Special Report 245

MINERAL LAND CLASSIFICATION: CONCRETE AGGREGATE IN THE GREATER SACRAMENTO AREA PRODUCTION-CONSUMPTION REGION

2018

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California Geological Survey

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MINERAL LAND CLASSIFICATION: CONCRETE AGGREGATE IN THE GREATER SACRAMENTO AREA PRODUCTION-CONSUMPTION REGION

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AB: Assembly Bill

AC: Asphaltic Concrete

ARA: Aggregate Resource Area

CC: Cache Creek

CCRMP: Cache Creek Resource Management Plan

CGS: California Geological Survey

DMR: Division of Mine Reclamation

DOF: Department of Finance

GIS: Geographic Information System

GHG: Green House Gas

GSA: Greater Sacramento Area

HWY: Highway

I: Interstate

MLC: Mineral Land Classification

MRZ: Mineral Resource Zone

NAIP: National Agricultural Imagery Program

OFR: Open File Report

P-C: Production-Consumption

PCC: Portland Cement Concrete

PM: Particulate Matter

SMARA: Surface Mining and Reclamation Act (of 1975)

SMGB: State Mining and Geology Board

SR: Special Report

USBM: United States Bureau of Mines

EXECUTIVE SUMMARY

This is the first mineral land classification (MLC) study of concrete aggregate resources in the newly-defined Greater Sacramento Area Production-Consumption (P-C) Region. The region is 6,080 square miles in area, of which 2,580 square miles were classified in ten former MLC studies. The earliest MLC study within the region was completed in 1975, and the most recent study was completed in 2010. None of the formerly-classified areas have undergone the process of designation by the State Mining and Geology Board (SMGB). The remaining 3,500 square miles of the P-C Region are newly classified for concrete aggregate resources. As of 2017, the P-C Region contains about 4,334 million tons of concrete aggregate resources, and 1,446 million tons of concrete aggregate reserves.

Sand, gravel, and crushed rock are "construction materials." These materials, collectively referred to as aggregate, provide bulk and strength to Portland cement concrete (PCC), asphaltic concrete (AC), Class II Base, and other aggregate commodities such as subbase, drain rock, and fill. The material specifications for PCC and AC aggregates 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. The present report evaluates lands within the Greater Sacramento Area P-C Region for concrete aggregate resources, which includes both PCC and AC aggregate.

Urban expansion continues in the P-C Region, threatening to preclude mineral resource extraction. Consequently, it is important that land-use decisions be made recognizing the presence and importance of local aggregate resources.

All lands within the P-C Region are assigned Mineral Resource Zone (MRZ) classifications (MRZ-1 through MRZ-4) based on geologic factors alone without regard for current land uses. In addition, the State Geologist is responsible for calculating the amount of aggregate resources contained in areas classified as MRZ-2. The mineral land classification map for the P-C Region is shown on Plate 1. Understanding that there are lands within these areas that have been urbanized, the State Geologist limits aggregate resource calculations to areas within "Sectors." Sectors are areas classified as MRZ-2 that have current land uses deemed compatible with possible future mining. For this study, the determination of compatible land uses was based on information from remotely-sensed imagery, field reconnaissance, and land-use maps as of 2016 and later. The aggregate resource Sector map is shown on Plates 2A and 2B. The State Geologist calculates the available resources of each Sector and identifies remaining resources that have been permitted for mining (i.e., "reserves"). The reserves and resources within all Sectors are compared with a forecast of the 50-year needs of the region.

This report re-evaluates and updates the concrete aggregate resources in areas previously evaluated. However, because of the nature of this compilation and update, it is not straightforward to compare the earlier reports to the present report. Source reports were completed at different times, ranging from 1988 to 2010. Different source reports classified and evaluated the land for construction aggregate (all grades), concrete aggregate (PCC- and AC-grades), or only PCC-grade aggregate. Some of the former study areas were defined by county boundaries, others were defined as P-C regions, and one was nominally defined as a P-C Region, but was described as more of a production region. Due to the different time periods and aggregate grades evaluated in each report, there is no straightforward and meaningful way to make a "then" and "now" comparison. Thus, no comparison is made in this report.

EVALUATION OF CONCRETE AGGREGATE RESOURCES

This report re-evaluates the concrete aggregate resources in 2,580 square miles of area previously classified by the California Geological Survey, in the reports listed below. The studies were conducted between 1988 and 2010.

- Special Report 132 (1988): *Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Yuba City-Marysville P-C Region*
- Special Report 156 (1988): *Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Sacramento-Fairfield P-C Region*
- Special Report 164 (1990): *Mineral Land Classification of Nevada County, California*
- Open-File Report 94-12 (1994): *Mineral Land Classification of the Triangle Properties Hofman Ranch Site, Browns Valley 7.5-minute Quadrangle, Yuba County, California, for Portland Cement Concrete-Grade Aggregate* (petition)
- Open-File Report 95-10 (1995): *Mineral Land Classification of Placer County, California*
- Open-File Report 99-09 (1999): *Mineral Land Classification: Portland Cement Concrete-Grade Aggregate and Kaolin Clay Resources in Sacramento County, California*
- Open-File Report 2000-03 (2000): *Mineral Land Classification of El Dorado County, California*
- Special Report 213 (2009): *Mineral Land Classification of the White Rock Road Properties, Mangini Property, Sacramento County, California – for Construction Aggregate* (petition)
- Special Report 214 (2010): *Mineral Land Classification of the Wilson Ranch – Walltown Quarry Site, Sacramento County, California – for Construction Aggregate* (petition)

These former reports identified 85 concrete aggregate resource Sectors, with a total area of 42,033 acres. The present study determines that, as of 2017, these Sectors contain an estimated 3,565 million tons of concrete aggregate resources. The present report identifies nine additional aggregate resource Sectors (numbered 86 through 94), with a combined area of 3,880 acres, and which contain an estimated 769 million tons of concrete aggregate resources. In total, the concrete aggregate resource Sectors have an area of 45,913 acres, which makes up just over one percent of the total area of the P-C Region.

CONCRETE AGGREGATE PRODUCTION

Based on 2017 data from the California Division of Mine Reclamation, 13 companies have current, valid permits to operate 30 mines capable of producing concrete-grade aggregate in the P-C Region. The locations of these mines are shown on Plates 1, 2A and 2B.

Aggregate production data for the P-C Region were obtained from aggregate producers, the U.S. Bureau of Mines, and the California Division of Mine Reclamation. Total production from the P-C Region from 1970 through 2016 is reported to be about 661 million tons. In this time period, annual aggregate production ranged from about 7 million tons in 2012 to about 26 million tons in 2005.

In the GSA, market dynamics and market regions have changed since past reports. It now makes sense to combine all or parts of six former P-C Regions and county study areas into one essentially isolated, or self-sufficient, P-C Region which captures nearly all aggregate production and consumption within the region. Significant aggregate exchange (imports and exports) were recognized between the six former study areas, and this aggregate exchange and interdependence has only increased since the times of those studies. Some of the areas with large resources and relatively low populations, such as the Yuba City-Marysville and Cache Creek areas, are net producers. Other areas with relatively large populations and lower resources, such as the Sacramento area, are net consumers. The present GSA P-C Region captures all of these interdependent parts.

ESTIMATE OF THE 50-YEAR AGGREGATE DEMAND

The SMGB guidelines for the classification and designation of mineral land specify that MLC reports include an estimate of the total quantity of construction aggregate needed to fulfill the P-C Regions needs for the next 50 years. Published population projections by the California Department of Finance estimate the population of the P-C Region to increase by 1,586,496 (approximately 58 percent) to 4,343,895 in 2066, from 2,757,399 in 2016. For this report, an average annual per capita consumption rate of 7.6 tons was multiplied by the projected population for each year to project aggregate demand. Based on this projection, an estimated 1,367 million tons of construction aggregate will be needed to satisfy demand in the P-C Region through the year 2066.

Of the 1,367 million tons of construction aggregate needed to meet the 50-year demand, 889 million tons (65 percent) will be needed for concrete aggregate. Total concrete aggregate reserves in the P-C Region are estimated to be approximately 1,446 million tons as of 2017. The reserves are projected to last beyond the year 2066, assuming mining continues until depleted. However, there is a substantial and important disparity between the geographic distribution of mineral resources and population centers. Only a minor proportion of concrete aggregate resources are located near population centers. If these resources become depleted or precluded due to land use changes, a significant increase in cost to the aggregate consumer should be expected, in the form of increasing aggregate cost, road wear and tear, traffic congestion, green house gas (GHG) emissions, and air pollution. Therefore, it is important that the reader keep in mind the location of resources and reserves as opposed to the location of consumption centers.

Potential alternative sources of aggregate for the P-C Region include deposits within the region that are currently classified MRZ-3, and imported aggregate. Significant sand and gravel, and igneous and metamorphic hard rock deposits, are classified MRZ-3 within the P-C Region. Further investigation may prove that, in some cases, some of these MRZ-3 areas may meet concrete-grade aggregate requirements.

Significant concrete aggregate production occurs near the P-C Region, especially to the north in the Oroville area, and to the south in the Stockton-Lodi area. If market conditions change substantially, it is possible that these regions could become significant sources of aggregate to the P-C Region. However, at present, it is estimated that aggregate imports satisfy less than 5 percent of the P-C Region's total demand. This situation is unlikely to change without significant, unexpected changes to the current market dynamics.

CONCLUSIONS

The following summarizes some of the major conclusions reached in this update report. Key results of this report are presented in Table ES-1.

- Of the 42,033 acres of total Sector area of the original 85 Sectors, 2,417 acres (about 6 percent) have become lost due to preclusion from land use, resource depletion, or re-evaluation of resources.

- This report identifies an additional 3,880 acres of land containing an estimated 769 million tons of concrete aggregate resources.
- An estimated 4,334 million tons of resources are identified in the P-C Region.
- The projected demand of construction aggregate in the P-C Region for the next 50 years (through the year 2066) is estimated to be 1,367 million tons. Of this total, 889 million tons will likely be used for concrete aggregate.
- The 1,446 million tons of currently permitted concrete aggregate reserves are projected to last beyond the year 2066.
- Presently, the P-C Region consumes approximately as much as it produces, with imports and exports estimated to account for less than 5% of consumption and production (respectively) within the P-C Region.
- Land-use planners and decision-makers in the P-C Region are faced with balancing a wide variety of needs in planning for a sustainable future for their communities. These include the need to plan carefully for the use of lands containing construction aggregate resources, to consider the permitting of additional aggregate resources in the P-C Region, and to take into consideration the demands of neighboring areas, within the P-C Region, that are competing for resources.

Table ES-1. Results Presented in this Report

Population (2016)	2,757,399
Concrete Aggregate Resources	4,334 million tons
Projected 50-year Demand of All Grades of Construction Aggregate	1,367 million tons
Projected 50-year Demand of Concrete Aggregate	889 million tons
Permitted Concrete Aggregate Reserves	1,446 million tons
Calculated Average Annual Per Capita Consumption	7.6 tons
Calculated Years Until Depletion	> 50
Concrete Aggregate Mines	30
Number of Mining Companies	13

PART I – INTRODUCTION

This report presents Mineral Land Classification (MLC) of the Greater Sacramento Area (GSA) Production-Consumption (P-C) Region for concrete aggregate resources. It updates information on concrete-grade aggregate from six previous regional MLC studies and three MLC petitions carried out between 1988 and 2010. Additionally, about 3,500 square miles of previously unclassified land within the study area (about 58 percent of the total study area) are classified for concrete aggregate resources. It includes a 50-year projection of construction aggregate demand for the region through the year 2066. The aggregate production data used in this update are current through December 2016. Land-use data is current as of January 2016, at latest.

The newly defined GSA P-C Region covers approximately 6,080 square miles (Figure 1) and includes the Sacramento-Fairfield and Yuba City-Marysville P-C Regions, Sacramento County, and the western portions of the Nevada, Placer, and El Dorado County study areas. Additionally, lands within Yuba, Sutter, Yolo, and Solano counties, which had not been previously classified, are classified in this new P-C Region.

P-C Regions are defined as market regions in which 95 percent or more of the aggregate produced is also consumed. Study areas of two of the past MLC studies (within the current GSA P-C Region) were defined by P-C Regions. In other cases, study areas have been defined by county boundaries. In the GSA, market dynamics and market regions have changed since past reports. It now makes sense to combine all or parts of several smaller P-C Regions and county study areas into one larger P-C Region to better describe the production and consumption of construction aggregate in the GSA. This new P-C Region boundary incorporates the overlapping market regions of three primary production districts: Yuba City-Marysville, Cache Creek, and American River, as well as minor production areas scattered throughout the region, especially in the Sierra Nevada foothills.

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), 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 these uses.

Aggregate materials are essential to modern society, both to maintain the existing infrastructure, and for new construction. 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. As transport distances increase, so do construction costs, fuel consumption, greenhouse gas (GHG) emissions, air pollution, traffic congestion, and road maintenance costs.

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

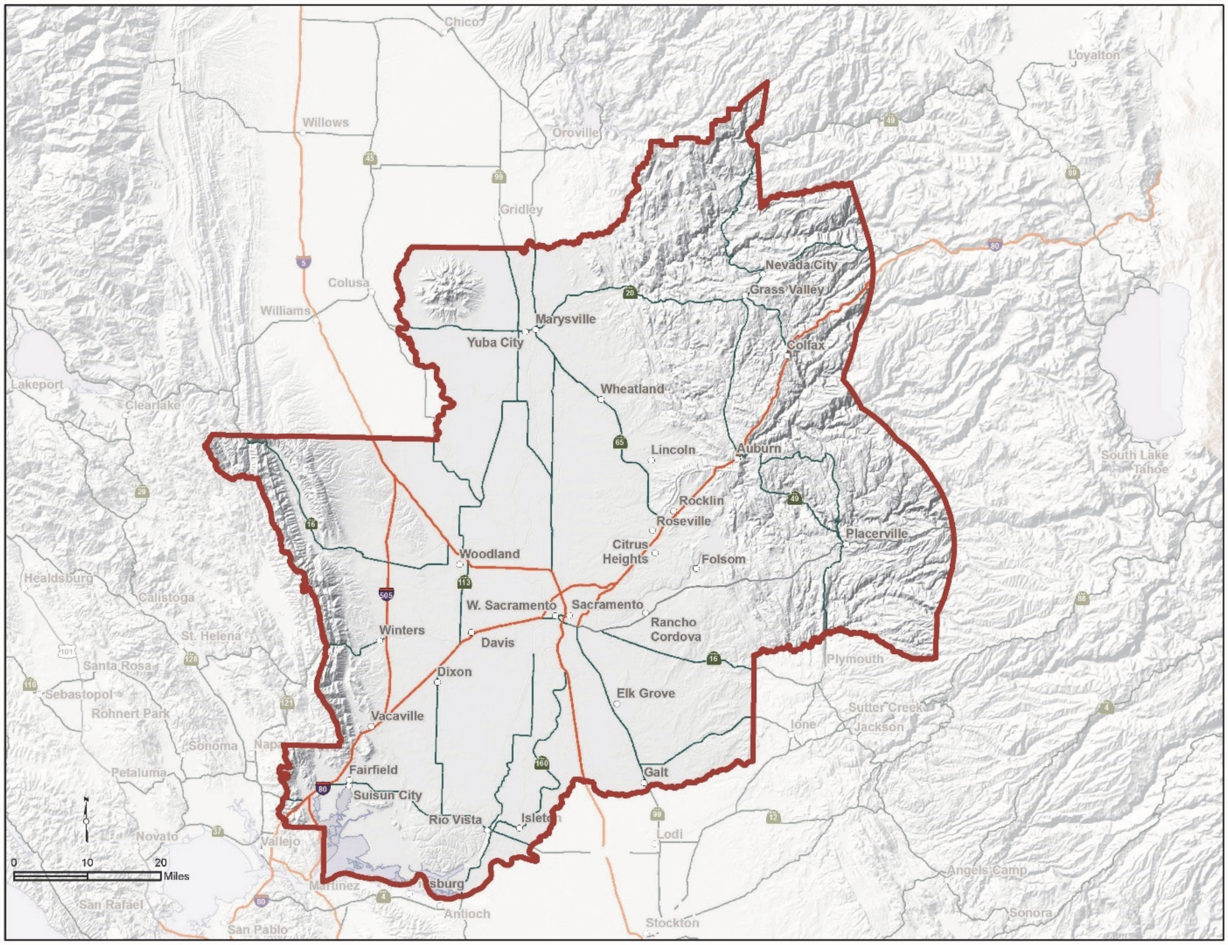

Figure 1. Boundary of the Greater Sacramento Area P-C Region

HISTORY OF MINERAL LAND CLASSIFICATION IN THE GREATER SACRAMENTO AREA P-C REGION

This report incorporates and updates information from nine previous MLC studies to evaluate the mineral resource potential for concrete aggregate (PCC- and AC-grade aggregate) within the GSA P-C Region. These MLC studies were published by CGS between 1988 and 2010 and are listed below. Six of these studies were regional and were based on P-C Region or county boundaries and three were MLC petitions which covered real or proposed mine sites. The geographic extents of the previous studies and their relationship to the GSA P-C Region are shown in Figure 2. Note that only the western portions of the Placer, Nevada, and El Dorado County study areas are included in the GSA P-C Region. Collectively, 2,580 square miles of land were subjected to MLC in the source reports, which is 42 percent of the current P-C Region. The remaining 58 percent, or 3,500 square miles, are newly classified.

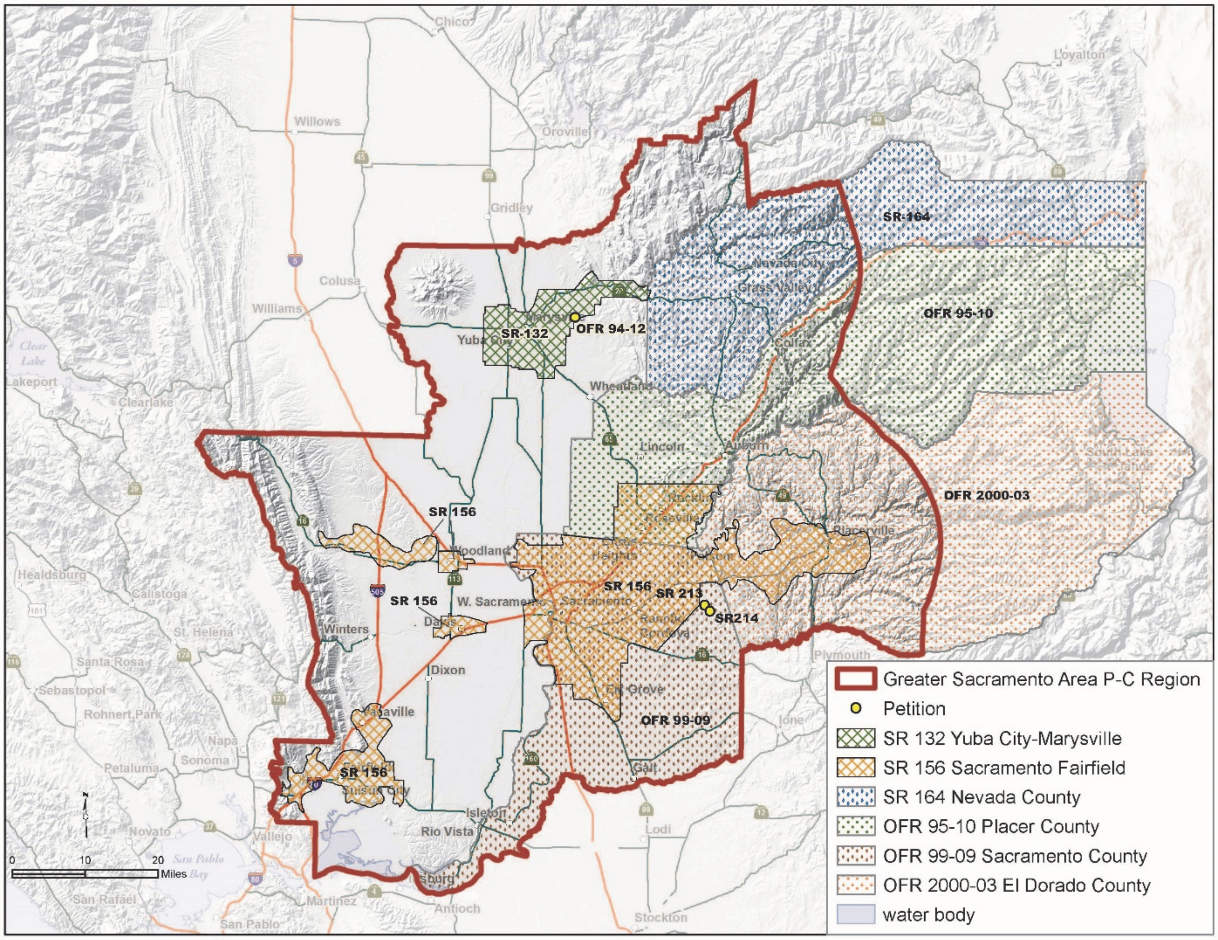

Figure 2. Greater Sacramento Area P-C Region boundary and previous Mineral Land Classification study boundaries

<u>Special Report 132 (1988):</u> *Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Yuba City-Marysville P-C Region*

Alluvial deposits and dredge tailings within and east of the Yuba City-Marysville area were evaluated for PCC-grade construction aggregate resource potential. Minor hard rock and older alluvial deposits were also evaluated for riprap and base-grade aggregate resource potential. Though this study area is nominally a P-C Region, the authors also noted that approximately 55 percent of material produced within the region was marketed beyond the region.

