MAP SHEET 52

(UPDATED 2018)

AGGREGATE SUSTAINABILITY IN CALIFORNIA

2018

CALIFORNIA GEOLOGICAL SURVEY
Department of Conservation

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2018

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INTRODUCTION

Sand, gravel, and crushed stone are “construction materials.” These commodities, collectively referred to as aggregate, provide the bulk and strength to Portland Cement Concrete (PCC), Asphaltic Concrete (AC, commonly called “black top”), plaster, and stucco. Aggregate is also used as road base, subbase, railroad ballast, and fill. Aggregate normally provides 80 to 100 percent of the material volume in the above uses.

The building and paving industries in California consume large quantities of aggregate and future demand for this commodity is expected to increase throughout California. Aggregate materials are essential to modern society, both to maintain the existing infrastructure and to provide for new construction. Therefore, aggregate materials are a resource of great importance to the economy of any area. Because aggregate is a low unit-value, high-bulk-weight commodity, it must be obtained from nearby sources to minimize economic and environmental costs associated with transportation. If nearby sources do not exist, then transportation costs can quickly exceed the value of the aggregate. Transporting aggregate from distant sources results in increased construction costs, fuel consumption, greenhouse gas emissions, air pollution, traffic congestion, and road maintenance.

To give an idea of the scale of these impacts, from 1987 to 2016, California consumed an average of about 180 million tons of construction aggregate (all grades) per year. Moving in 25 ton truckloads that is 7.2 million truck trips per year. With an average 25-mile haul (50-mile round trip) that amounts to 360 million truck miles traveled, more than 51 million gallons of diesel fuel used, and more than 570,000 tons of carbon dioxide emissions produced annually. If the haul distance is doubled to 50 miles (100-mile round trip) the numbers double to 720 million truck miles traveled, more than 102 million gallons of diesel fuel used, and over 1.1 million tons of carbon dioxide emissions produced.

Land-use planners and decision makers in California are faced with balancing a wide variety of needs in planning for a sustainable future for their communities and regions. Mining is often seen as a controversial land use during the permitting process. However, there are benefits to having local sources of construction aggregate. Increasingly, as existing permitted aggregate supplies are depleted, local land-use decisions regarding aggregate resources can have regional impacts that go beyond local jurisdictional boundaries.

These factors, universal need, increasing demand, the economic and environmental costs of transportation, and multiple land-use pressures make information about the availability and demand for aggregate valuable to land-use planners and decision makers charged with planning for a sustainable future for California’s citizens.

California Geological Survey (CGS) Map Sheet 52 and this accompanying report provide general information about the current availability of, and future demand for, California’s permitted aggregate reserves. Map Sheet 52 was originally published in 2002 (Kohler, 2002) and subsequently updated in 2006 (Kohler, 2006) and 2012 (Clinkenbeard, 2012). Map Sheet 52 (2018) is an update of the version published in 2012.

Map Sheet 52 updates data from 49 reports compiled by the CGS for more than 30 aggregate study areas throughout the state (see Appendix). These study areas cover about 30 percent of the state and provide aggregate for about 85 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 2018 Map Sheet 52 to the prior (2012) map.
- Part III - 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 as alluvial sand and gravel or crushed stone that meets standard specifications for use in PCC or AC unless otherwise noted.

The estimates of permitted resources, aggregate demand, and years of permitted reserves remaining on Map Sheet 52 (2018) and in this report, are based on conditions as of January 1, 2017 and do not reflect changes, such as production, mine closures, or new or expanded permits, that may have occurred since that time. Although the statewide and regional information presented on the map and in this report may be useful to decision-makers, it should not be used as a basis for local land-use decisions. The more detailed information on the location and estimated amounts of permitted and non-permitted resources, and future regional demands contained in each of the aggregate studies employed in the compilation of Map Sheet 52 should be used for local land-use and decision-making purposes.

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

Map Sheet 52 is a statewide map showing a compilation of data about aggregate availability collected over a period of about 40 years and updated to January 1, 2017. The purpose of the map is to compare projected aggregate demand for the next 50 years with currently permitted aggregate reserves in various regions of the state. The map also shows the projected years of permitted reserves remaining and highlights regions where less than 10 years of permitted aggregate supply remain. The following sections describe data sources and methodology used in the development of the map.

Mineral Land Classification Reports and Aggregate Studies

Aggregate reserves and projected aggregate demand shown on Map Sheet 52 are updated from mineral land classification reports published by CGS between 1979 and 2017 (see Appendix). They were prepared in response to California's Surface Mining and Reclamation Act of 1975 (SMARA) that requires 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 (State Mining and Geology Board, 2000). The regulations and guidelines can be found on the State Mining and Geology Board website at http://www.conservation.ca.gov/smgb.

