MAP SHEET 52

(UPDATED 2006)

AGGREGATE AVAILABILITY IN CALIFORNIA

2006

DEPARTMENT OF CONSERVATION
California Geological Survey

THE RESOURCES AGENCY	STATE OF CALIFORNIA	DEPARTMENT OF CONSERVATION
MIKE CHRISMAN	ARNOLD SCHWARZENEGGER	BRIDGETT LUTHER
SECRETARY FOR RESOURCES	*GOVERNOR*	*DIRECTOR*

CALIFORNIA GEOLOGICAL SURVEY
JOHN G. PARRISH, PH.D., *STATE GEOLOGIST*

MAP SHEET 52

(UPDATED 2006)

AGGREGATE AVAILABILITY IN CALIFORNIA

By

Susan Kohler

2006

DEPARTMENT OF CONSERVATION

CALIFORNIA GEOLOGICAL SURVEY

801 K Street, MS 14-34

Sacramento, CA 95814-3531

TABLE OF CONTENTS

TABLES

INTRODUCTION

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 aggregate resources. 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 aggregate studies employed in the compilation of Map Sheet 52 should be used for land-use and decision making purposes.

Map Sheet 52 (2006) is an update of the original version published in 2002 (Kohler, 2002). This updated Map Sheet 52 summarizes data from reports compiled by the CGS for 31 aggregate study areas throughout the state. These study areas cover about 25 percent of the state and provide aggregate for about 90 percent of California's population. This report is divided into three parts: Part I provides data sources and methods used to derive the information presented, Part II compares the updated 2006 Map Sheet 52 to the original map, and Part III is an overview of construction aggregate. **All aggregate data and any reference to "aggregate" in this report and on the map pertain to "construction aggregate" defined for this report as alluvial sand and gravel or crushed stone that meets standard specifications for use in portland cement concrete (PCC) or asphalt concrete (AC).** (See *Aggregate Quality and Use* section).

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

Map Sheet 52 is a statewide map showing a compilation of data about aggregate availability collected over a period of about 28 years and updated to January 1, 2006. The purpose of the map is to compare projected aggregate demand for the next 50 years with currently permitted aggregate resources in 31 regions of the state. The map also highlights regions where there is less than 10 years of permitted aggregate supply remaining (red circles). The following sections describe data sources and methodology that were used in the development of the map.

Mineral Land Classification Reports and Aggregate Studies

Data regarding aggregate resources and projected aggregate demand shown on Map Sheet 52 are updated from a series of mineral land classification reports published as Special Reports (SR) and Open-File Reports (OFR) by CGS between 1981 and 2005. These reports are referenced in the Appendix. They were prepared in response to California's Surface Mining and Reclamation Act of 1975 (SMARA) that require the State Geologist to classify land based on the known or inferred mineral resource potential of that land. SMARA, its regulations and guidelines, are described in Special Publication 51(Division of Mines and Geology, 2000). The Mineral Land Classification process identifies lands that contain economically significant mineral deposits. The primary goal of mineral land classification is to ensure that the mineral resource potential of lands is recognized and considered in land-use planning. The classification process includes an assessment of the quantity, quality, and extent of aggregate deposits in a study area.

Mineral land classification reports may be specific to aggregate resources, may contain information about both aggregate and other mineral resources, or they may only contain information on minerals other than aggregate. Reports that focus on aggregate include aggregate resource classification and mapping, quantitative calculations of permitted and non-permitted aggregate resources, calculated 50-year demand for aggregate resources, and an estimate of when the permitted resources will be depleted. Map Sheet 52 is a statewide updated summary of 50-year demands and permitted resource calculations for all SMARA classification reports pertaining to construction aggregate.

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 (a group of producing aggregate mines) and the market area they serve. The State Mining and Geology Board (SMGB) in 1989 changed the scope of the mineral classification studies from P-C regions to countywide studies because counties are one of the primary users of the reports. As a result of this change, classification reports became more user-friendly for local government planners.

Mineral land classification reports include information from one or more P-C regions, or from a county. For ease in discussion, the area covered by each P-C region or county aggregate study is referred to as an “aggregate study area”. These areas are shown at the lower left-hand corner of the map along with their respective OFR or SR number and publication date. It should be noted that an OFR or SR may include more than one aggregate study area.

As provided by SMARA, the State Geologist is required to review mineral land classification every 10 years following the census to determine if new classifications are necessary. The projected 50-year forecast of aggregate demand in the region may also be revised. Seven updated classification studies have been completed. Updated 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). Since 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 reports that cover an aggregate study area. Earlier reports covering the same areas or portions of areas are referenced in the Appendix with an asterisk (“*”).

Fifty-Year Aggregate Demand Forecast

The fifty-year aggregate demand forecast 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), and also is presented in Table 1. The demand information may be new, or updated from previously published mineral land classification reports. The demand forecast information depicted on Map Sheet 52 is for the period January 1, 2006 through December 2055.