<u>Special Report 156 (1988):</u> *Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Sacramento-Fairfield P-C Region*

Geologic materials within the Sacramento, Cache Creek, Woodland, Davis, and Fairfield areas were evaluated for PCC-grade construction aggregate resource potential. This study used a P-C Region model, but notably did not evaluate the geology and population outside of the aforesaid focus areas, resulting in multiple spatially-discontinuous study areas collectively identified as the P-C Region. The parts of this P-C Region within Placer, Sacramento, and El

Dorado counties have been superseded by the more recent MLC studies of these counties (OFR 95-10, OFR 99-09, OFR 2000-03).

Special Report 164 (1990): *Mineral Land Classification of Nevada County, California*

Geologic materials within Nevada County were evaluated for use in all grades of construction aggregate. Metallic and industrial minerals (including gold, silver, copper, lead, zinc, barite, chromite, quartz, clay, carbonate rock, and talc/asbestos) resource potentials were also evaluated.

Open-File Report 94-12 (1994): *Mineral Land Classification of the Triangle Properties Hofman Ranch Site, Browns Valley 7.5-minute Quadrangle, Yuba County, California, for Portland Cement Concrete-Grade Aggregate* (petition)

Quaternary alluvium approximately 1.5 miles south of the active channel of the Yuba River and seven miles east-northeast of Marysville, was evaluated for PCC-grade construction aggregate resource potential. This study updates the classification of the Yuba City-Marysville study (SR 132).

Open-File Report 95-10 (1995): *Mineral Land Classification of Placer County, California*

Geologic materials within Placer County were evaluated for concrete aggregate resource potential. Metallic and industrial minerals (including gold, silver, copper, zinc, chromite, quartz, clay, and shale) resource potentials were also evaluated.

Open-File Report 99-09 (1999): *Mineral Land Classification: Portland Cement Concrete-Grade Aggregate and Kaolin Clay Resources in Sacramento County, California*

Geologic materials within Sacramento County were evaluated for concrete aggregate resource potential. Kaolin clay resource potential was also evaluated.

Open-File Report 2000-03 (2000): *Mineral Land Classification of El Dorado County, California*

Geologic materials within El Dorado County were evaluated for use in all grades of construction aggregate. Metallic and industrial minerals (including gold, slate, and limestone) resource potentials were also evaluated.

Special Report 213 (2009): *Mineral Land Classification of the White Rock Road Properties, Mangini Property, Sacramento County, California – For Construction Aggregate* (petition)

Bedrock approximately 1.5 miles southeast of the intersection of White Rock Road and Scott Road, in unincorporated Sacramento County, was evaluated for use as construction aggregate. This petition did not update the previous Sacramento County report (OFR 99-09) because each study classified land for different grades of aggregate. However, information provided by the petitioner has been used to revise the MLC for PCC-grade aggregate from OFR 99-09.

Special Report 214 (2010): *Mineral Land Classification of the Wilson Ranch – Walltown Quarry Site, Sacramento County, California – for Construction Aggregate* (petition)

Bedrock approximately 1.5 miles southeast of the intersection of White Rock Road and Scott Road, in unincorporated Sacramento County, was evaluated for use as construction aggregate. This petition did not update the previous Sacramento County report (OFR 99-09) because each study classified land for different grades of aggregate. However, information provided by the petitioner has been used to revise the MLC for PCC-grade aggregate from OFR 99-09.

The grade of construction aggregate for which lands were classified varies among the previous MLC reports. This report classifies land for concrete-grade aggregate resource potential and does not alter any prior classification for other aggregate grades. The Nevada, Placer, El Dorado, and Sacramento County reports also classified for non-aggregate commodities such as metallic minerals (gold, silver, chromium, etc.) or industrial minerals (clays, etc.). This report does not alter those classifications.

JUSTIFICATION FOR THE CURRENT P-C REGION

Parts of six former study areas have been combined into a single isolated, or self-sufficient, market area which captures nearly all aggregate production and consumption within the region. Significant imports and exports were recognized in the six former study areas, but at the time, it was determined that each report still sufficiently captured their respective market regions.

The Yuba City-Marysville study (SR 132) determined that 55 percent of produced aggregate was exported, including about 40 percent exported to Sacramento County, and another 10 percent to Nevada and Placer counties. The Sacramento-Fairfield P-C Region study (SR 156) determined its P-C Region to be relatively isolated and self-sufficient, but nearly 5 percent of its needs were met by imports from Yuba City-Marysville. The SR 156 author also noted that greater imports from that region were likely in the future. Nevada, Placer, and El Dorado counties were all recognized as having western and eastern market regions. This report only covers their western market regions, which exchanged substantial material with each other, and with other surrounding counties. Nevada County imported material from both Yuba and Placer counties. Placer County met approximately 30 percent of its aggregate demand with imports from Sacramento and Yuba counties. El Dorado County met approximately 40 percent of its aggregate demand with imports from Sacramento and Placer counties. Sacramento County, which was considered to have a relatively large demand for aggregate, exported more than 10 percent of its production to Placer, Amador, Yolo, and El Dorado counties, and also imported material from Yolo, Yuba, and other counties. Thus, significant exchange of aggregate was recognized between the respective market regions of the six former study areas included in this new P-C Region.

Since the time of these previous reports, increased population and increased demand, coupled with depletion of aggregate resources in critical areas, have changed market patterns. Imports and exports in each of the former market regions have grown to the point that they can no longer be considered separately. Rather, they have coalesced into a single market region of interdependent production and consumption – the GSA P-C Region. Within this newly identified P-C Region, more than 95 percent of the aggregate produced is consumed, and vice versa. This approximate closed system condition allows for the calculation of the average per-capita aggregate consumption rates, which in turn can be used to project future aggregate demand.

OVERVIEW OF CONCRETE-GRADE AGGREGATE

Aggregate makes up 60 to 85 percent of the material volume in PCC and AC and provides the bulk and strength to these materials. Even from the highest-grade deposits, raw aggregate material is rarely physically and 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.

This update report reassesses and reclassifies lands in the GSA P-C Region for PCC- and AC-grade aggregate, collectively called concrete aggregate. Material mined from concrete-grade aggregate deposits is typically used for a range of products, including PCC and AC, but also potentially including base, subbase, fill, construction sand, decorative rock, and riprap. The material specifications for concrete aggregate are more restrictive than those of other aggregate grades. This restrictiveness makes deposits suitable for use as concrete aggregate the scarcest and most valuable of aggregate resources.

BACKGROUND OF CLASSIFICATION-DESIGNATION

The current and previous MLC reports were produced under the authority of the State Geologist as specified by the Surface Mining and Reclamation Act of 1975 (SMARA, PRC 2710 et seq.). SMARA was passed by the California State Legislature in response to the loss of significant mineral resources due to urban expansion, the need for current information concerning the location and quantity of essential mineral deposits, and to ensure reclamation of mined lands. To address mineral resource conservation, SMARA mandates a two-phase process known as Classification-Designation.

The objective of the Classification-Designation process is to ensure, through appropriate local lead agency policies and procedures, that mineral resources will be available when needed and do not become inaccessible as a result of inadequate information during the land-use decision-making process.

SMARA mandates that the State Mining and Geology Board (SMGB) develop guidelines for MLC. The SMGB adopted SMARA guidelines on June 30, 1978 and revised them in 2000. The guidelines are available on the California Department of Conservation website at http://www.conservation.ca.gov/smgb/Guidelines/Documents/ClassDesig.pdf

SMARA requires the State Geologist to classify specified areas into Mineral Resource Zones (MRZs). The guidelines also direct the State Geologist to include the following information in regional classification reports for construction aggregate resources: (1) the location and estimated total quantity of construction aggregate in areas with land-uses compatible with potential mining; (2) limits of the market area that these potential resources would supply; and (3) an estimate of the total quantity of aggregate material that will be needed to supply the area for the next 50 years. This additional information is not required for MLC petitions.

OVERVIEW OF CLASSIFICATION

The regional classification of aggregate resources involves six distinct but interrelated steps:

1. Determination of Study Area Boundary: A study area may be a county, a part of a county, or a region that may contain all or part(s) of one or more counties.
2. Establishment of MRZs: All lands within the study area are assigned MRZ classifications (MRZ-1, -2, -3, -4) based on geologic evaluation.
3. Identification of Sectors: Lands known to contain significant aggregate resources (areas classified as MRZ-2 in Step 2, above) are evaluated to determine if current uses of these lands preclude mining. Lands currently permitted for mining and areas found to have land uses compatible with possible mining are identified as *Sectors*.
4. Calculation of Resource Tonnages within Sectors: Investigation and analysis of on-site conditions, measurement of the areal extent of deposits, drill-hole information, waste-material percentages, and deposit densities are used to calculate total tonnages of aggregate *reserves* and *resources* within each Sector. Reserves are deposits permitted for mining; resources are all aggregate materials identified in Sectors, including reserves.
5. Forecast of 50-Year Needs and the Life Expectancy of Current Reserves: The total tonnage of aggregate needed to satisfy the demand in the area over the next 50 years is estimated.
6. Identification of Alternative Resources: Alternative sources of aggregate are identified and briefly discussed.

The MRZ classification system used in this and previous reports is discussed in Part II.

OVERVIEW OF DESIGNATION

This report contains the classification phase of the *Classification-Designation* process required by SMARA. The designation phase follows the receipt and acceptance of this classification report by the SMGB. Designation is the formal recognition by the SMGB, after consultation with lead agencies and other interested parties, of areas containing mineral deposits of regional or statewide economic significance. Procedures for the designation of lands containing significant mineral deposits are specified in Section II.2 of the SMGB's Guidelines for Classification and Designation of Mineral Lands. None of the previous MLC source reports in the GSA P-C Region resulted in designation. However, the SMGB may choose to pursue designation of mineral lands based on information in this report.

LEAD AGENCY RESPONSE TO CLASSIFICATION

The SMGB, upon receipt of the classification report from the State Geologist, transmits the report to the appropriate lead agencies and makes it available to other interested parties. Within 12 months of receipt of the report, each lead agency must develop and adopt mineral resource management policies to be incorporated in its general plan. These policies will:

1. Recognize the MLC information, including the MLC Maps transmitted to the lead agency by the SMGB.

2. Emphasize the conservation and development of the identified mineral deposits.

Table 1 shows lead agencies that have jurisdiction within the GSA P-C Region, and indicates if a given lead agency has areas classified MRZ-2, or permitted aggregate mines, within its jurisdiction. Note that within this report, we define a permitted mine as any site at which mining is legally permitted, either by a mine permit provided by the lead agency, or by a determination of vested rights.

The information in this update and the new projection of aggregate demands on the P-C Region should be used by lead agencies in evaluating the effectiveness of their current mineral resource management policies and in planning for future construction aggregate demands both in their jurisdictions and in neighboring areas. Lead agency mineral resource management policies should be updated as necessary, based upon this information.

Table 1. Lead Agencies within the Greater Sacramento Area P-C Region

Lead Agency	MRZ-2*	Permitted Mine*
SMGB	*	*
El Dorado County	*	*
Auburn Lake Trails	*	
Cameron Park		
Camino		
Cold Springs		
Coloma		
Diamond Springs		
El Dorado Hills		
Georgetown		
Grizzly Flats		
North Auburn		
Placerville		
Pollock Pines		
River Pines		
Shingle Springs		
Placer County	*	*
Alta		
Auburn		
Colfax		
Dutch Flat		
Foresthill		
Granite Bay		
Lincoln		
Loomis		
Meadow Vista	*	
Newcastle		
North Auburn		
Penryn		

Lead Agency	MRZ-2*	Permitted Mine*
Rocklin	*	
Roseville	*	
Sheridan	*	*
Nevada County	*	*
Alta Sierra		
Grass Valley		
Lake of the Pines		
Lake Wildwood		
Nevada City		
North San Juan		
Penn Valley		
Rough and Ready		
Washington		
Sacramento County	*	*
Antelope		
Arden-Arcade	*	
Carmichael	*	
Citrus Heights		
Clay		
Courtland		
Elk Grove		
Elverta		
Fair Oaks	*	
Florin	*	
Folsom	*	
Foothill Farms		
Franklin		
Freeport		
Fruitridge Pocket	*	

* = Within jurisdiction

Table 1 (cont'd.) Lead Agencies within the Greater Sacramento Area P-C Region

Lead Agency	MRZ-2*	Permitted Mine*
Sacramento County (cnt'd.)		
Galt		
Gold River	*	
Herald		
Hood		
Isleton		
La Riviera	*	
Lemon Hill	*	
Mather	*	
McClellan Park		
North Highlands		
Orangevale	*	
Parkway		
Rancho Cordova	*	*
Rancho Murieta		
Rio Linda		
Rosemont	*	
Sacramento	*	*
Vineyard	*	
Walnut Grove		
Wilton		
Solano County	*	*
Allendale		
Davis		
Dixon		
Elmira		
Fairfield		
Green Valley		
Hartley		
Rio Vista		
Suisun City		
Univ. of California-Davis		
Vacaville		
Vallejo		
Winters		

Lead Agency	MRZ-2*	Permitted Mine*
Sutter County	*	*
East Nicolaus		
Live Oak		
Meridian		
Nicolaus		
Rio Oso		
Robbins		
Sutter		
Trowbridge		
Yuba City		
Yuba County	*	*
Beale AFB		
Camptonville		
Challenge-Brownsville		
Dobbins		
Linda	*	
Loma Rica		
Marysville	*	
Olivehurst		
Plumas Lake		
Smartsville		
Wheatland		
Yolo County	*	*
Clarksburg		
Davis		
Dunnigan		
Esparto	*	
Guinda		
Knights Landing		
Madison	*	
Monument Hills	*	
Univ. of California-Davis		
West Sacramento		
Winters		
Woodland		
Yolo		

* = Within jurisdiction

PART II – UPDATE OF MINERAL LAND CLASSIFICATION FOR CONCRETE AGGREGATE IN THE GREATER SACRAMENTO AREA P-C REGION

This section of the report contains updated information concerning the location and quality of concrete aggregate resources in the GSA P-C Region.

MINERAL RESOURCE ZONES

As set forth in Section 2761(b) of SMARA, the State Geologist shall classify land solely on the basis of geologic factors and without regard to existing land use. Areas subject to MLC are divided by the State Geologist into various MRZ categories that reflect varying degrees of mineral resource potential.

MRZ-1: Areas where available geologic information indicates that little likelihood exists for the presence of significant mineral resources.

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

MRZ-3: Areas containing mineral occurrences of undetermined mineral resource significance.

MRZ-4: Areas where available information is inadequate for assignment to any other MRZ category.

CLASSIFICATION CRITERIA

To be considered significant for the purpose of MLC, a mineral deposit, or a group of mineral deposits that can be mined as a unit, must meet marketability and threshold value criteria adopted by the SMGB (http://www.conservation.ca.gov/smgb). Mineral deposits considered significant in this report must meet the specifications for concrete aggregate. Threshold values are intended to indicate in a general way the approximate minimum size of a mineral deposit that will be considered significant for classification and designation. The value criteria vary for different mineral deposits depending on their uniqueness and commodity-type category.

The SMGB determined threshold value based on the gross selling price of the first marketable product in 1998 dollars to be $12,500,000 for construction aggregate deposits. This 1998 threshold value was adjusted for inflation to reflect 2017 dollars, using an inflation factor of 1.62. The inflation factor is the ratio of the statewide weighted average Consumer Price Index of December 2017 to the average annual value of 1998, per the California Department of Finance (DOF) Consumer Price Index spreadsheet (California DOF website, March 2018). The threshold value in 2017 dollars for construction aggregate is $20,250,000. The price of concrete-grade aggregate in the GSA P-C Region ranges from $9 to $18 per ton, depending on specific grade, location, market conditions, and other factors. Assuming an average price of $13.5 per ton, $20,250,000 equates to about 1.5 million tons of aggregate material.

RE-EVALUATION OF MINERAL LAND CLASSIFICATION FOR CONCRETE AGGREGATE

This report re-evaluates and updates the MLC of nine source reports described in Part I. In total, 6,080 square miles of land was subjected to MLC (Plate 1), of which 3,500 square miles had not been previously classified. Based on analysis of new data showing above-threshold volumes of concrete grade materials, 3,009 acres of MRZ-3 and MRZ-4 have been reclassified to MRZ-2. Based on resource depletion from mining, new data showing insufficient (below threshold) volume, and issues with marketability, 528 acres of MRZ-2 have been reclassified to MRZ-1, -3 or -4. Subsequent sections describe significant changes in MLC.

Improvements in available data and technologies, including the availability of higher-resolution topography and remotely-sensed imagery and more detailed geologic mapping, and the full utilization of Geographic Information Systems (GIS), have allowed for minor adjustments to MRZ boundaries to improve spatial accuracy. These minor adjustments to MRZ boundaries typically do not exceed a few line widths at map scale and have not been described in further detail. Some changes between MRZ-1, -3 and -4 have been made based on new data or re-evaluation of previous data. These changes are not described in further detail. Areas previously classified as MRZ-2 for construction aggregate grades below concrete-grade are typically MRZ-3 in the current report, except where data supports upgrading the classification to MRZ-2 for concrete-grade aggregate. This report does not change the classification for aggregate grades other than concrete-grade, which is presented in the source reports. This report does not alter MLC for any commodities other than concrete aggregate. The reader should refer to the source reports for classification of other commodities such as industrial minerals and precious metals.

Geologic Map Compilation Used in New and Re-Evaluated Mineral Land Classification

Geologic mapping is one of the necessary inputs to the MLC process. The GSA P-C Region includes a large amount of previously-unclassified land. Additionally, new geologic mapping has been completed within the study area since the source MLC reports were published.

Thus, a new geologic map of the P-C Region was compiled to support new and updated MLC in this report. This geologic map was digitally compiled from numerous sources (see References), using GIS software.

Summary of Geology and Geography

The GSA P-C Region (Fig. 1) extends from the flat marshlands of the San Francisco Bay Delta in the southwest, to just beyond the conspicuous rugged prominence of the Sutter Buttes in the north. It extends from the eastern margin of the Coast Ranges on the west, to about 20 or 30 miles west and downslope of the Sierran Crest on the east. The P-C Region encompasses parts of the Sierra Nevada and Great Valley geomorphic provinces, and a very small part of the Coast Ranges province. It contains geologic units that collectively range in age from Paleozoic to Holocene, and comprise a wide variety of igneous, sedimentary, and metamorphic rock types.

The region hosts a population of approximately 2.8 million people distributed across more than 110 incorporated areas and wide expanses of unincorporated land. Most of this population is concentrated in the Sacramento area, and radiating away from Sacramento along the two major north-south (I-5 and HWY 99), and two major east-west (I-80 and HWY 50) highway corridors.

The GSA P-C Region is diverse geologically and geographically. Topographic extremes range from relatively high-relief mountainous terrain that exceeds 5,000 feet in the Sierra Nevada, to broad, flat, low-lying marshlands near sea level in the San Francisco Bay Delta. The western edge of the Sierra Nevada is characterized by rolling, low-relief foothills. The majority of the P-C Region, however, is underlain by the highly subdued alluvial topography of the Great Valley. This setting is the source of much of the aggregate resources in the P-C Region.

In the Sierra Nevada, rivers have cut deep canyons into both granitic rocks of the Sierra Nevada batholith, and the older metamorphosed sedimentary and volcanic rocks into which the batholith intruded. These sharply incised canyons alternate with high ridges and rocky peaks, many of which are capped by sedimentary and volcanic rocks of Eocene to Pliocene age. These ridges trend generally westward until they merge into rolling foothills, whose topographic pattern of minor, north-northwest trending ridges and valleys partly expresses the geologic structure of the Foothills metamorphic belt. After emerging from this foothill terrain, the westerly flowing rivers deposit sediment in extensive, coalescing alluvial fans at the eastern margin of the Great Valley.

