

MAP SHEET 52

AGGREGATE AVAILABILITY IN CALIFORNIA

By

Susan L. Kohler

2002

**CALIFORNIA DEPARTMENT OF CONSERVATION
CALIFORNIA GEOLOGICAL SURVEY
801 K STREET
SACRAMENTO, CA 95814-3531**

CALIFORNIA GEOLOGICAL SURVEY'S PUBLIC INFORMATION OFFICES:

Southern California Regional Office
655 S. Hope Street, Suite 7000
Los Angeles, CA 90071
(213) 239-0878

Publications and Information Office
801 K Street, MS 14-31
Sacramento, CA 95814-3531
(916) 445-5716

Bay Area Regional Office
185 Berry Street, Suite 210
San Francisco, CA 94107-1728
(415) 904-7707

CONTENTS

INTRODUCTION	1
PART I: DESCRIPTION OF MAP SHEET 52, AGGREGATE AVAILABILITY IN CALIFORNIA	1
Mineral Land Classification Reports and Aggregate Studies	2
Fifty-Year Aggregate Demand Forecast	3
Methodology	3
Effectiveness of the Per Capita Consumption Model	5
Permitted Aggregate Resources	6
Permitted Resource Calculations	6
Fifty-year Aggregate Demand Compared to Permitted Aggregate Resources	9
Non-Permitted Aggregate Resources	10
Aggregate Production Areas and Districts	10
Aggregate Study Areas with Less than Ten Years of Permitted Resources	10
End Uses of Aggregate	11
PART II: OVERVIEW OF CONSTRUCTION AGGREGATE	11
Annual Aggregate Production	12
Aggregate Price	12
Transportation	12
Aggregate Quality and Use	14
Factors Affecting Aggregate Deposit Quality	15
Comparison of Alluvial Sand and Gravel to Crushed Stone Aggregate	15
Factors Affecting Aggregate Demand	16
SUMMARY	16

CONCLUSIONS AND RECOMMENDATIONS	16
ACKNOWLEDGMENTS	18
REFERENCES CITED.....	19

APPENDICES

Appendix A. Mineral land classification reports by Department of Conservation, California Geological Survey (Special Reports and Open-File Reports with information on aggregate resources).....	19
Appendix B. Description of revisions made to permitted aggregate resource calculations and 50-year aggregate demand projections in aggregate classification reports (methods used in updating information used in the development of Map Sheet 52)	24

TABLES

Table 1. Comparison of 50-year aggregate demand to permitted aggregate resources for aggregate study areas as of January 1, 2001	4
Table 2. Summary of data used to revise the permitted aggregate resources and 50-year aggregate demand presented in the published reports	7

FIGURE

Figure 1. Sand and gravel, and crushed stone production from 1960-2000	13
--	----

INTRODUCTION

Department of Conservation, California Geological Survey (CGS) Map Sheet 52, scale 1:1,100,000, and this accompanying report provide general information about the current availability of California's permitted construction aggregate resources to state, regional, and local land-use planners and decision makers, as well as the general public. **Neither Map Sheet 52 nor this report is intended to be used as the sole source of information about aggregate availability in planning and decision-making at the local level. Although the statewide and regional information on the map and in this report may be useful to local decision-makers, the more detailed information contained in each of the 32 aggregate studies used in the compilation of Map Sheet 52 should be used for land-use and decision making purposes.**

Permitted aggregate resources are resources 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. Aggregate resources that are currently permitted for mining are important because they are the current source, and most likely future source, of construction aggregate used in a great variety of public works and private-sector construction projects. Furthermore, because the cost of aggregate is largely dependent on the distance the material must be hauled from where it is mined and processed to where it is sold, local sources of aggregate are essential in maintaining reasonable costs to the consumer.

Map Sheet 52 summarizes data from studies conducted by the CGS for 32 aggregate resource areas located throughout the state. These study areas cover about 25% of the state and provide aggregate for about 90% of California's population. This report is divided into two parts: Part I provides data sources and methods used to derive the information presented on Map Sheet 52, and Part II is an overview of construction aggregate. All of the aggregate data presented on Map Sheet 52 pertain to construction aggregate, which is alluvial sand and gravel or crushed stone that is used either directly or indirectly in the production of "structures." Structures include residential dwellings, commercial and public buildings, highways, roads, bridges, dams, airports, canals, military facilities, water and sewer facilities, railroads, and other public transit facilities.

PART I: DESCRIPTION OF MAP SHEET 52, AGGREGATE AVAILABILITY IN CALIFORNIA

Map Sheet 52 is a statewide map showing a compilation of data on aggregate availability that have been collected over a period of about 23 years and have been updated to January 1, 2001. The main focus of the map is a comparison of projected aggregate demand for the next 50 years with currently permitted aggregate resources in various regions of the state. The map also shows aggregate production areas having less than 10 years of aggregate supply remaining, locations of aggregate production areas and the relative magnitude of annual production from each area, and a diagram showing end uses of aggregate. The following sections describe data sources and methodology that were used for the development of the map.

Mineral Land Classification Reports and Aggregate Studies

Much of the information regarding aggregate resources and projected aggregate demand in California has been taken from a series of mineral land classification reports published as Special Reports and Open-File Reports by CGS between 1981 and 2001. These reports were prepared in response to California's Surface Mining and Reclamation Act of 1975 (SMARA) which requires the State Geologist to classify land based on the known or inferred mineral resource potential of that land. Classification is the process of identifying lands containing significant mineral deposits, based solely on geologic factors, and without regard to present land use or ownership. The primary goal of mineral land classification is to ensure that the mineral resource potential of lands is recognized and considered in the land-use planning process. The classification process includes an assessment of the quantity, quality, and extent of aggregate deposits in a study area based on:

1. Examination and compilation of relevant geologic maps, aerial photos, geologic literature, aggregate industry data (some of which are proprietary), and aggregate engineering test data.
2. Interviews with aggregate operators, government agency personnel, and geologic consultants.
3. Compilation and analysis of subsurface water well-log data and drilling records.
4. Field investigation of active and depleted aggregate mines and quarries and the geologic formations that could contain aggregate resources.

The preparation of mineral land classification reports has been an evolving process. Some mineral land classification reports are specific to aggregate resources, some contain information on both aggregate and other mineral resources, and some contain information only on non-aggregate resources. Mineral land classification reports focusing on aggregate include aggregate resource classification and mapping, estimates of permitted and non-permitted aggregate resources, 50-year demand for permitted aggregate resources, and an estimate of when the permitted resources will be depleted. The reports also include a discussion on alternative aggregate resources.

Mineral land classification studies completed before 1989 used production-consumption (P-C) regions as the study area boundary. A P-C region is one or more aggregate production districts and the market area that those districts serve. Because the counties are one of the primary users of mineral land classification reports, the State Mining and Geology Board (SMGB) passed a resolution in 1989 to change the scope of the reports from P-C regions to county-wide studies. As a result of this change, classification reports became more user-friendly for local government planners. However, because aggregate market areas do not generally follow county boundaries, forecasting aggregate needs became more difficult.

Mineral land classification reports that focus on aggregate resources include data either on one or more P-C regions, or a county. For discussion purposes, each P-C region or county aggregate study will be referred to as an "aggregate study." There are 32 aggregate studies that were used as the framework for Map Sheet 52. These study areas are shown on the lower left-hand corner on the map. Each aggregate study is assigned (referenced by) a Special Report (SR) number or an

Open-File Report (OFR) number. It is important to note that a SR or an OFR can include more than one aggregate study area. A list of these SRs and OFRs in numerical order is included in Appendix A. There are 28 completed aggregate studies and four studies that are in progress.