The aggregate study areas with the greatest projected future need for aggregate are the South San Francisco Bay, San Gabriel Valley, Temescal Valley-Orange County, Western San Diego County and San Bernardino. Each is expected to require more than a billion tons of aggregate by the end of 2055. Aggregate study areas that have small demands generally are located in less populated areas. These include the Sierra Nevada counties of Placer, Nevada, and El Dorado, and Merced and Tulare counties in the San Joaquin Valley.

AGGREGATE STUDY AREA [1]	**50-Year Demand** (million tons)	**Permitted Aggregate Resources** (million tons)	**Percentage of Permitted Aggregate Resources as Compared to the 50-Year Demand**
Bakersfield P-C Region	252	115	46
Barstow-Victorville P-C Region	179	133	74
Claremont-Upland P-C Region	300	147	49
El Dorado County	91	19	21
Fresno P-C Region	629	71	11
Glenn County	83	17	21
Merced County[2]			
Eastern Merced County	106	53	50
Western Merced County	53	Proprietary	<50
Monterey Bay P-C Region	383	347	91
Nevada County	122	31	25
Palmdale P-C Region	665	181	27
Palm Springs P-C Region	295	176	60
Placer County	171	45	26
North San Francisco Bay P-C Region	647	49	8
Sacramento County	733	67	9
Sacramento-Fairfield P-C Region	235	164	70
San Bernardino P-C Region	1,074	262	24
San Fernando Valley-Saugus-Newhall [3]	457	88	19
San Gabriel Valley P-C Region	1,148	370	32
San Luis Obispo-Santa Barbara P-C Region	243	77	32
Shasta County	122	51	42
South San Francisco Bay P-C Region	1,244	458	37
Stanislaus County	344	51	15
Stockton-Lodi P-C Region	728	196	27
Tehama County	72	36	49
Temescal Valley-Orange County [3]	1,122	355	32
Tulare County[2]			
Northern Tulare County	117	12	10
Southern Tulare County	88	Proprietary	<50
Ventura County [3]	309	106	34
Western San Diego County P-C Region	1,164	198	17
Yuba City-Marysville P-C Region	360	409	>100
Total	**13,536**	**4,343**	

[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 is made for each area.
[3] Two P-C regions have been combined into one study area.

Table 1. Comparison of 50-year demand to permitted aggregate resources for aggregate study areas as of January 1, 2006. (Study areas with less than ten years of permitted resources are in bold type).

Methodology

Before selecting a method for predicting a 50-year aggregate demand, historical aggregate use was compared to such factors as housing starts, gross national product, population, and several other economic factors. It was found that the only factor showing a strong correlation to historical aggregate use was population change. Consequently, a per capita aggregate consumption forecast model is used for most of the aggregate study projections. This method of forecasting aggregate consumption benefits from its simplicity and the availability of population forecast data. The California's Department of Finance (DOF) makes 50-year county population forecast using U.S. census data.

The steps used for forecasting California's 50-year aggregate needs using the per capita consumption model are: 1) collecting yearly historical production and population data for a period of years ranging from the 1960s through 2005; 2) dividing yearly aggregate production by the population for that same year to determine annual historical per capita consumption; 3) projecting yearly population for a 50-year period from the beginning of 2006 through 2055; and, 4) multiplying each year of projected population by the average historical per capita consumption, the sum of which equals a total 50-year aggregate demand. It should be noted that the years chosen to determine an average historical per capita consumption may differ depending upon historical aggregate use for that specific 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 aggregate every year is a simplification of actual usage patterns, but overall, an increase in the population leads 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 consumption is a commonly used and accepted national, state, and regional measure for purposes of forecasting.

The per capita consumption model has proved to be effective for predicting aggregate demand in major metropolitan areas. The Western San Diego and the San Gabriel Valley P-C regions are examples of how well the model works, having only a 2 percent and a 5 percent difference, respectively, in actual versus predicted aggregate demand (Miller, 1994; 1996). However, the per capita model may not work well in county aggregate studies or in P-C regions that import or export a large percentage of aggregate resulting in a low correlation between production districts and aggregate market areas. When this happens, projections are based on a historical production model where 50-year aggregate demand is determined by extending a best-fit line of historical aggregate production data for a county or region. This model was used to project Yuba City-Marysville's 50-year demand because the region exports about 70 percent its aggregate into neighboring areas such as northern Sacramento County and Placer County.

Permitted Aggregate Resources

Approximately 4.34 billion tons of permitted aggregate resources lie within the 31 aggregate study areas shown on Map Sheet 52. 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 of aggregate material. A "permit" is a legal authorization or approval by a lead agency, the absence of which would preclude mining operations. Although some permitted resources face legal challenges, these resources are included in this study pending resolution of those challenges. In California, mining permits usually are issued by local lead agencies (county or city governments). 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). Beneath the study area name located next to its corresponding pie diagram is the amount of permitted resource in tons along with the amount of 50-year demand. These figures are also given in Table 1. Tonnages are not given for eastern Merced County and for the southern Tulare County to preserve company proprietary data.

