annual per-capital consumption rate of 10.2 tons (the average per-capita consumption rate for the years 1960 to 1980) (see Figure 13) and (2) the projected population of the region for future years to the year 2033. Population projections for the years 1980 to 2020 (Figure 14) were obtained from the California Department of Finance (1983). This data was extrapolated for the study area on a straight line basis to the year 2033 to provide the 50-year population projection as specified under the SMARA guidelines. The results of these calculations (Table 6) reveal that an estimated 889 million tons of aggregate will be needed to satisfy the projected future demand for this construction material in the Sacramento-Fairfield P-C Region to the year 2033.

Factors Affecting Per-Capita Consumption Rates

The wide variations from year to year in the per-capita consumption rate (Figure 13) are probably reflections of changes in urban growth rates with time or reflections of the occurrence of major construction projects (for example, freeways). In part, these variations result from incompleteness and inaccuracies in the production records supplied to the U.S. Bureau of Mines. Certainly the economic climate is a powerful variable that influences the annual per-capita consumption rates for aggregate. Very high interest rates, for example, such as existed in California during the 1980 to 1982 period, tend to lower the amount of new construction in an area.

At some point in the future, the average annual per-capita consumption rate of 10.2 tons for the Sacramento-Fairfield P-C Region will probably decrease with the onset of urban maturity and then

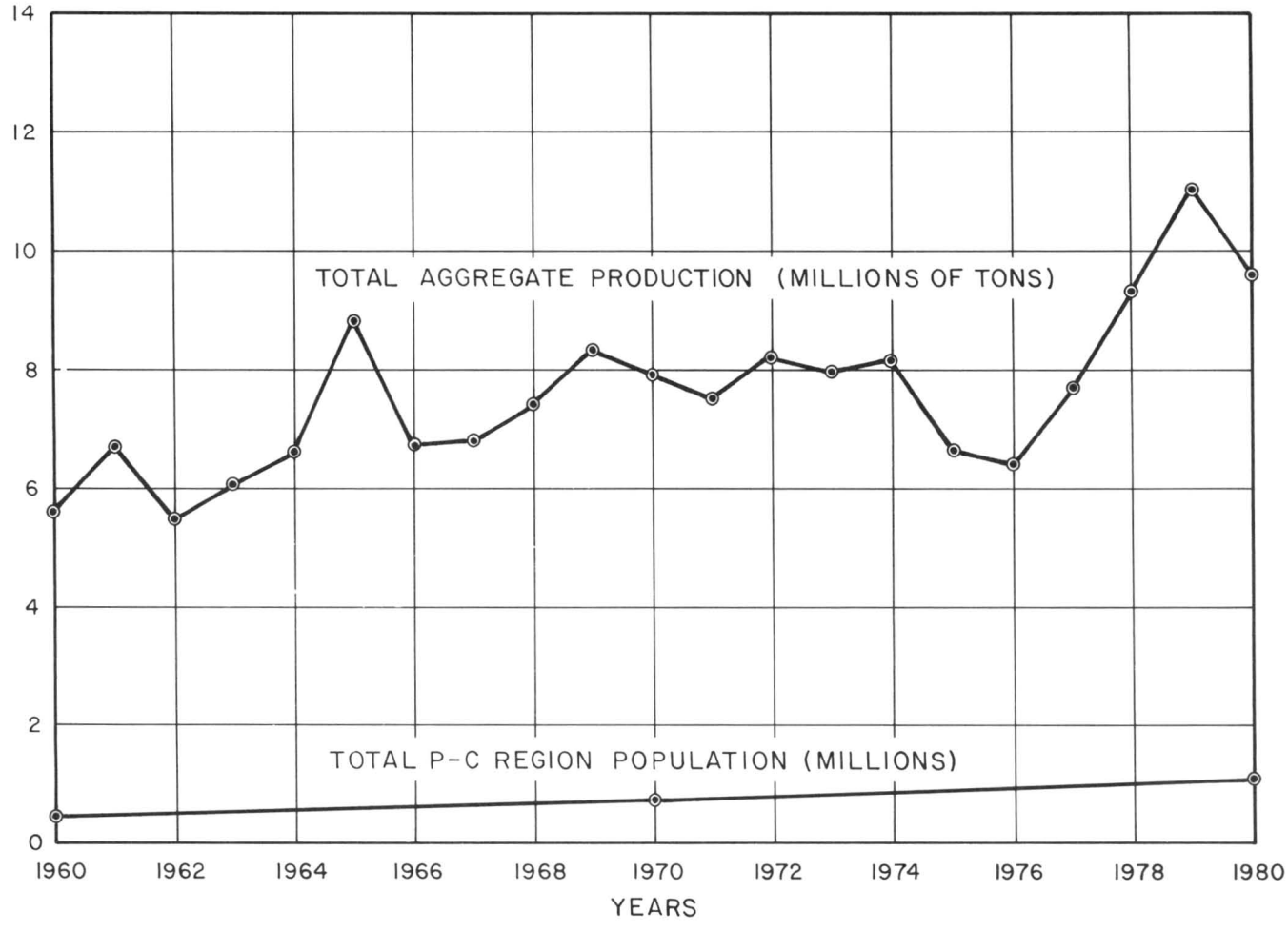


Figure 12. Population and aggregate production record of the Sacramento-Fairfield Production-Consumption Region for the years 1960-1980.

stabilize at a lower rate. However, should unforeseen events occur, such as massive urban renewal, disaster reconstruction, or a major recession, the per-capita consumption rate could change radically.