The Great Valley is filled with more than 35,000 feet of sediment (or at least 15,000 feet within the study area), shed since Jurassic time from the Klamath Mountains to the north and the Sierra Nevada to the east. Lesser amounts have been contributed during late Cenozoic time from the Coast Ranges to the west. The valley's modern alluvial surface includes subtly rumpled topography developed by rivers migrating across the land over time. These rivers flow towards the valley center, where they empty into the Sacramento River, approximately along the north-south axis of the valley, which then flows southwest into the marshlands of the San Francisco Bay Delta. Agricultural practices have altered much of this alluvial landscape so that it is even flatter now, and the original natural topography is no longer present in many places. The Sutter Buttes, which protrude from the valley floor and rise to over 2,000 feet, in the northern part of the region, are remnants of a stratovolcano that formed about 1.5 million years ago.

Rivers flowing east out of the canyons of the Coast Ranges deposit sediment in alluvial fans at the western margin of the Great Valley. The source rocks for these fans comprise a variety of sedimentary, igneous, and metamorphic rocks that collectively range in age from Mesozoic to Holocene. The fans are less voluminous and less well-developed than those along the eastern margin of the valley, which reflects more-recent uplift of the Coast Ranges, and smaller watersheds when compared to the Sierra Nevada. The distinct differences in geology between the Coast Ranges and the Sierra Nevada result in corresponding differences in composition of alluvium between their respective fan systems.

Geologic Controls on Aggregate Quality

Several agencies have established specifications for PCC, AC, and various other uses of aggregate, to ensure that aggregate is satisfactory for specific uses. 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, hardness and durability requirements ensure concrete bears its working load, without failure, for the duration of its lifetime. Chemical and mineral composition requirements prohibit or limit the use of rock materials containing mineral substances which can have deleterious effects. For example, gypsum, pyrite, opal, chalcedony, chert, volcanic glass, and other materials are restricted. Gypsum can retard the setting time of Portland cement. Pyrite dissociates to yield sulfuric acid and an iron oxide stain. Opal, chalcedony, chert, volcanic glass, and some other materials, may contain silica in a form that reacts with alkali substances in the cement, resulting in cracks and pop-outs. Specifications also call for precise particle-size distributions for the various uses of aggregate, to minimize void spaces that must be filled with cement paste.

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.

The major factors that affect the quality of construction aggregate are the rock type and the degree of weathering. 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 and chemical decay of rock materials at or near the Earth's surface. Weathering commonly decreases the physical strength of the rock, and may alter the chemical composition of the rock. The severity of weathering generally increases with age.

The following is a summary of the geology of the region. More detailed discussions of the geology, and geologic controls on aggregate quality, may be found in the source reports.

Paleozoic to Mesozoic Metamorphic Rocks

Paleozoic to Mesozoic metamorphic bedrock crops out in the Sierra Nevada mountains and foothills. These rocks feature a variety of metamorphosed sedimentary and igneous lithologies, including slate and phyllite, greenstone, meta-gabbro, meta-diabase, amphibolite, serpentinite, peridotite, metatuff, chert, and meta-limestone. These rocks are present as distinct belts, or accreted terranes. These terranes represent oceanic and island arc lithosphere that was accreted to the North American plate. These rocks have experienced several episodes of deformation, during and after accretion. The easternmost belt was accreted first (oldest), with age younging to the west (e.g., Saleeby, 1999, and references therein).

Foliated rocks, such as slate and phyllite, break into thin platy fragments which are unsuitable for many aggregate uses. Where extensively weathered, these rocks do not meet hardness and durability requirements. Even unweathered portions of some rocks may fail hardness and durability requirements. Metatuff, chert, and certain other rocks, may contain silica in a form that reacts with alkali substances and causes cracks, pop-outs, and other issues. Carbonate rocks such as limestone and dolomite may have excessive free silica, magnesium, or other impurities which may also cause chemical reactivity issues. However, some of these rocks can make crushed stone which meets concrete aggregate specifications. Within the P-C Region, several limestone bodies are mined for concrete aggregate within the P-C Region.

Meta-igneous rocks, including greenstone, are mined for concrete aggregate and riprap.

Mesozoic Igneous Intrusive Rocks

Several plutonic rock bodies with different ages and compositions are present within the moderate elevations of the study area. These igneous rocks formed when subduction produced magma, which rose up through the older metamorphic rocks (described above), and cooled and crystallized. These intrusions are mostly Cretaceous, and lesser Jurassic in age. These plutonic rocks are peripheral to the Sierra Nevada batholith, but are mostly of the same magmatic arc. Compositions are predominantly quartz diorite, granodiorite, granite, and gabbro (e.g., Saleeby, 1999, and references therein).

Weathered zones in the upper several to tens of feet typically do not meet hardness or durability requirements. Jointing, where extensive, may also cause the rock to form platy fragments when crushed, which are unsuitable for most grades of aggregate. Some high-silica igneous rocks, such as granite, may contain excessive silica in a form which causes chemical reactivity issues. However, many of these rocks do make crushed stone which meets concrete aggregate specifications. A quartz diorite intrusion is mined for concrete aggregate in the area south of Folsom. Other intrusive bodies have been mined to produce concrete aggregate and decorative stone, historically. Where weathered, material is utilized for road salt and as decorative rock (decomposed granite).

Late Jurassic to Cretaceous Great Valley Sequence

Within the study area, Cretaceous age marine sedimentary rocks of the Great Valley Group occur in a few minor isolated areas in the Sierra Nevada foothills on the east, and more extensively in the Coast Ranges foothills on the west. These rocks range from shale and mudstone to siltstone, sandstone and minor conglomerates, and are locally fossiliferous. These sediments accumulated to a thickness exceeding 35,000 feet (or at least 15,000 feet within the study area), in a shallow to deeper marine environment, in a basin which formed between the Sierra Nevada volcanic arc, and the corresponding subduction trench (e.g., Ingersoll, 1999, and references therein).

The finer-grained shales, mudstones and siltstones typically do not meet soundness and durability requirements. They may also break into platy fragments when crushed, which makes them unsuitable for most grades of aggregate. Sandstones with excessive fine-grained material often have high shrink-swell potential, which may cause cracking and other brittle failure in concrete. Silica-cemented sandstones, siliceous shales, and similar rocks, may have excessive silica in a form that causes chemical reactivity issues. Relatively little is known of the aggregate quality of these rocks. Rocks of these units have been rarely or never utilized for concrete aggregate.

Early Cenozoic Sedimentary Rocks

Early-Cenozoic sedimentary rocks are present on the east side of the study area. These sediments were deposited in rivers and deltas on the western edge of a broad plateau (named the Nevadaplano), which drained into the Pacific Ocean. These rocks experienced tropical to sub-tropical weathering during the early Eocene Climatic Optimum. Thus, these sediments are compositionally mature, and feature a predominance of quartz and kaolinite.

Finer-grained sediments deposited in river deltas, and (less commonly) in marine and estuarine environments, are dominated by kaolinitic clays and quartz sands and silts, and are commonly identified as the Ione Formation (Creely and Force, 2007). Minor lignite beds occur sporadically, and compositions become somewhat less mature, with the presence of feldspars, biotite and greater proportions of non-kaolinitic clays, towards the top of the section. These deposits are exposed extensively along the eastern margin of the Great Valley.

Coarser sediments deposited further upstream in the ancestral river system consist of quartz-dominated sands, gravels, and silts, and are commonly identified as the "auriferous gravels." These gravels are gold-bearing (especially in the lowermost stratigraphic sections), and were the primary target of historic hydraulic and drift gold mining. The lowermost section, which is sporadically exposed, includes metamorphic and minor granitic rock clasts, and were termed the "blue gravels" (e.g., Lindgren, 1911). As with the Ione Formation sediments, the uppermost sections have more variable compositions, and may be of late Eocene or early Oligocene age. These deposits outcrop sporadically in the moderate and higher elevations of the study area.

A substantial proportion of these rocks are too fine-grained to meet coarseness requirements for concrete aggregate. As mentioned previously, sandstones may be subject to cracking and other brittle failure, or chemical reactivity issues. However, some occurrences, with appropriate grain size distribution, and without potentially chemically-reactive components, may meet concrete aggregate specifications, though no aggregate test data is available to demonstrate this. These rocks, and hydraulic mine tailings sourced from these sediments, are mined in the foothills and mountains, primarily to produce road base. However, young alluvium partly sourced from these rocks can make PCC-grade aggregate within the study area.

Oligocene to Miocene Volcanic and Volcaniclastic Rocks

Oligocene to Miocene age volcanic and volcaniclastic rocks of the Valley Springs Formation outcrop in the moderate and higher elevations in the eastern portion of the study area. The volcanic rocks are predominantly rhyolitic, and lesser dacitic, pyroclastic flow deposits. The pyroclastic flows erupted from volcanoes in what is now central Nevada, and flowed down generally westward-flowing river channels to the present-day Sierra Nevada foothills (e.g., Henry et al., 2012). The volcaniclastic sediments vary from coarse gravels to siltstones, and often have an ashy matrix. Clasts have variable composition, incorporating volcanic clasts, quartz lithologies from the older gravels, and metamorphic and igneous rock clasts from eroded bedrock.

Volcanic glass is commonly present in these pyroclastic rocks, and in the ashy matrix of the volcaniclastic sediments, and is composed chiefly of non-crystalline silica. This silica glass may cause chemical reactivity issues when present in concrete. Because the volcanic glass is present in both soft and hard components, it is very difficult to remove with common aggregate processing (beneficiation) techniques. Many of the unwelded tuffs are unlikely to meet hardness or durability requirements. Within the study area, the rocks of this formation have very rarely or never been utilized for concrete aggregate, and they are not presently known to be an economic source of concrete aggregate within the study area.

Miocene to Pliocene Volcanic and Volcaniclastic Rocks

Miocene to Pliocene age volcanic and volcaniclastic rocks of the Mehrten Formation outcrop as erosion-resistant (often ridge-capping) deposits in the moderate and higher elevations of the study area. The volcanic rocks are predominantly andesitic in composition, and are present as volcanic mudflows (lahars), mudflow breccias, and minor pyroclastic rocks (e.g., Piper et al., 1939; Cousens et al., 2008). These rocks were produced by subduction arc magmatism of the ancestral Cascade arc located near the eastern Sierra Frontal Fault zone (Busby et al., 2008). The sediments are largely derived from erosion of the volcanic rocks, and include cobble conglomerates, coarse sands, and silts.

Distinctly different Miocene to Pliocene age volcanic and volcaniclastic rocks of the Sonoma Volcanics outcrop sporadically in the southwestern portion of the study area. These rocks range in composition from basaltic to rhyolitic, and include lava flows, flow breccias, and pyroclastic deposits. They are thought to be related to the northward migration of the Mendocino triple junction.

The volcanic rocks contain volcanic glass, which may cause chemical reactivity issues. These rocks have rarely or never been utilized for PCC-grade aggregate within the study area. However, though uncommon, the coarser conglomerates of the Mehrten Formation have historically been crushed to produce AC-grade aggregate within the P-C Region.

Pliocene to Quaternary Sedimentary Rocks

Pliocene to Quaternary age sedimentary rocks outcrop extensively, as broad alluvial fans and basinal deposits in the lower elevations, and as river sediments confined to canyons within the higher elevations of the study area. These sediments have been divided into several geologic units, all of which are compositionally similar, and feature a varied assortment of granitic, metamorphic, and lesser volcanic clasts (e.g., Marchand and Allwardt, 1981). A significant portion of these sediments eroded from glacial deposits, following each of several episodes of glaciation in the Sierra Nevada.

The two chief factors which control aggregate quality in these alluvial deposits are grain-size distribution, and extent of weathering. Within the study area, many of the more central parts of the valley, and especially the delta, are dominated by clays and silts, which do not meet grain-size requirements for concrete aggregate. However, large volumes of coarser sediments are present near the valley margins, and historically were dredged for gold, producing vast tailing deposits (see below).

The age of the coarser sediments ranges from Pliocene to latest Quaternary, and significantly impacts the extent of weathering. Much of the younger Quaternary alluvium is relatively fresh, unweathered, hard, and durable. Where this younger alluvium has an appropriate grain-size distribution, the material commonly makes concrete aggregate. A vast majority of concrete aggregate mines in the P-C Region exploit these rocks, which have been the primary source of concrete aggregate in this region for many decades.

However, much of the Pliocene to early Quaternary alluvium has undergone extensive weathering. As a result, there is a significant proportion of soft, friable clasts, which break readily. Also, chemical alteration during weathering has resulted in the development of silica rinds, which may cause chemical reactivity issues. Because of the high proportion of soft clasts, and the presence of potential chemical reactivity issues, much of this material requires additional processing, and produces a higher percentage of waste. As a result, it is commonly not economical to produce concrete aggregate from this older material.

Quaternary Volcanic Rocks

Quaternary volcanic rocks and volcaniclastic sediments outcrop within the Sutter Buttes. The Sutter Buttes are remnants of a stratovolcano that erupted approximately 1.5 million years ago. At higher elevations, near the center of the Buttes, numerous lava domes are exposed.

These rocks range in composition from rhyolitic to andesitic. At lower elevations, on the flanks of the Buttes, a variety of pyroclastic flow, debris flow, and volcaniclastic sediment deposits are exposed (Hausback et al, 2011). Older (Cretaceous to Quaternary) shales and sandstones are also present, in a semi-circular distribution at lower elevations, where they were tilted and forced upwards as magma rose upward through them, toward the surface. Minor fine-grained lake deposits are also present at higher elevations.

Relatively little is known of the aggregate quality of the material of the Sutter Buttes. Volcanic rocks and volcaniclastic sediments deposited on the flanks of the Sutter Buttes have been mined and utilized for a variety of construction and other aggregate products, including construction sand, Class II base aggregate, and decorative (landscape) rock. However, this material is not known to have been utilized for concrete aggregate, and it is not known to meet concrete aggregate specifications. This material contains volcanic glass, which may cause chemical reactivity issues if used in concrete.

Dredge Tailings

Two of the largest and most voluminous dredge fields in California are located within the GSA P-C Region: the Yuba Goldfields, and the Folsom-American River dredge field (Doolittle, 1905; Winston and Janin, 1910; Clark, 2005).

The Yuba Goldfields, or Hammonton dredge field, is located along the Yuba River, approximately 8 miles east and upstream of the town of Marysville, and was mined from 1904 to 1968 (and very sporadically since then). This field is approximately 7,600 acres, ranges in thickness from 60 to 140 feet, and has an estimated dredged volume of greater than 1 billion cubic yards.

The Folsom-American River dredge field is located along and south of the American River, approximately 15 miles east of downtown Sacramento, and was dredged from 1899 to 1962. This field is nearly 18,000 acres, ranges in thickness from 40 to 110 feet, and has an estimated volume of 1 billion cubic yards.

The process of gold dredging involves the excavation, washing, sorting, and redistribution of sediments and overburden (soils and vegetation). This produces tailings that are unconsolidated and recently washed, which may reduce processing costs. However, this process also separates coarser sediments from finer sediments, and then redeposits them as separate, alternating layers. Consequently, the material being mined at any given time may be too coarse or too fine to meet grain-size distribution requirements, which may necessitate additional stockpiling and blending. Scrap metal from broken dredges is sometimes buried within the tailings, making it necessary to conduct magnetic surveys to locate such potentially damaging objects before mining. Depending on the depth of dredging, and the thickness of alluvial deposits, the dredging process may intermix deposits of different ages and aggregate quality.

The Hammonton dredge field contains a high percentage of hard, durable material and relatively little heavily weathered or otherwise undesirable materials that would require significant additional processing to produce a suitable aggregate product. Thus, these dredge tailings tend to be economically mineable, and often meet concrete aggregate specifications. These dredge tailings are actively mined to produce concrete aggregate.

The tailings of the Folsom—American River dredge field are of more variable, and often lower, aggregate quality. Before dredging, parts of this area had significant soil overburden, and older, extensively weathered Quaternary and Pliocene sediments present near the surface.

The more-weathered alluvium also contains some aggregate clasts with silica rinds which may cause chemical reactivity issues. Younger and less weathered alluvium was also present near the surface in part of this area. However, the depth of dredging often exceeded the thickness of these younger, less weathered sediments. Consequently, the dredging process often mixed the less weathered sediments together with the overlying soil, and the underlying extensively-weathered sediments. Thus, significant portions of this dredge field have tailings with a relatively large proportion of soft, friable aggregates, and soil. Processing such material results in a high percentage of waste (typically exceeding 30 percent). Parts of the dredge field with a high percentage of waste material, and with clasts which may have silica rinds causing chemical reactivity issues, typically do not meet concrete aggregate specifications. However, other areas, where the depth of dredging did not exceed the thickness of the younger alluvium, may contain material that meets concrete aggregate specifications.

Areas within the P-C Region Reclassified to MRZ-2 for Concrete Aggregate

Approximately 300 acres of land about eight miles east-northeast of Marysville, and less than one mile north of Hammonton-Smartsville Road, is reclassified from MRZ-3 to MRZ-2. This area is between the MRZ-2 area of the main Yuba City-Marysville deposit (originally classified in SR 132), and the MRZ-2 area for the Teichert Marysville mine (reclassified from MRZ-3 and MRZ-4 to MRZ-2 in OFR 94-12). This area is underlain by alluvium of the Yuba River. Reclassification is based on available mining and subsurface data and in consideration to the geology and the classification of surrounding land. The northern portion of this area overlaps with the Western Aggregates mining operation. This new MRZ-2 area corresponds to Sector 91 shown on Plate 2A.

Approximately 877 acres of land south of Folsom, about two miles southeast of the intersection of White Rock Road and Scott Road, is reclassified from MRZ-3 to MRZ-2. This area was classified MRZ-3 for concrete aggregate in OFR 99-09. It was later classified MRZ-2 for construction aggregate in two petitions (SR 213 and SR 214). This area is underlain predominantly by monzonitic to quartz dioritic intrusive rocks. Data provided for those petitions indicate this 877 acre MRZ-2 area also meets concrete-grade aggregate specifications. Two newly permitted mines (Teichert Quarry and Stoneridge Quarry) are located within this MRZ-2 area, which corresponds to Sector 88 shown on Plate 2A.

Approximately 668 acres of land in Sacramento, less than half of a mile south of Jackson Highway, split by Elder Creek Road, and in between Bradshaw and Excelsior roads, has been reclassified from MRZ-3 to MRZ-2. This area was classified MRZ-3 in the Sacramento County report (OFR 99-09) and has been reclassified to MRZ-2 due to evaluation of subsurface data, and new mining data. This new MRZ-2 area corresponds to Sector 90 shown on Plate 2A. Teichert’s Aspen 8 and 9 mine is operating within this area.

Approximately 561 acres of land in Rancho Cordova, approximately two and one-half miles southeast of the intersection of Highway 50 and Sunrise Blvd (Plate 2A), has been reclassified from MRZ-3 to MRZ-2. This area was classified MRZ-3 in the Sacramento County report (OFR 99-09) and has been reclassified to MRZ-2 due to evaluation of new mining data. This new MRZ-2 corresponds to sector 92 shown on Plate 2A. Teichert’s Grantline West mining operation is located within this area.

Approximately 294 acres of land in Folsom, approximately one mile southeast of the intersection of White Rock Road and Grant Line Road (Plate 2A), has been reclassified from MRZ-3 to MRZ-2. This area was classified MRZ-3 in the Sacramento County report (OFR 99-09) and has been reclassified to MRZ-2 due to evaluation of new mining data. This new

MRZ-2 corresponds to sector 93 shown on Plate 2A. Teichert’s East Mining Site / Grantline mining operation is located within this area.

Approximately 309 acres of land adjacent and northwest of the Sheridan Pit MRZ-2 area have been reclassified from MRZ-3 to MRZ-2. This area is adjacent to the Bear River, near the margin of the Great Valley, approximately four miles east-northeast of Highway 65 at Wheatland. This area was classified MRZ-3 in the Placer County report (OFR 95-10), and has been reclassified to MRZ-2 due to evaluation of subsurface data, and mine expansion plans. This new MRZ-2 area corresponds to Sector 94 shown on Plate 2B. Cemex’s Patterson Sand and Gravel mine is operating within this area.

Areas within the P-C Region Reclassified from MRZ-2 to MRZ-1, -3 or -4 for Concrete Aggregate

An 87 acre section of the Bear River immediately upstream of Bear’s Elbow, immediately downstream of Rollins Reservoir, and about two miles northwest of Colfax, is reclassified from MRZ-2 to MRZ-3 and MRZ-4. This area has been reclassified to MRZ-3 or -4 according to the classification of bedrock over which the river flows. The river sediment was originally classified MRZ-2 for concrete aggregate in OFR 95-10. However, re-evaluation of high-resolution imagery and topographic data shows insufficient sediment volume to meet threshold along this stretch. The changed MRZ area corresponds to the “lost” portion of Sector 49 shown on Plate 2B.