Permitted aggregate resource calculations shown on the map and in Table 1 were determined from information provided in reclamation plans, mining plans and use permits issued by the lead agencies. When information was inadequate to make reliable independent calculations, CGS staff used resource estimates provided by mine operators or owners. These data were checked against rough calculations made by CGS staff, and any major discrepancies were discussed with the mine operators or owners. All permitted resource calculations are current as of the beginning of 2006.

Fifty-year Aggregate Demand Compared to Permitted Aggregate Resources

Fifty-year aggregate demand compared to currently permitted aggregate resources, is represented by a pie diagram for each of the 31 aggregate study areas shown on Map Sheet 52. Each pie diagram is located in the approximate center of the aggregate study area it represents. There are four different sizes of diagrams, each size representing a 50-year demand range. The smallest pie diagram represents 50-year demands ranging from 25 million to 200 million tons, while the largest diagram represents demands of over 800 million tons. The amount of 50-year demand in tons is shown on the map along with the amount of permitted resources beneath the study area name located next to its corresponding pie diagram (permitted resources, left / 50-year demand, right). 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 the currently permitted resources. For example, if the blue portion is 25 percent and the purple portion is 75 percent of a pie diagram that represents a total demand of 400 million tons, 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. The pie representing the Yuba City-Marysville aggregate study area (north-central California) is completely colored blue showing permitted aggregate resources are equal to or greater than the area's 50-year aggregate demand.

Except for Yuba City-Marysville, all of the aggregate study areas have less permitted aggregate resources than they are projected to need for the next 50-years. Twenty-five of the 31 aggregate study areas have less than half of the permitted resources they are projected to need.

Non-Permitted Aggregate Resources

Non-permitted aggregate resources are deposits that may meet specifications for construction aggregate, are recoverable with existing technology, have no land overlying them that is incompatible with mining, and currently are not permitted for mining. While not shown on Map Sheet 52, non-permitted aggregate resources are identified and discussed in each of the mineral land classification reports used to compile the map (See Appendix). There are currently an estimated 74 billion tons of non-permitted construction aggregate resources in the 31 aggregate study areas shown on the map. While this number is large, it is unlikely that all of these resources will ever be mined because of social, environmental, or economic factors. Aggregate resources located too close to urban or environmentally sensitive areas can limit or stop their development. These resources may also be located too far from a potential market to be economic. In spite of such possible constraints, non-permitted aggregate resources are the most likely future sources of construction aggregate potentially available to meet California's continuing demand. Factors used to calculate non-permitted resource amounts and to determine the aerial extent of these resources, are given in each of the aggregate classification reports listed in the Appendix.

Aggregate Production Areas and Districts

Aggregate production areas are shown on the map by five different sizes of triangle. 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 the Department of Conservation's Office of Mine Reclamation (OMR) records for the calendar year 2005. The smallest triangle represents a production area that produces less than 0.5 million tons of aggregate per year. These triangles represent a single mine operation. About 85 percent of the production areas on the map fall into this category, and many are located in rural parts of the state. The largest triangle represents aggregate mining districts with production of more than 10 million tons per year. Only two aggregate production districts fall into this category – the Temescal Valley District in western Riverside County and the San Gabriel Valley District in Los Angeles County. The Temescal Valley Production District produced about 12 million tons of aggregate in 2005 and is the largest sand and gravel production district in the United States.

Aggregate Study Areas with Less than Ten Years of Permitted Resources

Four of the 31 aggregate study areas – North San Francisco Bay, Sacramento County, Fresno County, and northern Tulare County – are projected to 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. Calculations 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 region runs out of aggregate and begins to import aggregate from another region, a 20-year supply can quickly drop to just a few years.

PART II COMPARISONS BETWEEN THE ORIGINAL (2002) AND THE UPDATED (2006) MAP SHEET 52

The original Map Sheet 52 was completed in early 2001 and published in 2002. **Permitted aggregate resource data were current as of January 1, 2001.** Most of the data for the map were collected and compiled in 2000. The latest aggregate production and location data available during this time were from 1999 records. The aggregate demand projections for the original map were based on DOF county population projections from the 1990 U.S. census (2000 census data were not yet available). Fifty-year aggregate demand from January 1, 2001 through the year 2050 was determined for 34 study areas.

The updated Map Sheet 52 was completed and published in 2006. **Permitted aggregate resource data for the updated map is current as of January 1, 2006.** All work conducted for the updated study also took place during 2006. The latest aggregate production and location data available for the updated map are from 2005 records. The aggregate demand projections for the updated map were based on DOF county population projections from the 2000 U.S. census. Fifty-year aggregate demand from January 1, 2006 through the year 2055 was determined for 31 study areas.