Comparison of the 50-Year Aggregate Demand with Current Reserves

The total PCC-grade aggregate reserves for the Sacramento-Fairfield P-C Region were estimated to be 97 million tons as of November 1982 (see Table 5). At the average rate of past aggregate consumption in the region (10.2 tons per person annually), these reserves are theoretically sufficient to supply the P-C region to mid-1990.

According to U.S Bureau of Mines aggregate production statistics for the years 1960 to 1980 and information from aggregate operators in the P-C region, roughly 40 percent of the total aggregate consumed in the study region has been PCC grade. If the region continues to require the same percentage of PCC-grade aggregate, the total amount of PCC-grade aggregate that would be needed to supply the Sacramento-Fairfield area to the year 2033 is estimated to be 355 million tons. As of November 1982, approximately 97 million tons of PCC-grade aggregate reserves existed in the study area. Thus, an additional 258 million tons of PCC-grade aggregate would be needed to supply the projected needs of the P-C region to the year 2033. If current and past practices of using PCC-quality aggregate for uses other than concrete continues, the additional PCC material needed to the year 2033 would exceed this 258 million ton amount. Should the P-C region's 97 million tons of PCC reserves be used solely for concrete-grade aggregate, they would theoretically last until the year 2000.

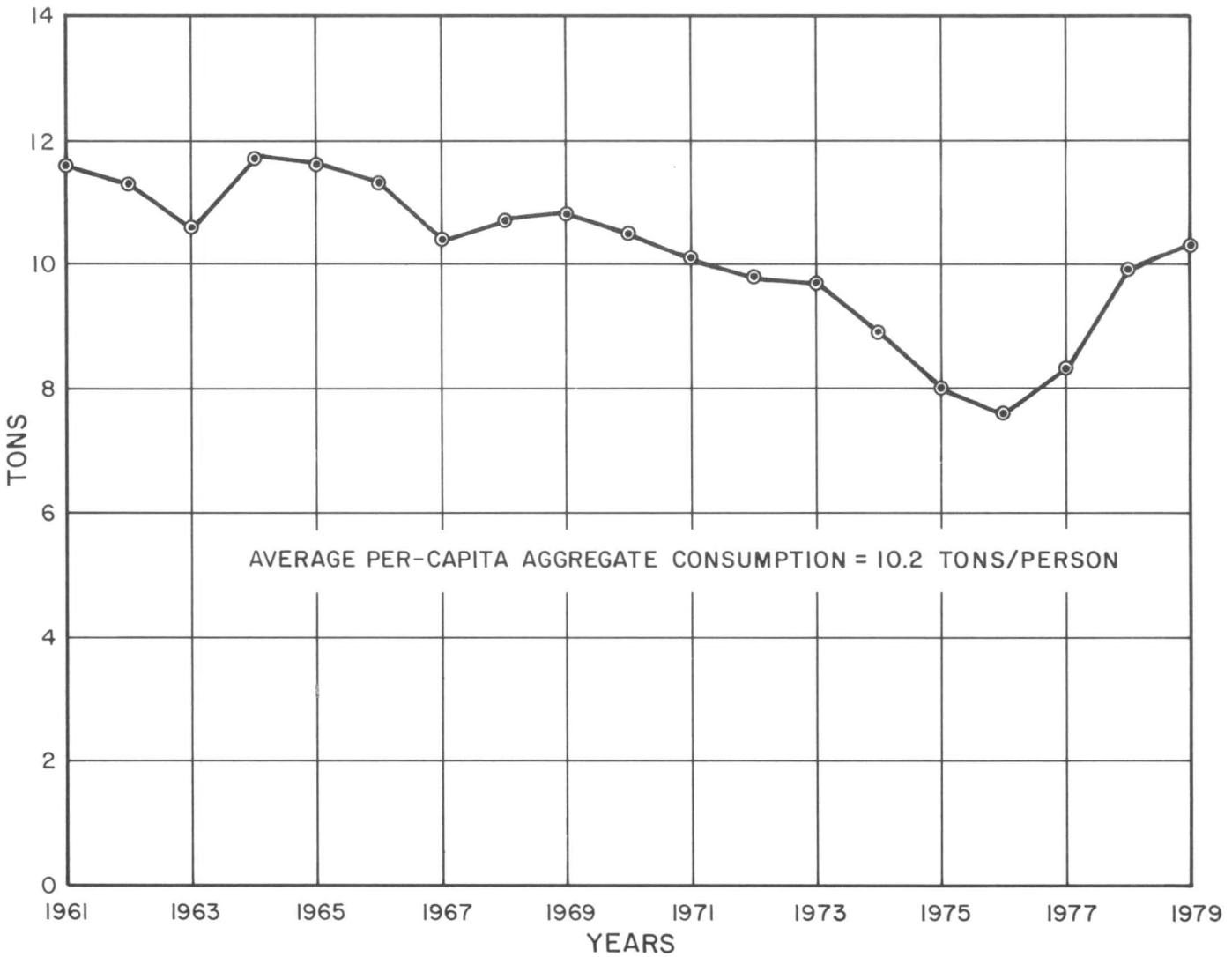


Figure 13. Annual per-capita consumption of aggregate in the Sacramento-Fairfield Consumption Region for the years 1960-1980.