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, estimates of permitted and non-permitted aggregate resources, projected 50-year demand for aggregate resources, and an estimate of when the permitted reserves will be depleted. Map Sheet 52 is a statewide updated summary of 50-year demands and permitted resources for all regional SMARA classification reports pertaining to construction aggregate.

Mineral land classification studies for aggregate may use either a Production-Consumption (P-C) region or a county 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. P-C regions sometimes cross county boundaries. 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." SMARA guidelines recommend that the State Geologist periodically review the mineral land classification in defined study regions to determine if new classifications are necessary. The projected 50-year forecast of aggregate demand in the region may also be revised.

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 ("*"). Original mineral land classification reports and update reports are listed in the Appendix and can be found on the CGS Information Warehouse at http://maps.conservation.ca.gov/cgs/informationwarehouse/.

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 chart (See *Fifty-Year Aggregate Demand Compared to Permitted Aggregate Reserves* section), and is presented in Table 1 of this report. 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, 2017 through December 2066.

The aggregate study areas with the greatest projected future demand for aggregate are the South San Francisco Bay and Temescal Valley-Orange County areas. Each is expected to require more than a billion tons of aggregate by the end of 2066. Other areas with projected high demands are Western San Diego County, San Gabriel Valley, San Bernardino, Sacramento County, and Palmdale. Each of these areas is projected to need more than 500 million tons of aggregate in the next 50 years. Aggregate study areas having smaller demands generally are in rural, less populated areas. The aggregate study areas of El Dorado County, Glenn County, Nevada County, Shasta County, and Tehama County are all projected to require less than 100 million tons of aggregate over the next 50 years.

Methodology

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.

2. Dividing yearly aggregate production by the population for that same year to determine annual historical per capita consumption.

3. Determining the average of the annual historical per capita consumption values for the range of years being used.

4. Projecting yearly population for a 50-year period from the beginning of 2017 through 2066.

5. Multiplying each year of projected population by the average historical per capita consumption and adding the results for each year to obtain the 50-year aggregate demand.

Table 1. Comparison of 50-Year Demand to Permitted Aggregate Reserves for Aggregate Study Areas as of January 1, 2017.

AGGREGATE STUDY AREA[1]	50-Year Demand (million tons)	Permitted Aggregate Reserves (million tons)	Permitted Aggregate Reserves Compared to 50-Year Demand (percent)	Projected Years Remaining
Bakersfield P-C Region	338	1,708	505	More than 50
Barstow-Victorville P-C Region	163	117	72	31 to 40
Claremont-Upland P-C Region	202	90	45	21 to 30
El Dorado County	82	15	18	11 to 20
Fresno P-C Region	305	556	182	More than 50
Glenn County	41	22	54	21 to 30
Merced County	154	61	40	21 to 30
Monterey Bay P-C Region	333	297	89	41 to 50
Nevada County	41	52	127	More than 50
North San Francisco Bay P-C Region	492	263	53	21 to 30
Palmdale P-C Region	569	163	29	11 to 20
Palm Springs P-C Region	238	163	68	31 to 40
Placer County	188	387	206	More than 50
Sacramento County	724	327	45	21 to 30
Sacramento-Fairfield P-C Region	295	109	37	21 to 30
San Bernardino P-C Region	939	156	17	11 to 20
San Fernando Valley/ Saugus-Newhall[2]	**387**	**17**	**4**	**10 or fewer**
San Gabriel Valley P-C Region	751	297	40	21 to 30
San Luis Obispo-Santa Barbara P-C Region	226	58	26	11 to 20
Shasta County	82	49	60	31 to 40
South San Francisco Bay P-C Region	1,320	506	38	21 to 30
Stanislaus County	160	39	24	11 to 20
Stockton-Lodi P-C Region	409	203	50	21 to 30
Tehama County	49	30	61	31 to 40
Temescal Valley-Orange County[2]	1,079	862	80	41 to 50
Tulare County	130	53	41	21 to 30
Ventura County[2]	241	84	35	11 to 20
Western San Diego County P-C Region	763	265	35	11 to 20
Yuba City-Marysville P-C Region	344	679	197	More than 50
Total	11,045	7,628	69	

[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] Two P-C regions have been combined into one study area.

Bold = study area with ten or fewer years of permitted reserves.

For this update, the range of years of historical production and population data used were generally from 1980-2016.

The per capita consumption model has proved to be effective for projecting aggregate demand in major metropolitan areas. 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 P-C region production and population. In such areas, projections may be made based on historical production or, multiple projections based on differing assumptions may be used to better characterize a range of future demand.