As mandated by SMARA, the State Geologist is required to review mineral land classification after a period of 10 years to determine if reclassification of the area is necessary and/or if the projected 50-year forecast of construction aggregate demand in the region should be revised. Since completion of the original mineral land classification studies, seven additional updated studies have been completed which revise the information in the corresponding original reports. Update studies were done by counties (Los Angeles, Orange, and Ventura) and by P-C regions (South San Francisco Bay, Monterey Bay, Western San Diego County, and Fresno). The combined Claremont-Upland and San Bernardino P-C Regions (SR 175), and the North San Francisco Bay P-C Region (SR 179) updates are in progress. Because Los Angeles and Ventura counties had more than one P-C region, separate updated 50-year forecasts were made for each region. The Los Angeles County update (OFR 94-14) includes the San Fernando Valley, San Gabriel Valley, Saugus-Newhall, and the Palmdale P-C regions. The Ventura County update (OFR 93-10) included the Western Ventura and the Simi Valley P-C regions. The index map of aggregate studies shown in the lower left hand corner of Map Sheet 52 shows the latest updated reports that cover an aggregate study area. Earlier reports covering the same areas or portions of areas are referenced in the updated report and in Appendix A with an asterisk (“*”).

Fifty-Year Aggregate Demand Forecast

Fifty-year aggregate demand for each of the aggregate study areas is presented on Map Sheet 52 as a pie diagram (see *Fifty-Year Aggregate Demand Compared to Permitted Aggregate Resources* section of this report) and is also presented in Table 1. The forecast information used in the production of the map has been updated and modified from forecasts presented in previously published mineral land classification reports or reports that are in progress. The updated or modified forecast information depicted on Map Sheet 52 is for the period January 1, 2001 through December 2050. Most 50-year projections of aggregate demand for Map Sheet 52 were made, first by extending the demand curves in the original reports to the end of 2050, followed by summing of the annual aggregate demand over the 50-year interval from January 1, 2001 through the end of 2050. Because the Western Ventura County and the Simi Valley P-C regions showed a large change in historical consumption since the original report was completed, new 50-year forecasts were made for these two regions. The methodology and the effectiveness of forecasting are discussed below.

Methodology

Before choosing a method for predicting a 50-year aggregate demand, historical aggregate use was compared to factors such as housing starts, gross national product, population, and several other economic factors. It was determined that the only factor that showed a strong correlation to historical aggregate use was population change. Consequently, a per capita aggregate consumption model was used to forecast 50-year aggregate demand. This method of forecasting aggregate consumption benefits from its simplicity and the general availability of population

Table 1. Comparison of 50-year aggregate demand to permitted aggregate resources for aggregate study areas as of January 1, 2001. **Aggregate study areas with less than ten years of permitted resources are bolded** (see page 10, *Aggregate Study Areas with Less than Ten years of Permitted Resources*).

Aggregate Study ¹ (P-C Region/County)	50-Year Demand (million tons)	Permitted Aggregate Resources (million tons)	Percentage of Permitted Aggregate Resources as Compared to the 50-Year Demand
Tehama County	52	40	77
Glenn County	79	56	71
Sacramento-Fairfield P-C Region	225	130	58
North San Francisco Bay P-C Region	648	178	27
Stockton-Lodi P-C Region	337	260	77
South San Francisco Bay P-C Region	1,213	564	46
Merced County ²			
Eastern Merced County	98	15	15
Western Merced County	49	>50	>100
Monterey Bay P-C Region	381	243	64
San Luis Obispo-Santa Barbara P-C Region	99	93	94
Saugus-Newhall P-C Region	86	151	>100
Western Ventura County P-C Region	141	0	0
Simi Valley P-C Region	116	129	>100
San Fernando Valley P-C Region	646	confidential	<1
San Gabriel Valley P-C Region	1,250	241	19
Claremont-Upland P-C Region	270	134	50
Orange County	233	27	12
Western San Diego County P-C Region	1,099	275	25
Temescal Valley P-C Region	970	810	84
Palm Springs P-C Region	198	70	35
San Bernardino P-C Region	969	356	37
Barstow-Victorville P-C Region	165	115	70
Palmdale P-C Region	172	216	>100
Bakersfield P-C Region	246	167	68
Tulare County ²			
North Tulare County	107	12	11
South Tulare County	77	196	>100
Fresno P-C Region	565	98	17
Stanislaus County	311	35	11
Sacramento County	686	65	9
El Dorado County	85	13	15
Placer County	126	43	34
Nevada County	169	35	21
Yuba City-Marysville P-C Region	30	>2000	>100
Shasta County	118	28	24
Total	12,016	>6,845	

¹ Aggregate study areas follow either a Production-Consumption (P-C) region boundary or a county boundary. A P-C region includes one or more aggregate production districts and the market area that those districts serve. Aggregate resources are evaluated within the boundaries of the P-C region. County studies evaluate all aggregate resources within the county boundary.

² The county study has been divided into two areas, each having its own production and market area. A separate permitted resource calculation and 50-year forecast has been made for each area.

forecast data. California's Department of Finance regularly forecasts the state's population for all areas of California for use by city and county governments. Planning for allocations of resources by population forecasting is a familiar exercise for local governments.

The steps used for forecasting California's 50-year aggregate needs entail: 1) collecting yearly historical production and population data for a period of years ranging from the 1960s through 2000; 2) dividing yearly aggregate production by the population for that same year to determine annual historical per capita consumption; 3) determining an average historical per capita consumption; 4) projecting yearly population for a 50-year period; and 5) multiplying each year of projected population by the average historical per capita consumption rate to get a total 50-year aggregate demand. It should be noted that the years chosen to determine an average historical per capita consumption differ depending upon historical aggregate use for that region. For example, in Shasta County, major construction projects from the 1940s through the 1970s caused historical per capita consumption rates to be extremely high and unrepresentative of future aggregate demand (Dupras, 1997). Consequently, an average historical per capita consumption rate for Shasta County was based on the years 1980-1995.

Effectiveness of the Per Capita Consumption Model

The assumption that each person will use a certain amount of construction aggregate every year is a gross simplification of actual usage patterns, but it is intuitively correct to assume that an increase in the number of people will lead to the use of more aggregate. Over a long enough period, perhaps 20 years or longer, the random impacts of major public construction projects and economic recessions tend to be smoothed out and consumption trends become similar to historic per capita consumption rates. Per capita aggregate consumption has, therefore, become a commonly used national, state, and regional measure for purposes of forecasting.

The per capita consumption model has proven to be effective for prediction of aggregate demand in the major metropolitan areas. The Western San Diego P-C Region and the San Gabriel Valley P-C Region are examples of how well the model works having only a 2% and a 5% difference respectively, in actual versus predicted aggregate demand (Miller, 1994; 1996). However, the model may not work well in county aggregate studies where boundaries have little correlation to the aggregate market area and in P-C regions that import or export a large percentage of aggregate. In such cases, projections were based on a modified per capita consumption model. For example, if a P-C region imports 30% of its aggregate, the total 50-year projected aggregate demand for the P-C region may be decreased by 30%.

Where no correlation could be made between population and historical use, 50-year aggregate demand was based on projections of historical production. This lack of correlation can exist when a study area has a large percentage of aggregate imported into the region such as in Orange County (Miller, 1995) or when a large percentage of aggregate is exported from a region such as in the Monterey Bay P-C Region (Kohler-Antablin, 1999).

Permitted Aggregate Resources

Permitted aggregate resources (also called reserves) are aggregate deposits that have been determined to be acceptable for commercial use, exist within properties owned or leased by aggregate producing companies, and have permits allowing mining and processing of aggregate material. A “permit” means any authorization from or approval by a lead agency, the absence of which would preclude mining operations. In California, mining permits are issued by local lead agencies (county or city governments) not by the state. Map Sheet 52 shows permitted aggregate resources as a percentage of the 50-year demand on each pie diagram (see *Fifty-Year Aggregate Demand Compared to Permitted Aggregate Resources* section of this report). The actual tonnage is given in Table 1. Individual operator or company data are proprietary, and the estimates for permitted resources are composites of three or more companies in each study area. Approximately 6,845 million tons of construction-grade permitted aggregate resources lie within the 32 aggregate study areas shown on Map Sheet 52.