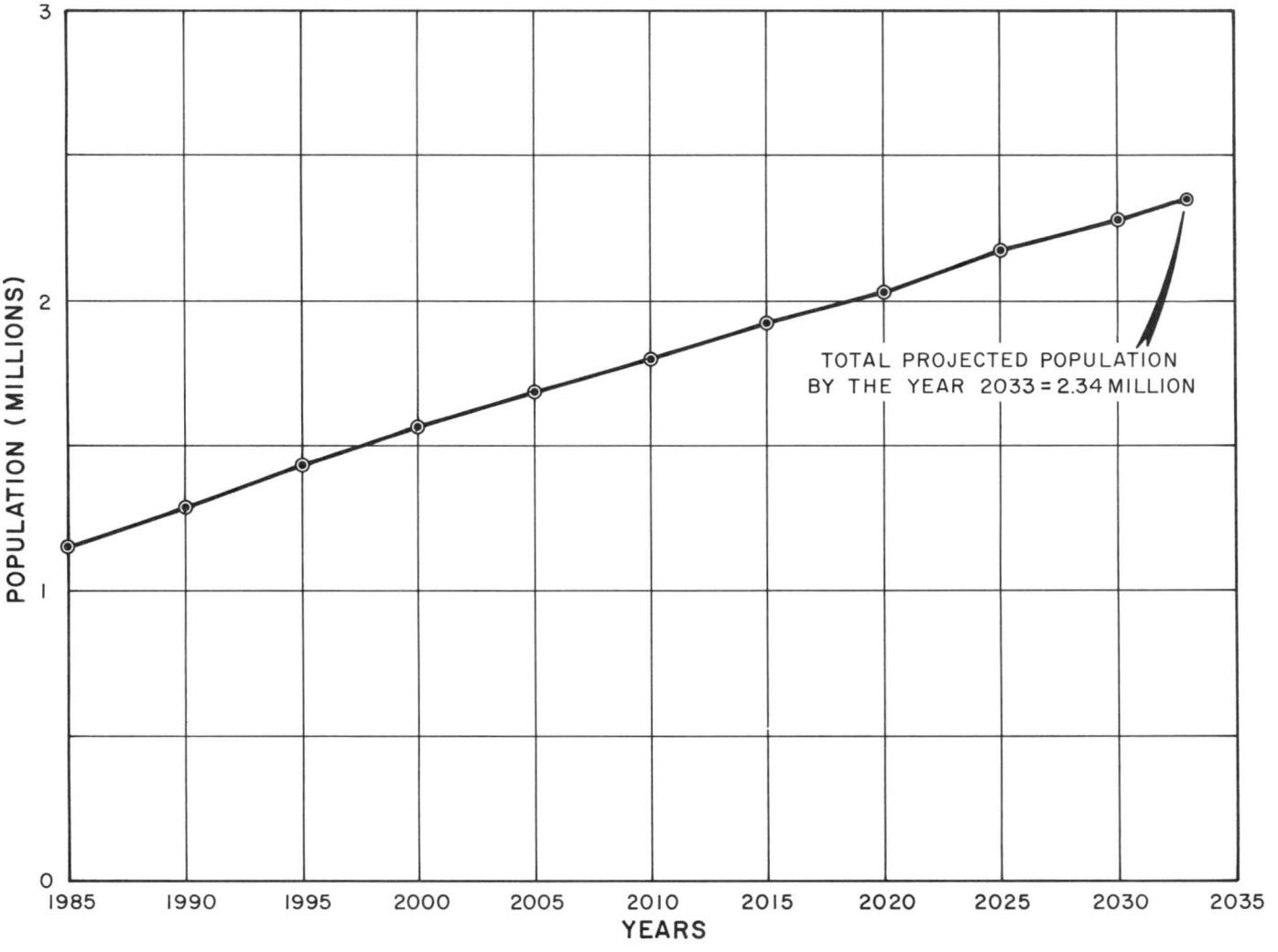


Figure 14. Projected population in the Sacramento-Fairfield P-C Region to the year 2033, based upon data from the State Department of Finance Population Projections, 1985 through 2020.

ALTERNATIVE SOURCES OF AGGREGATE

Potential sources of PCC-grade aggregate, in addition to the deposits classified as MRZ-2, exist within the Sacramento-Fairfield P-C Region. These potential sources lie within areas that are classified MRZ-3 and include volcanic, granodioritic, and metamorphic bedrock. In addition, untested MRZ-3 alluvial deposits that may provide alternative sources of PCC-grade aggregate in the study area include the following: dredge tailings; channel deposits; and beds of the Riverbank, Modesto, and Laguna formations (see Figure 11).