For regions that export large amounts of aggregate to neighboring P-C regions, projections are based on an 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 of its aggregate into neighboring areas such as Sacramento County and Placer County. The 50-year demand for Glenn and Tehama counties, the Palmdale P-C Region, and the Temescal Valley-Orange County area was also projected using this method.

Permitted Aggregate Reserves

Approximately 7.6 billion tons of permitted aggregate reserves lie within the aggregate study areas shown on Map Sheet 52. Permitted aggregate 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 reserves face legal challenges, these reserves 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 reserves as a percentage of the 50-year demand on each pie chart (See *Fifty-Year Aggregate Demand Compared to Permitted Aggregate Reserves* section). Beneath the study area name located next to its corresponding pie chart is the permitted resource in tons along with the 50-year demand. These figures are also given in Table 1.

Permitted aggregate resource calculations shown on the map and in Table 1 initially 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. Permitted reserve calculations have been updated to account for production from 2010-2016 and are current as of the beginning of 2017.

Fifty-Year Aggregate Demand Compared to Permitted Aggregate Reserves

Fifty-year aggregate demand compared to the currently permitted aggregate reserves is represented by a pie chart for each aggregate study area on Map Sheet 52. Each pie chart is in the approximate center of the aggregate study area it represents. There are four different sizes of charts, each representing a 50-year demand range. The smallest pie chart represents 50-year demands of less than 200 million tons, while the largest chart represents demands of over 800 million tons. The 50-year demand (in tons) is shown on the map with the amount of permitted reserves beneath the study area name located next to its corresponding pie chart (permitted reserves, 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 reserves. For example, if the blue portion is 25 percent and the purple portion is 75 percent of a pie chart that represents a total demand of 400 million tons, the permitted reserves 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 Bakersfield aggregate study area is completely colored blue, showing permitted aggregate reserves are equal to or greater than the area's 50-year aggregate demand. Detailed examples are provided in the legend of Map Sheet 52.

Except for the Bakersfield P-C Region, Fresno P-C Region, Nevada County, Placer County, and the Yuba City-Marysville P-C Region, all the aggregate study areas have less permitted aggregate reserves than they are projected to need for the next 50 years. Fifteen of the aggregate study areas shown on the map have less than half of the permitted reserves they are projected to need in the next 50 years.

Estimates of Years of Permitted Reserves Remaining

The right-hand column of Table 1 indicates the projected years of permitted reserves remaining for the various aggregate study areas. Calculations of depletion years are made by comparing the currently permitted reserves 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. Data are presented as ranges; 10 or fewer, 11-20, 21-30, 31-40, 41-50, and more than 50 years. This information is included on Map Sheet 52 beneath the study area name along with the permitted reserves and the projected 50-year demand. These estimates are based on conditions as of January 1, 2017 and do not reflect changes, such as new or expanded permits, that may have occurred since that time.

Only one of the aggregate study areas in Table 1, the San Fernando Valley-Saugus Newhall area, is projected to have less than 10 years of permitted aggregate reserves remaining as of January 1, 2017.

Seven of the aggregate study areas in Table 1 have between 11 and 20 years of permitted aggregate reserves remaining, ten have between 21 and 30 years of permitted aggregate reserves remaining, four have 31 to 40 years remaining, two have 41 to 50 years, and five have more than 50 years of permitted reserves remaining.

These numbers are estimates and the actual lifespan of existing permitted reserves in a study area can be influenced by many factors. In periods of high economic growth, demand may increase, shortening the life of permitted reserves. Large projects, such as the construction or maintenance of major infrastructure, or rebuilding after a disaster such as an earthquake could also deplete permitted reserves more rapidly. Increased demand from neighboring regions with dwindling or depleted permitted reserves may also accelerate the depletion of permitted reserves in a study area. Conversely, a slow economy may reduce demand for a period of time, extending the life of permitted reserves, or new or expanded permits may be granted in a study area, increasing the permitted reserves and the lifespan of permitted reserves in that area.

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 use 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 approximately 74 billion tons of non-permitted construction aggregate resources in the aggregate study areas shown on Map Sheet 52. While this number seems large, it is unlikely that all of these resources will ever be mined because of social, environmental, or economic factors. The location of aggregate resources too close to urban or environmentally sensitive areas can limit or prevent their development. Resources may also be located too far from a potential market to be economic. Despite 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 mineral land classification reports listed in the Appendix.

Aggregate Production Areas and Districts

Aggregate production areas are shown on Map Sheet 52 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 Division of Mine Reclamation (DMR) records for the calendar year 2016.

