



2005 Minerals Yearbook

ARIZONA

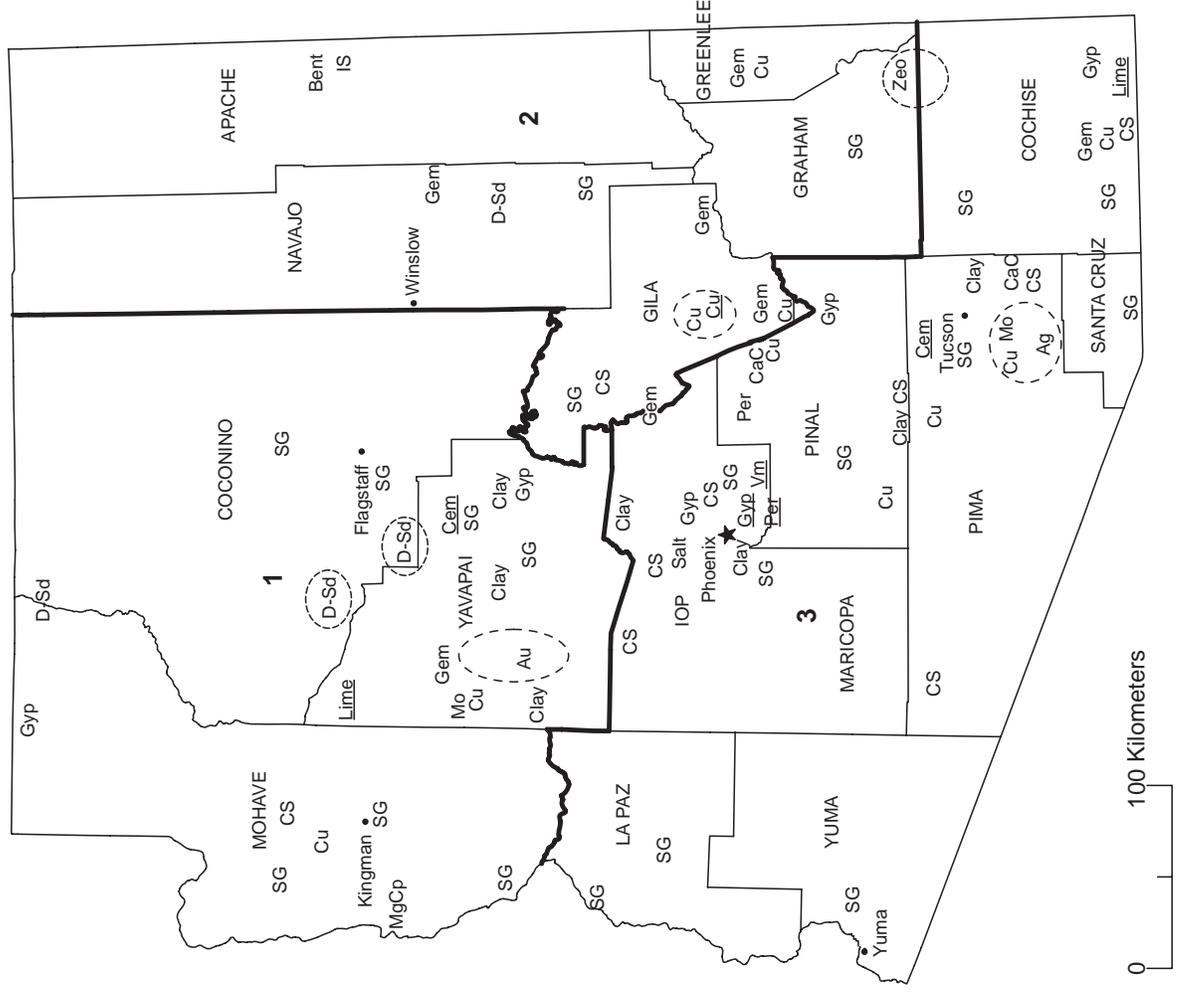
ARIZONA

LEGEND

- County boundary
- ★ Capital
- City
- 1 — Crushed stone/sand and gravel districts

MINERAL SYMBOLS (Major producing areas)

- Ag Silver
- Au Gold
- Bent Bentonite
- CaC Calcium carbonate
- Cem Cement plant
- Clay Common clay
- CS Crushed stone
- Cu Copper
- Cu Copper plant
- D-Sd Dimension sandstone
- Gem Gemstones
- Gyp Gypsum
- Gyp Gypsum plant
- IOP Iron Oxide Pigments
- IS Industrial sand
- Lime Lime plant
- MgCp Magnesium Compounds
- Mo Molybdenum
- Per Perlite
- Per Perlite plant
- Salt Salt
- SG Construction sand and gravel
- Vm Vermiculite plant
- Zeo Zeolites
- (---) Concentration of mineral operations



THE MINERAL INDUSTRY OF ARIZONA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Geological Survey and the Arizona Department of Mines and Mineral Resources for collecting information on all nonfuel minerals.