Another potential source of PCC-grade aggregate is the ground occupied by Mather Air Force Base. The Base is underlain by large resources of Riverbank Formation, which is the principal source of high-quality aggregate elsewhere in the P-C Region. Politically and practically, the deposits under Mather are very unlikely to be made available for mining in the near future. However, if conditions change at some future time, these deposits should not be overlooked.

Potential Alluvial PCC-Grade Aggregate

Alluvium classified MRZ-3 includes Tertiary and Quaternary river-channel deposits and dredge tailings in the Sacramento-Folsom area. Alluvium is considered desirable as PCC-grade aggregate because of its texture and ease of mining. Future PCC-grade aggregate needs in the P-C region may require a transition from the mining of premium quality alluvial materials in MRZ-2 areas to the mining of an inferior grade alluvium that requires more extensive and costly processing.

The most promising MRZ-3 PCC-grade aggregate deposits are shown on Plates 12, 13, 20, 21, 22, and 23 of this report.

The long-term aggregate needs of the Sacramento-Fairfield P-C Region may be difficult to satisfy entirely from local sources, and imports are likely to increase as local sources are depleted. The voluminous dredge tailings just east of Yuba City and Marysville near the town of Hammonton are a probable source of future

TABLE 7. Projected aggregate consumption to the year 2033 for the Sacramento-Fairfield P-C Region.

FIVE YEAR PER-CAPITA CONSUMPTION = 51 TONS/PERSON
ONE YEAR PER-CAPITA CONSUMPTION = 10.2 TONS/PERSON

Years	Average * Population (million tons)	Aggregate Consumption All Aggregate (million tons)	Aggregate** Consumption PCC Aggregate (million tons)
1983-1984	1.12	22.8	9.1
1985-1989	1.23	62.7	25.1
1990-1994	1.37	70.0	27.9
1995-1999	1.50	76.5	30.6
2000-2004	1.62	82.6	33.0
2005-2009	1.74	88.7	35.5
2010-2014	1.85	94.4	37.7
2015-2019	1.96	100.0	40.0
2020-2024	2.09	106.7	42.6
2025-2029	2.22	113.2	45.3
2030-2033	2.32	71.0	28.4
TOTAL AGGREGATE	= 888.6 million tons		
TOTAL PCC AGGREGATE	= 355.2 million tons		

* Population projections for the years 1985-2020 were obtained from the California Department of Finance Report 83-P-3. Population projections for the years 2020-2033 were projected by a linear-regression analysis from data in Report 83-P-3.

** Approximately 40 percent of the aggregate consumed from 1960 to 1980 was PCC quality.

imports. The tailings, which have been used locally and contain proven high-quality PCC-grade aggregate, lie about 45 miles north of Sacramento.

Potential Crushed Rock Aggregate

Crushed stone from massive consolidated rock formations may provide an alternative to depleted PCC-grade alluvial deposits. Large areas classified MRZ-3 in the eastern portion of the Sacramento-Fairfield P-C Region contain potential PCC-grade aggregate.

Granodioritic rock of the Pine Hill Intrusive Complex and the Penryn and Rocklin plutons to the east of Sacramento in Placer and El Dorado counties may be suitable for PCC-grade aggregate. Massive amounts of metasedimentary and metavolcanic greenstone extending from Folsom Lake east to Placerville in El Dorado County are other deposits that may meet crushed PCC-grade aggregate specifications. These deposits are commonly located in regions where little or no PCC aggregate is currently produced.

The MRZ-3 areas contain two other promising rock units that may provide crushed PCC-grade aggregate. These are the volcanic rocks associated with the Sonoma Volcanic Complex and the Putnam Peak Basalt. These rock units are located to the west and north of Fairfield within the study area, so it is unlikely that they could economically serve the eastern portion of the P-C region.

At the present time, however, economic considerations indicate that crushed rock cannot compete with alluvial PCC-grade aggregate resources that are available in the Sacramento-Fairfield P-C Region.

TABLE 8. Conclusions.

THE SACRAMENTO-FAIRFIELD P-C REGION	AREA IN SQUARE MILES	PERCENTAGE OF THE TOTAL
• Total Sacramento-Fairfield P-C Region Area	855	100%
• Total MRZ-2 Area	78	9%
• Total Sector Area	43	5%
• Total Area currently permitted for mining	7.9	1%
• Estimated Sacramento-Fairfield P-C Region Depleted Aggregate Areas	3	0.4%

THE ESTIMATED TOTAL SACRAMENTO-FAIRFIELD P-C REGION RESERVES AND RESOURCES OF PCC-GRADE AGGREGATE

- Estimated total Sacramento-Fairfield P-C Region Reserves = 97,000,000 tons
- Estimated total Sacramento-Fairfield P-C Region Resources = 1,231,000,000 tons

THE ESTIMATED TOTAL SACRAMENTO-FAIRFIELD P-C REGION AGGREGATE REQUIREMENTS TO THE YEAR 2033.