The smallest triangle represents an area that produced less than 0.5 million tons of aggregate in 2016. These triangles often represent a single mine operation and many are in rural parts of the state. The largest triangle represents aggregate mining districts with production of more than 5 million tons in 2016. 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.

PART II: COMPARISONS BETWEEN THE PRIOR (2012) AND THE UPDATED (2018) MAP SHEET 52

The prior version of Map Sheet 52 was published in 2012. Permitted aggregate resource data for that map were current as of January 1, 2011. Work conducted for that study took place during 2011/2012. The latest aggregate production and location data available for the prior map were from 2010 records. The aggregate demand projections for the prior map were based on California Department of Finance (DOF) county population projections from the 2010 U.S. census. Fifty-year aggregate demand from January 1, 2011 through the year 2060 was determined for the included study areas.

This updated Map Sheet 52 was completed and published in 2018. Permitted aggregate resource data for the updated map is current as of January 1, 2017. All work conducted for the updated study took place during 2017/2018. The latest aggregate production and location data available for the updated map are from 2016 records. The aggregate demand projections for the updated map were based on DOF county population estimates and projections for 2010 to 2060 (DOF, 2018). Fifty-year aggregate demand from January 1, 2017 through the year 2066 was determined for the included study areas.

Changes have occurred in both aggregate supplies (permitted aggregate reserves) and in 50-year aggregate demand since Map Sheet 52 (2012) was completed. Changes in permitted aggregate reserves are shown in Table 2. Changes in 50-year demand are shown in Table 3.

Aggregate Study Area Changes

Six aggregate study areas on the original (2002) Map Sheet 52 were modified for the 2006 map, resulting in three fewer study areas. They included the Southern California P-C regions of Orange County, Temescal Valley, San Fernando Valley, Saugus-Newhall, Western Ventura County, and Simi Valley. These regions were combined into three regions when they began to run out of permitted reserves and became dependent on aggregate sources from neighboring regions. The importation of aggregate from neighboring regions typically results in longer haul distances, higher costs, and increased carbon dioxide emissions, air pollution, traffic congestion, and highway maintenance. The shift in supply area also results in more rapid depletion of permitted reserves in neighboring regions.

In the 2006 and 2012 versions of Map Sheet 52, information for eastern and western Merced County and northern and southern Tulare county were reported. This was because separate market regions existed in those study areas. While those separate market regions may still exist, in this update, information is reported for Merced and Tulare counties and not for the eastern and western or northern and southern areas, respectively.

Table 2. Comparison of Permitted Aggregate Reserves Between Map Sheet 52, 2012 and Map Sheet 52, 2018.

AGGREGATE STUDY AREA	Map Sheet 52, 2012 Permitted Aggregate Reserves as of 1/1/11 (million tons)	Map Sheet 52, 2018 Permitted Aggregate Reserves as of 1/1/17 (million tons)	Percent Difference
Bakersfield P-C Region	143	1,708	1,094
Barstow Victorville P-C Region	124	117	-6
Claremont-Upland P-C Region	109	90	-17
El Dorado County	18	15	-17
Fresno P-C Region	46	556	1,109
Glenn County	33	22	-33
Merced County**	N/A**	61	N/A**
Monterey Bay P-C Region	323	297	-8
Nevada County	26	52	100
North San Francisco Bay P-C Region	110	263	139
Palmdale P-C Region	152	163	7
Palm Springs P-C Region	152	163	7
Placer County	152	387	155
Sacramento County	42	327	679
Sacramento-Fairfield P-C Region	128	109	-15
San Bernardino P-C Region	241	156	-35
San Fernando Valley/Saugus-Newhall*	77	17	-78
San Gabriel Valley P-C Region	322	297	-8
San Luis Obispo-Santa Barbara P-C Region	75	58	-23
Shasta County	52	49	-6
South San Francisco Bay P-C Region	404	506	25
Stanislaus County	45	39	-13
Stockton Lodi P-C Region	232	203	-13
Tehama County	32	30	-6
Temescal Valley-Orange County*	297	862	190
Tulare County**	N/A**	53	N/A**
Ventura County (combined Western Ventura County and Simi Valley P-C Region)*	96	84	-13
Western San Diego County P-C Region	167	265	59
Yuba City-Marysville P-C Region	392	679	73
Total	4,067	7,628	88

* Two P-C Regions have been combined into one study area.
** In Map Sheet 52 (2012) separate values for east and west Merced County and north and south Tulare County were presented. In this update, information is given only for the counties as a whole and not the parts.

Table 3. Comparison of 50-Year Demand Between Map Sheet 52, 2012 and Map Sheet 52, 2018.