In 2005, Arizona's nonfuel raw mineral production was valued¹ at \$4.35 billion, based upon annual U.S. Geological Survey (USGS) data. This was a \$1 billion, or nearly 30% increase from the State's total nonfuel mineral value in 2004, which then had climbed \$1.17 billion, accounting for a 53.7% increase from 2003 to 2004. Arizona led the Nation in total nonfuel mineral production value, rising from third in rank in 2004 among the 50 States, accounting for nearly 7.9% of the U.S. total.

Arizona continued to be the Nation's leading copper-producing State in 2005 and accounted for nearly 61% of total U.S. copper mine production and value. Copper was the State's foremost nonfuel mineral produced, accounting for nearly 61% of Arizona's total nonfuel mineral production value, followed in descending order of value by molybdenum concentrates, construction sand and gravel (with nearly 12% of the State's total value), cement (portland and masonry), crushed stone (more than 1.5% of the value), and lime (table 1).

Arizona's substantial increase primarily resulted from the increased values of copper, molybdenum concentrates, and construction sand and gravel. Although small decreases in production took place for the first two mineral commodities, their values rose by \$506 million and significantly more than \$300 million, respectively. With a slightly less than 7% increase in construction sand and gravel production, its value increased by \$86 million, or by 20%. Smaller yet substantial increases also took place in cement and lime. With a significant increase in unit value, the total value of cement rose by about 12%, while a 65% increase in lime production resulted in the commodity's value increasing almost as much, up by about 62%. The largest decrease in value was in that of crushed stone, down by \$6.6 million, although its unit value rose by more than 7%. Lesser, although significant decreases, also took place in the production and values of dimension sandstone and salt (table 1).

The prices for copper and of molybdenum concentrates markedly rose during the past 2 years, but the trend toward the substantial rise in molybdenum concentrate prices began in December 2002 and continued on through 2003 and 2005. For example, as reported in Platts Metals Week (in dollars per pound of contained molybdenum) the annual average price of molybdenic oxide rose from \$8.27 per kilogram (kg) in 2002 to \$11.75 per kg in 2003 to \$36.76 per kg in 2004 and nearly doubled to \$70.10 per kg in 2005. Molybdenic oxide reached its alltime high of \$80.75 per kg in May 2005 and then followed a generally

¹The terms "nonfuel mineral production" and related "values" encompass variations in meaning, depending upon the mineral products. Production may be measured by mine shipments, mineral commodity sales, or marketable production (including consumption by producers) as is applicable to the individual mineral commodity.

All 2005 USGS mineral production data published in this chapter are those available as of December 2006. All USGS Mineral Industry Surveys and USGS Minerals Yearbook chapters—mineral commodity, State, and country—can be retrieved over the Internet at URL <http://minerals.usgs.gov/minerals>.

downward trend for the rest of the year to close at \$58.60 per kg in December 2005. The Platts Metals Week average producer price for copper rose from \$0.76 per pound in 2002 to \$1.73 per pound in 2005.

In 2005, Arizona continued to lead the Nation in the quantity of copper produced and remained second in gemstones (based on value), third in the production of crude perlite, fourth in zeolites, sixth overall in dimension stone (dimension sandstone), and seventh in silver. The State rose in rank in three nonfuel mineral commodities: to 1st from 2d in pumice and pumicite, 2d from 3rd in construction sand and gravel, and to 10th from 12th in the production of lime. Arizona decreased to third from first in molybdenum concentrates and continued to be a significant producer of, in descending order of value, portland cement, crushed stone, and masonry cement.

The Arizona Department of Mines and Mineral Resources² (ADMMR) provided the following narrative information. Data presented in ADMMR reports may differ somewhat from data reported by the USGS in table 1.

Commodity Review

Industrial Minerals

International aggregate producer Lafarge North America Inc. entered the Phoenix metropolitan sand and gravel market by acquiring Sun State Rock and Materials Corporation in the southwest valley, an area with great future growth potential. Lafarge North America Inc. has an interest in additional sites for exploration and purchase. Vulcan Materials Co. continued its expansion in Arizona by acquiring New West Materials Co. LLC, whose assets included three aggregate and asphalt facilities in the Phoenix area and two aggregate and asphalt facilities in Tucson. The Tucson operations were Vulcan's first in that market.