An 87 acre section of the northeastern MRZ-2 area along the North Fork American River from Big Bend to Yankee Jim’s Bridge, about five miles west of Foresthill and four miles northeast of Applegate, is reclassified from MRZ-2 to MRZ-1 and MRZ-4 (classification of underlying bedrock). The river sediment was originally classified MRZ-2 for concrete aggregate in OFR 95-10. However, reassessment using high-resolution imagery and topographic data shows insufficient sediment volume to meet threshold, along this stretch. The changed MRZ area corresponds to the northern “lost” section of Sector 51 shown on Plate 2B.

The 16 acre Rattlesnake Bar MRZ-2 area is located immediately west of Rattlesnake Bar Road, about one mile southeast and inland of the northern arm of Folsom Lake, and about four miles southwest of Pilot Hill. This area is underlain by a limestone body, and was originally classified in OFR 2000-03. This deposit is roughly tabular and steeply dipping (~80 degrees), and relatively thin (as thin as 80 feet in places). It has substantial zones of high-silica, and high magnesium (dolomitic) compositions, which present alkali-silica and alkali-carbonate reactivity potentials, respectively. Historic underground mining has depleted a portion of the most economical high-purity limestone zones and has left a system of poorly-documented underground workings, which complicates future mining. With consideration to all of these characteristics, this deposit is uneconomical under current and foreseeable market conditions, and so it has been reclassified to MRZ-1, and corresponds to Sector 85 shown on Plate 2B.

The 235 acre former Granite 1 mine site, located in Sacramento, approximately one mile northeast of the intersection of Bradshaw Road and Jackson highway, is reclassified from MRZ-2 to MRZ-1 due to resource depletion. This new MRZ-1 area corresponds to Sector 71 shown on Plate 2B.

The 97 acre former Aspen III South mine site, located in Sacramento, approximately one mile southwest of the intersection of Bradshaw Road and Jackson Highway, is reclassified from MRZ-2 to MRZ-1 due to resource depletion. This new MRZ-1 area corresponds to Sector 76 shown on Plate 2A.

A 6 acre area located along Indian Creek about one mile downstream of the Indian Diggins limestone deposit, about seven miles north of the town of Volcano, and three miles south of Omo Ranch Road, has been reclassified from MRZ-2 to MRZ-1. This area is underlain by a Paleozoic age limestone body, and was originally classified in OFR 2000-03. Re-evaluation of resource tonnage, deposit geometry, surrounding topography, and remoteness, indicates that this deposit fails to meet marketability or economic viability requirements. This new MRZ-1 area corresponds to Sector 84 shown on Plate 2B.

DESCRIPTION OF AREAS NEWLY-SUBJECTED TO MINERAL LAND CLASSIFICATION

In addition to updating MLC of earlier studies, this report also classifies about 3,500 square miles (58 percent of the current study area) of previously-unclassified land (Figure 2). Due to data limitations, an absence of concrete aggregate production within previously-unclassified land, and possibly due to an inherently low concrete aggregate potential of the underlying geology, no new MRZ-2 areas have been identified in this previously-unclassified land. However, geologic mapping, subsurface data, correlations with geologic units classified in other reports, and minor historical mining data, have all been used to identify areas with very low concrete aggregate potential (MRZ-1), moderate concrete aggregate potential (MRZ-3), and areas for which insufficient data is available to make a determination (MRZ-4).

The areas not previously classified include significant portions of the Sierra Nevada foothills and mountains, as well as large parts of the Great Valley.

The geologic units underlying previously-unclassified lands in the eastern and southeastern study area include a wide range of igneous and metamorphic bedrock, and overlying sedimentary and volcanic rocks. Many of the granitic rocks, and high-purity limestones were classified as MRZ-3 based on correlations with previously-classified geologic units and rock composition. Other geologic units dominated by slate, or other extensively foliated metamorphic rock, were classified as MRZ-1 because such foliation makes the rock unsuitable for concrete-grade aggregate. Much of the remaining rock in this area was classified MRZ-4 due to insufficient data to make a more meaningful determination.

The geologic units underlying previously-unclassified lands in the northern and western study area are predominantly younger Cenozoic sedimentary rocks filling the Great Valley. Older (Jurassic to Cretaceous) sedimentary rocks of the Great Valley Sequence outcrop less extensively in the westernmost part of this area. Younger (Quaternary) volcanic and volcaniclastic rocks of the Sutter Buttes are also present. Many of the basin-filling sediments further from their source area are very fine-grained (predominantly clay and silt). These sedimentary deposits have been classified as MRZ-1 where sufficient data indicates the grain size is too fine for use in concrete aggregate. Significant subsurface (well log) data on the upper 60 feet was also used to make this determination. Where these younger sedimentary deposits are closer to their source, but their grain size distribution is not sufficiently well known, they have been classified as MRZ-4. The older Great Valley Sequence rocks have been sparsely classified as MRZ-3, based on close correlations with previously-classified rock. However, the Great Valley Sequence rocks have largely been classified MRZ-4 along with much of the volcanic and volcaniclastic rocks of the Sutter Buttes due to insufficient data.

PART III – RE-EVALUATION OF CONCRETE AGGREGATE RESOURCES IN THE GREATER SACRAMENTO AREA P-C REGION

This section describes the results of re-evaluation of concrete aggregate resources in the GSA P-C Region based on new information. This includes re-evaluation of areas previously identified in the six MLC source reports and nine newly-identified areas. Reserve estimates within these areas are based on mining permits available as of June 2017.

CONCEPTS USED IN IDENTIFYING AGGREGATE RESOURCE SECTORS

In the MLC process, the identification and creation of MRZs is based on geologic factors alone without regard for current land use. This results in the identification of resource areas on MRZ maps, but does not quantify the resource base available to meet the future needs of a region.

The State Geologist is responsible for identifying and quantifying the aggregate resources contained in areas classified as MRZ-2. Recognizing that there are lands within these areas that have already been urbanized, and therefore the mineral resources within them have a limited opportunity for conservation, development, and utilization, the State Geologist limits the aggregate resource calculations to areas within "Sectors."

Sectors are areas classified as MRZ-2 by the State Geologist that have current land uses compatible with mining. The SMGB defines compatible land uses as those that are non-urbanized or that have very low-density residential developments (one dwelling unit per ten acres or less); land without high-cost improvements; and land used for agriculture, grazing, or open space. Urbanization and/or incompatible land uses are defined by the SMGB as improvements of high cost, such as high-density residential developments, intensive industrial developments, commercial developments, and major public facilities. For this update, the determination of land use as accessible for mineral extraction was based on conditions as of January 2016. The land use was determined by reference to remotely-sensed imagery, field reconnaissance, and consultation with local planners.

The delineation of Sectors helps land-use planners and local governments focus on the areas that remain accessible for potential mineral extraction. The State Geologist calculates the available resources of each Sector and determines the amount of remaining resources that have been permitted for mining (i.e., "reserves"). The calculated amount of reserves and resources within all the Sectors of a region are compared with the CGS's forecast of the 50-year needs of the region for the particular mineral resource.

Each Sector meets or exceeds the SMGB's criteria for threshold value. Each Sector may be considered for designation as an area of regional or statewide significance by the SMGB pursuant to SMARA. The SMGB only considers lands within Sectors for designation.

The SMGB's criteria for identifying Sectors focuses on the apparent suitability of the land for mining. However, due to lack of public information, and other factors, this evaluation can only consider some land commitments (such as approved tracts), and may not consider others that restrict the accessibility of some of the Sectors for mining. It is possible, therefore, that the available resource base, as calculated by the CGS, may be overestimated.

REEVALUATION OF PREVIOUSLY IDENTIFIED AGGREGATE RESOURCE SECTORS

In total, 85 concrete-grade aggregate resource areas (ARAs) and Sectors were identified in the six source reports. This number does not include Sectors or ARAs for non-concrete-grade aggregate resources. In areas where source report boundaries overlap, only Sectors or ARA's from the most recent source report are utilized. MRZ-2 areas identified in reports written in response to petitions are not represented in this number, because those reports do not define Sectors. These MRZ-2 areas are described in the section on New Sectors.

Sectors and ARA's from source reports were digitized as needed, and brought into a GIS for compilation. Technologies and datasets not previously available were then used to aid further evaluation. Adjustments made to the MRZ map were incorporated into the Sector map. Sectors were compared with 2014 and 2016 NAIP imagery, as well as land usage maps, to identify areas that have become precluded due to incompatible land use.

For the sake of clarity, Sector and ARA names from the source reports were converted into one single naming system in this report. This was done firstly in chronologic order of source report, and secondly, by former ARA or Sector number. Appendix A shows current Sector numbers in relation to former Sector or ARA numbers and source reports. Appendix B shows the parameters and assumptions used in tonnage calculations. Original and revised Sectors and resources are summarized in Tables 2a through 2f and shown on Plates 2A and 2B. These 85 Sectors are described below. All mines referenced in this report should be assumed to be permitted mines unless otherwise noted (e.g. "historic" or "closed").

Yuba City-Marysville (SR 132) – Sectors 1 to 18 (Table 2a, Plate 2A):

Sectors 1 through 9 are located along the Yuba River from 7 to 20 miles upstream of the town of Marysville. These Sectors are underlain by dredge tailings of the Hammonton Dredge Field, and lesser Quaternary age alluvium of the Yuba River. Included within these alluvial sediments as a minor component are fine-grained hydraulic mine tailings ("slickens"). These native and reworked sediments are predominantly sand to cobble sized, but lesser clay- and silt-dominated intervals are also present. These Sectors have a total area of 8,089 acres. Approximately three acres within Sector 7 are precluded from mining by the New Parks Bar Bridge. These Sectors host five aggregate mines.

Sectors 10 through 18 are located along the Yuba River approximately from the town of Marysville to eight miles upstream. These Sectors are underlain by Quaternary alluvium of the Yuba River, including active channel sediments. These Sectors have a total area of 6,020 acres, and host one aggregate mine. Sectors 15 and 18 do not have sufficient tonnage to meet threshold, but have been preserved as-is from the source report, because the material in each Sector can be mined in conjunction with adjacent Sectors 14 and 17.

Sacramento-Fairfield (SR 156) – Sectors 19 to 34 (Table 2b, Plate 2A):

Sectors 19 through 34 are located along Cache Creek, from the southern end of the Capay Valley down to within one-half mile of the Interstate 5 overpass. They are underlain by Quaternary age alluvium, which is composed predominantly of metamorphic and sedimentary rock fragments sourced from the Coast Ranges. Grain sizes range from clay to medium coarse gravel, but are predominantly sand to pebble size (~3/8 inch median clast size in the active channel). These 16 Sectors have a total area of 16,997 acres, of which 148 acres have become precluded due to urbanization. These Sectors host six aggregate mines.

Table 2A. Re-evaluation of Sectors from SR 132

Sector Number	Total Area (acres)	Area Lost (acres)	Reason	Current Resources (mt)
1	1,238	--	--	161
2	1,026	--	--	134
3	35	--	--	5
4	29	--	--	5
5	2,490	--	--	339
6	1,611	--	--	371
7	1,316	3	urbanization	173
8	275	--	--	12
9	69	--	--	3
10	56	--	--	8
11	540	--	--	75
12	21	--	--	2
13	1,037	--	--	121
14	3,306	--	--	617
15	6	--	--	0
16	249	--	--	35
17	794	--	--	93
18	11	--	--	1
Totals	**14,109**	**3**	--	**2,155**

Total Area includes area lost. Acreage may differ slightly from that stated in source report, due to a change in the method used to calculate area.
mt: million tons
-- Not Applicable

At the time of the source report (1988), in-channel mining was permitted, and several in-channel mining operations were active. Since then, regulations on in-channel mining have changed, and little or no in-channel mining has occurred since 1996. Because of these changes to in-channel mining restrictions, construction aggregate resources for the Cache Creek area have been reassessed for this report.

The Cache Creek Resources Management Plan (CCRMP) (Yolo County, 2002) defines the in-channel boundary and off-channel mining is not allowed within 200 feet of this boundary (per Yolo County Title 10, Chapter 3, as referenced in the CCRMP). Only sediment deposited in the previous year is allowed to be extracted from the area defined as in-channel. It is estimated that approximately 200,000 tons of sediment are deposited in Cache Creek (annual

Table 2B. Re-evaluation of Sectors from SR 156

Sector Number	Total Area (acres)	Area Lost (acres)	Reason	Current Resources (mt)
19	686	--	--	19
20	4,883	18	urbanization	164
21	203	--	--	3
22	53	--	--	2
23	789	--	--	47
24	1,308	--	--	78
25	61	--	--	3
26	131	--	--	7
27	68	--	--	3
28	629	--	--	38
29	353	--	--	11
30	3,590	130	urbanization	154
31	630	--	--	2
32	3,467	--	--	118
33	60	--	--	3
34	86	--	--	4
Totals	**16,997**	**148**	--	**656**

Total Area includes area lost. Acreage may differ slightly from that stated in source report due to a change in the method used to calculate area.
mt: million tons
-- Not Applicable

average). Thus, the in-channel area, for the purpose of our 50-year projection, is collectively estimated to have 10 million tons resources (200,000 tons/year multiplied by 50 years).

Approximately 2,921 acres of these Sectors are within the 200 foot buffered in-channel area. This acreage was removed from the Sectors before performing off-channel resource calculations. This 2,921 acre area is included in Table 2b. Aggregate resources within the off-channel parts of Sectors were estimated using area, thickness, waste factor, and in-place density (Appendix B).

Nevada County (SR 164) – Sectors 35 to 41 (Table 2c, Plate 2B):

Sectors 35 and 36 are located on San Juan Ridge, about one mile southeast of the historic gold mining town of North Columbia, and about a mile north of the South Yuba River.

Table 2C. Re-evaluation of Sectors from SR 164

Sector Number	Total Area (acres)	Area Lost (acres)	Reason	Current Resources (mt)
35	233	--	--	14
36	13	--	--	1
37	164	--	--	18
38	80	--	--	9
39	101	--	--	12
40	43	--	--	2
41	33	--	--	2
Totals	**667**	**0**	--	**58**

Total Area includes area lost. Acreage may differ slightly from that stated in source report,due to a change in the method used to calculate area.
mt: million tons
-- Not Applicable

These Sectors are underlain by Eocene age fluvial sediments (the “auriferous gravels”) and hydraulic mining debris sourced from said sediments. These Sectors have a total area of 246 acres, and have historically been mined for gold and minor construction aggregate. No mining operation is active within these Sectors at present. Although Sector 36 does not have sufficient tonnage to meet threshold, it is preserved as-is from the source report because the material in it can be mined in conjunction with Sector 35.

Sectors 37 to 39 are located along Greenhorn Creek, from two to nine miles upstream of its confluence with the Bear River at Rollins Reservoir. These Sectors are underlain by Quaternary age fluvial gravels, sands, and silts sourced from the auriferous gravels (some of which were remobilized by hydraulic mining) as well as Mesozoic age metamorphic and igneous bedrock of the Sierra Nevada. These Sectors have a total area of 345 acres, and host one aggregate mine.

Sectors 40 and 41 are located on Steephollow Creek, just upstream of its confluence with the Bear River, and about one mile upstream of Rollins Reservoir. These Sectors are underlain by Quaternary age fluvial gravels, sands and silts sourced from the auriferous gravels and lesser Mesozoic metamorphic and igneous bedrock of the Sierra Nevada. These Sectors have a total area of 76 acres. Minor sand and gravel mining occurred within these Sectors historically, but no mining is active at present.

Placer County (OFR 95-10) – Sectors 42 to 54 (Table 2d, Plate 2B);

Sectors 42 and 48 are located on the Bear River near the margin of the Great Valley, two to five miles east-northeast of Highway 65 at Wheatland. These Sectors are underlain by Quaternary age fluvial sediments of the Bear River. These Sectors have a total area of 1,428 acres. Sector 42 hosts one aggregate mine.

Table 2D. Re-evaluation of Sectors from OFR 95-10

Sector Number	Total Area (acres)	Area Lost (acres)	Reason	Current Resources (mt)
42	480	--	--	***
43	852	--	--	***
44	261	261	urbanization	0
45	398	--	--	12
46	123	--	--	8
47	305	305	urbanization	0
48	948	--	--	20
49	407	87	re-evaluation	8
50	98	--	--	7
51	260	260	urbanization and re-evaluation	0
52	469	--	--	175
53	21	21	urbanization	0
54	395	--	--	***
Totals	5,017	934	--	526

Total Area includes area lost. Acreage may differ slightly from that stated in source report, due to a change in the method used to calculate area.
mt: million tons
***: proprietary
-- Not Applicable

Sectors 43 and 52 are located on Coon Creek near the margin of the Great Valley, approximately four miles east-southeast of Highway 65 at Sheridan. These Sectors are underlain by Quaternary age fluvial sediments of Coon Creek, and Mesozoic age quartz diorite. These Sectors have a total area of 1,321 acres and host one aggregate mine.

Sector 44 is located less than one mile east of Highway 65, in the City of Rocklin. This Sector is underlain by Miocene age andesitic and lesser dacitic volcanic and volcaniclastic sedimentary rocks of the Mehrten Formation. Material within this Sector was mined for concrete and base grade aggregates, historically. However, mining has ceased, and all 261 acres of the Sector have become precluded due to urbanization.

Sectors 45, 46, 49, and 50 are located along the Bear River, from Lake Combie to about five miles upstream of Rollins Reservoir. These Sectors are primarily underlain by young (Quaternary age) sediments of the Bear River, including those sediments deposited in the river channel stretches now filled by Lake Combie and Rollins Reservoir. Thickness and grain size distribution is variable. These Sectors have a total area of 1,026 acres, of which 87 acres have been removed due to new information and analysis indicating insufficient sediment thickness.

Material within these Sectors were mined for concrete aggregate and other construction products, historically, but no mining is occurring at present.

Sector 47 is located along the Middle Fork American River approximately five miles east-northeast of the town of Auburn. This Sector is underlain predominantly by young (Quaternary age) sediments. This Sector has an area of 305 acres, all of which lies within the boundary of the Auburn State Recreation Area, and is thereby precluded from mining.

Sector 51 is located along the North Fork American River, in the canyon northwest of Foresthill Road and southeast of Highway 80, about six miles west of the town of Foresthill and a similar distance northeast of the town of Auburn. This Sector is underlain by young (Quaternary age) fluvial sediments and Paleozoic to Mesozoic age metamorphosed volcanic and sedimentary rocks. This Sector has a total area of 260 acres. Mining is precluded from 111 acres due to overlap with the Auburn State Recreation Area. Based on new data and re-evaluation, the remaining 149 acres have been removed due to insufficient sediment thickness and poor accessibility. No active or historical mining is known to have occurred in this Sector.

Sector 53 is located approximately one and one-half miles east of the town of Lincoln, just north of Highway 193, and approximately three miles northeast of Highway 65. This Sector is underlain by Jurassic age granitic rock of the Penryn Pluton, which has historically been quarried for dimension stone and crushed stone aggregate. However, mining operations ceased and all 21 acres of this Sector have become precluded due to urbanization.

Sector 54 is off-channel, immediately adjacent to and upstream of Lake Combie. This Sector is underlain by Jurassic age bedrock consisting predominantly of basaltic to andesitic metavolcanic rocks. This Sector has an area of 395 acres and hosts one aggregate mine.

Sacramento County (OFR 99-09) – Sectors 55 to 76 (Table 2e, Plate 2B):

Sectors 55 to 66, 71, 72, and 74 to 76 are located in Sacramento and are generally arranged in a belt running approximately from the intersection of Watt Avenue and Gerber Road in the southwest, to the intersection of Sunrise Blvd and White Rock Road in the northeast. These Sectors are underlain by young (Quaternary age) alluvium of the Riverbank Formation, and total 4,018 acres in area. Of this total area, all 332 acres of Sectors 71 and 76 are depleted. Additionally, parts of Sectors 63, 65, and 66, totaling 171 acres, as well as all 747 acres of Sector 74 are urbanized. These Sectors host four aggregate mines.

Sectors 67 to 70, and 73 are located immediately west of Sunrise Blvd at its intersection with Jackson Highway, approximately 10 miles east-southeast of downtown Sacramento. These Sectors are underlain by Quaternary fluvial sediments of the Turlock Lake and Riverbank Formations. These Sectors have a total area of 917 acres, and host one aggregate mine.

El Dorado County (OFR 2000-03) – Sectors 77 to 85 (Table 2f, Plates 2A and 2B):

Sectors 77 and 78 are located immediately east-northeast of Highway 49 and one mile north-northwest of the town of Cool. These Sectors are underlain by an elongate body of Paleozoic and/or Mesozoic age limestone that trends north-northwest and dips steeply to the east. These Sectors total 127 acres in area, and host one aggregate mine.