Significant changes also have occurred in aggregate supply (permitted aggregate resources) and demand in the five years since the original Map Sheet 52 was completed. Changes in permitted aggregate resources between the original Map Sheet 52 (2002) and updated Map Sheet 52 (2006) are shown on Table 2. New mining regulations, mine closures, new mining permits, and five years of consumption have contributed to these changes.

Significant changes have also occurred in 50-year aggregate demand figures for several study areas due to updated aggregate production and county population projection. Table 3 compares the changes in demand between Map Sheet 52 (2002) and the updated 2006 map.

The updated map had three fewer aggregate study areas (a total of 31) because of aggregate shortages that caused changes in market areas. These changes are discussed in the following section.

Aggregate Study Area Changes

Six aggregate study areas on the original Map Sheet 52 have been modified for the updated map, resulting in three fewer study areas. They include the Southern California P-C regions of Orange County, Temescal Valley, San Fernando Valley, Saugus-Newhall, Western Ventura County, and Simi Valley. These P-C regions were modified because they no longer fit the definition of a production-consumption region. The Western Ventura County P-C region is depleted of permitted resources, and the Orange County, San Fernando Valley and Saugus Newhall regions are nearly depleted. When these regions began to run out of permitted aggregate resources, they became dependent on aggregate sources from neighboring regions, resulting in market areas that no longer were served by their original production district.

Orange County's permitted resources are nearly exhausted and now the county relies on Temescal Valley for much of its aggregate needs. These two P-C Regions were combined into the Temescal Valley-Orange County aggregate study area. Permitted resources for this new study area total

AGGREGATE STUDY AREA	Permitted Aggregate Resources as of 1/1/01 (million tons) Map Sheet 52, 2002	Permitted Aggregate Resources as of 1/1/06 (million tons) Map Sheet 52, 2006	Percent Difference (%)
Bakersfield P-C Region	167	115	-31
Barstow Victorville P-C Region	115	133	15
Claremont-Upland P-C Region	134	147	10
Eastern Merced County	15	53	253
El Dorado County	13	19	46
Fresno P-C Region	98	71	-27
Glenn County	56	17	-70
Monterey Bay P-C Region	243	347	43
Nevada County	35	31	-11
Northern Tulare County	12	12	0
North San Francisco Bay P-C Region	178	49	-73
Palmdale P-C Region	216	181	-16
Palm Springs P-C Region	70	176	151
Placer County	43	45	5
Sacramento County	65	67	3
Sacramento-Fairfield P-C Region	130	164	26
San Bernardino P-C Region	356	262	-26
San Fernando Valley-Saugus Newhall *	**154	88	-43
San Gabriel Valley P-C Region	241	370	54
San Luis Obispo-Santa Barbara P-C Region	93	77	-17
Shasta County	28	51	82
Southern Tulare County	196	Proprietary	Proprietary
South San Francisco Bay P-C Region	564	458	-19
Stanislaus County	35	51	45
Stockton Lodi P-C Region	260	196	-25
Tehama County	40	36	-10
Temescal Valley-Orange County*	**837	355	-58
Ventura County (combined Western Ventura County and Simi Valley P-C Region)*	**129	106	-18
Western Merced County	>50	Proprietary	Proprietary
Western San Diego County P-C Region	275	198	-28
Yuba City-Marysville P-C Region	>2,000	409	-80
Total	**6,848**	**4,343**	

* Two P-C Regions have been combined for updated Map Sheet 52

**Total for combined P-C Regions

Table 2. Comparison of permitted aggregate resources between Map Sheet 52, 2002 and Map Sheet 52, 2006.

AGGREGATE STUDY AREA	50-Year Demand as of 1/1/01 (million tons) Map Sheet 52, 2002	50-Year Demand as of 1/1/06 (million tons) Map Sheet 52, 2006	Percent Difference (%)
Bakersfield P-C Region	246	252	2
Barstow-Victorville P-C Region	165	179	8
Claremont-Upland P-C Region	270	300	11
Eastern Merced County	98	106	8
El Dorado County	85	91	7
Fresno P-C Region	565	629	11
Glenn County	79	83	5
Monterey Bay P-C Region	381	383	0.5
Nevada County	169	122	-28
Northern Tulare County	107	117	9
North San Francisco Bay P-C Region	648	647	-0.15
Palmdale P-C Region	172	665	287
Placer County	126	171	36
Palm Springs P-C Region	198	295	49
Sacramento County	686	733	7
Sacramento-Fairfield P-C Region	225	235	4
San Bernardino P-C Region	969	1,074	11
San Fernando Valley/Saugus Newhall *	** 732	457	-38
San Gabriel Valley P-C Region	1,250	1,148	-8
San Luis Obispo-Santa Barbara P-C Region	99	243	145
Shasta County	118	122	3
Southern Tulare County	77	88	14
Stanislaus County	311	344	11
Stockton Lodi P-C Region	337	728	115
South San Francisco Bay P-C Region	1,213	1,244	3
Tehama County	52	72	38
Temescal Valley-Orange County *	** 1,203	1,122	-7
Ventura County (combined Western Ventura County and Simi Valley P-C Regions) *	** 257	309	20
Western Merced County	49	53	8
Western San Diego County P-C Region	1,099	1,164	6
Yuba City-Marysville P-C Region	30	360	1,100
Total	**12,016**	**13,536**	

* Two P-C Regions have been combined for updated Map Sheet 52
**Total for combined P-C Regions

Table 3. Comparison of 50-year demand between Map Sheet 52, 2002 and Map Sheet 52, 2006.