AGGREGATE STUDY AREA	Map Sheet 52, 2012 50-Year Demand as of 1/1/11 (million tons)	Map Sheet 52, 2018 50-Year Demand as of 1/1/17 (million tons)	Percent Difference
Bakersfield P-C Region	438	338	-23
Barstow-Victorville P-C Region	159	163	3
Claremont-Upland P-C Region	203	202	0
El Dorado County	76	82	8
Fresno P-C Region	435	305	-30
Glenn County	59	41	-31
Merced County**	N/A**	154	N/A**
Monterey Bay P-C Region	346	333	-4
Nevada County	100	41	-59
North San Francisco Bay P-C Region	521	492	-6
Palmdale P-C Region	577	569	-1
Placer County	151	238	58
Palm Springs P-C Region	295	188	-36
Sacramento County	670	724	8
Sacramento-Fairfield P-C Region	196	295	51
San Bernardino P-C Region	993	939	-5
San Fernando Valley/Saugus-Newhall*	476	387	-19
San Gabriel Valley P-C Region	809	751	-7
San Luis Obispo-Santa Barbara P-C Region	240	226	-6
Shasta County	93	82	-12
South San Francisco Bay P-C Region	1,381	1,320	-4
Stanislaus County	214	160	-25
Stockton Lodi P-C Region	436	409	-6
Tehama County	62	49	-21
Temescal Valley-Orange County*	1,077	1,079	0
Tulare County **	N/A**	130	N/A**
Ventura County (combined Western Ventura County and Simi Valley P-C Regions)*	298	241	-19
Western San Diego County P-C Region	1,014	763	-25
Yuba City-Marysville P-C Region	403	344	-15
Total	12,047	11,045	-8

* Two P-C Regions have been combined into one study area.
** In Map Sheet 52 (2012) separate values for east and west Merced County and north and south Tulare County were presented. In this update, information is given only for the counties as a whole and not the parts.

No additional study areas have been combined in this update. It is likely that in some future update the San Fernando Valley-Saugus Newhall aggregate study area and the Palmdale study area may be combined as permitted reserves in the San Fernando Valley-Saugus Newhall aggregate study area are depleted. In addition, a study of the Greater Sacramento Area currently nearing completion will likely result in the combination of several previously existing study areas.

Changes in Permitted Aggregate Reserves

Fifteen of the study areas shown on the updated map experienced a decrease in permitted aggregate reserves since the 2012 map was completed (See Table 2). Most of these decreases likely represent aggregate production within those study areas since the last update of Map Sheet 52.

A large part of the reduction in the San Fernando Valley-Saugus Newhall study area is due to the subtraction of the 56 million tons of permitted aggregate reserves previously associated with the CEMEX Soledad Canyon Sand and Gravel Mining Project. In 2015, the Bureau of Land Management withdrew the contracts that would have allowed mining. The issue is currently under appeal with the Interior Board of Land Appeals. If, at a future date, the contracts are restored then the permitted reserves will be restored.

Twelve of the study areas shown on the updated map had increases in permitted aggregate reserves. Most of these increases are because of newly permitted or expanded mining operations within the various study areas. An expansion may increase the footprint of the mine or increase permitted mining depth. Some of these increases may be the result of recalculation of the permitted aggregate reserves in a study area.

Total permitted reserves for all the included study areas increased to 7,628 million tons from 4,067 million tons – an apparent increase of 3,561 million tons. The actual increase was likely slightly more because of production since 2010. Approximately two-thirds of the increase is due to permitting activities in the Bakersfield, Fresno, and Sacramento study areas.

Changes in Fifty-Year Demand

Of the study areas shown on the updated Map Sheet 52, five had increases in 50-year demand, two had less than a one percent change, and 20 showed decreases in projected 50-year demand (See Table 3). The large number of study areas with decreasing 50-year demand is likely due in part to incorporation of lower per capita consumption rates caused by the slow recovery of the construction industry in California in the years following the economic recession of 2007-2009.

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

The 2018 Map Sheet 52 shows only one aggregate study area with less than a 10-year supply of permitted aggregate reserves – San Fernando Valley-Saugus Newhall.

Compared to the 2012 version of the map, which showed four aggregate study areas with less than a 10-year supply of aggregate – Sacramento County and the Fresno, San Fernando Valley-Saugus Newhall, and Western San Diego P-C regions.

PART III: OVERVIEW OF CONSTRUCTION AGGREGATE

Construction aggregate was the leading non-fuel mineral commodity produced in California in 2016. Valued at $1.42 billion, aggregate made up about 42 percent of California's $3.4 billion non-fuel mineral production in 2016.

Aggregate Quality and Use

Aggregate normally makes up 80 to 100 percent of the material volume in PCC and AC and provides the bulk and strength to these materials. Rarely, even from the highest-grade deposits, is in-place aggregate 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 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."