Table 2E. Re-evaluation of Sectors from OFR 99-09

Sector Number	Total Area (acres)	Area Lost (acres)	Reason	Current Resources (mt)
55	72	--	--	4
56	575	--	--	34
57	49	--	--	2
58	336	--	--	***
59	176	--	--	***
60	273	--	--	***
61	80	--	--	4
62	106	--	--	5
63	257	2	urbanization	11
64	103	--	--	4
65	153	81	urbanization	3
66	131	88	urbanization	2
67	141	--	--	7
68	111	--	--	5
69	158	--	--	7
70	264	--	--	20
71	235	235	depletion	0
72	576	--	--	1
73	243	--	--	2
74	747	747	urbanization	0
75	52	--	--	3
76	97	97	depletion	0
Totals	4,935	1,250	--	**131**

Total Area includes area lost. Acreage may differ slightly from that stated in source report, due to a change in the method used to calculate area.
mt: million tons
***: proprietary
-- Not Applicable

Sectors 79 and 81 are located a few miles east of the town of Diamond Springs, north of Pleasant Valley Road, and west of Cedar Ravine Road. These Sectors are underlain by two separate limestone bodies with a combined area of 32 acres. Sector 79 hosts one aggregate mine.

Table 2F. Re-evaluation of Sectors from OFR 2000-03

Sector Number	Total Area (acres)	Area Lost (acres)	Reason	Current Resources (mt)
77	119	--	--	***
78	8	--	--	***
79	22	--	--	***
80	60	60	re-evaluation	0
81	10	--	--	2
82	27	--	--	6
83	40	--	--	18
84	6	6	re-evaluation	0
85	16	16	re-evaluation	0
Totals	308	82	--	**39**

Total Area includes area lost. Acreage may differ slightly from that stated in source report, due to a change in the method used to calculate area.
mt: million tons
***: proprietary
-- Not Applicable

Sector 80 is located approximately seven miles west-northwest of the town of Placerville and two miles north-northeast of the town of Rescue, on the east side of Lotus Road. It is underlain by serpentinite of the Foothills Metamorphic Belt. This Sector has an area of 60 acres. This Sector has been removed due to presence of naturally occurring asbestos, which precludes much of the material from being utilized for concrete-grade aggregate.

Sector 82 is located on the Middle Fork Cosumnes River approximately six miles upstream of the Mt. Aukum Road crossing and four miles southwest of the town of Grizzly Flats. This Sector is underlain by Paleozoic and/or Mesozoic marble, and has an area of 27 acres. Historical quarrying operations have occurred in this area but no mining has occurred in recent decades.

Sectors 83 and 84 are located along Indian Creek, about seven miles north of the town of Volcano, and two and one-half miles south of Omo Ranch Road. These Sectors are underlain by separate Paleozoic and/or Mesozoic limestone bodies. These Sectors total 46 acres in area. Sector 83 is known as the Indian Diggins limestone deposit, and has been mined historically. Sector 84 has been removed because of issues with marketability and because re-evaluation of resources indicates mining to a depth sufficient to meet threshold would be uneconomical, due to small surface exposure and steepness of surrounding topography.

Sector 85 is located approximately one mile southeast and inland of the northern arm of Folsom Lake, and just west of Rattlesnake Bar Road. This Sector is underlain by a north-trending lens of Paleozoic and/or Mesozoic limestone. This Sector totals 16 acres, and has been mined historically. However, no mining operations are active within this Sector at the time of writing. Due to the factors discussed in Part II, which resulted in reclassification of this area from MRZ-2 to MRZ-1, this deposit is uneconomical under current and foreseeable market conditions and has been removed.

In total, 42,033 acres of previously-defined Sectors were re-evaluated for concrete-grade aggregate resources. Of the total acreage, 2,417 acres (or 5.8 percent) were lost due to urbanization, removal or depletion. The remaining 39,616 acres host 3,565 million tons of concrete aggregate resources.

Direct comparison of resource estimates between the source reports and the current report is not feasible due to inconsistencies in aggregate grade evaluated in each source report.

NEWLY-IDENTIFIED CONCRETE AGGREGATE RESOURCE SECTORS WITHIN THE GREATER SACRAMENTO AREA P-C REGION

Nine new concrete aggregate resource Sectors are identified in this update report. These are Sectors 86 through 94 (Plates 2A and 2B). Values used to calculate resources and reserves are included in Appendix B. Sector areas and resources are summarized in Table 3. Sector descriptions follow.

Sector 86 is located adjacent to and northwest of the Bear River at the upstream end of Lake Combie (Plate 2B). The area of this Sector was originally classified MRZ-2 for PCC-grade aggregate in a study (OFR 83-28) conducted in response to a petition. This Sector is underlain by bedrock consisting predominantly of metamorphosed basaltic and andesitic volcanic rocks. The MRZ-2 boundary has been slightly adjusted according to geology, mine plans, and parcel maps. This Sector has a total area of 80 acres. No mining has occurred within this Sector.

Sector 87 is located immediately south of the Hammonton Dredge Field, approximately seven miles east-northeast of the town of Marysville and one and one-half miles south of the Yuba River (Plate 2A). This Sector is underlain by Quaternary age alluvium predominantly of the Riverbank Formation and younger. This area was classified as MRZ-3 and -4 for PCC-grade aggregate in the first MLC of this area (SR 132 in 1988), and was reclassified to MRZ-2 for PCC-grade aggregate in OFR 94-12, which was conducted in response to a petition. This Sector is 595 acres in area, and hosts one aggregate mine.

Sector 88 is located approximately one and one-half miles southeast of the intersection of White Rock Road and Scott Road, and south of the boundary of the City of Folsom (Plate 2A). This Sector is underlain by Jurassic and/or Cretaceous age monzonitic to quartz-dioritic intrusive rocks and lesser Jurassic age metamorphosed sedimentary rocks. This area was classified MRZ-2 in Special Reports 213 and 214, which were conducted in response to petitions. Testing data indicate the unweathered igneous intrusive rock is of PCC-grade. This Sector has a total area of 874 acres, and hosts two newly permitted aggregate mines.

Sector 89 is located adjacent to and west-northwest of the Bear River at the upstream end of Lake Combie (Plate 2B). The area of this Sector was first classified MRZ-2 for PCC-grade aggregate in a study (OFR 83-28) conducted in response to a petition. This Sector is underlain by bedrock consisting predominantly of metamorphosed basaltic and andesitic volcanic rocks. The area classified as MRZ-2 has been adjusted slightly, according to geology, mine plans, and parcel maps. This Sector has a total area of 206 acres. No mining is occurring within this Sector at present.

Table 3. Newly-Identified Sectors

Sector Number	Total Area (acres)	Current Resources (mt)
86	80	42
87	595	***
88	874	***
89	206	95
90	668	***
91	293	27
92	561	***
93	294	***
94	309	***
Totals	3,880	**769**

Total Area includes area lost. Acreage may differ slightly from that stated in source report, due to a change in the method used to calculate area.
mt: million tons
***: proprietary

Sector 90 is located in Sacramento, less than half a mile south of Jackson Highway, between Bradshaw and Excelsior roads (Plate 2A). This Sector is underlain by Pliocene and Quaternary age sediments of the ancestral American River. This Sector has a total area of approximately 668 acres, and hosts one aggregate mine.

Sector 91 is located immediately south of the Hammonton Dredge Field, approximately seven miles east-northeast of the town of Marysville and one and one-half miles south of the Yuba River (Plate 2A). This Sector is underlain by Quaternary age alluvium predominantly of the Riverbank Formation and younger. This Sector has an area of 293 acres, and hosts one aggregate mine.

Sector 92 is located in Rancho Cordova, approximately two and one-half miles southeast of the intersection of Highway 50 and Sunrise Blvd (Plate 2A). This Sector is underlain by dredge tailings of the Folsom—American River dredge field. These tailings were probably sourced from alluvium of the Pleistocene Riverbank Formation. This Sector has an area of 561 acres, and hosts one aggregate mine.

Sector 93 is located in Folsom, approximately one mile southeast of the intersection of White Rock Road and Grant Line Road (Plate 2A). This Sector is underlain by dredge tailings of the Folsom—American River dredge field, which were probably sourced from alluvium of the Pliocene Laguna Formation. This Sector has an area of 294 acres, and hosts one aggregate mine.

Sector 94 is located about four miles east of Wheatland, adjacent to the Bear River, and immediately north of and adjacent to Sectors 42 and 48 (Plate 2A). This Sector is underlain by Quaternary alluvium of the Bear River. This Sector has a total area of 309 acres and hosts one aggregate mine.

RECALCULATION OF AVAILABLE CONCRETE AGGREGATE RESOURCES

Concrete aggregate resources within all or parts of the six former study areas were re-evaluated and re-calculated for the present report. A summary of the concrete-grade aggregate resources and areas of the GSA P-C Region is presented in Table 4.

Table 4. Resource Totals for Source Reports and Present Report

Source	Total Area (acres)	Total Resource (mt)
Re-evaluated Sectors from SR 132	14,109	2,155
Re-evaluated Sectors from SR 156	16,997	656
Re-evaluated Sectors from SR 164	667	58
Re-evaluated Sectors from OFR 95-10	5,017	526
Re-evaluated Sectors from OFR 99-09	4,935	131
Re-evaluated from OFR 2000-03	308	39
Newly-Identified Sectors	3,880	769
Greater Sacramento Area P-C Region	**45,913**	**4,334**

mt: million tons

PART IV – CONCRETE AGGREGATE PRODUCTION IN THE GREATER SACRAMENTO AREA P-C REGION

As of 2017, based on data from the California Division of Mine Reclamation (DMR), 13 companies have current, valid permits to operate 30 mines, in the GSA P-C Region, capable of producing concrete-grade aggregate:

- Teichert Aggregates (15 mines)
- Granite Construction Co. (3 mines)
- CEMEX (2 mines)
- Hansen Brothers Enterprises (1 mine)
- Kino Aggregates (1 mine)
- Knife River (1 mine)
- Orchard Growers (1 mine)
- Sierra Rock (1 mine)
- Silica Resources (1 mine)
- Syar (1 mine)
- Tsakopoulos (1 mine)
- Vulcan Materials (1 mine)
- Western Aggregates (1 mine)

Ten mining companies operate 11 additional mines in the region to produce construction aggregate that has not been demonstrated to be of concrete grade. Concrete aggregate mines are shown on Plates 2A and 2B, and all construction aggregate mines irrespective of grade are shown on Plate 1. Brief descriptions of the construction aggregate mines can be found in Appendix C.

AGGREGATE PRODUCTION DATA

Aggregate production data for the GSA P-C Region from 1970 through 1990 were compiled primarily from previous MLC reports and supplemented by United States Bureau of Mines (USBM) records. Within portions of this time period, USBM production data was only available every other year. Where this was the case, production for years with no data was estimated by linear interpolation. Aggregate production data from 1990 to 2016 was obtained from the DMR.

Total construction aggregate production within the P-C Region from 1970 to 2016 is reported to be approximately 661 million tons (Table 5). Within this time period, annual aggregate production has ranged from a low of 7 million tons in 2012 to a high of 26 million tons in 2005. Some of this variability is due to economic fluctuations, such as the decrease that coincides with the economic recession of 2007-2009 (Figure 3).

Table 5. Construction Aggregate production (all grades) in the Greater Sacramento Area P-C Region from 1970 to 2016

Year	Production (tons)	Year	Production (tons)	Year	Production (tons)
1970	9,653,822	1986	14,578,311	2002	23,685,856
1971	8,901,154	1987	15,287,706	2003	24,457,592
1972	9,811,881	1988	15,857,104	2004	25,287,572
1973	9,602,674	1989	16,626,426	2005	26,255,971
1974	9,905,435	1990	17,454,667	2006	24,627,684
1975	8,213,443	1991	15,339,087	2007	21,496,100
1976	7,819,955	1992	13,843,836	2008	12,622,507
1977	9,498,800	1993	12,866,557	2009	10,609,805
1978	11,489,763	1994	14,148,624	2010	8,325,089
1979	14,113,953	1995	15,084,444	2011	8,709,852
1980	12,195,200	1996	15,054,048	2012	7,285,564
1981	10,033,943	1997	14,544,656	2013	9,079,794
1982	8,412,699	1998	16,673,009	2014	9,902,726
1983	9,388,637	1999	21,582,667	2015	11,056,673
1984	10,449,726	2000	22,487,481	2016	10,853,288
1985	12,468,682	2001	23,454,674	**TOTAL:**	**661,099,137**

AGGREGATE CONSUMPTION

A “Production-Consumption Region” is defined as an area in which 95 percent of the aggregate produced is also consumed, and vice versa. CGS MLC studies for a region typically use the P-C model, and assume that regional aggregate *production* approximately equals regional aggregate *consumption*. This assumption is valid for the GSA P-C Region.

However, though at least 95 percent of the aggregate produced within the GSA P-C Region is consumed within the region, there are still important geographic disparities between production and consumption. Aggregate is produced at mine sites, and it is consumed in population centers, roadways, and other infrastructure (e.g., bridges, dams, aqueducts). The distance between mine sites and consumption areas is variable throughout the region. The highest concentrations of aggregate resources tend to be far from the highest concentration of population. This geographic separation between aggregate resources and population centers has been generally increasing over time.

The GSA P-C Region is large, measuring more than 100 miles across in east-west and north-south directions. As can be seen on Plate 1, the distribution of aggregate mines (and aggregate resources) is uneven, and is concentrated in a handful of areas. In general,

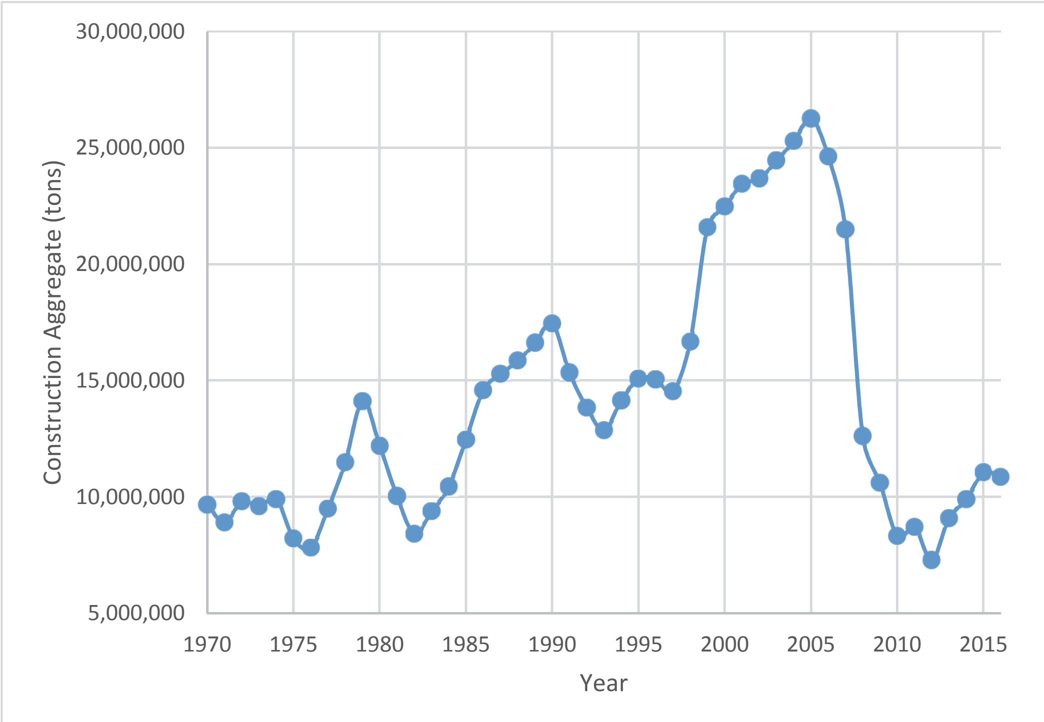

Figure 3. Construction Aggregate Production (all grades) in the Greater Sacramento Area P-C Region

population is much more widespread and dispersed than aggregate resources, but it is still concentrated in cities and along highway corridors.

Within the GSA P-C Region, there are three primary production areas (Plates 1 and 2A):

- Yuba River – adjacent to the Yuba River near Yuba City-Marysville
- Cache Creek – adjacent to the Cache Creek near Madison
- American River – south of the American River near Sacramento

These three areas satisfy a majority of the aggregate demand within the P-C Region. However, they do not produce equal shares of the aggregate, nor do they host equal reserves. The Yuba River area hosts several times more aggregate resources than the other two areas, but the American River area has historically provided the greatest proportion of aggregate production, because it is closest to the region's largest population center. This situation is not static – it is changing. As the American River area's aggregate deposits become depleted or lost to conflicting land uses, and as the quality and economy of remaining material continues to decrease, an increasing amount of regional demand is met by production from the Yuba River area.

The relative contributions of aggregate from each of these three production areas, compared with the other smaller production areas, can be seen in Figure 4. Though production from the American River area was dominant for several decades, this situation began to change around the turn of the century, as production from the Yuba River area began to ramp up and exceed Cache Creek and other production. Then, in the 2000 to 2007 period, production from

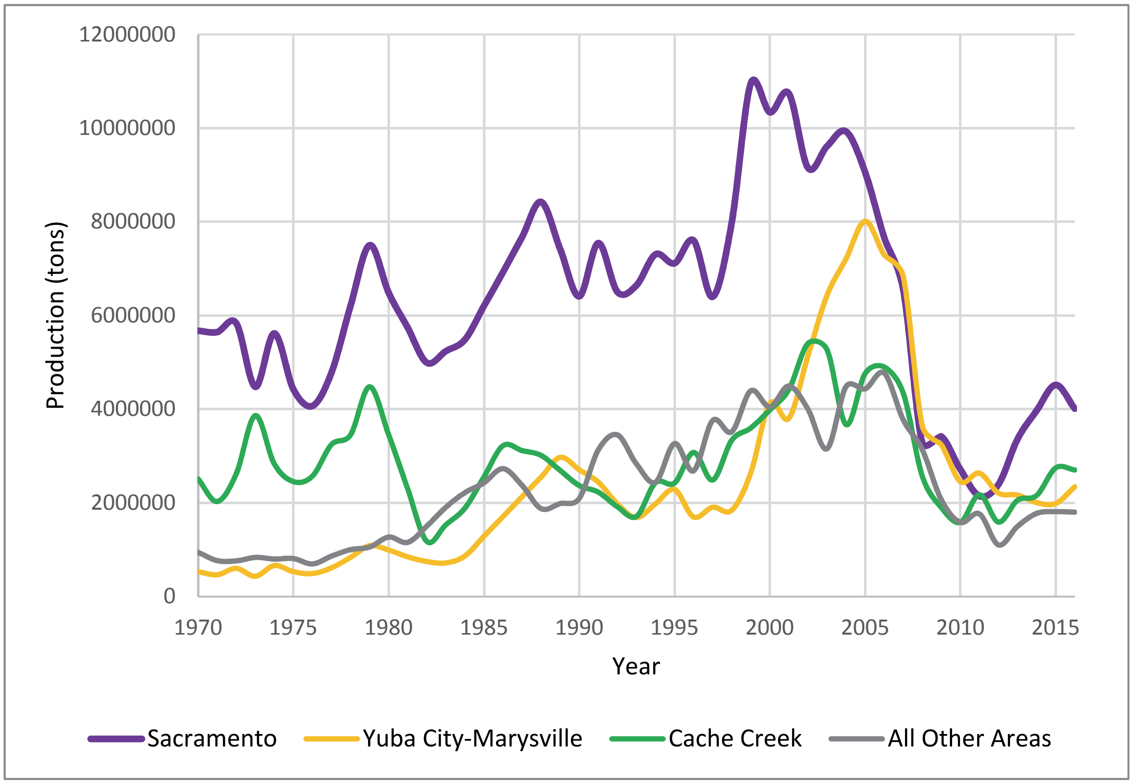

Figure 4. Construction aggregate production in the Greater Sacramento Area P-C Region from 1970 to 2016 by producing region

American River begins to decrease and demand is increasingly met by Yuba River production. At the end of this period, production from the Yuba River area approximately equals that from the American River area. In the most recent years, following the recession of 2007-2009, Sacramento area production has begun to recover more rapidly than elsewhere, but this signal is relatively minor.

In the early 2000's, the most economical, high-grade alluvial aggregate sources in the American River area were largely depleted or precluded by land use changes, and mining shifted to less economical alluvial deposits (with a higher waste fraction) and to hard rock deposits. Looking to the future, it is likely that the Yuba River production area will become an increasingly important source of aggregate for the GSA P-C Region. This will result in increased distances between aggregate source and end use.