355 million tons as compared to the total resources for both of the original P-C regions of 837 million tons. This results in a decrease of 58 percent (See Table 2).

Western Ventura County has depleted its permitted aggregate resources and now relies heavily on aggregate production from the Simi Valley area. For the updated map, these two regions have been combined to form the Ventura County aggregate study area. Permitted aggregate resources for this area decreased by about 18 percent since the original Map Sheet 52 (See Table 2). A shortage of coarse aggregate in Ventura County has resulted in rock being hauled up to 60 miles into the county from the Palmdale aggregate production region.

Both the San Fernando Valley and the Saugus Newhall P-C regions shown on the original map are rapidly running out of permitted aggregate resources. These two regions have been merged for the updated map to form the San Fernando Valley-Saugus Newhall aggregate study area. Loss of permitted aggregate resources because of mine closures in the Saugus Newhall P-C region has resulted in increased importation of aggregate into the region from the San Fernando Valley P-C region. This puts an additional drain on San Fernando Valley's permitted resources that already are in short supply. The new San Fernando Valley-Saugus Newhall aggregate study area, shown on the updated map, has 88 million tons of permitted resources, or 19 percent of its projected 50-year demand (See Table 1). The 88 million tons includes 56 million tons of newly permitted aggregate resources granted to CEMEX in 2004 for its Soledad Canyon operation in Los Angeles County.

Decreases in Permitted Aggregate Resources

Eighteen of the 31 study areas shown on the updated map experienced a decrease in permitted aggregate resources since the original map was completed (See Table 2). Included in these 18 areas are Western Merced County and Southern Tulare County. Permitted resources for both of these county study areas cannot be shown because they are proprietary. Six of the18 areas had significant decreases of over 50 percent. They include the Glenn County, North San Francisco Bay, Temescal Valley-Orange County, Western Merced County, Southern Tulare County, and Yuba City-Marysville aggregate study areas.

Total permitted resources for all 31 areas decreased from 6.848 billion tons to 4.343 billion tons – a loss of 2.5 billion tons. Most of this decrease was because of aggregate consumption and a large reduction in Yuba City-Marysville's permitted aggregate resources. Approximately 1.2 billion tons of aggregate has been consumed in the 31 study areas during the five-year period from 2001-2005. The Yuba City-Marysville area had a decrease in permitted aggregate resources of 1.6 billion tons despite the addition of over 100 million tons of newly permitted resources to the area. The submission of revised reclamation plans contributed to most of the decrease. Other reasons for reductions in permitted aggregate resources throughout the state include economic or environmental conditions causing mine closures, new in-stream mining regulations, natural changes in the quality of aggregate deposits, and haulage restrictions.

Increases in Permitted Aggregate Resource

Of the 31 study areas shown on the updated Map Sheet 52, 12 areas had increases in permitted aggregate resources. Most of these increases are because of newly permitted or expanded mining operations. An expansion may increase the footprint of the mine or, as in the case of San Gabriel

Valley, mining depth. Significant increases exceeding 50 percent occurred in the Eastern Merced County, Palm Springs, San Gabriel Valley, and Shasta County aggregate study areas (See Table 2).

Changes in Fifty-Year Demand

All but five study areas shown on the updated Map Sheet 52 had increases in 50-year demand (See Table 3). Only two study areas had any significant decrease; these are Nevada County and the new combined aggregate study area of San Fernando Valley-Saugus Newhall. The North San Francisco Bay, San Gabriel Valley, and the Temescal Valley-Orange County study areas had slight decreases.

Nevada County's demand decreased because updated population projections by DOF (based on 2000 census data) for the county were lower than those made by DOF using 1990 census data. The 2000 census-based DOF projections were not available at the time the original study for Map Sheet 52 was being conducted. In most growing areas such as the Palm Springs region and Placer County, the 2000 census-based projections were higher than the 1990 census-based projections.

The nearly depleted permitted resources in the San Fernando Valley-Saugus Newhall study area has resulted in importation of aggregate from the Palmdale P-C region. In order to better reflect aggregate consumption in the San Fernando Valley-Saugus Newhall aggregate study, the method used to calculate 50-year demand for the area was changed from a per capita consumption to a historical production model. (See *Effectiveness of the Per Capita Consumption Model* section.). The new model resulted in a 38 percent decrease in the study area's 50-year demand.