- Estimated total aggregate requirements to the year 2033 = 900,000,000 tons
- Estimated total PCC aggregate requirements to the year 2033 = 360,000,000 tons

CONCLUSIONS

The estimated total amount of available PCC-grade aggregate resources in the 855-square-mile Sacramento-Fairfield Production-Consumption Region is 1.2 billion tons (almost 140 million tons of which is in dedicated parklands) (Table 5). These resources are located within 13 sectors that lie in areas classified MRZ-2. The total area covered by these sectors is 43 square miles.

In general, American River aggregate deposits are deficient in fine aggregate sizes while Cache Creek aggregate deposits have a favorable blending of coarse and fine aggregate sizes needed for concrete. As a result of the size-distribution differences between the American River and Cache Creek deposits, American River operators have imported roughly 8% to 14% of Cache Creek's annual aggregate production.

Based on the projected population growth and the estimated average annual per-capita consumption rate of 10.2 tons per-capita determined from the years 1960-1980, approximately 900 million tons of aggregate would be needed by the Sacramento-Fairfield P-C Region to the year 2033. As of November 1982, there were 97 million tons of permitted PCC-grade aggregate reserves, a supply adequate to last only until mid-1990 for all aggregate uses. An additional 803 million tons of aggregate will be required to meet the projected needs of the Sacramento-Fairfield P-C Region to the year 2033. If the P-C region's 97 million tons of PCC reserves are used solely for PCC-grade aggregate, they would theoretically last until the year 2000. However, it can be expected that much of the PCC reserves will be used for non-PCC applications, so the mid-1990 depletion date is probably more realistic. Unforseen events such as a higher actual population growth rate could shorten the life expectancy of the current aggregate reserves significantly.

Data from the U.S. Bureau of Mines and from area operators indicate that approximately 40 percent of the aggregate consumed in the study region is used in Portland cement concrete. Of the projected 900 million tons of aggregate needed to the year 2033, roughly 360 million tons will be needed for Portland cement concrete.

Rapid population growth and urbanization in the Sacramento-Fairfield P-C Region have had a decided impact upon the quantity of available aggregate resources of the study area. Access to prime aggregate resources has been lost to development and urban growth at a rapid rate in the Sacramento area. Once lost to such competing land uses, aggregate resources are not likely to be utilized. Since 1980, access to over 130 million tons of PCC-grade aggregate in MRZ-2 areas east of Sacramento bordering the Highway 50 corridor has been irreversibly lost.[1] Due to this high rate of loss, the conservation of the remaining American River PCC resources is critical if the long-term community needs are to be satisfied with nearby low-cost, high-quality aggregate.

1. Tonnages projected from 1980 aerial photos at a scale of 1:8,400.

ADDITIONAL INSIGHT: ANALYSIS OF AGGREGATE NEEDS ASSUMING AN EAST-WEST DIVISION OF THE P-C REGION

To determine whether or not the half of the P-C region west of West Sacramento would have adequate PCC-grade aggregate reserves for that area alone, the Sacramento-Fairfield P-C Region was divided into two parts (see Figure 2), and the reserves and expected 50-year demand for each area were calculated. Per-capita consumption was calculated using data obtained from the U.S. Bureau of the Census statistics and the U.S. Bureau of Mines production records. The per-capita consumption data and population projections by the California Department of Finance (1983) were used to calculate future PCC-grade aggregate needs.

The half of the P-C region east of Davis was assumed to rely solely on the American River deposits. The American River production district contained 57 million tons of PCC-grade aggregate reserves as of November 1982. Based on the assumed annual consumption rate of 8.5 tons per person in this part of the P-C region (Table 9), the reserves would be theoretically depleted by 1989.

The western half of the P-C region, the part west of West Sacramento, was assumed to rely solely on the Cache Creek deposits. As of November 1982, the Cache Creek production area contained approximately 40 million tons of PCC aggregate reserves. Based on the average annual consumption rate of 21.4 tons per person in this part of the P-C region (Table 10), the reserves would theoretically be depleted by 1994.

It is evident from these hypothetical assumptions that the PCC-grade aggregate reserves in both the Cache Creek and the American River deposits are limited. To meet the 50-year PCC-grade aggregate needs of the P-C region, other reserves will have to be permitted for mining. Both the western and eastern parts of the P-C region face essentially the same shortfalls whether they were to function as isolated marketing areas or as the common market-area that they are.

TABLE 9. Aggregate consumption of the eastern half of the P-C region.