Metals

Copper and Molybdenum.—The rise in copper and molybdenum prices contributed significantly to the dramatic rise in the value of the State's mineral production. Shortages of mining truck tires, pit flooding, and labor strikes resulted in a 4.4% decline in copper production for 2005 despite the rise in copper prices and byproduct credits.

Five Phelps Dodge Corp. mines accounted for 78% of Arizona's copper production and helped the company post a record annual net income of more than \$1.6 billion for 2005. The Morenci Mine was the leading copper-producing complex in the United States. In 2005, the mine produced 363,000

²Nyal J. Niemuth, Mining Engineer, authored the text of the State mineral industry information provided by the Arizona Department of Mines and Mineral Resources.

metric tons (t) (800 million pounds) of copper via the solvent extraction-electrowinning (SX-EW) concentration and refining process. This represented more than 52% of Arizona's total production. In June, Phelps Dodge's board approved spending \$210 million at Morenci to construct the first commercial scale concentrate-leach-direct-electrowinning facility and to restart the flotation mill. The concentrator was expected to resume production during 2006 using chalcopyrite ore from the Western Copper, Garfield, and other mine areas and produce 29,000 t of copper in concentrate. When completed, the pressure leaching plant is expected to use medium-temperature technology (160° C) to produce 68,000 metric tons per year (t/yr) of electrowinning copper. It was tested successfully for 7 months at the demonstration pressure leach plant at the Bagdad Mine. That plant reverted to the high temperature (225° C) process so that the Bagdad Mine could take advantage of the greater amount of acid generated by the high-temperature process for its oxide leaching operations. The technology used is proprietary and is shared under a development agreement between Placer Dome Inc. (acquired by Barrick Gold Corp.) and Phelps Dodge Corp.

Phelps Dodge's byproduct molybdenum production totaled 13,600 t largely from the Sierrita and Bagdad Mines. Molybdenum prices reversed roles with copper and made Sierrita the top revenue producer, out performing Phelps Dodge Corporation's Morenci Mine in earnings for part of the year. The electrolytic refinery at the Miami Mine was permanently closed in 2005. Smelting continued there along with residual leaching operations. The Safford project received tentative board approval of a \$550 million expenditure to build two new open pits, Dos Pobres and San Juan, and a heap-leach SX-EW facility. Final approval was contingent on the project receiving State operating permits. Leach production was anticipated to begin in late 2008 at an annual rate of 109,000 t/yr. The deposits are about 488 million metric tons (Mt) and contain an average grade of 0.37% copper. Plans were to construct a plant to produce acid from elemental sulfur in the Safford area. The development is expected to have a positive impact on the local economy. The project was expected to generate 1,000 construction and 500 permanent jobs. A major drilling program, about 180,000 meters (m), was getting underway at year's end on two deposits located within 6.4 kilometers (km) (4 miles) of Dos Pobres Mine.

Safford was also the home of Phelps Dodge's Process Technology Center. In addition to its hydrometallurgical research capabilities, it will provide a high quality and cost effective central analytical facility, replacing labs located at its Arizona and New Mexico mines. Phelps Dodge's Tohono Mine restarted operation in the fourth quarter of 2004 to recover copper from existing leach piles. Cathode production totaled 2,300 t for 2005. Mineralized material reported for the Tohono deposit includes 250 Mt milling material grading 0.70% and 366 Mt leachable material grading 0.63%.

Asarco Inc. moved its headquarters to Tucson from Phoenix in April and announced it had become a limited liability corporation. The company is Arizona's second leading producer and struggled through a very difficult year. During the first half of the year things proceeded relatively well, as production from Ray, Mission, and Silver Bell Mines totaled 48,000 t, an increase of 25% compared with production in 2004. This

increase took place despite the Ray Mine suffering from flooding caused by heavy winter rains and the Hayden smelter being closed for maintenance for 50 days. In July the union workforce went on a strike that lasted 16 weeks. Production declined to roughly one-half of capacity.

On August 9, Asarco LLC, filed for Chapter 11 of the Federal Bankruptcy in Federal Court in Texas. The resulting deconsolidation provided a debt reduction of \$443 million for Asarco's owner Grupo Mexico. The strike ended in November after limited replacement worker hiring forced the company to abandon the concessions it had been seeking. Production from the three mines for the year totaled 141,000 t of copper, a decline of 9.5% largely owing to lost production during the strike.

Resolution Copper Co. plans to spend \$250 million during the current phase of exploration and development on their giant Resolution Copper project located near Superior in Pinal County. Surface drilling resumed in February 2005. The company planned to increase exploration drilling following the development of two shafts. Deepening of the number 9 and sinking the number 10 shaft was scheduled to begin during 2006.