These three major production areas have been the source of most aggregate consumed in the GSA for many years. However, as aggregate supply and market dynamics change, and as population grows and its distribution changes, a few producing areas or deposits of regional importance have emerged. In Placer County, the Meadow Vista hard rock quarry and the two sand and gravel pits at the valley margin (Sheridan Pit and Teichert Lincoln quarry) have reserves and production of increasing regional importance. In the Sacramento area, south of Folsom, two recently-permitted hard rock quarries (Teichert Quarry and Stoneridge Quarry) will likely be of regional importance in the future. These mines exemplify the shift towards new aggregate sources, including hard rock sources, which were formerly uneconomical. These hard rock deposits account for 80 percent of the Sacramento area's remaining aggregate resources.

PART V – ESTIMATE OF THE 50-YEAR DEMAND FOR AGGREGATE IN THE GREATER SACRAMENTO AREA P-C REGION

The SMGB guidelines for the classification and designation of mineral land (SMGB, 2000) specify that MLC reports for regions containing construction materials classified as MRZ-2 include

> "[an] estimate of the total quantity of construction aggregate that will be needed to supply the requirements of the county or marketing region in which it occurs for the next 50 years. The marketing region is defined as the area within which such material is usually mined and marketed. The amount of construction aggregate needed for the next 50 years is projected using past consumption rates adjusted for anticipated changes in population."

This section of the report contains the estimate of future aggregate demand for the GSA P-C Region, projected through the year 2066.

Some of the source MLC studies have overlapping area, population, and resources. Three of the source studies include population and aggregate resources outside of the current study area. A significant portion of the land and population within the current study area was not included in any of the former studies. Different reports evaluated different grades of construction aggregate. For all of these reasons, it is not possible or meaningful to compare the earlier source report demand projections with the current demand projection.

HISTORIC POPULATION

Historic population of the GSA P-C Region for the years 1970 to 2016 was estimated from the California Department of Finance (DOF) and US Census population datasets. Spatial population distributions are available from the US Census Bureau for years 1990, 2000, and 2010. Annual population by county is available from the California DOF. The P-C Region includes all of Yuba, Sutter, Yolo and Sacramento counties, but only parts of Nevada, Placer, El Dorado, and Solano counties. The US Census bureau spatial population datasets were used to

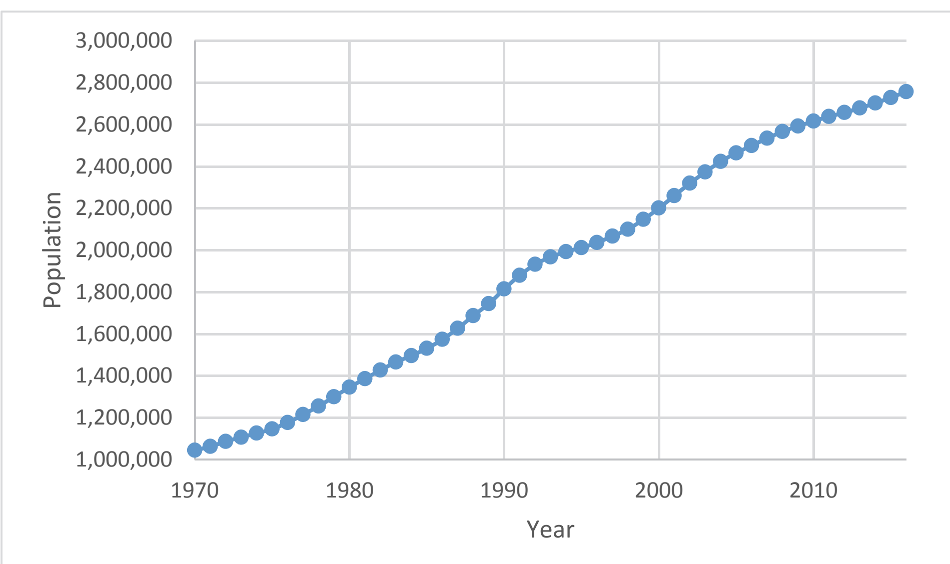

Figure 5. Annual historic population in the GSA P-C Region. Points represent real data.

determine what percentage of the population of each of the four counties lies within the P-C Region, for each of the three years that data is available (1990, 2000, and 2010). For these counties, the percentages of population living within the P-C Region were interpolated linearly between 1990, 2000, and 2010. Static percentage values were used for the time periods before and after this range, because no data is available to assess any change in percentage. Historic population of the P-C Region is presented in Figure 5 and Table 6.

Table 6. Annual Historic Population in the Greater Sacramento Area P-C Region

Year	Population	Year	Population	Year	Population
1970	1,044,721	1986	1,573,871	2002	2,319,808
1971	1,062,415	1987	1,626,714	2003	2,373,523
1972	1,086,741	1988	1,687,360	2004	2,423,812
1973	1,106,578	1989	1,744,206	2005	2,464,748
1974	1,125,792	1990	1,814,577	2006	2,500,019
1975	1,146,331	1991	1,880,072	2007	2,534,961
1976	1,176,868	1992	1,932,288	2008	2,566,860
1977	1,214,883	1993	1,967,394	2009	2,592,613
1978	1,255,380	1994	1,992,845	2010	2,616,528
1979	1,299,920	1995	2,012,232	2011	2,638,672
1980	1,345,577	1996	2,036,148	2012	2,657,802
1981	1,386,391	1997	2,067,118	2013	2,679,311
1982	1,427,466	1998	2,100,259	2014	2,703,327
1983	1,465,788	1999	2,146,989	2015	2,729,356
1984	1,496,476	2000	2,201,442	2016	2,757,399
1985	1,531,137	2001	2,260,175		

HISTORIC PER CAPITA AGGREGATE CONSUMPTION

Historic population data and historic construction aggregate production data were compared to determine annual per capita consumption for the years 1970 to 2016 in the GSA P-C Region. The average of the annual per capita consumption rates for the 1970 to 2016 time period is 7.6 tons. Within this time period, the rate fluctuates considerably. The calculated annual per capita consumption ranges from a low of 2.7 in 2012 to a high of 10.9 in 1979 (Table 7 and Figure 6). The average of the annual per capita rate is used to project future demand.

Table 7. Annual per capita consumption in the Greater Sacramento Area P-C Region

Year	Population	Production	Per-Capita	Year	Population	Production	Per-Capita
1970	1,044,721	9,653,822	9.2	1994	1,992,845	14,148,624	7.1
1971	1,062,415	8,901,154	8.4	1995	2,012,232	15,084,444	7.5
1972	1,086,741	9,811,881	9.0	1996	2,036,148	15,054,048	7.4
1973	1,106,578	9,602,674	8.7	1997	2,067,118	14,544,656	7.0
1974	1,125,792	9,905,435	8.8	1998	2,100,259	16,673,009	7.9
1975	1,146,331	8,213,443	7.2	1999	2,146,989	21,582,667	10.1
1976	1,176,868	7,819,955	6.6	2000	2,201,442	22,487,481	10.2
1977	1,214,883	9,498,800	7.8	2001	2,260,175	23,454,674	10.4
1978	1,255,380	11,489,763	9.2	2002	2,319,808	23,685,856	10.2
1979	1,299,920	14,113,953	10.9	2003	2,373,523	24,457,592	10.3
1980	1,345,577	12,195,200	9.1	2004	2,423,812	25,287,572	10.4
1981	1,386,391	10,033,943	7.2	2005	2,464,748	26,255,971	10.7
1982	1,427,466	8,412,699	5.9	2006	2,500,019	24,627,684	9.9
1983	1,465,788	9,388,637	6.4	2007	2,534,961	21,496,100	8.5
1984	1,496,476	10,449,726	7.0	2008	2,566,860	12,622,507	4.9
1985	1,531,137	12,468,682	8.1	2009	2,592,613	10,609,805	4.1
1986	1,573,871	14,578,311	9.3	2010	2,616,528	8,325,089	3.2
1987	1,626,714	15,287,706	9.4	2011	2,638,672	8,709,852	3.3
1988	1,687,360	15,857,104	9.4	2012	2,657,802	7,285,564	2.7
1989	1,744,206	16,626,426	9.5	2013	2,679,311	9,079,794	3.4
1990	1,814,577	17,454,667	9.6	2014	2,703,327	9,902,726	3.7
1991	1,880,072	15,339,087	8.2	2015	2,729,356	11,056,673	4.1
1992	1,932,288	13,843,836	7.2	2016	2,757,399	10,853,288	3.9
1993	1,967,394	12,866,557	6.5	**AVERAGE**			**7.6**

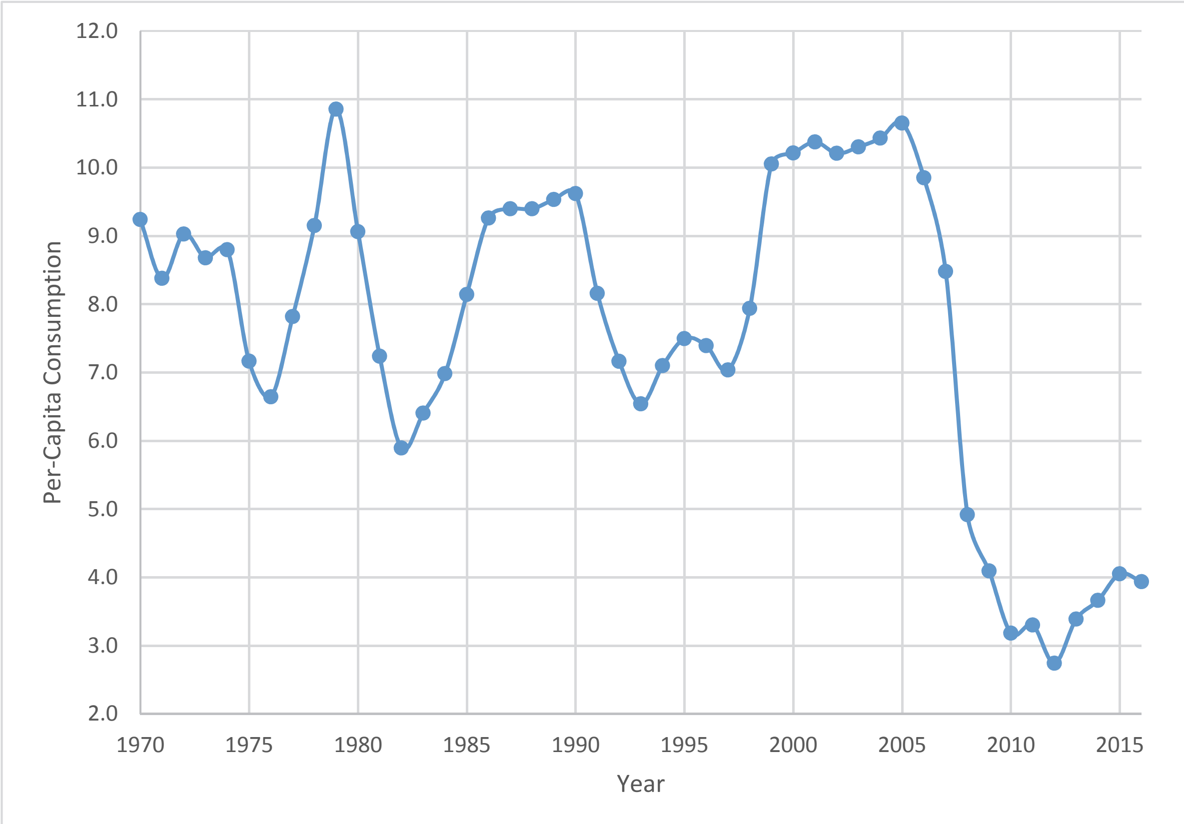

Figure 6. Annual Per Capita Consumption of Construction Aggregate in the Greater Sacramento Area P-C Region. Points represent real data; line is interpolated.

POPULATION PROJECTION THROUGH THE YEAR 2066

The population of the GSA P-C Region for years 2017 through 2066 was projected using California DOF Demographic Research Unit data (DOF Report P-1, 2014) (Table 8, Figure 7). As mentioned earlier, historic P-C Region populations for the four counties that are only partially within the P-C Region were determined using a GIS for years 1990, 2000, and 2010 and changing percentages were interpolated linearly between these years. A static percentage (calculated using the last available (2010) data) was used for the projection. The available DOF population projections only go through year 2060, and were extended linearly to 2066. The population of the P-C Region is projected to increase 58 percent, from 2,757,399 in 2016 to 4,343,895 in 2066.

Table 8. 50-year Population Projection for the Greater Sacramento Area P-C Region

Year	Projected Population	Year	Projected Population	Year	Projected Population
2017	2,805,703	2034	3,382,578	2051	3,898,607
2018	2,837,969	2035	3,415,951	2052	3,926,720
2019	2,870,555	2036	3,449,023	2053	3,955,115
2020	2,903,388	2037	3,481,580	2054	3,983,439
2021	2,936,984	2038	3,513,677	2055	4,012,248
2022	2,970,532	2039	3,545,507	2056	4,041,287
2023	3,004,464	2040	3,576,764	2057	4,070,373
2024	3,038,700	2041	3,607,873	2058	4,099,854
2025	3,073,017	2042	3,638,534	2059	4,129,565
2026	3,107,467	2043	3,668,843	2060	4,159,786
2027	3,142,106	2044	3,698,387	2061	4,190,471
2028	3,176,693	2045	3,727,544	2062	4,221,156
2029	3,211,546	2046	3,756,476	2063	4,251,841
2030	3,246,307	2047	3,784,965	2064	4,282,525
2031	3,281,031	2048	3,813,481	2065	4,313,210
2032	3,315,447	2049	3,841,619	2066	4,343,895
2033	3,349,236	2050	3,870,120		

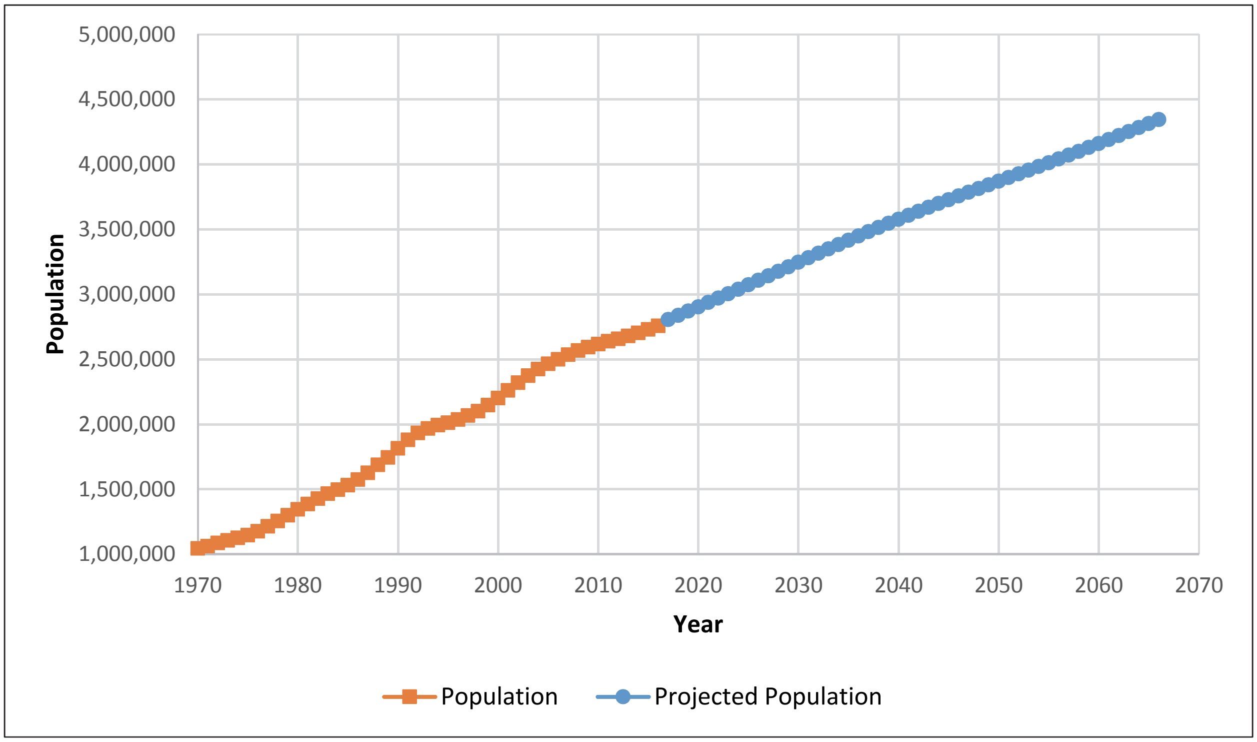

Figure 7. Actual and projected population of the Greater Sacramento Area P-C Region for years 1970 to 2066

PROJECTED AGGREGATE DEMAND THROUGH THE YEAR 2066

The population projection and average annual per capita consumption rate, calculated for years 1970 to 2016, were used to forecast demand for construction aggregate within the GSA P-C Region in the years 2017 to 2066. The average annual per capita consumption rate of 7.6 tons was multiplied by the projected population for each year to estimate the projected aggregate demand shown in Table 9. Historical aggregate consumption and the projected aggregate demand are plotted together in Figure 8.

Table 9. Projected annual aggregate demand in the Greater Sacramento Area P-C Region

Year	Projected Population	Per Capita Rate	Annual Demand (tons)	Year	Projected Population	Per Capita Rate	Annual Demand (tons)
2017	2,805,703	7.6	21,323,341	2042	3,638,534	7.6	27,652,858
2018	2,837,969	7.6	21,568,567	2043	3,668,843	7.6	27,883,207
2019	2,870,555	7.6	21,816,217	2044	3,698,387	7.6	28,107,743
2020	2,903,388	7.6	22,065,747	2045	3,727,544	7.6	28,329,335
2021	2,936,984	7.6	22,321,081	2046	3,756,476	7.6	28,549,218
2022	2,970,532	7.6	22,576,043	2047	3,784,965	7.6	28,765,734
2023	3,004,464	7.6	22,833,930	2048	3,813,481	7.6	28,982,459
2024	3,038,700	7.6	23,094,117	2049	3,841,619	7.6	29,196,307
2025	3,073,017	7.6	23,354,930	2050	3,870,120	7.6	29,412,913
2026	3,107,467	7.6	23,616,752	2051	3,898,607	7.6	29,629,413
2027	3,142,106	7.6	23,880,008	2052	3,926,720	7.6	29,843,070
2028	3,176,693	7.6	24,142,865	2053	3,955,115	7.6	30,058,872
2029	3,211,546	7.6	24,407,748	2054	3,983,439	7.6	30,274,139
2030	3,246,307	7.6	24,671,934	2055	4,012,248	7.6	30,493,088
2031	3,281,031	7.6	24,935,837	2056	4,041,287	7.6	30,713,783
2032	3,315,447	7.6	25,197,395	2057	4,070,373	7.6	30,934,834
2033	3,349,236	7.6	25,454,195	2058	4,099,854	7.6	31,158,889
2034	3,382,578	7.6	25,707,595	2059	4,129,565	7.6	31,384,691
2035	3,415,951	7.6	25,961,229	2060	4,159,786	7.6	31,614,377
2036	3,449,023	7.6	26,212,578	2061	4,190,471	7.6	31,847,581
2037	3,481,580	7.6	26,460,009	2062	4,221,156	7.6	32,080,785
2038	3,513,677	7.6	26,703,946	2063	4,251,841	7.6	32,313,989
2039	3,545,507	7.6	26,945,853	2064	4,282,525	7.6	32,547,192
2040	3,576,764	7.6	27,183,408	2065	4,313,210	7.6	32,780,396
2041	3,607,873	7.6	27,419,838	2066	4,343,895	7.6	33,013,600
				Cumulative Demand:			**1,367,423,634**

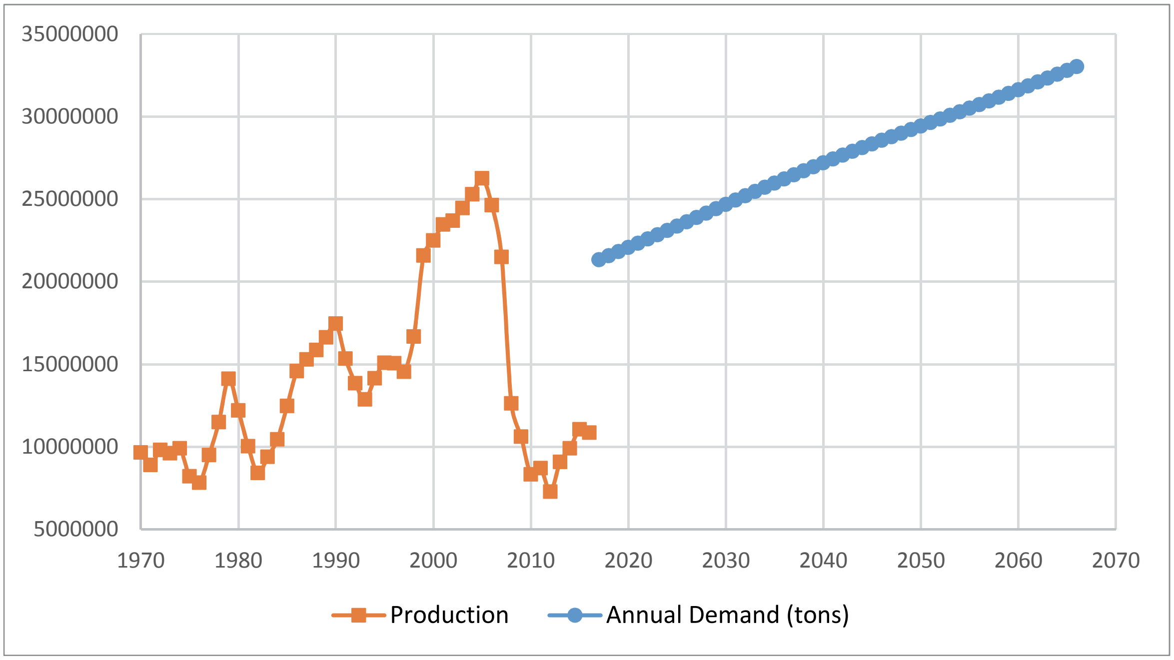

Figure 8. Historical aggregate consumption and projected annual aggregate demand in the Greater Sacramento Area P-C Region

This projection shows that an estimated 1,367 million tons of aggregate will be needed to satisfy the future demand of the GSA P-C Region through the year 2066. Of this total, it is estimated that 65 percent, or 889 million tons, will be used for concrete aggregate, with the remainder being used in other construction aggregate products. This percentage is based on estimates of current concrete aggregate usage provided by operators and compilation of information in source reports and USBM records.