Changes in Permitted Aggregate Resources and Demand

Table 4 shows the percentages of permitted aggregate resources as compared to the 50-year demand for the 2002 and updated 2006 Map Sheet 52. The graphic representations of these ratios are shown on both maps as pie diagrams – the blue portion of the pie depicting percentage of the 50-year demand met with current permitted aggregate resources. An increase in percent between the original and the updated map shows that permitted resources have increased relative to demand. Three of the 31 study areas shown on Table 4 could not be compared to the 2002 map because they are newly combined study areas that did not exist on the 2002 map (See *Aggregate Study Area Changes* section). Increases occurred in 10 of the 28 study areas that could be compared: Barstow-Victorville, Eastern Merced County, El Dorado County, Monterey Bay, Nevada County, Palm Springs, Sacramento-Fairfield, San Gabriel Valley, Shasta County, and Stanislaus County. Except for Nevada County, increases were because of new or expanded permits resulting in additional permitted aggregate resource for that study area. Nevada County's permitted resources decreased slightly. The increase in the supply to demand ratio for Nevada County was caused by a decrease in the county's population growth estimate.

Sixteen of the 28 study areas including Southern Tulare County and Western Merced County, had decreases in supply to demand percentages between the original and the updated map (See Table 4). Large decreases occurred in the Glenn County, Palmdale, San Luis Obispo-Santa Barbara, Southern Tulare County, Stockton-Lodi, and the Western Merced County aggregate study areas. All of these areas also had large decreases in permitted aggregate resources.

AGGREGATE STUDY AREA	Percentage of Permitted Aggregate Resources as Compared to 50-Year Demand as of 1/1/01 Map Sheet 52, 2002	Percentage of Permitted Aggregate Resources as Compared to 50-Year Demand as of 1/1/06 Map Sheet 52, 2006
Bakersfield P-C Region	68	46
Barstow-Victorville P-C Region	70	74
Claremont-Upland P-C Region	50	49
Eastern Merced County	15	50
El Dorado County	15	21
Fresno P-C Region	17	11
Glenn County	71	21
Monterey Bay P-C Region	64	91
Nevada County	21	25
Northern Tulare County	11	10
North San Francisco Bay P-C Region	27	8
Palmdale P-C Region	>100	27
Palm Springs P-C Region	35	60
Placer County	34	26
Sacramento County	9	9
Sacramento-Fairfield P-C Region	58	70
San Bernardino P-C Region	37	24
San Fernando Valley-Saugus Newhall *	**	19
San Gabriel Valley P-C Region	19	32
San Luis Obispo-Santa Barbara P-C Region	94	32
Shasta County	24	42
Southern Tulare County	>100	Proprietary
South San Francisco Bay P-C Region	46	37
Stanislaus County	11	15
Stockton Lodi P-C Region	77	27
Tehama County	77	49
Temescal Valley-Orange County *	**	32
Ventura County (combined Western Ventura County and Simi Valley P-C Regions)*	**	34
Western Merced County	>100	Proprietary
Western San Diego County P-C Region	25	17
Yuba City-Marysville P-C Region	>100	100

* Two P-C Regions have been combined for updated Map Sheet 52
**No percentage due to combining of two P-C Regions

Table 4. Percentage of permitted aggregate resources as compared to 50-year demand for Map Sheet 52, 2002 and Map Sheet 52, 2006.

Comparison of Areas with Less than 10-Years of Permitted Aggregate Resources

The 2006 Map Sheet 52 shows four aggregate study areas – Sacramento County, Fresno County, Northern Tulare County, and the North San Francisco P-C Region, with less than a 10-year supply of permitted aggregate resources. The map shows these areas with red halos around the pie diagrams. The original Map Sheet 52 shows seven areas with less than a 10-year supply of permitted aggregate. Fewer short-supply areas (red circles) shown on the updated map does not mean that California's supply has improved relative to demand. Three of these short supply areas have been combined with neighboring regions. This resulted in all three areas extending their permitted resource life to more than ten years. When regions combine, transportation cost usually increases because of longer and or more time-consuming hauls.

PART III: OVERVIEW OF CONSTRUCTION AGGREGATE

Construction aggregate is the leading non-fuel mineral commodity produced in California, as well as in the nation. Valued at $1.63 billion, aggregate made up about 44 percent of California's $3.72 billion non-fuel mineral production in 2005. California is the nation's leading producer of construction aggregate with a total production of 235 million tons in 2005.

Aggregate Price

The price of aggregate throughout California varies considerably depending on location, quality, and supply and demand. The highest quality aggregate is that which meets the California Department of Transportation's specifications for use in Portland Cement Concrete (PCC). All prices discussed in this section are for PCC-grade aggregate at the plant site or FOB (freight on board). Transportation cost is discussed in the next section. Price variance makes it difficult to estimate the average price of PCC-grade aggregate for the state.