Permitted resource estimates shown on Table 1 and used for Map Sheet 52 were revised from estimates made in the mineral land classification reports. All permitted resource estimates are current as of January 1, 2001. Table 2 and Appendix B summarize these revisions. Permitted resource estimates from reports with recent completion dates were updated by subtracting aggregate production for each year since the permitted resources were calculated and adding any newly permitted resources. For example, if permitted resources were determined through 1996, aggregate production was subtracted for 1997, 1998, 1999, and 2000, and newly permitted resources since 1996 were added to the original tonnage. Reports with older completion dates usually required new calculations of permitted resources. CGS staff made tonnage estimates from information in reclamation plans that were submitted to the Office of Mine Reclamation (OMR) by mine operators. Estimates were also discussed with operators. In cases where reclamation plans were inadequate to make independent calculations, estimates obtained from companies were used. Aggregate studies having new permitted resource estimates are noted with a superscript (“3”) and corresponding footnote on the index map.

The amount of permitted resources available in any given study area is a dynamic number. The estimates of permitted resources presented on Map Sheet 52 are based on the best information available at the time of this study. However, permitted resources are constantly changing due to continuing aggregate production, closure of existing mining operations, changes in permit conditions at existing mining operations, issuance of new or expanded mining permits, or other factors. Also, permitted resources may include aggregate deposits that are permitted, but for a variety of reasons have not yet begun to be mined or may not be mined in the future. Those interested in current information should consult with local lead agencies to determine the present status of mining operations in areas of interest.

Permitted Resource Calculations

In most cases, CGS staff independently calculated permitted resources for each mining property located within the 32 aggregate study areas. The methodology used for calculating permitted resources varied depending on the information that was available at the time of the study. Site visits were made by CGS staff to each mining operation at which time company representatives were asked questions such as deposit thickness, waste factors, in-situ density, aggregate uses,

AGGREGATE AVAILABILITY IN CALIFORNIA
MAP SHEET 52

2002

7

Table 2. Summary of data used to revise the permitted aggregate resources and 50-year aggregate demand presented in the published reports. Reports that have new permitted resource calculations are shown in *italics*; the Production Since Report and the Permitted Resources Added Since Report columns are not applicable (NA) for these reports. Confidential data are indicated by a "C."

Aggregate Study Area SR = Special Report OFR = Open-File Report	Last Database Year ¹	Report Permitted Resources ^{2,3}	Production Since Report ³	Permitted Resources Added Since Report ³	Updated Permitted Aggregate Resources ^{3,4}	Updated 50-Year Demand ^{3,4}
1. Tehama County SR 176	2000	41	1	0	40	52
2. Glenn County OFR 97-02	1995	61	5	0	56	79
3. <i>Sacramento-Fairfield SR 156</i>	1985	40	NA	NA	130	225
4. <i>North San Francisco Bay SR 176</i>	2000	178	NA	NA	178	648
5. <i>Stockton-Lodi SR 160</i>	1986	80	NA	NA	260	337
6. South San Francisco Bay OFR 96-03	1994	676	112	0	564	1,213
7. Merced OFR 99-08 Eastern Merced County Western Merced County	1999 1999	4 >50	3 C	14 0	15 >50	98 49
8. Monterey Bay OFR 99-01	1997	269	26	0	243	381
9. San Luis Obispo-Santa Barbara SR 162	1987	107	22	8	93	99
10. Saugus-Newhall OFR 94-14	1992	158	7	0	151	86
11. Western Ventura County OFR 93-10	1991	C	C	0	0	141
12. Simi Valley OFR 93-10	1991	156	27	0	129	116
13. San Fernando Valley OFR 94-14	1992	51	C	0	C	646
14. San Gabriel Valley OFR 94-14	1992	334	93	0	241	1,250
15. <i>Claremont-Upland SR 176</i>	2000	134	NA	NA	134	270
16. <i>Orange County OFR 94-15</i>	1993	84	NA	NA	27	233

Table 2 is continued on following page.

CALIFORNIA DEPARTMENT OF CONSERVATION
CALIFORNIA GEOLOGICAL SURVEY

Aggregate Study Areas SR = Special Report OFR = Open-File Report	Last Database Year ¹	Report Permitted Resources ^{2,3}	Production Since Report ³	Permitted Resources Added Since Report ³	Updated Permitted Aggregate Resources ^{3,4}	Updated 50-Year Demand ^{3,4}
17. Western San Diego County OFR 96-04	1994	352	77	0	275	1,099
18. Temescal Valley SR 165	1989	924	114	0	810	970
19. <i>Palm Springs SR 159</i>	1985	67	NA	NA	70	198
20. <i>San Bernardino SR 175</i>	2000	356	NA	NA	356	969
21. <i>Barstow-Victorville OFR 92-06</i>	1990	87	NA	NA	115	165
22. Palmdale OFR 94-14	1992	207	21	30	216	172
23. <i>Bakersfield SR 147</i>	1984	212	NA	NA	167	246
24. Tulare County OFR 97-01 North Tulare County South Tulare County	1994 1994	19 200	7 4	0 0	12 196	107 77
25. Fresno OFR 99-02	1997	93	15	20	98	565
26. <i>Stanislaus County SR 173</i>	1991	28	NA	NA	35	311
27. Sacramento County OFR 99-09	1998	53	21	33	65	686
28. El Dorado County SR 178	2000	13	0	0	13	85
29. <i>Placer County OFR 95-10</i>	1994	50	NA	NA	43	126
30. <i>Nevada County SR 164</i>	1989	29	NA	NA	35	169
31. <i>Yuba City-Marysville SR 132</i>	1984	1,260	NA	NA	>2,000	30
32. Shasta County OFR 97-03	1995	30	6	4	28	118
Total					>6,845	12,016

¹ Last Database Year is the most recent year that aggregate production data were available at the time the report was completed.

² Report Permitted Resources is the tonnage of aggregate resources permitted to be mined by the lead agency at the time the report was complete.

³ Numbers are in millions of tons (one ton = 2,000 pounds).

⁴ Updated to January 1, 2001.

quality, extent of the permitted property, and permit conditions. Mining regulations vary greatly depending on the lead agencies involved. Information needed to determine permitted resources includes mining limits, minimum setbacks, finished slopes for pit and quarry walls, and mining depth. Mining plans, reclamation plans, and cross sections were used if available. Site-specific mining regulations were also obtained from lead agency files and from OMR files. Whenever possible, calculations of permitted resources were compared to company estimates, and, if major discrepancies were found, every effort was made to resolve them.

Fifty-year Aggregate Demand Compared to Permitted Aggregate Resources.

Fifty-year aggregate demand compared to current permitted aggregate resources is represented by one or two pie diagrams for each aggregate study shown on Map Sheet 52. Each pie diagram is located in the approximate center of the study area it represents. There are four different sizes of pies, each size representing a 50-year demand range. The smallest pie category represents 50-year demands ranging from 25-200 million tons while the largest represents a 50-year demand of over 800 million tons. The actual 50-year demand tonnage is shown on the map next to the pie diagram. The whole pie represents the total 50-year aggregate demand for a particular aggregate study area. The blue portion of the pie represents the permitted aggregate resource (shown as a percentage of the 50-year demand) while the purple-colored portion of the pie represents that portion of the 50-year demand that will not be met by these resources. For example, if the blue portion is 25%, and the purple portion is 75% of a pie diagram that represents a total of 400 million tons of aggregate demand, the permitted resources are 100 million tons, and the region will need an additional 300 million tons of aggregate to supply the area for the next 50 years. If a pie is completely colored purple, such as in the case of Western Ventura County, the region no longer contains any permitted resources. A pie that is completely colored blue shows that permitted aggregate resources are equal to or greater than the 50-year aggregate demand.

Except for Tulare and Merced counties, all of the aggregate study areas have just one 50-year demand pie diagram located in the center of the aggregate study area that it represents. The Tulare County and Merced County aggregate studies each have two 50-year pie diagrams because there are two distinct market areas in each of these counties.

As can be seen on Table 1 and Map Sheet 52, some regions of the state have more than enough permitted aggregate reserves to meet the projected 50-year demand in those areas, but most have less permitted resources than will be required to meet the projected 50-year demand. There are several options by which the future 50-year demand for construction aggregate may be met in these areas.