COMPARISON OF THE 50-YEAR AGGREGATE DEMAND WITH CURRENT AGGREGATE RESERVES

The term “reserves” is used herein to refer to identified mineral resources that are permitted to be mined. Generally, this implies the operator possesses a current permit and reclamation plan approved by the lead agency.

The amount of concrete aggregate reserves in the GSA P-C Region was calculated based on review of lead agency permit files, approved reclamation plans, and consultation with planners and industry representatives. Total concrete aggregate reserves in the P-C Region are estimated to be approximately 1,446 million tons as of 2017 (Table 10). These reserves exceed the 50 year projected demand of 1,367 million tons by 79 million tons, equivalent to a few years of aggregate demand. It is important to note that not all aggregate reserves may be minable under the present permits because of operating restrictions or permit expiration dates.

The projected lifespan of the aggregate reserves assumes that mining of these reserves continues at the calculated per capita rate until they are depleted. Several factors besides population growth could change both the rate of utilization and the availability of these identified aggregate reserves. Unforeseen events such as massive urban renewal, infrastructure projects, reconstruction in the wake of a disaster, or major economic recessions or expansions could all impact the rate of aggregate consumption. Changing mine regulations, development of mining lands, and permitting of new mines could all affect availability of aggregate reserves.

Table 10. Summary of Aggregate Resources, Reserves, Projected 50-year Demand, and Depletion Date for the Greater Sacramento Area P-C Region

Estimated Concrete-Grade Aggregate Resources	4,334 mt
Concrete-Grade Aggregate Permitted Reserves	1,446 mt
Projected 50-year Demand for All Grades of Construction Aggregate	1,367 mt
Estimated Years Until Depletion of Current Concrete-Grade Aggregate Reserves	> 50 years

mt: million tons

ECONOMIC, SOCIETAL, AND ENVIRONMENTAL COSTS OF INCREASING TRANSPORT DISTANCE

An important difference between construction aggregate and other non-fuel mineral commodities is the extent to which transportation contributes to its total economic, societal, and environmental cost. Construction aggregate is a low unit-value, high bulk-weight commodity – it is relatively cheap and heavy. If nearby sources do not exist, then transportation costs may significantly increase the cost of the aggregate by the time it reaches the consumer. In some cases, the cost of transporting aggregate can equal or exceed the base cost of the aggregate. Increased cost of aggregate translates to more expensive construction projects in both the public and private sectors.

Aggregate transportation incurs a variety of costs. Economic costs include the cost of fuel, vehicles and vehicle maintenance, labor, and road maintenance. Societal costs include damaged roads and increased traffic congestion due to increased truck traffic. Environmental costs include air pollution as greenhouse gas (GHG) such as CO_2, and particulate matter (PM) emissions. Transport distance is the fundamental control on all of these costs. Increasing transport distance increases the economic, societal, and environmental costs of aggregate.

All present-day modes of aggregate transport utilize fossil fuels as their energy source. GHGs and PM are byproducts of the combustion of fossil fuels. Thus, at the present time, the production and release of GHG and PM into the atmosphere is an unavoidable result of aggregate transport. However, the amount of GHG and PM produced is roughly proportional to the distance the aggregate is transported. Because transport distance is a fundamental control on the amount of GHG and PM that is produced, one of the most effective ways to reduce GHG and PM emissions is to reduce transport distance. Local aggregate sources are needed to minimize transport distance.

The GSA P-C Region is large. Aggregate resources and population are distributed widely within the region. For any given site of aggregate consumption, there are many potential aggregate sources. The distance between a given site of consumption and each potential aggregate source may vary by several hundred percent, or several tens of miles. The recognition, conservation, and permitting of local aggregate resources, by local lead agencies, maximizes the availability of nearby sources. This minimizes transport distance, and thereby minimizes the economic, societal, and environmental cost of aggregate to the inhabitants of the GSA P-C Region.

CHANGING MARKET DYNAMICS IN THE GREATER SACRAMENTO AREA P-C REGION

Established in the early history of California, the communities of the Sacramento region have undergone dramatic growth since the middle of the last century, with development between 1950 and 2010 creating almost nine tenths of Sacramento's current urbanized region (Wheeler and Beebe, 2011). Construction during this growth has been fed by a series of aggregate mines in the region. Though a small number of these mines are dispersed throughout the region, there are three conspicuous concentrations of mines: South of the American River in Sacramento, along Cache Creek near the western valley margin, and along the Yuba River near Yuba City-Marysville (Plate 2A). However, the geographic distribution of aggregate mines in the GSA, and the amount of aggregate supplied by each region, has changed with time as the population and urban areas have grown.

Commercial mining of construction aggregates in the Sacramento Region began in the first decade of the 20th century, as the need for materials for roads, highways, and other infrastructure developed (Tucker and Waring, 1917; Logan, 1925; Carlson, 1955). Many of the early sand and gravel operations in the Sacramento area were located within and adjacent to the American River between Folsom and Sacramento. Aggregate mining in the Cache Creek area and on the Yuba River near Yuba City-Marysville began in the first quarter of the 20th century (Bradley, 1917; O'Brien, 1950; Tucker and Waring, 1917).

The migration of aggregate mines with time in the GSA P-C Region reflects a gradual depletion or preclusion of the most desirable and economical deposits. As local deposits of clean, durable and well-graded alluvium become depleted, or access becomes precluded by change in land use, older and more weathered and friable alluvium, as well as dredge tailings with soil and old alluvium mixed in, have become economical for some uses.

Importation of aggregate from the Cache Creek and Yuba River production areas into the Sacramento area began several decades ago, to supplement deficiencies of various aggregate sizes and due to rising costs of local aggregate. However, importation from the Yuba River production area has greatly increased over the past few decades, as mines within the Sacramento area are increasingly unable to meet local demand. Presently, there is a large disparity between the spatial distribution of population, and that of resources and reserves (Table 11).

Table 11. Approximate proportions of Resources, Reserves, and Population, by region

Area	Resources	Reserves	Population
Sacramento	15%	23%	59%
Cache Creek	15%	5%	5%
Yuba City-Marysville	52%	46%	7%
All Other Areas	18%	27%	29%

Production of crushed stone from igneous and metamorphic bedrock near Folsom has been permitted and is expected to begin in the near future. As an aggregate source, crushed stone typically requires more costly processing than sand and gravel. When used as PCC aggregate, crushed stone, as compared to sand and gravel, typically also requires more cement paste in order to meet workability requirements, which further increases the cost. However, due to local depletion and preclusion of durable (and more economical) sand and gravel deposits, and the significant costs of transporting aggregate from more distant sources, hard rock crushed stone has become an economically viable and important source of concrete aggregate to the Sacramento area.

Significant utilization of the Folsom-American River dredge tailings for concrete aggregate, significant importation of aggregate from the Yuba River area, and utilization of local hard rock deposits, were all considered uneconomical only a few decades ago. They have become economically viable and important due to changing market conditions, depletion of local resources, population growth, and urbanization.

POTENTIAL ALTERNATIVE SOURCES OF AGGREGATE FOR THE GREATER SACRAMENTO AREA P-C REGION

Local Potential Concrete Aggregate Sources

In the foothills and mountains, areas classified as MRZ-3 and underlain by igneous, sedimentary and metamorphic rocks may, in the future, prove to host significant concrete aggregate resources.

Igneous intrusive (plutonic) rocks are exposed sporadically in the foothills, and are often classified as MRZ-3 and MRZ-2. For example, quartz diorite and monzonite underlie Sector 88, which is classified MRZ-2. Igneous intrusive rocks of the Rocklin and Penryn plutons are classified MRZ-3 in the area immediately north of Folsom Lake. Numerous other plutonic bodies are classified as MRZ-3. Further investigation may demonstrate that some of these MRZ-3 areas host significant concrete aggregate resources.

The auriferous gravels and hydraulic mine tailings derived from them are typically classified as MRZ-2 and MRZ-3 and may be useable as concrete aggregate in some cases. Further investigation may demonstrate that some of these deposits currently classified MRZ-3 host significant concrete aggregate resources.

Metavolcanic rocks, such as those underlying Sectors 54, 86, and 89, are common in the Sierra Nevada mountains and foothills. These rocks are classified as MRZ-2 where adequate information demonstrates their concrete aggregate resource potential. Significant additional areas of these rocks are classified as MRZ-3. Further investigation may demonstrate that some of these MRZ-3 areas host significant concrete aggregate resources.

Imported Aggregate

Construction aggregate has been imported to the GSA P-C Region from the Stockton-Lodi P-C Region (to the south) since at least the early 2000's. In 1988, the authors of the first MLC study of the Stockton-Lodi P-C Region (SR 160) determined that aggregate was exported to Amador, Calaveras, Contra Costa, and Alameda counties. In 2012, the authors of the second and most recent MLC study of the Stockton-Lodi P-C Region determined that, at least by the early 2000's, approximately 10% of the Mokelumne River production (within the Stockton-Lodi P-C Region) was exported to southern Sacramento County. This amounts to less than a few percent of the GSA P-C Region's total aggregate consumption. It is possible that a greater amount of aggregate will be imported into the GSA P-C Region in the future. However, the Stockton-Lodi P-C Region has three resource areas. Aggregate has only been exported to the GSA P-C Region from the northern resource area, because it is the closest and therefore has the lowest transport cost. At the same time, the majority of aggregate resources are in the two more southern resource areas. Thus, the Stockton-Lodi P-C Region aggregate resources that are within a reasonable transport distance of the GSA P-C Region are relatively minor, and are therefore unlikely to become a more significant source of aggregate to the GSA P-C Region in the future.

No construction aggregate is known to have been imported from the San Francisco Bay Area into the GSA P-C Region, historically. However, it is possible that aggregate could be transported by barge, railway, or truck, from the Bay Area into the GSA P-C Region in the future. MLC studies of construction aggregate resources have been conducted for the North San Francisco Bay P-C Region (SR 205, 2013) and South San Francisco Bay P-C Region (OFR 96-03, 1996). These studies determined that essentially no material is exported to neighboring regions. Rather, both P-C Regions rely on imports to meet construction aggregate demand. Given the large populations and resultant demand for aggregate in these areas, coupled with their relative scarcity of aggregate resources, it seems more likely that material would be exported from the GSA P-C Region into the San Francisco Bay area, rather than the other way around. Thus, the San Francisco Bay Area is unlikely to become a significant source of imported aggregate.

RECYCLED AGGREGATE

Concrete and slab asphalt from demolition of roads and structures may be processed to produce a recycled aggregate product. Recycled concrete and slab asphalt must be broken up in an energy-intensive process, and metal reinforcements in concrete must be cut. These processing costs, necessary to produce recycled aggregate, are substantial. Additionally, recycled aggregate products typically only meet specifications for relatively low-grade materials – the highest grade typically being aggregate base. Commonly, concrete recycling facilities are significant distances from the demolition debris source, which adds transportation costs. Recycling-on-site partly alleviates this cost, but has its own limitations, and is less common at present.

Despite these costs, during the past several decades, the recycling of concrete and slab asphalt demolition debris has increased within California. Unfortunately, no single entity records the statewide aggregate recycling volume per year, thus little data is available to assess this increasing trend. However, data from conversations with aggregate recyclers and relevant governmental entities indicates that this trend of increasing recycling has been more stepwise than linear.

Beginning with the passing of the landfill diversion law (AB 341) in 1989, which required that 25 percent of solid waste be diverted from landfills by 1995 and 50 percent by 2000, demolition debris producers and waste recipients (landfills) have been both pressured and incentivized to recycle concrete, slab asphalt, and other construction materials. Before this bill was introduced, the primary controllers on rate of recycling for these materials were general economic factors described above. After this bill was introduced, the primary controller became the simple availability and accessibility of recyclable demolition debris. Thus, it is most likely that, shortly after the introduction of this bill, concrete recycling rates increased sharply, in a stepwise manner, and moved to approach equilibrium with demolition rates.

In densely urbanized (built-out) areas, new construction typically requires demolition of pre-existing structures, which produces recycled aggregate material. Thus, in densely urbanized areas, construction (and demolition) activity strongly controls the rate of demolition debris recycling. This is not the case in sparsely-urbanized or non-urbanized areas, such as new home developments, where little or no pre-existing recyclable material is present. New construction in such sparsely- or non-urbanized areas produces little or no recycled aggregate.

PART VI – CONCLUSIONS

This Classification report re-evaluates previous MLC and mineral resource Sectors in the GSA P-C Region, recalculates the available resources, and identifies new mineral resource Sectors based on more recent information (Table 12). The compiled and updated MLC and the compiled and updated mineral resource Sectors are shown on Plates 1, 2A and 2B.

Table 12. Greater Sacramento Area P-C Region: Summary Table

Total Concrete Aggregate Resources	4,334 mt
Total Concrete Aggregate Reserves	1,446 mt
Population	2,757,399
Average Annual Per Capita Consumption	7.6 tons
Projected 50-Year Demand of Concrete Aggregate	889 mt
Years Until Depletion	> 50
Number of Concrete Aggregate Resource Sectors	94
Number of Concrete Aggregate Mines	30
Number of Mining Companies	13

mt: million tons

As of 2017, the P-C Region contained approximately 4,334 million tons of identified concrete aggregate resources, and 1,446 million tons of permitted concrete aggregate reserves.

Current valid aggregate resource Sectors (not urbanized or otherwise precluded) within the P-C Region have a combined area of 43,496 acres out of the P-C Region's 3,891,200 acre total area. This amounts to about one percent of the region. Reserve areas (from currently permitted mines) account for less than half of this 1 percent.

Based on available historic population and production data, and population projections, the P-C Region will need approximately 1,367 million tons of construction aggregate during the next 50 years. Of this projected demand, it is estimated that 65 percent, or approximately 889 million tons, must be suitable for use in concrete. The current concrete aggregate reserves of 1,446 million tons should last beyond the year 2066.

These numbers are estimates, and the actual lifespan of existing permitted reserves 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 and maintenance of major infrastructure, or rebuilding after a disaster such as an earthquake, could also deplete permitted reserves more rapidly than we have projected. Conversely, an economic downturn (recession) may reduce demand for a period of time, or new or expanded permits may be granted, thereby increasing the tonnage and lifespan of permitted reserves.

As mines close or reserves are depleted, the local demand for aggregate may be met in several ways:

- New mines, or expansions to existing mines, may be permitted, increasing the local supply of needed aggregate.
- Other mines in the region may increase production to fill the demand.
- Aggregate imports may increase.

Permitting of new mines, or expanding existing mines, maintains local production of needed construction aggregate. If other existing mines increase production to meet local demand, and no new mines or expansions are permitted, this would accelerate the overall depletion of local reserves. Aggregate imports and exports across the current P-C Region boundary have historically been very limited. If the P-C Region began to import more material, it could lead to further increases in the cost of aggregate and in the societal and environmental impacts associated with the transportation of aggregate.

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. Mining is often seen as a controversial land use during the permitting process. However, there are substantial 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. Planning for future construction aggregate needs in Cache Creek, Yuba City-Marysville, and Sacramento regions should not only take into account local needs, but also the needs of the region as a whole.

Relying on aggregate from distant source areas leads to more rapid depletion of reserves/resources in those areas, potentially contributing to price increases or aggregate shortages. In addition to the greater economic costs, there are often increased environmental and societal costs associated with transporting material from more distant sources when compared to utilization of local sources. The environmental impacts include higher emissions of greenhouse gases (such as CO_2), and particulate matter air pollution. The societal impacts include increased traffic congestion and road maintenance due to increased truck traffic. These environmental and societal impacts occur within the area of aggregate consumption, in the aggregate source area, and in areas through which the material is transported. Reliance on more distant sources may also place responsibility and authority for permitting in the hands of decision makers in other jurisdictions.

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APPENDIX A

Current Sector numbers correlated with source reports and source report ARA / Sector numbers.

This Report	Historical / Source Report		
Number	**Report**	**Type**	**Number**
1	SR 132	Sector	A-1
2	SR 132	Sector	A-2
3	SR 132	Sector	A-3
4	SR 132	Sector	A-4
5	SR 132	Sector	A-5
6	SR 132	Sector	A-6
7	SR 132	Sector	A-7
8	SR 132	Sector	A-8
9	SR 132	Sector	A-9
10	SR 132	Sector	B-1
11	SR 132	Sector	B-2
12	SR 132	Sector	B-3
13	SR 132	Sector	B-4
14	SR 132	Sector	B-5
15	SR 132	Sector	B-6
16	SR 132	Sector	B-7
17	SR 132	Sector	B-8
18	SR 132	Sector	B-9
19	SR 156	Sector	A-1
20	SR 156	Sector	A-2
21	SR 156	Sector	A-3
22	SR 156	Sector	A-4
23	SR 156	Sector	B-1
24	SR 156	Sector	B-2

This Report	Historical / Source Report		
Number	**Report**	**Type**	**Number**
25	SR 156	Sector	B-3
26	SR 156	Sector	B-4
27	SR 156	Sector	B-5
28	SR 156	Sector	B-6
29	SR 156	Sector	B-7
30	SR 156	Sector	C
31	SR 156	Sector	D-1
32	SR 156	Sector	D-2
33	SR 156	Sector	D-3
34	SR 156	Sector	D-4
35	SR 164	ARA	6
36	SR 164	ARA	6a
37	SR 164	ARA	13
38	SR 164	ARA	14
39	SR 164	ARA	15
40	SR 164	ARA	21
41	SR 164	ARA	22
42	OFR 95-10	ARA	1
43	OFR 95-10	ARA	2
44	OFR 95-10	ARA	3
45	OFR 95-10	ARA	4
46	OFR 95-10	ARA	5
47	OFR 95-10	ARA	6
48	OFR 95-10	ARA	7

This Report	Historical / Source Report		
Number	**Report**	**Type**	**Number**
49	OFR 95-10	ARA	ARA 08
50	OFR 95-10	ARA	ARA 09
51	OFR 95-10	ARA	ARA 10
52	OFR 95-10	ARA	ARA 11
53	OFR 95-10	ARA	ARA 12
54	OFR 95-10	ARA	ARA 13
55	OFR 99-09	ARA	1
56	OFR 99-09	ARA	2
57	OFR 99-09	ARA	3
58	OFR 99-09	ARA	4
59	OFR 99-09	ARA	5
60	OFR 99-09	ARA	6
61	OFR 99-09	ARA	7
62	OFR 99-09	ARA	8
63	OFR 99-09	ARA	9
64	OFR 99-09	ARA	10
65	OFR 99-09	ARA	11
66	OFR 99-09	ARA	12
67	OFR 99-09	ARA	13
68	OFR 99-09	ARA	14
69	OFR 99-09	ARA	15
70	OFR 99-09	ARA	16
71	OFR 99-09	ARA	17
72	OFR 99-09	ARA	18

This Report	Historical / Source Report		
Number	**Report**	**Type**	**Number**
73	OFR 99-09	ARA	19
74	OFR 99-09	ARA	20
75	OFR 99-09	ARA	21
76	OFR 99-09	ARA	22
77	OFR 2000-03	ARA	01a
78	OFR 2000-03	ARA	01b
79	OFR 2000-03	ARA	2
80	OFR 2000-03	ARA	3
81	OFR 2000-03	ARA	6
82	OFR 2000-03	ARA	7
83	OFR 2000-03	ARA	8
84	OFR 2000-03	ARA	9
85	OFR 2000-03	ARA	10
86	(This Report)	Sector	
87	(This Report)	Sector	
88	(This Report)	Sector	
89	(This Report)	Sector	
90	(This Report)	Sector	
91	(This Report)	Sector	
92	(This Report)	Sector	
93	(This Report)	Sector	
94	(This Report)	Sector	

APPENDIX B

Factors used to determine Resource Tonnages (not including indications of irregular pit configurations or historic extraction).