Mercator Minerals Ltd. made significant strides in increasing both copper production and resources at Mineral Park. Additions to the SX-EW plant allowed it to double production and achieve a capacity of 5,000 t/yr. Reserves for the property are 70 Mt grading 0.23% copper, while measured resources total 313 Mt at a copper equivalent grade of 0.41% using copper at \$1.00 per pound and molybdenum at \$7.00 per pound. Mercator Minerals Ltd. replaced its mining contractor by acquiring its own truck and shovel fleet. To accommodate future production increases, the company purchased an 18,000 metric-ton-per-day mill from Asarco LLC. If a future feasibility study was positive, the mine could resume producing copper and molybdenum concentrates for the first time in 25 years.

After a joint venture with BHP-Billiton failed to develop, Cambior Inc. decided to put the Carlota oxide copper property, along with equipment it had acquired up for auction. The equipment included 10 used 172-metric-ton trucks, 1 used P&H 2800 shovel and a SX-EW plant. The winning bid was \$37.5 million in cash and gold by Quadra Mining Ltd. Quadra Mining Ltd. planned to begin construction in mid-2006 and expected production to begin in 2007. The Carlota project anticipated an 11-year life with an average production of 30,000 t/yr of copper cathode (Niemuth, 2006³).

Augusta Resource Corp. entered into an agreement to acquire the Rosemont Mine copper deposit located south of Tucson in the Santa Rita Mountains. The purchase price was \$20.8 million to be paid during 3 years. Previous drilling by Anaconda Copper Mining Co., AMAX Inc., and Asarco, LLC had identified 360 Mt of copper/molybdenum skarn-related mineralization in four deposits that contain approximately 2 Mt of copper. A 9,000-m drill program to produce a resource estimate has been completed.

General Minerals Corp. advanced three copper exploration targets. It acquired the legal rights allowing Teck Cominco Ltd.

³A reference that includes a section mark (§) is found in the Internet Reference Cited section.

to drill on the Monitor property located northeast of the Ray Mine. Teck Cominco Ltd. began drilling for shallow and deep copper and silver target areas in November. Teck Cominco Ltd. obtained the legal rights to begin work at the Markham Wash geophysical prospect located in the Safford District in early 2006. BHP Billiton Ltd. obtained the legal rights to begin drilling on the Dragoon project where General Minerals has identified a 3-square-km- (1 mile) geophysical target. Redhawk Resources Inc. acquired a large land position totaling 18 square km (7 square miles) in the Copper Creek district that contains high level breccia pipes as well as porphyry style mineralization. The company is logging and relogging more than 120,000 m from previous drilling. It is also evaluating resources previously announced by AMT International Mining Corp. for three pipes to determine exploration and mining plans.

Southern Silver Exploration Corp. acquired an option in the Tombstone project, a multitarget porphyry skarn prospect 8 km (5 miles) southwest of the town of Tombstone. Nord Resources Corp. completed a geophysical induced polarization (IP) survey that identified an anomaly attributed to sulfide mineralization at depth on the Coyote Springs property in the Safford District.

Gold.—Precious metals benefited from increased prices. American Bonanza Gold Corp. completed a 40,000-m drill program at the Copperstone gold project in western Arizona. Golden Arch Resources Ltd. conducted exploration drilling at the Mildred Peak/Jupiter project in Pima County. Similarly, Terraco Gold Corp. conducted exploration drilling at the Golden Eagle/Bonanza project in La Paz County. Galaxy Minerals Inc. reported acquiring a small mill for its Yellow Jacket Mine in Santa Cruz County.

Government Programs

The Aggregate Mine Land Reclamation bill became law in May. It applies to aggregate operations started after April 1, 1997, with more than 2 hectares (5 acres) of private land. Existing operations must submit plans to the State Mine Inspector by January 1, 2007, and after that date, new mines

require approval before beginning to operate. The bill requires financial assurance mechanisms and public community notification. It limits authority of flood control districts to regulate stability and capacity of floodplains.

The Maricopa County Board of Supervisors modified Rule 316, Nonmetallic Mineral Processing, which tightened dust emissions. It requires paving of dirt roads on sites, installation of rumble strips, wheel cleaners, and street sweepers.

Comments for the environmental assessment of the Drake Quarry (limestone for cement manufacture) located on Prescott Forest Service lands were due in December. Construction of the cement plant on adjacent private land may begin in the second half of 2006. Because of heightened concerns over the State's continuing drought and water supply in the Verde River watershed, USGS released OFR2004-1439 Hydrogeologic Review of the Drake Cement Project. Subsequently, Drake Cement LLC planned its operation to minimize water consumption.