1. Permits for new aggregate mines or expansions to existing aggregate mines may be granted to accommodate the demand for aggregate.
2. Aggregate may be imported from other regions of the state or even from outside of the state to meet the demand for aggregate. Due to the costs associated with transporting aggregate, such options may increase the cost of aggregate to the consumer.

3. Increased aggregate recycling may reduce the future demand for aggregate resources. However, recycled material cannot now be used to make concrete aggregate or asphalt aggregate. Its use in California is limited to class II asphalt base and some Recycled Asphalt Pavement – old asphalt that is torn up and mixed in small percentages with new asphalt paving at the batch plant.

Non-Permitted Aggregate Resources

Non-permitted aggregate resources are deposits of sand and gravel or crushed stone that may meet specifications for construction-grade aggregate, are recoverable with existing technology, have no land overlying them that is incompatible with mining, and are currently not permitted for mining. While not shown on Map Sheet 52, non-permitted aggregate resources are identified and discussed in the individual mineral land classification reports used to compile the map (see Appendix A). There are currently an estimated 74 billion tons of non-permitted construction-grade aggregate resources in the 32 aggregate study areas shown on the map. While this number seems large, it is unlikely that a significant portion of these resources will ever be mined due to social, environmental, or economic factors. Land-use conflicts occurring when non-permitted aggregate resources are located too close to urban or environmentally sensitive areas, can limit or stop the development of these resources. Non-permitted resources may also be located too far from a potential market to be economically mined and transported to the market area. In spite of these possible constraints, non-permitted aggregate resources are the most likely future sources of construction aggregate potentially available to meet California's continuing demand.

The factors used to determine the areal extent and tonnage of non-permitted resources are given in each of the aggregate classification reports listed in Appendix A.

Aggregate Production Areas and Districts

Aggregate production areas (both sand and gravel, and crushed stone) are shown on the map as five different triangle sizes. A triangle may represent one or more active aggregate mines. The relative size of each symbol corresponds to the amount of yearly production for each mine or group of mines. Yearly production was based on data from OMR records for the calendar year 2000. The smallest triangle represents a production area that produces less than 0.5 million tons of aggregate per year. These triangles usually represent just one mine operation. About 85% of the production areas on the map fall into this category and are mostly located in rural parts of the state. The largest triangle represents aggregate mining districts with production over 10 million tons per year. Only two production areas fall into this category: the Temescal Valley Production District in western Riverside County; and the San Gabriel Valley Production District in Los Angeles County. The San Gabriel Valley Production District produced over 15 million tons of aggregate in 2000, and is the largest aggregate production district in the United States.

Aggregate Study Areas with Less than Ten Years of Permitted Resources

Seven of the 32 aggregate study areas shown on Map Sheet 52 have less than 10 years of permitted aggregate resources remaining. They are highlighted by red halos around the pie diagrams on Map Sheet 52 and appear in bold type in Table 1. Aggregate study areas with less than five years of

permitted resources remaining include Western Ventura County (depleted in 1997) and the San Fernando Valley. Aggregate study areas where permitted resources will be depleted in 5 to 10 years include the eastern portion of Merced County, the northern portion of Tulare County, Sacramento County, Orange County, and Stanislaus County.

Estimates of depletion years are made by comparing the currently permitted resources to the projected annual aggregate consumption in the study area on a year-by-year basis. This is not the same as dividing the total projected 50-year demand for aggregate by 50 because, as population increases, so does the projected annual consumption of aggregate for a study area. It should be noted that these numbers are estimates and they can quickly change. For example, if a neighboring P-C region runs out of aggregate and begins to import aggregate from another region, a 10-year supply can quickly drop to just a few years supply.

End Uses of Aggregate

The map of Aggregate Availability in California includes a pie diagram showing end uses of all construction aggregate. The diagram is based on a nationwide study done by Coopers and Lybrand (1998a, b) and has been modified for Map Sheet 52. The diagram shows that building construction uses about 56% of total construction aggregate produced and includes residential housing (34%), commercial buildings (17%), schools and hospitals (2%), and other public buildings (3%). Road construction and maintenance use about 29% of all construction aggregate produced; public highways, streets and transit facilities comprise 26%, while private roads amount to about 3%. Other construction aggregate uses include water and sewer facilities 5%, railroads 1%, utilities 4%, other public facilities 3%, and other private facilities 2%.

Both the public and private sectors are consumers of construction aggregate. Nationwide, about 43% of all construction aggregate is used for public works projects and is paid for with tax dollars. In California, this would have amounted to roughly \$573,000,000 spent by public agencies in 2001 to purchase construction aggregate. The amount of construction aggregate used in public works projects varies in different areas of the country and state and also varies with fluctuations of the economy. The California Traffic Congestion Relief Plan announced in April 2000, will fund nearly 100 high-priority transportation projects throughout the state, at a cost of 5.3 billion dollars.

PART II: OVERVIEW OF CONSTRUCTION AGGREGATE

Construction aggregate is the leading non-fuel mineral commodity produced in California as well as in the nation. Valued at \$1.33 billion, aggregate made up about 41% of California's \$3.27 billion non-fuel mineral production in 2001. California is the nation's leading producer of construction aggregate. Total production of construction aggregate in 2001 amounted to almost 230 million tons.

Annual Aggregate Production

A histogram (Figure 1) shows California's annual production of construction aggregate for the years 1960-2000. Historical production data were obtained from OMR records, and from U.S. Geological Survey (USGS) and U.S. Bureau of Mines mineral statistics.

Large public works construction projects can significantly influence aggregate consumption trends. For example, massive interstate highway, dam, and aqueduct projects throughout California in the 1960s through the early 1970s caused aggregate production to be generally high and fairly constant for these years in spite of a recession in the early 1970s. With the completion of these large projects by the mid 1970s, California's aggregate industry became more sensitive to the ups and downs of the economy. Figure 1 reveals three main production lows that generally correspond to recessionary periods in the mid 1970s, the early 1980s, and early 1990s. Aggregate production lows do not correspond exactly to recessionary times because there is generally a lag time between onset of recessions and decline in aggregate use. Conversely, there were large increases in aggregate use in the late 1980s and the late 1990s corresponding with periods of strong economic growth.

Aggregate Price

In general, aggregate is more expensive in northern California than in southern California. Some of the most expensive aggregate in the state is in the north San Francisco and Monterey Bay regions. This higher cost is due mainly to a general shortage of portland cement concrete-grade (PCC-grade) permitted aggregate resources in these areas. PCC-grade aggregate from the north San Francisco Bay region can cost up to \$20.00 per ton compared to the Los Angeles area where PCC-grade aggregate generally does not exceed \$8.00 per ton. The average cost of PCC-grade aggregate in California is about \$8-\$10 per ton.

Transportation

Transportation plays a major role in the cost of aggregate to the consumer. Because aggregate is a low-unit-value, high-bulk-weight commodity, it must be obtained from nearby sources to minimize both the dollar cost to the aggregate consumer and other environmental and economic costs associated with transportation. If nearby sources do not exist, then transportation costs can quickly exceed the value of the aggregate. Transporting aggregate a distance of 25 to 35 miles will generally double the price of the aggregate. Transporting aggregate from distant sources also results in increased fuel consumption, air pollution, traffic congestion, and road maintenance. Moreover, transportation cost is the principal constraint defining the market area for an aggregate mining operation.

An adequate supply of local aggregate is critical to the building and infrastructure needs of California. In order to ensure local sources of aggregate, it is necessary to identify California's permitted aggregate resources and to project future aggregate demand.