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 percent by weight of crushed particles. Crushed stone is preferable to natural gravel in 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 make 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. 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 costlier 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.

Aggregate Price

The price of aggregate throughout California varies considerably depending on location, quality, and supply and demand. The highest quality aggregate, and typically most costly, is that which meets the specifications for use in PCC or AC. All prices discussed in this section are for PCC/AC-grade aggregate at the plant site or FOB (freight on board). Transportation cost, which adds to the final cost of aggregate, is discussed in the next section.

Regional variations make it difficult to estimate the average price of PCC-grade aggregate for the state. Over the last decade, prices have varied from more than $20 per ton in areas with depleting or depleted aggregate supplies and high demands such as San Diego and parts of the Bay Area, to $9 to $12 per ton in areas such as Yuba City-Marysville with abundant aggregate supplies and low to moderate demands. In many areas of the state it is likely that prices fall between these two endmembers.

Transportation and Increasing Haul Distances

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.

This makes the mining of aggregate much more competitive than most other mined commodities. The location, distance to market, and access to major transportation routes greatly influence the economic feasibility of an aggregate mine.

Most aggregate in California moves to its final point of use by truck. Trucking is typically charged at an hourly rate and rates may vary in different regions of the state. The typical distance traveled per hour may also vary, being greater in less congested or more rural areas, and less in densely populated urban areas. Other factors that affect hauling rates include fuel costs, toll bridges and toll roads, road conditions, and terrain. Transportation cost is the principal constraint defining the market area for an aggregate mining operation and the cost of transporting aggregate over long distances can equal or exceed the base cost of the aggregate.

Throughout California, aggregate haul distances have gradually increased as more 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

(2002) map into three regions for the updated maps. In some parts of the state, one-way haul distances that were 20-30 miles decades ago are now sometimes 100 miles or more. Increased aggregate haul distances not only increase the cost of aggregate to the consumer, but also increase environmental and societal impacts such as increased fuel consumption, carbon dioxide (CO_2) emissions, air pollution, traffic congestion, and road maintenance.

Imported Aggregate

In some regions, local aggregate production is sufficient to meet the local demand, but in others, there is more demand than can be met by local production leading to a shortfall that is typically met by importing construction aggregate from neighboring aggregate producing regions.

There are both advantages and disadvantages to importing construction aggregate. Imports can provide needed aggregate in areas with depleted reserves/resources and can supply specific types of aggregate that are in short supply in the region. However, imported aggregate is often more expensive because of additional transportation costs. Increased costs for aggregate leads to more expensive construction projects in both the public and private sectors. Importing aggregate from neighboring regions also leads to more rapid depletion of reserves/resources in those regions, potentially contributing to price increases or aggregate shortages in those regions.

In addition to the greater economic costs, there are often increased environmental and societal costs associated with the import of aggregate when compared to local production. The environmental impacts include higher emissions of greenhouse gases, such as CO_2, and air pollution. The societal impacts include increased traffic congestion and road wear and maintenance due to increased truck traffic. In the case of imports, these environmental and societal impacts occur both within the importing region and in the neighboring regions that supply the material and through which the material is transported.

Currently almost all aggregate produced or imported into California is transported to its final point of use by truck. In discussions of aggregate import, other modes of transportation such as rail, barge, or ship are often mentioned as alternative methods of moving aggregate. In 2011, the San Diego Association of Governments (SANDAG) Service Bureau published the San Diego Region Aggregate Supply Study (SANDAG Service Bureau, 2011). This study included an evaluation of fuel use and CO_2 emissions for several scenarios involving different transport options for importing aggregate into the San Diego area. While the published study is specific to the San Diego region, it provides an interesting analysis of the impacts of importing construction aggregate. The following discussion is adapted from Special Report 240 (Gius, Busch, and Miller, 2017).

The SANDAG study looked at the impacts based on various combinations of transport options for the following five scenarios:

- In region production
- Import by truck from neighboring regions
- Import by rail/truck from San Bernardino County
- Import by barge/truck from Baja California, Mexico
- Import by ship/truck from British Columbia, Canada.

Fuel consumption, CO_2 emissions, and some other pollutant emissions (nitrogen oxides (NO_x) and particulate matter (PM)) were estimated based on round-trip travel, with aggregate transported to the point of use and the vehicle returning empty. For scenarios involving non-truck transport (rail, barge, and ship), delivery to the final point of use by truck was included. The transport scenarios and transport type and mileage considerations are presented in Table 4. More detail can be found in the SANDAG study (SANDAG Service Bureau, 2011).