Year	American River Aggregate Production* (Tons)	Eastern P-C Population**	Per-Capita Consumption (Tons/Person/Yr.)
1960	4,308,000	441,000***	9.8
1961	5,346,000	462,000	11.6
1962	4,123,000	483,000	8.5
1963	****	504,000	–
1964	5,234,000	525,000	10.0
1965	7,009,000	546,000	12.8
1966	4,965,000	566,000	8.8
1967	5,023,000	587,000	8.6
1968	5,529,000	608,000	9.1
1969	6,387,000	629,000	10.2
1970	5,673,000	650,000 ***	8.7
1971	5,644,000	671,000	8.4
1972	5,836,000	691,000	8.4
1973	4,476,000	712,000	6.3
1974	5,616,000	732,000	7.7
1975	4,422,000	753,000	5.9
1976	4,067,000	774,000	5.3
1977	4,780,000	794,000	6.0
1978	6,205,000	815,000	7.6
1979	7,499,000	835,000	9.0
1980	6,484,000	856,000***	7.6

AVERAGE PER-CAPITA CONSUMPTION = 8.5 Tons/Person/Year

* Data taken from the U.S. Bureau of Mines production statistics and rounded to nearest 1,000 tons.
** Population data is interpolated from each 10-year census.
*** U.S. Census Bureau Data.
**** Data not available.
***** Assumes approximately 10 percent of the Cache Creek production is annually transported out of the western half of the P-C Region.

TABLE 10. Aggregate consumption of the western half of the P-C region.

Year	Total Cache Creek Production* (Tons)	0.90 of Cache Creek Production***** (Tons)	Western P-C Population **	Per-Capita Consumption (Tons/Person/Yr.)
1960	1,446,000	1,301,000	47,897***	27.2
1961	1,541,000	1,387,000	53,718	25.8
1962	1,528,000	1,375,000	59,539	23.1
1963	****	****	65,360	–
1964	1,547,000	1,392,000	71,181	19.6
1965	2,017,000	1,815,000	77,002	23.6
1966	1,948,000	1,753,000	82,643	21.2
1967	2,018,000	1,816,000	88,643	20.5
1968	2,126,000	1,913,000	94,464	20.3
1969	2,148,000	1,933,000	100,285	19.3
1970	2,509,000	1,853,000	106,160 ***	17.5
1971	2,028,000	1,825,000	110,900	16.5
1972	2,616,000	2,354,000	115,640	20.4
1973	3,862,000	3,476,000	120,380	28.9
1974	2,829,000	2,546,000	125,120	20.3
1975	2,453,000	2,208,000	129,860	17.0
1976	2,570,000	2,313,000	134,600	17.2
1977	3,244,000	2,920,000	139,340	21.0
1978	3,451,000	3,106,000	144,080	21.6
1979	4,476,000	4,028,000	148,820	27.1
1980	3,452,000	3,107,000	153,567***	20.2

AVERAGE PER-CAPITA CONSUMPTION = 21.4 Tons/Person/Year

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APPENDIX 1

Interim Criteria for Sectorization of MRZ-2 Areas for Aggregate

The purpose of sectorizing MRZ-2 areas is to provide a semi-quantified estimate of construction aggregate resources which are likely to be available to satisfy society's needs during the next 50 years. This estimate, when compared to DMG projected needs for the next half century, provides the context for communities to plan for future resource availability in their land-use policies. The determination of sectors is intended for the use of the State Mining and Geology Board in identifying areas that are candidates for designation under SMARA. The development of sectors provides a perception of future mineral resource availability in the face of future needs and also portrays where these available minerals are generally located. This information is distributed by the Board to all affected lead agencies to provide them with the data necessary to plan for future resource availability in their land-use policies.

Areas within MRZ-2 classifications are sectorized if they have current land uses which are similar to those in areas which have undergone mineral extraction in the past. Areas within MRZ-2 classifications which have generally not been available for surface mining in the past for specified social or economic reasons are not sectorized. Since such areas are unlikely to be used for surface mining during the foreseeable future, their inclusion in estimates of future resource availability would be misleading.

The estimation of future mineral resource availability in sectors is not a precise analysis, but rather is the best general estimate which can be made with the data presently available. Areas within and without sectors can be used for mining or other land uses at the discretion of the local governments which are charged with responsibility for making land-use decisions. Establishment of sectors in no way infringes on this authority. Rather, it provides a perception of future mineral resource availabilities in the face of future needs and also portrays where these available minerals are generally located.

The following criteria were used by DMG in identifying mineral resource areas which are available for future use. These criteria, in conjunction with the geologic and geometric characteristics of specific mineral deposits was used in sectorizing MRZ-2 areas. Use of these criteria assure that sectors contain geologically homogenous mineral deposits which, based upon current land use, will be available for future use.

The following specific land uses are considered to be generally incompatible with mining and have been excluded from sectorized lands. Mineral resource areas containing land uses not specifically listed will be considered for sectorization. The criteria are to be applied only to lands classified as MRZ-2.

There are two general categories of exclusion: Economic Exclusion and Social Exclusion.