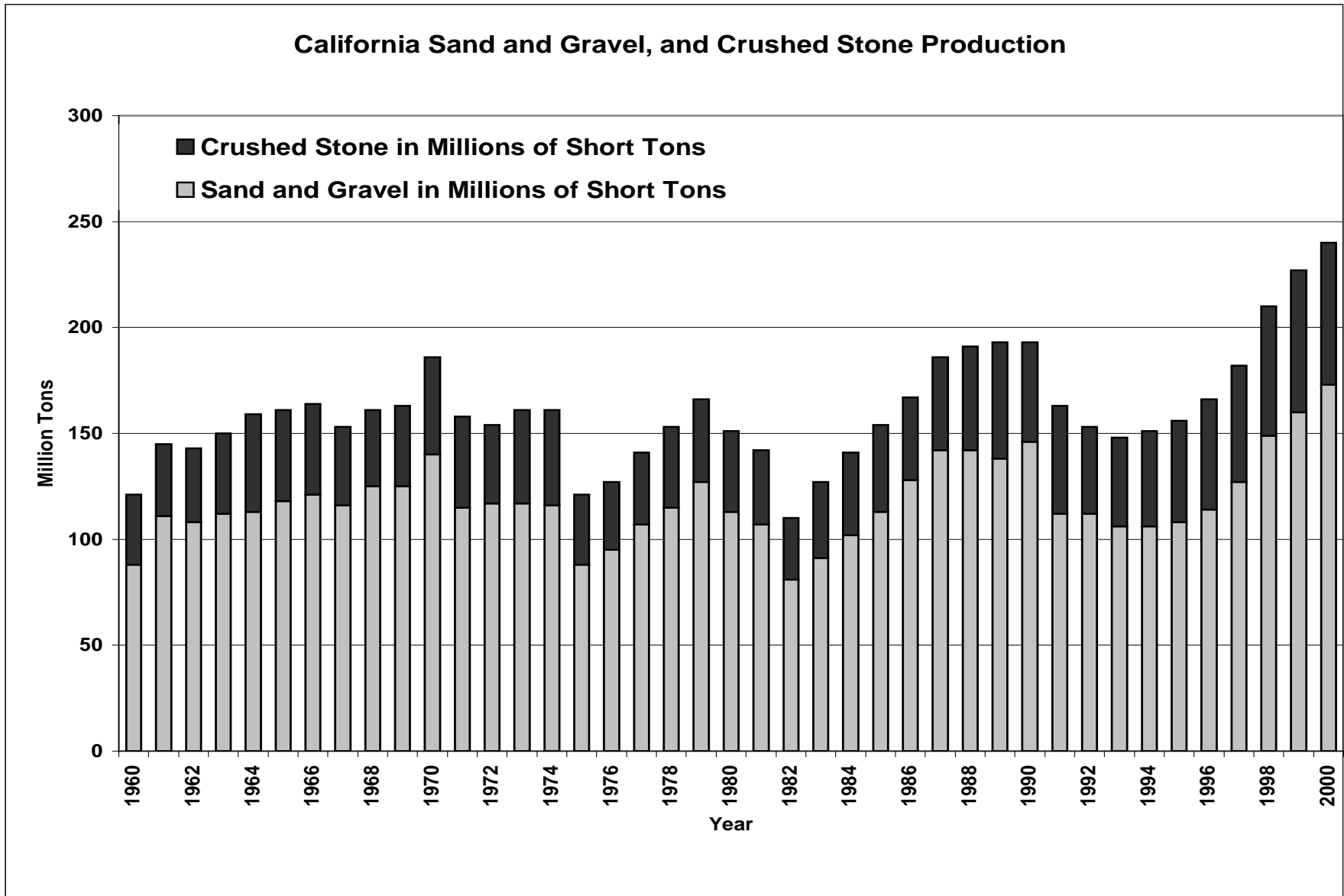


Figure 1. Sand and gravel, and crushed stone production from 1960 - 2000. (One short ton = 2,000 pounds.)

Aggregate materials are essential both to maintain the existing infrastructure and to provide for new construction. The demand for aggregate is expected to increase throughout California as our economy grows.

Aggregate Quality and Use

Construction aggregate provides the bulk and strength to portland cement concrete (PCC), asphaltic concrete (AC), plaster, and stucco. Aggregate is also used as road base, subbase, railroad ballast, and fill. Aggregate normally forms 80% to 100% of the material volume in these uses. 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 the material can meet specifications for a particular use, and what processing is required. Specifications for various uses of aggregate 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 test aggregate using standard test procedures of the American Society for Testing Materials (ASTM), the American Association of State Highway Officials, and other organizations.

Most aggregate specifications have been established to ensure the manufacture of strong, durable structures capable of withstanding the physical and chemical effects of weathering and use. For example, specifications for PCC and concrete products prohibit or limit the use of rock materials containing mineral substances such as gypsum, pyrite, zeolite, opal, chalcedony, chert, siliceous shale, volcanic glass, and some high-silica volcanic rocks. Gypsum retards the setting time of portland cement; pyrite dissociates to yield sulfuric acid and an 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." Alkali reactions in PCC can be minimized by the addition of pozzolanic admixtures such as fly ash or naturally occurring pozzolanic materials. Pozzolan materials are defined as a siliceous or siliceous and aluminous material of natural or artificial origin that, in the presence of moisture, reacts with calcium hydroxide to form cementitious compounds. Naturally occurring pozzolanic materials include diatomaceous earth, diatomite, volcanic ash, opaline shale, pumicite, tuff, and certain clays such as kaolinite.

Specifications also call for precise particle-size distribution for the various uses of aggregate. Aggregate is commonly classified into two general sizes: coarse and fine. Coarse aggregate is rock retained on a 3/8-inch or a #4 U.S. sieve. Fine aggregate passes a 3/8-inch 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 (1992) require that at least 25% by weight of coarse aggregate (1/4- to 3/4-inch diameter) used as Class II aggregate base material shall be crushed particles. Furthermore, aggregate material used with bituminous binder (asphalt) to form sealing coats on road surfaces shall consist of at least 90% by weight of crushed particles. Crushed stone is preferable to natural gravel in asphaltic concrete (AC) because asphalt adheres better to broken surfaces than to rounded surfaces, and the interlocking of angular particles strengthens the AC and road base.

The material specifications for PCC and AC aggregate, collectively referred to as "concrete aggregate," are more restrictive than the specifications for aggregate for other applications such as base, subbase, and fill. The restrictiveness of these specifications makes deposits acceptable for

use as PCC or AC aggregate the scarcest and most valuable aggregate resources. This also means that aggregate produced from such deposits can be, and commonly is, used in applications other than concrete. Because of its versatility, value, importance in construction, and relative scarcity, deposits of concrete aggregate are of major concern when planning for future availability of aggregate commodities. Some areas of California, such as the Los Angeles Basin, have abundant high-quality aggregate deposits that typically meet the specifications for concrete aggregate. Aggregate consumers in these areas of the state typically pay lower prices for construction aggregate. In other areas of the state, such as the San Francisco Bay area, deposits of high quality aggregate that meets the specifications for concrete aggregate are much less common, and the cost of concrete aggregate to the consumer is typically higher.

Factors Affecting Aggregate Deposit Quality

The major factors that affect the quality of an aggregate deposit are the rock type and the degree of weathering of the deposit. Rock type determines the hardness, durability, and potential chemical reactivity of the rock when mixed with cement to make concrete. In alluvial sand and gravel deposits, rock type is variable and reflects the rocks present in the drainage basin of the stream or river. In crushed stone deposits, rock type is typically less variable, although in some types of deposits such as sandstones or volcanic rocks there may be significant variability of rock type within a deposit. Rock type may also influence aggregate shape. For example, some metamorphic rocks, such as slates, tend to break into thin platy fragments that are unsuitable for many aggregate uses, while many volcanic and granitic rocks break into blocky fragments more suited to a wide variety of aggregate uses. Deposit type also affects aggregate shape. For example, in alluvial sand and gravel deposits, the natural abrasive action of the stream rounds the edges of rock particles, in contrast to the sharp edges of particles from crushed stone deposits.

Weathering is the in-place physical or chemical decay of rock materials at or near the Earth's surface. Weathering commonly decreases the physical strength of the rock and may make the material suitable only for uses in which high strength and durability are not specified. Weathering may also alter the chemical composition of the aggregate making it less suitable for some aggregate uses. If weathering is severe enough, the material may not be suitable for use as construction aggregate. Typically, the older a deposit is, the more likely it has been subjected to weathering, and the severity of weathering commonly increases with increasing age of the deposit.