Table 4. Summary of SANDAG Aggregate Transport Scenarios

SANDAG AGGREGATE TRANSPORT SCENARIOS	
TRANSPORT OPTION	**MILEAGE BY MODE**
Local: Truck	26 miles one way / 52 miles round trip
Import: Truck	100 miles one way / 200 miles round trip
Import: Rail + Truck	Rail: 200 miles one way / 400 miles round trip Truck: 20 miles one way / 40 miles round trip
Import: Barge + Truck	Barge: 70 miles one way / 140 miles round trip Truck: 20 miles one way / 40 miles round trip
Import: Ship + Truck	Ship: 1,540 miles one way / 3,080 miles round trip Truck: 20 miles one way / 40 miles round trip

Adapted from SANDAG Service Bureau, 2011

Transportation methods that move larger amounts of aggregate per load can be more efficient in terms of fuel consumption (gallons of fuel consumed per net ton-mile traveled) and CO_2, NO_x, and PM emissions (grams of CO_2, NO_x, and PM emitted per net ton-mile traveled). However, even though these transport options may be more efficient on a net ton-mile basis, the total fuel consumption and emissions are dependent on the distance traveled. If those distances are large, total fuel consumption and emissions may exceed those of less efficient transportation methods over shorter distances. This is demonstrated by SANDAG's findings. Even though transport by rail, barge, and ship have lower fuel consumption and CO_2 emissions per net ton-mile than transport by truck (Table 5), the total fuel usage and CO_2 emissions for those transport scenarios are greater than in-region production with truck delivery because of the distances involved (Table 6).

Table 5. Fuel Consumption and CO_2 Emissions from Aggregate Transport with Payload

Mode	Payload	Fuel Consumption (gallons/net ton per mile)	CO_2 Emissions (grams/net ton per mile)
Truck	25 tons	0.0086	86.9
Rail	100 tons per hopper car	0.0021	21.4
Barge	1,500 tons	0.0068	69.6
Ship	72,786 tons	0.0004	5.3

Adapted from Tables 4-2 and 4-4, SANDAG Service Bureau, 2011

Table 6. Fuel Consumption and Emissions for Aggregate Transport Scenarios – Estimates per Million Tons of Aggregate Transported

Transport Option	Total Fuel Consumption (gallons)	Total CO_2 Emissions (metric tons)	Total NO_x Emissions (metric tons)	Total PM Emissions (metric tons)
Local: Truck	296,000	3,000	26.5	1.1
Import: Truck	1,138,000	11,537	102	4.4
Import: Rail + Truck	788,000	7,985	120.4	3.3
Import: Barge + Truck	804,000	8,210	147.1	5.1
Import: Ship + Truck	1,406,000	16,703	282.2	16.3

Adapted from SANDAG Service Bureau, 2011

Table 6 shows that, per million tons of aggregate transported, local production with transport by truck consumes less fuel and produces less CO_2, NOx, and PM than the other transport options investigated by SANDAG. Transport Option 2, import of one million tons of aggregate by truck from neighboring regions, consumes almost four times as much fuel and produces almost four times the emissions as the local production and delivery of a similar amount of aggregate. In addition, the impacts occur not only in the Western San Diego County P-C Region, but in neighboring regions through which the materials are transported.

While this analysis pertains to San Diego County, similar analyses, with appropriate parameters, could be done for other regions. What it does point out is that, even though some methods of transportation may be more efficient on a per ton-mile basis, if the transport distances are great enough, the overall impacts may be greater than those of local production.

Factors Affecting Aggregate Demand

Several factors may influence aggregate demand. In periods of high economic growth, demand may increase, depleting permitted reserves more rapidly than expected. Large projects, such as the construction or maintenance of major infrastructure, or rebuilding after a disaster such as an earthquake could also deplete permitted reserves more rapidly. Increased demand from neighboring regions with dwindling or depleted permitted reserves may also accelerate the depletion of permitted reserves in a study area. Conversely, a period of declining economy or of low economic growth, such as that during the recession of 2007 to 2009 and the subsequent slow economic recovery, can reduce demand for a period of time, extending the life of permitted reserves. In some cases, importation of aggregate from other areas may extend the life of a region’s permitted reserves.

SUMMARY AND CONCLUSIONS

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 the 30-year period from 1987 to 2016, Californians consumed an average of about 180 million tons of construction aggregate (all grades) per year or about 5.3 tons per person per year. Demand for aggregate is expected to increase as the state's population continues to grow and infrastructure is maintained, improved, and expanded. For example, the Road Repair and Accountability Act of 2017 (SB1) will provide approximately 5 billion dollars annually for a variety of maintenance, rehabilitation, and other transportation related projects over the next decade. Because aggregate is a low unit-value, high-bulk-weight commodity, it must be obtained from nearby sources to minimize the dollar cost to the aggregate consumer and other environmental and economic costs associated with transportation.