I. *Economic Exclusion*
Specific excluded land uses are:

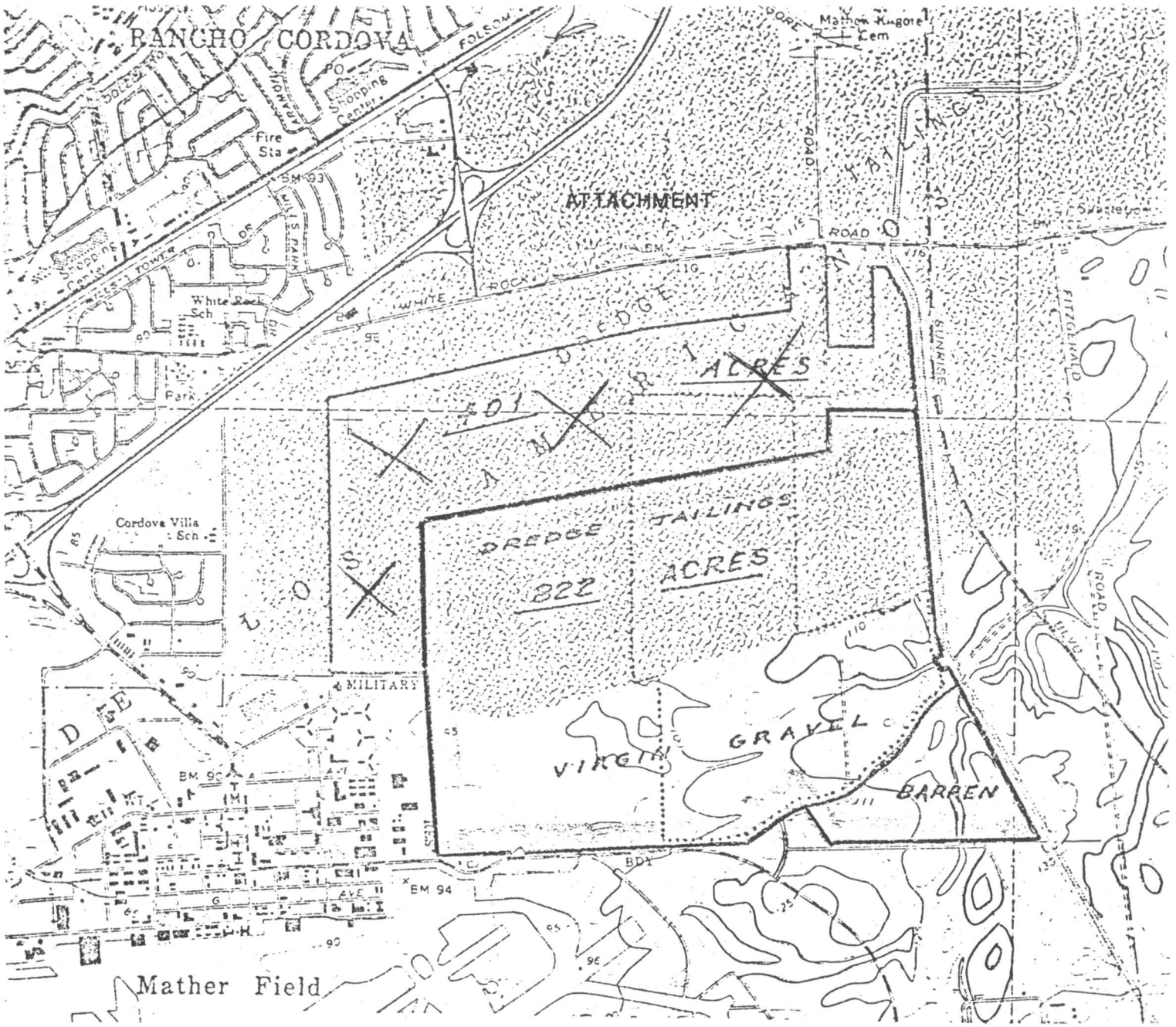
1. Residential areas
2. Commercial areas with land improvements (buildings),
3. Industrial areas (buildings and adjacent needed storage and parking facilities), and
4. Major public or private engineering projects, including:
   a. canals
   b. freeways
   c. bridges
   d. airports and associated developments such as parking lots
   e. dams
   f. railroads
   g. major pipelines
   h. major power transmission lines

II. *Social Exclusion*
Specific excluded land uses are:

1. Cemeteries,
2. Geologic scientific zones,
3. Public parks, developed historical sites and structures, and public recreation areas of all types,*
4. Public or private schools, institutions, hospitals, and prisons, including adjacent grounds and related structures, and
5. Military bases and reservations.

*NOTE: Since the development of these interim criteria, a policy change regarding parklands has occurred. Parklands are now sectorized if they are not excluded on the basis of economic criteria. Sectorized parklands are, however, treated separately in the classification reports, and their mineral resources are not mixed with those occurring on other types of land.

APPENDIX 2



Map showing Lone Star Rancho Cordova deposit

COUNTY OF SACRAMENTO
PLANNING AND COMMUNITY DEVELOPMENT DEPARTMENT

ENVIRONMENTAL IMPACT SECTION

SUSAN R. ZIEGLER
DIRECTOR

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ENVIRONMENTAL COORDINATOR

May 7, 1985

Rudolph G. Strand, Geologist
California Division of Mines and Geology
1416 Ninth Street, Room 1341
Sacramento, CA 95814

Subject: MINERAL LAND CLASSIFICATION: PORTLAND CEMENT CONCRETE-GRADE AGGREGATE IN THE SACRAMENTO-FAIRFIELD PRODUCTION-CONSUMPTION REGION - 1985 California Department of Conservation, Division of Mines and Geology. Special Report 156

Dear Mr. Strand:

As you may recall, Mr. Freitas spoke before the State Mines and Geology Board on April 17, 1985 regarding Special Report 156 Mineral Land Classification: Portland Cement Concrete Grade Aggregate In The Sacramento Fairfield Production - Consumption Region (1985).