The highest priced aggregate in the state is in the San Diego area, where PCC-grade sand is in very short supply, causing prices to range from $20-$22 /ton. Coarse PCC-grade aggregate is more abundant in the area and averages about $15 per ton. San Diego has started to import sand from Mexico. The price of aggregate in the Northern San Francisco Bay area is up to $18/ton for PCC-grade sand and $16/ton for coarse PCC-grade aggregate. Most of this aggregate is mined from terrace or in-stream deposits of the Russian River located in Alexander Valley. Aggregate is more plentiful and the demand is greater in the South San Francisco Bay area (includes the San Jose metropolitan area). The cost of alluvial sand is about $16/ton, and gravel runs about $15/ton. The price of high strength crushed stone from limestone and diorite in this region is higher at $16 to $17/ton. Sand shortages and subsequent higher prices have resulted in the economical importation of sand from Canada to the San Francisco Bay Region. Aggregate shipped from Canada to the San Francisco Bay and loaded onto trucks costs about $18-$19/ton.

The greater Los Angeles area has some of the best quality sand and gravel in the state. Aggregate prices in the major metropolitan areas supplied by alluvial fan deposits in the San Gabriel Valley and San Fernando Valley average $13-$16/ton. Aggregate from the more sparsely populated but rapidly growing Palmdale area (Northern Los Angeles County) averages about $10/ton. Much of the coarse aggregate consumed in Ventura County comes from the Palmdale Region – a haul distance of about 60 miles. The added cost for such a long haul is about $9/ton. The average cost for sand in Ventura County, supplied from the Simi Valley production region, is about $13-$16/ton – about the same as the greater Los Angeles area. Aggregate price in the Central Valley regions of Northern Tulare County and Fresno County ranges from $14-$18/ton. Aggregate shortages in the Fresno area have resulted in rock being imported into the area from Coalinga, a 60-mile haul. Aggregate prices in the Stockton-Lodi and Sacramento regions run about $10 and $11/ ton, respectively. The price of PCC-grade aggregate in the Yuba City-Marysville region averages about $7-$8/ton – some of the least expensive in the state. Relatively abundant aggregate in this region has kept aggregate prices low.

Transportation

Transportation plays a major role in the cost of aggregate to the consumer. Aggregate is a low-unit-value, high-bulk-weight commodity, and 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 may significantly increase the cost of the aggregate by the time it reaches the consumer. For straight hauls with minimal traffic, the price of aggregate increases about 15 cents per ton for every mile that it is hauled from the plant. Currently, transporting aggregate a distance of 30 miles will increase the FOB price by about $4.50 per ton. For example, to construct one mile of six-lane interstate highway requires about 113,505 tons of aggregate. Transporting this amount of aggregate 30 miles adds $510 thousand to the base cost of the material at the mine. In major metropolitan areas, this rate is often greater because of heavy traffic that increases the haul time. Other factors that affect hauling rates include toll bridges and toll roads, road conditions, and elevation climbs. 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.

Increased Haul Distances

Throughout California, aggregate haul distances have been gradually increasing as local sources of aggregate diminish. Consequently, older P-C regions, most of which were established in the late 1970s have changed considerably since their boundaries were drawn. This is especially evident in Los Angeles, Orange, and Ventura counties where aggregate shortages have led to the merging of six P-C regions shown on the original map into three regions for the updated map (See *Aggregate Study area Changes* section).

The following lists some examples of aggregate hauls in Southern California that have caused significant transportation price increases:

- The Palmdale P-C Region in Northern Los Angeles County currently exports about half of its aggregate into the adjacent San Fernando Valley-Saugus Newhall Region. Some material from Palmdale also goes to downtown Los Angeles. Coarse aggregate from the Palmdale Region is hauled as far as 60 miles to the Western Ventura County.

- Aggregate from the San Gabriel Valley production district is hauled as far south as northern San Diego County.

- Although Orange County imports material mainly from Temescal Valley, some aggregate is hauled to Orange County from the San Bernardino, Upland-Claremont and the San Gabriel Valley production districts.

- Aggregate mined from the Claremont-Upland production district is hauled out of its region to downtown Los Angeles, Orange County and to San Bernardino.

- Northern San Diego County imports aggregate from the San Bernardino production area and from Temescal Valley.

- Aggregate is hauled from the Barstow-Victorville production district into San Bernardino.

- Aggregate is hauled from southwestern Imperial County into downtown San Diego, a distance of about 90 miles.

- Between 1 million and 2 million tons of aggregate are shipped annually by rail from the Cochella Valley area into Los Angeles County.

- Sand is being shipped by barge from Mexico into the San Diego Bay region.

Aggregate Quality and Use

Normally forming 80 to 100 percent of the material volume in the mix, aggregate provides the bulk and strength to PCC and AC. 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 PCC, AC, and various other 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 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 PCC and AC 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 pozzalonic 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 that 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. 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 are more restrictive than specifications for other applications such as Class II base, subbase, and fill. These restrictive specifications makes deposits acceptable for use as PCC or AC aggregate, the scarcest and most valuable aggregate resources. Aggregate produced from such deposits can be, and commonly is, used in applications other than concrete. PCC and AC-grade aggregate deposits are of major importance when planning for future availability of aggregate commodities because of their versatility, value, and relative scarcity.