Sector Number	Total Area (ac)	Area Lost (acres)	Deposit Thickness (yd.)	Deposit Density (t/yd3)	Percent Waste	Current Resources (mt)
1	1,238		***	1.40	15	161
2	1,026		***	1.40	15	***
3	35		26.67	1.40	15	5
4	29		26.67	1.40	15	5
5	2,490		***	1.40	15	339
6	1,611		40.00	1.40	15	371
7	1,316	3	***	1.40	15	173
8	275		6.67	1.55	15	12
9	69		6.67	1.55	15	3
10	56		20.00	1.70	15	8
11	540		***	1.70	15	75
12	21		16.67	1.70	15	2
13	1,037		16.67	1.70	15	121
14	3,306		26.67	1.70	15	617
15	6		6.67	1.70	15	0
16	249		20.00	1.70	15	35
17	794		16.67	1.70	15	93
18	11		16.67	1.70	15	1
19	686	92(i)	5.00	1.65	20	19
20	4,883	18 + 1,521(i)	10.00	1.65	20	164
21	203	17(i)	2.67	1.65	25	3
22	53		6.67	1.65	25	2
23	789		10.00	1.65	25	47
24	1,308		10.00	1.65	25	78
25	61		8.33	1.65	25	3
26	131		8.33	1.65	25	7
27	68		8.33	1.65	25	3
28	629		10.00	1.65	25	38
29	353		5.00	1.65	25	11
30	3,590	130 + 416(i)	***	1.65	25	154
31	630	359(i)	***	1.65	20	2

*** Proprietary; NR = Not Reported; (i) = Acreage in-channel (see Cache Creek Sector resources discussion);
t = tons; mt = million tons; yd. = yards; yd3 = cubic yards; ac = acres.
(N/A) – S = Not Applicable – Resources estimated from stream replenishment, not from deposit volume
(GIS) = Resources estimated from volumetric calculation of irregular deposit shape, including irregular topography, in GIS.

Sector Number	Total Area (ac)	Area Lost (ac)	Deposit Thickness (yd.)	Deposit Density (t/yd3)	Percent Waste	Current Resources (mt)
32	3,467	517(i)	8.33	1.65	25	118
33	60		8.33	1.65	25	3
34	86		8.33	1.65	25	4
35	233		10.00	1.50	20	14
36	13		***	1.50	20	1
37	164		(N/A) - S	1.50	10	18
38	80		(N/A) - S	1.50	10	9
39	101		(N/A) - S	1.50	10	12
40	43		8.33	1.50	10	2
41	33		8.33	1.50	10	2
42	480		***	***	***	***
43	852		***	***	***	***
44	261	261	NR	NR	NR	NR
45	398		***	1.55	15	12
46	123		10.00	1.55	10	8
47	305	305	5.73	1.55	10	0
48	948		3.12	1.55	10	20
49	407	87	***	1.55	10	8
50	98		10.00	1.55	10	7
51	260	260	5.00	1.55	10	0
52	469		39.00	2.20	10	175
53	21	21	58.33	2.30	10	0
54	395		***	2.20	10	220
55	72		8.33	1.71	15	4
56	575		8.33	1.71	15	34
57	49		6.67	1.71	15	2
58	336		***	***	***	***
59	176		***	***	***	***
60	273		***	***	***	***
61	80		6.67	1.71	20	4
62	106		6.67	1.71	20	5

*** Proprietary; NR = Not Reported; (i) = Acreage in-channel (see Cache Creek Sector resources discussion);
t = tons; mt = million tons; yd. = yards; yd3 = cubic yards; ac = acres.
(N/A) – S = Not Applicable – Resources estimated from stream replenishment, not from deposit volume
(GIS) = Resources estimated from volumetric calculation of irregular deposit shape, including irregular topography, in GIS.

Sector Number	Total Area (acres)	Area Lost (acres)	Deposit Thickness (yd.)	Deposit Density (t/yd3)	Percent Waste	Current Resources (mt)
63	257	2	6.67	1.71	20	11
64	103		6.67	1.71	25	4
65	153	81	6.67	1.71	25	3
66	131	88	6.67	1.71	25	2
67	141		8.33	1.67	30	7
68	111		8.33	1.67	30	5
69	158		8.33	1.67	30	7
70	264		***	1.67	30	20
71	235	235	***	1.71	15	0
72	576		***	1.71	15	1
73	243		***	1.67	30	2
74	747	747	***	1.71	15	0
75	52		8.33	1.71	15	3
76	97	97	***	1.71	15	0
77	119		***	***	***	***
78	8		***	***	***	***
79	22		***	***	***	***
80	60	60	***	2.24	5	0
81	10		(GIS)	2.20	10	2
82	27		(GIS)	2.20	10	6
83	39		(GIS)	2.25	10	18
84	6		6.22	2.20	10	0
85	16	16	33.33	2.20	15	0
86	80		(GIS)	2.20	10	42
87	595		***	***	***	***
88	874		***	2.35	35	***
89	206		(GIS)	2.20	10	95
90	668		***	***	***	***
91	293		16.00	1.40	15	27
92	561		***	1.40	30	***
93	294		***	1.40	30	***
94	309		***	1.40	20	***

*** Proprietary; NR = Not Reported; (i) = Acreage in-channel (see Cache Creek Sector resources discussion);
t = tons; mt = million tons; yd. = yards; yd3 = cubic yards; ac = acres.
(N/A) – S = Not Applicable – Resources estimated from stream replenishment, not from deposit volume
(GIS) = Resources estimated from volumetric calculation of irregular deposit shape, including irregular topography, in GIS.

APPENDIX C

Descriptions of all permitted aggregate mines in the Greater Sacramento Area P-C Region.

Map No.	Mine Name	Mine Operator
Mine ID	County	Aggregate Grade
Mine Description		

1	Butte Sand & Gravel	Butte Sand & Gravel
91-51-0001	Sutter	Base
This mine is located on the southern flank of the Sutter Buttes, immediately north of South Butte Road, and approximately three miles west of the town of Sutter. Volcanic rocks and volcaniclastic sediments are mined to produce a range of construction aggregate products, including base, plaster sand, and decorative rock.		
2	**Bihlman Butte Rock**	**Bihlman Butte Rock**
91-51-0002	Sutter	Base
This mine is located on the northern flank of the Sutter Buttes, immediately south of Pennington Road and approximately six miles west of Live Oak. Volcanic rocks and volcaniclastic sediments are mined to produce primarily base aggregate and decorative rock.		
3	**Simpson Lane**	**Orchard Growers**
91-58-0025	Yuba	Concrete
This mine is located downstream of the Hammonton dredge field, approximately two miles east of the town of Marysville. Quaternary age sand of the Yuba River is intermittently mined to produce PCC-grade aggregate. This operation involves mining of the upper several feet of alluvium, which is then replaced with material better suited to agricultural use.		
4	**Kino Aggregates**	**Dantoni Pit**
91-58-0011	Yuba	Concrete
This mine is located approximately five miles east-northeast of the town of Marysville, at the western margin of the Hammonton dredge field. Dredge tailings sourced from Quaternary alluvium of the Yuba River are mined to produce PCC-grade aggregate.		
5	**Hallwood Plant**	**Knife River Construction**
91-58-0002	Yuba	Concrete
This mine is located at the margin of the Hammonton dredge field, approximately six miles east-northeast of the town of Marysville. Pliocene(?) to Quaternary age alluvium of the Yuba River is mined to produce PCC-grade aggregate. Historically, dredge tailings sourced from said native alluvium was also mined to produce PCC-grade aggregate.		

<table>
<tr><td>6</td><td>Hallwood Plant</td><td>Teichert Aggregates</td></tr>
<tr><td>91-58-0006</td><td>Yuba</td><td>Concrete</td></tr>
<tr><td colspan="3">This mine is located at the margin of the Hammonton dredge field, approximately seven miles east-northeast of the town of Marysville. Dredge tailings sourced from Pliocene(?) to Quaternary age alluvium of the Yuba River are mined to produce PCC-grade aggregate.</td></tr>
<tr><td>7</td><td>Western Aggregates</td><td>Western Aggregates</td></tr>
<tr><td>91-58-0001</td><td>Yuba</td><td>Concrete</td></tr>
<tr><td colspan="3">This mine is located within the Hammonton dredge field, approximately eight miles east-northeast of the town of Marysville. Dredge tailings sourced from Pliocene(?) to Quaternary alluvium of the Yuba River are mined to produce PCC-grade aggregate.</td></tr>
<tr><td>8</td><td>Marysville Property</td><td>Teichert Aggregates</td></tr>
<tr><td>91-58-0019</td><td>Yuba</td><td>Concrete</td></tr>
<tr><td colspan="3">This mine is located approximately seven miles east-northeast of the town of Marysville, south and adjacent to the Hammonton dredge field. Quaternary age native alluvium of the Yuba River is mined to produce PCC-grade aggregate.</td></tr>
<tr><td>9</td><td>Sperbeck Quarry</td><td>Nordic Industries</td></tr>
<tr><td>91-58-0004</td><td>Yuba</td><td>Base & Riprap</td></tr>
<tr><td colspan="3">This mine is located approximately 12 miles northeast of Marysville, immediately southeast of Spring Valley Road, a little less than four miles north of its intersection with Browns Valley Road. Greenstone of the foothills metamorphic belt is mined to produce riprap, base aggregate, and other products.</td></tr>
<tr><td>10</td><td>Stringer Pit</td><td>Silica Resources</td></tr>
<tr><td>91-58-0022</td><td>Yuba</td><td>Concrete</td></tr>
<tr><td colspan="3">This mine is located on the Yuba River, approximately 13 miles east-northeast of the town of Marysville. Young, native alluvium of the Yuba River is mined to produce a range of industrial sand products, and PCC-grade aggregate.</td></tr>
<tr><td>11</td><td>Parks Bar Quarry</td><td>Nordic Industries</td></tr>
<tr><td>91-58-0013</td><td>Yuba</td><td>Base & Riprap</td></tr>
<tr><td colspan="3">This mine is located approximately 15 miles east-northeast of Marysville, on the north shore of the Yuba River, just upstream of the Highway 20 bridge crossing. Metavolcanic rocks of the Foothills Metamorphic Belt are mined to produce riprap, and lesser base aggregate and other products.</td></tr>
</table>

12	**Ridge Rock Quarry**	**Ridge Rock Quarry**
91-29-0010	Nevada	Base
This mine is located immediately north of Pleasant Valley Road, approximately nine miles north-northeast of Grass Valley, and four miles southwest of San Juan. Hydraulic gold mining occurred on site, historically. Mesozoic igneous rocks, hydraulic mine tailings, and auriferous gravels, are mined to produce base-grade aggregate, decomposed granite, and other products.		
13	**Greenhorn Gravel Plant**	**Hansen Brothers Enterprises**
91-29-0006	Nevada	Concrete
This mine is located approximately seven miles east-southeast of the town of Grass Valley, on Greenhorn Creek, approximately three miles upstream of Rollins Reservoir. Pleistocene(?) to Holocene alluvium of Greenhorn Creek is mined to produce concrete-grade aggregate.		
14	**Meadow Vista Quarry**	**Teichert Aggregates**
91-31-0004	Placer	Concrete
This mine is located approximately 10 miles north-northeast of Auburn, where the Bear River flows into Lake Combie. Native alluvium of the Bear River, and metavolcanic bedrock of the Foothills Metamorphic Belt are mined to produce PCC-grade aggregate.		
15	**Patterson Sand and Gravel**	**Cemex**
91-31-0009	Placer	Concrete
This mine is located approximately four miles east of Wheatland, on the Bear River near where it flows out into the Sacramento Valley and deposits sediment on a substantial fan. Native alluvium of the Bear River alluvial fan is mined to produce PCC-grade aggregate.		
16	**Teichert Aggregates Facility Lincoln**	**Teichert Aggregates**
91-31-0021	Placer	Concrete
This mine is located approximately five miles north-northwest of the town of Lincoln, on the flood plain of Coon Creek. Alluvium of Coon Creek and granitic bedrock is intended to be mined to produce concrete-grade aggregate.		
17	**Cool Cave Quarry**	**Teichert Aggregates**
91-09-0005	El Dorado	Concrete
This mine is located on Highway 49, immediately south of the Middle Fork of the American River, one and one-half miles upstream of the confluence of the North and Middle Forks of the American River, and three miles east of Auburn. A relatively large Paleozoic limestone body and metavolcanic rocks within the Foothills Metamorphic Belt, and later diorite intrusions, are mined to produce limestone for agricultural and industrial uses, and crushed stone for base aggregate, riprap, and concrete aggregate.		

18	**Bear Creek Quarry**	**Butte Equipment Rental**
91-09-0001	El Dorado	Base
This mine is located approximately three miles south of Georgetown and three miles northeast of Garden Valley. Serpentinite is mined to produce base aggregate and other products.		
19	**Diamond Quarry**	**Sierra Rock**
91-09-0003	El Dorado	Concrete
This mine is located approximately three miles south-southeast of Placerville. Limestone and other metasedimentary and metamorphic rocks of the Foothills Metamorphic Belt are mined to produce PCC-grade aggregate and other products.		
20	**Snow's Quarry**	**ACT Associates**
91-09-0012	El Dorado	Base
This mine is located adjacent to the east of Snows Road, approximately two miles south of Camino. Auriferous gravels are mined to produce base aggregate and other products.		
21	**Van Vleck Rancho Sand and Gravel Site**	**Van Vleck Ranching & Resources**
91-34-0001	Sacramento	Base
This mine is located adjacent to the south of Jackson Highway, approximately two miles east-southeast of Rancho Murieta. Pliocene and probably older alluvium is mined to produce base aggregate and other products.		
22	**Stoneridge Quarry**	**Tsakopoulos**
91-34-0057	Sacramento	Concrete
This mine is located approximately three miles southeast of the intersection of White Rock Road and Scott Road, south of the boundary of the City of Folsom. Monzonite to quartz diorite is expected to be mined to produce PCC-grade aggregate.		
23	**Teichert Quarry**	**Teichert Aggregates**
91-34-0049	Sacramento	Concrete
This mine is located approximately two miles southeast of the intersection of White Rock Road and Scott Road, south of the boundary of the City of Folsom. Monzonite to quartz diorite is expected to be mined to produce PCC-grade aggregate.		

24	**East Mining Site / Grantline**	**Teichert Aggregates**
91-34-0039	Sacramento	Concrete
This mine is located just over a mile southeast of the intersection of White Rock and Grant Line Roads, in Folsom. Dredge tailings are mined to produce concrete-grade aggregate.		
25	**Clark Site, a.k.a. White Rock Road Pit**	**Teichert Aggregates**
91-34-0023	Sacramento	Base
This mine is located approximately one mile southwest of the intersection of White Rock Road and Grant Line Road. Dredge tailings and possibly Pliocene and younger native alluvium are mined to produce base aggregate.		
26	**White Rock - Rio Del Oro Mining Project**	**Granite Construction Co.**
91-34-0048	Sacramento	Base
This mine is located adjacent to the south of White Rock Road, approximately two miles east of Sunrise Boulevard. Dredge tailings are mined to produce base aggregate.		
27	**Grantline West**	**Teichert Aggregates**
91-34-0047	Sacramento	Concrete
This mine is located in Rancho Cordova, approximately three miles southeast of the intersection of Highway 50 and Sunrise Blvd. Dredge tailings of the Folsom—American River dredge field, sourced from alluvium of the Pliocene Laguna Formation, are mined to produce PCC-grade aggregate.		
28	**Grech Ranch Site**	**Triangle Rock Products, Inc.**
91-34-0038	Sacramento	Concrete
This mine is located in an unincorporated part of Sacramento County immediately west of Sunrise Blvd and approximately seven miles south of Highway 50. Pleistocene to Holocene(?) age alluvium is mined to produce PCC-grade aggregate.		
29	**Aspen VIII and IX**	**Teichert Aggregates**
91-34-0053	Sacramento	Concrete
These mines are located just south of Jackson Highway and east of Bradshaw Road, in Sacramento. Pliocene alluvium of the Laguna Formation is intended to be mined to produce concrete-grade aggregate. Though referred to as Aspen VIII and Aspen IX, they are grouped together because they have a common CA Mine ID and mine permit.		

30	**Aspen VI**	**Teichert Aggregates**
91-34-0037	Sacramento	Concrete
This mine is located just north of Jackson Highway and east of Bradshaw Road, in Sacramento. Pleistocene age alluvium of the Riverbank Formation is mined to produce PCC-grade aggregate.		
31	**Aspen V South**	**Teichert Aggregates**
91-34-0046	Sacramento	Concrete
This mine is located about a half mile northeast of the intersection of Jackson Highway and Bradshaw Road. This site is underlain by Quaternary alluvium of the Riverbank Formation, which was mined to produce PCC-grade aggregate.		
32	**Aspen IV South Site**	**Teichert Aggregates**
91-34-0045	Sacramento	Concrete
This mine is located about a half mile southeast of the intersection of Jackson Highway and Bradshaw Road. The site is underlain by alluvium of the Riverbank Formation and younger alluvium of the active Morrison Creek, which runs through the mine site. This alluvium is mined to produce PCC-grade aggregate.		
33	**Vineyard I**	**Granite Construction Co.**
91-34-0043	Sacramento	Concrete
This mine is located four miles southwest of Mather AFB and immediately adjacent to Morrison Creek. Pleistocene alluvium of the Riverbank Formation is mined to produce PCC-grade aggregate.		
34	**Perkins Pit**	**Granite Construction Co.**
91-34-0021	Sacramento	Concrete
This mine is located in the City of Sacramento, approximately one mile south of the American River and five miles southeast of the downtown area. Pleistocene alluvium of the Riverbank Formation was mined to produce PCC-grade aggregate.		
35	**Schwarzgruber**	**Teichert Aggregates**
91-57-0006	Yolo	Concrete
This mine is located on Cache Creek, approximately five miles west of the town of Woodland. Pleistocene alluvium of the Cache Creek, present in river terraces, is mined to produce PCC-grade aggregate.		

36	**Woodland Plant**	**Teichert Aggregates**
91-57-0002	Yolo	Concrete
This mine is located on Cache Creek, approximately five miles west of the town of Woodland. Pleistocene alluvium of the Cache Creek, present in river terraces, is mined to produce PCC-grade aggregate.		
37	**Solano Concrete Off-Channel**	**Cemex**
91-57-0008	Yolo	Concrete
This mine is located on Cache Creek, approximately 10 miles west of the town of Woodland. Pleistocene alluvium of the Cache Creek, present in river terraces, is mined to produce PCC-grade aggregate.		
38	**Esparto Reiff Property**	**Teichert Aggregates**
91-57-0011	Yolo	Concrete
This mine is located on Cache Creek, approximately 12 miles west of the town of Woodland. Pleistocene alluvium of the Cache Creek, present in river terraces, is mined to produce PCC-grade aggregate.		
39	**Cache Creek Off-Channel**	**Syar Industries**
91-57-0015	Yolo	Concrete
This mine is located on Cache Creek, approximately 12 miles west of the town of Woodland. Pleistocene alluvium of the Cache Creek, present in river terraces, is mined to produce PCC-grade aggregate.		
40	**Capay**	**Granite Construction Co.**
91-57-0014	Yolo	Concrete
This mine is located on Cache Creek, approximately 14 miles west of the town of Woodland. Pleistocene alluvium of the Cache Creek, present in river terraces, is mined to produce PCC-grade aggregate.		
41	**Nelson Hill Quarry**	**Oliver De Silva**
91-48-0001	Solano	Base
This mine is located on the summit of Nelson Hill, immediately south of Interstate 80 and east of Cordelia Junction. Miocene to Pliocene age mafic lava flows and flow breccias of the Sonoma Volcanics are mined to produce base aggregate and other products.		