Mr. Freitas conveyed to the Board that we have no problem with the classification of mineral resources contained in that report. However, we do have a specific concern regarding the identification of certain MRZ-2 areas as aggregate resource sectors.

Our concern relates to the fact that once an area is identified as a sector, it implies that the aggregate resources found within that sector are available for future use.

It is our opinion that land use decisions made by the Sacramento County Board of Supervisors and other policy factors make the harvesting of aggregates from some sectors very unlikely. This would imply that larger quantities of aggregates are available than realistically exist. Following is a sector by sector description of circumstances that would affect the availability of aggregates in Sacramento County.

- **Sector K-1, K-2, K-3, J-1, J-2, J-3, J-4, J-5**

  All these sectors are within the American River Parkway. The American River Parkway is a public regional recreational resource serving approximately 4 million users per year. Since 1959, approximately 33 million dollars has been spent to develop, operate, and maintain the parkway. The source of this money included Federal and State grants, County funds, and private contributions. A major portion of Sacramento County's funding came from a 12.6 million dollar bond issue approved overwhelmingly by the voters in 1972. Much of this money was spent to purchase property being mined by the Lone Star and Erickson Companies in the mid 1970's. Since that time, the American River has been designated a Wild and Scenic River by the Federal Government and State of California. For these reasons, as well as others, we are confident that no mining would be permitted in the future in these sectors.

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- **Sector L**
  This area is owned by the U.S. Bureau of Reclamation and managed by the State Department of Parks and Recreation. A. Teichert and Sons, Inc. presently has a surface mining operation on the site. We have no objection to placing that portion lying north of the American River (Mississippi Bar area) within a sector.

- **Sectors E-1, E-2, E-3**
  These sectors are within the City of Folsom. The City of Folsom should be consulted regarding recently approved projects in this area, especially sector E-1.

- **Sector H-3**
  Development of this property is now taking place. Consequently the mining of aggregate resources from the subject site is very unlikely.

- **Sector H-4**
  This area is part of a development project known as Gold River, approved by Sacramento County in 1981. As such, Sacramento County is a party to the development agreements. It is very unlikely that this area would be mined to recover aggregate resources.

- **Sector H-5**
  A use permit was granted in 1981 for the harvesting of aggregates from the site. A development project proposed for sector H-5 (known as Tributary Point) was recommended for approval to the Board of Supervisors. The Board is scheduled to hear this proposal on May 22, 1985. It is unlikely that any aggregates not yet mined under the use permit will be harvested.

- **Sector H-1**
  This sector encompasses land owned by Aerojet General Corporation and contains extensive improvements. Aerojet General Corporation should be contacted for additional information and their Master Plan which delineates existing and proposed uses.

- **Sector H-2**
  This sector was recently acquired from McDonnell-Douglas Corporation by Aerojet General Corporation. We have no objections over the identification of this sector.

- **Sectors G-1 and G-2**
  A development proposal involving the northerly one third of these two combined sectors has recently been approved by Sacramento County. Only the southerly two thirds, consisting of about 800 acres are available for surface mining (see attached map).

- **Sector F-9**
  Several development projects, the largest of which is known as Bradshaw Technology Park, have been approved for this sector area by Sacramento County and are now under construction. It is very unlikely that this sector would be mined.

- **Sector F-10**
  Several development projects now under construction have been approved for a major portion of this sector. It is very unlikely that surface mining will occur here in the future.

- **Sector F-8**
  An industrial development project has been approved for this sector area by the Sacramento County Board of Supervisors.

- **Sectors I-1, I-2, I-4, I-5 and I-6**
  These sectors are presently divided into many small individual ownerships. It has been our experience that the mining industry has difficulties in purchasing too many small parcels for prices which justify mining.

- **Sectors F-1 and F-4**
  These sectors are nearly entirely within the City of Sacramento. The City should be consulted regarding mining potential on these sectors. The portion of Sector F-1 located in the County of Sacramento is under many ownerships and is partly developed with industrial uses. Mining is unlikely here.

- **Sector F-2**
  This sector is divided into many ownerships with some existing industrial uses. Mining may or may not be viable under these conditions.

- **Remaining Sectors (F-5, F-7, F-3, F-9(5), F-11, F-12, F-6, I-3)**
  The majority of land in these sectors is owned by major aggregate companies, or otherwise is considered to have a potential for aggregate mining. The potential for surface mining occurring on sectors I-6 and I-3 may be affected by development recently proposed for nearby properties.

We are very appreciative for the attention and consideration you have chosen to extend to the staff of Sacramento County.

Sincerely,

Sue Ziegler
Planning Director

Alcides Freitas
Environmental Coordinator

cc: Members State Mines and Geology Board

Attachment