Comparison of Alluvial Sand and Gravel to Crushed Stone Aggregate

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 typically preferred to crushed stone for PCC aggregate because the rounded particles of alluvial sand and gravel result in a wet mix that is easier to work than a mix made of angular fragments. Also, crushed stone is less desirable in applications where the concrete is placed by pumping, because sharp edges will increase wear and damage to the pumping equipment. The workability of a mix consisting of portland cement with crushed stone aggregate can be improved by adding more sand

and water, but more cement must then be added to the mix to meet concrete durability standards. This results in a more expensive concrete mix and a higher cost to the consumer. In addition,

aggregate from a crushed stone deposit is typically more expensive than that from an alluvial deposit due to the additional costs associated with the ripping, drilling and blasting necessary to remove material from most quarries and the additional crushing required to produce the various sizes of aggregate. Manufacturing sand by crushing is more costly than mining and processing naturally occurring sand. Although more care is required in pouring and placing a wet mix containing crushed stone, PCC made with this aggregate is as satisfactory as that made with alluvial sand and gravel of comparable rock quality. Due to environmental concerns and regulatory constraints in many areas of the state, it is likely that extraction of sand and gravel resources from instream and floodplain areas will become more difficult in the future. If this trend continues, crushed stone may become increasingly more important to the California market.

Factors Affecting Aggregate Demand

Strong economic growth may contribute to a faster rate of aggregate depletion than what has been forecasted in the CGS classification reports. The nation's strong economy since about 1995 has brought about a resurgence of new home and business construction as well as large construction projects such as airports, new roads, rail systems, and re-paving of existing roads. Large construction projects expected to make a major drain on California's aggregate supply locally include the expansion of the San Francisco Airport and the proposed 700-mile high-speed rail system connecting northern and southern California. The San Francisco Airport expansion is estimated to need as much as 66 million tons of crushed stone over a two-year period, to construct the platform runways. Unforeseen events such as a major earthquake in populated areas may also contribute to an increased aggregate demand.

Several factors may contribute to extending the life of California's permitted aggregate resources. A recession in the state's or the nation's economy will result in a decrease in construction activities. Also, an increase in the use of recycled aggregate for base rock will decrease the need for new aggregate. The importation of aggregate from other states and countries such as Canada and Mexico is also expected to extend the life of California's permitted aggregate resources. New state-of-the-art ships are capable of hauling up to 70,000 tons of aggregate.

SUMMARY

Construction aggregate is the largest non-fuel mineral commodity produced in California as well as in the nation. Aggregate production plays a major role in the economy of California. Demand for aggregate is expected to increase as the state's population continues to grow and infrastructure is maintained and improved upon. For the last 23 years, CGS has identified and assessed aggregate resources throughout the state and continues to do so. Map Sheet 52 summarizes updated data from these CGS aggregate studies. The map presents state, regional, and local land-use planners and decision makers, the aggregate industry, and the general public with a statewide overview of aggregate needs and permitted resources.

CONCLUSIONS AND RECOMMENDATIONS

Construction aggregate is essential to the needs of our modern society, providing material for the construction and maintenance of roadways, dams, canals, buildings and other parts of the infrastructure of our state. Construction aggregate can also be found in our homes, schools, hospitals and shopping centers. In 2000 and 2001, California consumed from 230 to 240 million tons of construction aggregate annually, or about 7 tons per person for every man, woman, and child in the state. About 43% of construction aggregate is used in public works projects nationwide, and is paid for with tax dollars. The remaining 57% is purchased by private parties and used for residential and commercial buildings, private roads, and other private facilities. Because the cost of transporting construction aggregate is a significant part of the total cost to the consumer, aggregate mines generally are located close to communities that consume the aggregate.

The following conclusions can be drawn from Map Sheet 52 and this accompanying report. Reference is made to the 34 aggregate consumption areas that are represented by the 34 pie diagrams shown on Map Sheet 52:

1. Seven of the aggregate consumption areas are estimated to have less than ten years of permitted aggregate resources remaining as of January 2001 (pie diagrams highlighted with red borders).
2. An additional five of the aggregate consumption areas have less than 25% of the permitted aggregate resources they will need to meet the projected 50-year aggregate demand in those areas.
3. Seven of the aggregate consumption areas have 25% to 50% of the permitted aggregate resources they will need to meet the projected 50-year aggregate demand in those areas.
4. Five of the aggregate consumption areas have between 50% and 75% of the permitted aggregate resources they will need to meet the projected 50-year aggregate demand in those areas.
5. Four of the aggregate consumption areas have between 75% and 100% of the permitted aggregate resources they will need to meet the projected 50-year aggregate demand in those areas.
6. Six of the aggregate consumption areas have adequate permitted aggregate resources to meet or exceed the projected 50-year demand in those areas. However, most of these study areas are in more rural parts of the state where demand for construction aggregate is lower.

Map Sheet 52 provides local land-use planners and decision-makers with general information about California's construction aggregate availability. More detailed information on aggregate resources is given in the supporting aggregate studies that are referenced at the end of this report.

The information presented on Map Sheet 52 and in the referenced reports is provided to assist land-use planners and decision-makers in identifying those areas containing construction aggregate resources and to identify potential future demand for these resources in different regions of the

state. This information should help planners and decision makers to balance the need for construction aggregate with the many other competing land use issues in their jurisdictions and to provide for adequate supplies of construction aggregate to meet future needs.

Land-use planners should become familiar with the information presented in the mineral land classification reports that pertain to their jurisdictions, and, as mandated by SMARA, incorporate the information into their land-use planning process. Staff of the Department of Conservation's California Geological Survey are available to assist local planners, decision makers, and others in interpreting the information contained in these reports. Interested parties are encouraged to contact the CGS for further assistance.

ACKNOWLEDGMENTS

A preliminary version of the map was reviewed by aggregate industry representatives, local government planners, and private consultants, with expertise in aggregate mining issues. The reviewers were chosen to represent northern, central, and southern California and were asked to review the content, clarity, usability, and aesthetics of the map. The CGS staff would like to thank the following participants for their comments: Bruce Jensen, Senior Planner for Alameda County Community Development Agency; Dave Morrison, Assistant Director for Yolo County Planning and Public Works Department; Rich Touslee, Senior Associate Planner for San Bernardino County Advance Planning Mining Division; Steve Bledsoe, President of the Southern California Rock Products Association; Gene Block, Retired (former Vice President of Legislative Affairs, Vulcan Materials Company, Western Division); William Butler, Vice President and General Manager of Hansen Aggregates Mid Pacific Inc.; Pete Cotter, Regional Manager for Aggregate Resources, RMC Pacific Materials; Linda Falasco, Executive Director of the Construction Material Association of California; and John Hecht, President of West Coast Environmental and Engineering.

REFERENCES CITED

California Department of Transportation, 1992, Standard Specifications.

Coopers and Lybrand, 1998a, The economic and budgetary impact of repealing the percentage depletion deduction for aggregate: in house report, 19 p.

Coopers and Lybrand, 1998b, C and L study evaluates impact of repealing the percentage depletion deduction for aggregates: *Aggregates Manager*, v. 3 no. 3, p. 6-8.

Division of Mines and Geology, 2000, California surface mining and reclamation policies and procedures: Special Publication 51, third revision.

Dupras, D.L., 1997, Mineral land classification of alluvial sand and gravel, crushed stone, volcanic cinders, limestone, and diatomite within Shasta County, California.

Kohler-Antablin, S.L., 1999, Update of mineral land classification: aggregate materials in the Monterey Production-Consumption Region, California.

Miller, R.V., 1994, Update of mineral land classification of portland cement concrete aggregate in Ventura, Los Angeles, and Orange counties, California: Part II – Los Angeles County.

Miller, R.V., 1995, Update of mineral land classification of portland cement concrete aggregate in Ventura, Los Angeles, and Orange counties, California: Part III – Orange County.

Miller, R.V., 1996, Update of minerals land classification: aggregate materials in the western San Diego County Production-Consumption Region.