Comparing regional needs to available reserves and resources demonstrates the important aggregate resource issues facing lead agencies in California. These issues include the need to plan carefully for the use of lands containing these resources and the need to consider the permitting of additional aggregate resources before currently permitted deposits are depleted.

Increasingly, as existing permitted aggregate supplies are depleted, local land-use decisions regarding aggregate resources are having regional impacts that go beyond local jurisdictional boundaries. Planning for future construction aggregate needs in our communities should take into consideration not only the needs of the community, but also the needs of the region and neighboring regions. Importing aggregate from neighboring regions leads to more rapid depletion of reserves/resources in those regions, potentially contributing to price increases or aggregate shortages in those regions.

In addition to the greater economic costs, there are often increased environmental and societal costs associated with the import of aggregate when compared to local production. The environmental impacts include higher emissions of greenhouse gases, such as CO_2, and air pollution. The societal impacts include increased traffic congestion and road maintenance due to increased truck traffic. In the case of imports, these environmental and societal impacts occur both within the importing region and in the neighboring regions that supply the material and through which the material is transported. Finally, reliance on imports places responsibility and authority for permitting related to the local aggregate supply in the hands of decision makers in other jurisdictions.

For more than 40 years, under SMARA, CGS has conducted on-going studies that identify and evaluate aggregate resources throughout the state. Map Sheet 52 (2018) is an updated summary of supply and demand data from these studies. The map presents a statewide overview of projected future aggregate needs and currently permitted reserves.

The following conclusions can be drawn from Map Sheet 52 (2018) and this accompanying report:

- In the next 50 years, the study areas identified on Map Sheet 52 (2018) will need approximately 11 billion tons of aggregate.
- The study areas shown on Map Sheet 52 currently have about 7.6 billion tons of permitted reserves, which is about 69 percent of the total projected 50-year aggregate demand identified for these study areas. This is about 10 percent of the total aggregate resources located within the study areas.
- One aggregate study area is projected to have 10 or fewer years of permitted aggregate reserves remaining as of January 2017 (San Fernando Valley / Saugus Newhall area).
- Seven aggregate study areas have between 11 and 20 years of aggregate reserves remaining.
- Ten aggregate study areas have between 21 and 30 years of aggregate reserves remaining.
- Four aggregate study areas have between 31 and 40 years of aggregate reserves remaining.
- Two aggregate study areas have between 41 and 50 years of aggregate reserves remaining.
- Five aggregate study areas (Bakersfield, Fresno, and Yuba City-Marysville P-C regions, and Nevada and Placer counties) have more than 50 years of aggregate reserves remaining.

The information presented on Map Sheet 52 (2018) 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 estimate 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.

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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.

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*****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.

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*****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., 1989.

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 for Portland Cement Concrete-Grade Aggregate in the Palm Springs Production-Consumption Region, Riverside County, California. Busch, L.L., 2007.

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SR 205 Update of Mineral Land Classification of Aggregate Resources in the North San Francisco Bay P-C Region: Sonoma, Napa, and Marin Counties and Southwestern Solano County, California. Miller, R.V. and Busch, L.L., 2013

SR 206 Update of Mineral Land Classification for Portland Cement Concrete-Grade Aggregate in the San Bernardino Production-Consumption Region, San Bernardino and Riverside Counties, California. Miller, R.V. and Busch, L.L., 2008.

SR 209 Update of Mineral Land Classification for Portland Cement Concrete-Grade Aggregate in the San Gabriel Valley Production-Consumption Region, Los Angeles County, California. Kohler, S.L., 2010.

SR 210 Update of Mineral Land Classification: Aggregate Materials in the Bakersfield Production-Consumption Region, Kern County, California. Busch, L.L., 2009.

SR 215 Update of Mineral Land Classification: Aggregate Materials in the San Luis Obispo-Santa Barbara Production-Consumption Region, California. Busch, L.L. and Miller, R.V., 2011.

SR 231 Update of Mineral Land Classification for Portland Cement Concrete-Grade Aggregate in the Temescal Valley Production Area, Riverside County, California. Miller, R.V. and Busch, L.L., 2014.

SR 240 Update of Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Western San Diego County Production-Consumption Region, California. Gius, F.W., Busch, L.L., and Miller, R.V. 2017.

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

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.

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OFR 97-01: Mineral Land Classification of Concrete Aggregate Resources in the Tulare County Production-Consumption Region, California. By Taylor, G.C., 1997.

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

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