Factors Affecting Aggregate Deposit Quality

The major factors that affect the quality of construction aggregate 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 unsuitable for high strength and durability uses. 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 PCC or AC aggregate. Typically, the older a deposit is, the more likely it has been subjected to weathering. 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. Owing 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 less common in the future. If this trend continues, crushed stone may become increasingly important to the California market.

Factors Affecting Aggregate Demand

Strong economic growth may contribute to a faster rate of aggregate depletion than forecasted in the CGS classification reports. The nation's strong economy since the mid 1990s 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.

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. California currently imports about one percent of the aggregate it consumes.

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. For the last 28 years, CGS has conducted on-going studies that identify and evaluate aggregate resources throughout the state. Map Sheet 52 (Updated 2006) is an updated summary of supply and demand data from these studies. The map presents a statewide overview of aggregate needs and permitted resources.

In a five-year period (2001-2005), permitted aggregate resources have decreased by about 2.5 billion tons. Also, during this same period, more aggregate study areas had decreases in permitted aggregate resources than increases. Decreases were caused by changes in permitted resource calculations, aggregate consumption, and social and economic conditions leading to mine closures.

Aggregate price at the plant site and transportation cost have increased significantly in the past five years. Areas throughout the state are experiencing shortages in local permitted aggregate resources and are being forced to transport aggregate longer distances, significantly increasing the FOB cost by the time it reaches its final destination. Areas in very short supply of permitted aggregate resources include Fresno, North San Francisco Bay, Southern Tulare County, and Sacramento County. The shortage of PCC-grade sand in the San Diego and the San Francisco Bay areas has driven up the price in both areas, making importation of sand from Canada and Mexico into these regions competitive.

CONCLUSIONS AND RECOMMENDATIONS

Construction aggregate is essential to the needs of modern society, providing material for the construction and maintenance of roadways, dams, canals, buildings and other parts of California's infrastructure. Aggregate is also found in homes, schools, hospitals and shopping centers. In 2005, California consumed about 235 million tons of construction aggregate or about 6.6 tons per person. Because transporting 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 31 aggregate consumption areas that are represented by the pie diagrams shown on Map Sheet 52:

- About 32 percent of the total projected 50-year aggregate demand identified for the 31 study areas is currently permitted.
- Only six percent of the total aggregate resources identified within the 31 study areas are currently permitted.
- California currently has about 4.3 billion tons of permitted resources identified in the 31 study areas shown on Map Sheet 52.

- In the next 50 years, California will need approximately 13.5 billion tons of aggregate. This figure does not account for accelerated construction programs as a result of major bond initiatives, or from reconstruction following a major, damaging earthquake.
- Four of the updated aggregate study areas are projected to have less than ten years of permitted aggregate resources remaining as of January 2006 (pie diagrams highlighted with red borders).
- Ten of the updated aggregate study areas show less than 25 percent of the aggregate resources to meet the projected 50-year aggregate demand.
- About one-half (16) of the updated aggregate study areas show that 25 to 50 percent of the aggregate resources are available to meet the 50-year aggregate demand.
- Three (one tenth) of the updated aggregate study areas show between 50 and 75 percent of the aggregate resources are available to meet the 50-year aggregate demand.
- One study area shows between 75 and 100 percent of the aggregate resources to be available to meet its 50-year aggregate demand.
- Only one of the study areas has adequately permitted aggregate resources to meet or exceed its projected 50-year demand. The 2002 map showed six areas.

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 is intended to help planners and decision makers 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.

REFERENCES CITED

California Department of Transportation, 1992, Standard Specifications.

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, S.L., 2002, Aggregate Availability in California, California Geological Survey, Map Sheet 52, scale 1:1,100,000, 26p.

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

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

SPECIAL REPORTS

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 165: Mineral Land Classification of the Temescal Valley Area, Riverside County, California.
By Miller, R.V., Shumway, D.O., and Hill, R.L., 1991.

SR 173: Mineral Land Classification of Stanislaus County, California.
By Higgins, C.T., and Dupras, D.L., 1993.

SR 198: Update of Mineral Land Classification: Aggregate Materials in Palm Springs Production-Consumption Region, California.
By Busch, L.L., 2006. (in progress).

SR 199: Update of Mineral Land Classification- Stockton Lodi Production-Consumption Region, San Joaquin County, California.
By Taylor, G.C., 2006. (in progress).

OPEN-FILE REPORTS

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.

OFR 2000-18: Mineral Land Classification of Concrete-Grade Aggregate Resources in Tehama County, California.
By Foster, B.D., 2001

OFR 2000-03: Mineral Land Classification of EL Dorado County, California.
By Busch L.L., 2001

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