**APPENDIX A: MINERAL LAND CLASSIFICATION REPORTS BY
DEPARTMENT OF CONSERVATION, CALIFORNIA GEOLOGICAL
SURVEY (Special Reports and Open-File Reports, with information on
aggregate resources)**

SPECIAL REPORTS (SR)

- SR 132: Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Yuba City-Marysville Production-Consumption Region.
By Habel, R.S., and Campion, L.F., 1986.
- *SR 143: Part I: Mineral Land Classification of the Greater Los Angeles Area: Description of the Mineral Land Classification Project of the Greater Los Angeles Area.
By Anderson T. P., Loyd, R.C., Clark, W.B., Miller, R.M., Corbaley, R., Kohler, S.L., and Bushnell, M.M., 1979.
- *SR 143: Part II: Mineral Land Classification of the Greater Los Angeles Area: Classification of Sand and Gravel Resource Areas, San Fernando Valley Production-Consumption Region.
By Anderson T.P., Loyd, R.C., Clark, W.B., Miller, R.M., Corbaley, R., Kohler, S.L., and Bushnell, M.M., 1979.
- *SR 143: Part III: Mineral Land Classification of the Greater Los Angeles Area: Classification of Sand and Gravel Resource Areas, Orange County-Temescal Valley Production-Consumption Region.
By Miller, R.V., and Corbaley, R., 1981.
- *SR 143: Part IV: Mineral Land Classification of the Greater Los Angeles Area: Classification of Sand and Gravel Resource Areas, San Gabriel Valley Production-Consumption Region.
By Kohler, S.L., 1982.
- *SR 143: Part V: Mineral Land Classification of the Greater Los Angeles Area: Classification of Sand and Gravel Resource Areas, Saugus-Newhall Production-Consumption Region and Palmdale Production-Consumption Region.
By Joseph, S.E, Miller, R.V., Tan, S.S., and Goodman, R.W., 1987.
- *SR 143: Part VI: Mineral Land Classification of the Greater Los Angeles Area: Classification of Sand and Gravel Resource Areas, Claremont-Upland Production-Consumption Region.
By Cole, J.W., 1987.

- *SR 143: Part VII: Mineral Land Classification of the Greater Los Angeles Area: Classification of Sand and Gravel Resource Areas, San Bernardino Production-Consumption Region.
By Miller, R.V., 1987.
- *SR 145: Part I: Mineral Land Classification of Ventura County: Description of the Mineral Land Classification Project of Ventura County.
By Anderson, T.P., Loyd, R.C., Kiessling, E.W., Kohler, S.L., and Miller, R. V., 1981.
- *SR 145: Part II: Mineral Land Classification of Ventura County: Classification of the Sand, Gravel, and Crushed Rock Resource Areas, Simi Production-Consumption Region.
By Anderson, T.P., Loyd, R.C., Kiessling, E.W., Kohler, S.L., and Miller, R. V., 1981.
- *SR 145: Part III: Mineral Land Classification of Ventura County: Classification of the Sand and Gravel, and Crushed Rock Resource Areas, Western Ventura County Production-Consumption Region.
By Anderson, T.P., Loyd, R.C., Kiessling, E.W., Kohler, S.L., and Miller, R. V., 1981.
- *SR 146: Part I: Mineral Land Classification: Project Description: Mineral Land Classification for Construction Aggregate in the San Francisco-Monterey Bay Area.
By Stinson, M.C., Manson, M.W., and Plappert, J.J., 1987.
- *SR 146: Part II: Mineral Land Classification: Aggregate Materials in the South San Francisco Bay Production-Consumption Region.
By Stinson, M.C., Manson, M.W., and Plappert, J.J., 1987.
- *SR 146: Part III: Mineral Land Classification: Aggregate Materials in the North San Francisco Bay Production-Consumption Region.
By Stinson, M.C., Manson, M.W., and Plappert, J.J., 1987.
- *SR 146: Part IV: Mineral Land Classification: Aggregate Materials in the Monterey Bay Production-Consumption Region.
By Stinson, M.C., Manson, M.W., and Plappert, J.J., 1987.
- SR 147: Mineral Land Classification: Aggregate Materials in the Bakersfield Production-Consumption Region.
By Cole, J.W., 1988.
- *SR 153: Mineral Land Classification: Aggregate Materials in the Western San Diego County Production-Consumption Region.
By Kohler, S.L., and Miller, R.V., 1982.
- SR 156: Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Sacramento-Fairfield Production-Consumption Region.
By Dupras, D.L., 1988.

- *SR 158: Mineral Land Classification: Aggregate Materials in the Fresno Production-Consumption Region.
By Cole, J.W., and Fuller, D.R., 1986.
- SR 159: Mineral Land Classification: Aggregate Materials in the Palm Springs Production-Consumption Region.
By Miller, R.V., 1987.
- SR 160: Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Stockton-Lodi Production-Consumption Region.
By Jensen, L.S., and Silva, M.A., 1989.
- SR 162: Mineral Land Classification: Portland Cement Concrete Aggregate and Active Mines of All Other Mineral Commodities in the San Luis Obispo-Santa Barbara Production-Consumption Region.
By Miller, R.V., Cole, J.W., and Clinkenbeard, J.P., 1991.
- SR 164: Mineral Land Classification of Nevada County, California.
By Loyd, R.C., and Clinkenbeard, J.P., 1990.
- SR 173: Mineral Land Classification of Stanislaus County, California.
By Higgins, C.T., and Dupras, D.L., 1993.
- SR 175: Update of Mineral Land Classification of Portland Cement Concrete Aggregate in the Claremont-Upland and San Bernardino Production-Consumption Regions, California.
By Koehler, B.M., and Miller, R.V., 2002 (in progress).
- SR 176: Mineral Land Classification of Concrete-Grade Aggregate Resources in Tehama County, California.
By Foster, B.D., 2002 (in progress).
- SR 178: Mineral Land Classification of EL Dorado County, California.
By Busch L.L., 2002 (in progress).
- SR 179: Update of the Mineral Land Classification: Aggregate Materials in the North San Francisco Bay Production-Consumption Region.
By Dupras, D.L., 2002 (in progress).

OPEN-FILE REPORTS (OFR)

- OFR 92-06: Mineral Land Classification of Concrete Aggregate Resources in the Barstow-Victorville Area.
By Miller, R.V., 1993.

- OFR 93-10: Update of Mineral Land Classification of Portland Cement Concrete Aggregate in Ventura, Los Angeles, and Orange Counties, California: Part I - Ventura County.
By Miller, R.V., 1993.
- OFR 94-14: Update of Mineral Land Classification of Portland Cement Concrete Aggregate in Ventura, Los Angeles, and Orange Counties, California: Part II - Los Angeles County.
By Miller, R.V., 1994.
- OFR 94-15: Update of Mineral Land Classification of Portland Cement Concrete Aggregate in Ventura, Los Angeles, and Orange Counties, California: Part III - Orange County.
By Miller, R.V., 1995.
- OFR 95-10: Mineral Land Classification of Placer County, California.
By Loyd, R.C., 1995.
- OFR 96-03: Update of Mineral Land Classification: Aggregate Materials in the South San Francisco Bay Production-Consumption Region.
By Kohler-Antablin, S.L., 1996.
- OFR 96-04: Update of Mineral Land Classification: Aggregate Materials in the Western San Diego County Production-Consumption Region.
By Miller, R.V., 1996.
- OFR 97-01: Mineral Land Classification of Concrete Aggregate Resources in the Tulare County Production-Consumption Region, California.
By Taylor, G.C., 1997.
- OFR 97-02: Mineral Land Classification of Concrete-Grade Aggregate Resources in Glenn County, California.
By Shumway, D.O., 1997.
- OFR 97-03: Mineral Land Classification of Alluvial Sand and Gravel, Crushed Stone, Volcanic Cinders, Limestone, and Diatomite within Shasta County, California.
By Dupras, D.L., 1997.
- OFR 99-01: Update of Mineral Land Classification: Aggregate Materials in the Monterey Bay Production-Consumption Region, California.
By Kohler-Antablin, S.L., 1999.
- OFR 99-02: Update of Mineral Land Classification: Aggregate Materials in the Fresno Production-Consumption Region, California.
By Youngs, L.G. and Miller, R.V., 1999.
- OFR 99-08: Mineral Land Classification of Merced County, California.
By Clinkenbeard, J.P., 1999.

OFR 99-09: Mineral Land Classification: Portland Cement Concrete-Grade Aggregate and Clay Resources in Sacramento County, California.
By Dupras, D.L., 1999.

* These Mineral Land Classification reports have been updated and are not shown on the index map (lower left-hand corner of Map Sheet 52).

APPENDIX B: DESCRIPTION OF REVISIONS MADE TO PERMITTED AGGREGATE RESOURCE CALCULATIONS AND 50-YEAR AGGREGATE DEMAND PROJECTIONS IN AGGREGATE CLASSIFICATION REPORTS (Methods used in updating information used in the development of Map Sheet 52.)

1. Tehama County (SR176, report in progress)
 - Determined permitted resources from preliminary estimates that may differ from final report.
 - Determined 50-year forecast from preliminary data that may differ from final report.
2. Glenn County (OFR 97-02)
 - Subtracted 1996-2000 production from report permitted resources.
 - Updated 50-year forecast (2001 through 2050).
3. Sacramento-Fairfield (SR 156)
 - Determined new permitted resources for the Cache Creek area (Yolo County) only. The remaining aggregate production areas covered in the Sacramento-Fairfield P-C Region have been updated in the Sacramento County aggregate study area, OFR 99-09.
 - Updated 50-year forecast (2001 through 2050).
4. North San Francisco Bay (SR 179, report in progress)
 - Determined permitted resources from preliminary estimates that may differ from final report.
 - Determined 50-year forecast from preliminary data that may differ from final report.
5. Stockton-Lodi (SR 160)
 - Determined new permitted resources.
 - Updated 50-year forecast (2001 through 2050).
6. South San Francisco Bay (OFR 96-03)
 - Subtracted 1995-2000 production from report permitted resources.
 - Updated 50-year forecast (2001 through 2050).
7. Merced County (OFR 99-01)
 - Subtracted 2000 production from report permitted resources for Western Merced County.
 - Added 14,000,000 tons of permitted resources since original report estimates were made for Western Merced County.
 - Updated 50-year forecast (2001 through 2050) for Western Merced County.

- Subtracted 2000 production from report permitted resources for Eastern Merced County.
 - Updated 50-year forecast (2001 through 2050) for Eastern Merced County.
8. Monterey Bay (OFR 99-01)
- Subtracted 1998-2000 production from report permitted resources.
 - Updated 50-year forecast (2001 through 2050).
9. San Luis Obispo-Santa Barbara (SR 162)
- Subtracted 1988-2000 production from report permitted resources.
 - Added 8,000,000 tons of permitted resources since original report estimates.
 - Updated 50-year forecast (2001 through 2050).
10. Saugus-Newhall (OFR 94-14)
- Subtracted 1993-2000 production from report permitted resources.
 - Updated 50-year forecast for Los Angeles County (2001 through 2050).
 - Multiplied the total 50-year aggregate demand by 0.04 to determine a separate demand for the Saugus Newhall P-C Region. The region has historically produced about 4% of Los Angeles County's aggregate.
11. Western Ventura County (OFR-93-10)
- Subtracted 1992-2000 production from report permitted resources.
 - Made new 50-year forecast for Ventura County and multiplied the total projected county demand by 0.55 to determine a separate demand for the Western Ventura County P-C Region. The region has historically produced about 55% of the Ventura County's aggregate.
12. Simi Valley (OFR 93-10)
- Subtracted 1992-2000 production data from report permitted resources.
 - Made new 50-year forecast for Ventura County and multiplied the total projected county demand by 0.45 to calculate a separate demand for the Simi Valley P-C Region. The region has historically produced about 45% of Ventura County's aggregate.
13. San Fernando Valley (OFR 94-14)
- Subtracted 1993-2000 production from report permitted reserves.
 - Updated 50-year forecast for Los Angeles County (2001 through 2050).
 - Multiplied the total 50-year aggregate demand by 0.30 to calculate a separate demand for the San Fernando Valley P-C Region. The region has historically produced approximately 30% of Los Angeles County's aggregate.
14. San Gabriel Valley (OFR 94-14)
- Subtracted 1993-2000 production from report permitted resources.
 - Updated 50-year forecast for Los Angeles County (2001 through 2050).
 - Multiplied the total 50-year aggregate demand by 0.58 to calculate a separate demand for the San Gabriel Valley P-C Region. The region has historically consumed about 58% of Los Angeles County's aggregate.

15. Claremont-Upland (SR 175, report in progress)
 - Determined permitted resources from preliminary estimates that may differ from final report.
 - Determined 50-year forecast from preliminary data that may differ from final report.
16. Orange County (OFR 94-14)
 - Determined new permitted resources using company data.
 - Updated 50-year forecast (2001 through 2050).
17. Western San Diego County (OFR 96-04)
 - Subtracted 1995-2000 production from report permitted resources.
 - Updated 50-year forecast (2001 through 2050).
18. Temescal Valley (SR 165)
 - Subtracted 1989-2000 production from report permitted resources.
 - Made new 50-year forecast.
19. Palm Springs (SR 159)
 - Calculated new permitted resources.
 - Updated 50-year forecast (2001 through 2050).
20. San Bernardino (SR-175, report in progress)
 - Determined permitted resources from preliminary estimates that may differ from final report.
 - Determined 50-year forecast from preliminary data that may differ from final report
21. Barstow-Victorville (ORF 92-06)
 - Calculated new permitted resources.
 - Updated 50-year forecast (2001 through 2050).
22. Palmdale (OFR 94-14)
 - Subtracted 1993-2000 production from report permitted resources.
 - Updated 50-year forecast for Los Angeles County (2001 through 2050).
 - Multiplied the total 50-year aggregate demand for Los Angeles County by 0.08 to get a separate demand for the Palmdale P-C Region that has historically produced approximately 8% of Los Angeles County's aggregate.
23. Bakersfield (SR 147)
 - Determined new permitted resources using company estimates.
 - Updated 50-year forecast (2001 through 2050).
24. Tulare County (OFR 97-01)
 - Subtracted 1995-2000 production from report permitted resources for North Tulare County.
 - Subtracted 1995-2000 production from report permitted resources for South Tulare County.
 - Updated 50-year forecast for Tulare County (2001 through 2050).

- Multiplied the total 50-year aggregate demand for Tulare County by 0.58 to get a separate demand for North Tulare County that has historically produced about 58% of Tulare County's aggregate.
- Multiplied the total 50-year aggregate demand for Tulare County by 0.42 to get a separate demand for South Tulare County that has historically produced about 42% of Tulare County's aggregate.

25. Fresno (OFR 99-02)

- Subtracted 1998-2000 production from report permitted resources.
- Added 20,000,000 tons of new permitted resources since report.
- Updated 50-year forecast (2001 through 2050).

26. Stanislaus County (SR 173)

- Calculated new permitted resources.
- Updated 50-year forecast (2001 through 2050).

27. Sacramento County (OFR 99-09)

- Subtracted 1999 and 2000 production from report permitted resources.
- Added 33,000,000 tons of new permitted resources since report.
- Updated 50-year forecast (2001 through 2050).

28. El Dorado County (SR 178, report in progress)

- Determined permitted resources from preliminary estimates that may differ from final report.
- Determined 50-year forecast from preliminary data that may differ from final report.

29. Placer County (OFR 95-10)

- Calculated new permitted resources.
- Updated 50-year forecast (2001 through 2050).

30. Nevada County (SR 164)

- Calculated new permitted resources.
- Updated 50-year forecast (2001 through 2050).

31. Yuba City-Marysville

- Determined new permitted resources from company information.
- Updated 50-year forecast (2001 through 2050).

32. Shasta County (OFR 97-03)

- Subtracted 1996-2000 production from report permitted resources.
- Updated 50-year forecast (2001 through 2050).