The U.S. Supreme Court refused to hear the 9th Circuit Court of Appeals decision regarding the State of Arizona's refusal to buy aggregate materials from Dale McKinnon's private property known as Woodruff Butte. The Hopi, Navajo, and Zuni Indians have declared Woodruff Butte to be a sacred site. McKinnon claimed his rights were violated by the State not issuing commercial source approval, thus prohibiting sale of his aggregate materials to State projects.

For more details on the geology and distribution of metallic commodities, refer to the Arizona Department of Mines and Mineral Resource's new OFR23-06 Arizona's Metallic Resources - Trends and Opportunities posted at www.admmr.state.az.us.

Internet Reference Cited

Niemuth, N.J., 2006 (July), Arizona mining update, Arizona Department of Mines and Mineral Resources Circular 118, accessed June 12, 2008, at URL http://www.admmr.state.az.us/Info/mining_update2005.pdf.

TABLE 1
NONFUEL RAW MINERAL PRODUCTION IN ARIZONA^{1,2}

(Thousand metric tons and thousand dollars)

Mineral	2003		2004		2005	
	Quantity	Value	Quantity	Value	Quantity	Value
Copper ³	741	1,390,000	723	2,130,000	690	2,640,000
Gemstones	NA	1,440	NA	1,450	NA	1,370
Sand and gravel:						
Construction	62,600	340,000	79,600	430,000	84,900	516,000
Industrial	W	W	W	792	W	W
Stone, crushed	9,950	49,100	14,100 ^r	75,900 ^r	12,000 ⁴	69,300 ⁴
Combined values of cement, clays (bentonite, common), gold, gypsum, (crude), lime, molybdenum concentrates, perlite (crude), pumice and pumicite, salt, silver, stone (crushed traprock [2005], dimension sandstone), zeolites (2004-05), and values indicated by symbol W	XX	394,000	XX	709,000	XX	1,120,000
Total	XX	2,180,000	XX	3,350,000 ^r	XX	4,350,000

^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data. Withheld values included in "Combined value" data. XX Not applicable.

¹Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Recoverable content of ores, etc.

⁴Excludes certain stones; kind and value included with "Combined values" data.

TABLE 2
ARIZONA: CRUSHED STONE SOLD OR USED, BY KIND¹

Kind	2004			2005		
	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Number of quarries	Quantity (thousand metric tons)	Value (thousands)
Limestone ²	7 ^r	6,370 ^r	\$27,400 ^r	7	6,340	\$33,200
Marble	(3)	55	275	(3)	67	361
Granite	17 ^r	5,340 ^r	31,900 ^r	17	3,650	21,900
Traprock	2 ^r	375	2,860	2	W	W
Sandstone and quartzite	3	492	6,000	5	597	6,790
Volcanic cinder and scoria	7 ^r	177 ^r	980 ^r	5	151	813
Miscellaneous stone	5	1,310	6,490 ^r	3	1,250	6,180
Total	XX	14,100 ^r	75,900 ^r	XX	12,000	69,300

^rRevised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes limestone-dolomite reported with no distinction between the two.

³Sales/distribution yards.

TABLE 3
ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 2005, BY USE¹

(Thousand metric tons and thousand dollars)

Use	Quantity	Value
Construction:		
Coarse aggregate (+1½ inch), riprap and jetty stone	W	W
Coarse aggregate, graded, bituminous aggregate (coarse)	W	W
Coarse and fine aggregates:		
Graded road base or subbase	(2)	(2)
Terrazzo and exposed aggregate	(2)	(2)
Other coarse and fine aggregates	37	386
Total	1,040	13,800
Other construction materials	57	592
Agricultural, poultry grit and mineral food	W	W
Chemical and metallurgical:		
Cement manufacture	(2)	(2)
Lime manufacture	(2)	(2)
Total	3,950	19,600
Special, other fillers or extenders	(3)	(3)
Unspecified:⁴		
Reported	1,700	8,690
Estimated	4,400	24,000
Total	6,100	32,000
Grand total	12,000	69,300

W Withheld to avoid disclosing company proprietary data; included in "Grand total."

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Withheld to avoid disclosing company proprietary data; included in "Total."

³Less than ½ unit.

⁴Reported and estimated production without a breakdown by end use.

TABLE 4
ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 2005, BY USE AND DISTRICT¹

(Thousand metric tons and thousand dollars)

Use	District 1		District 2		District 3		Unspecified districts	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction:								
Coarse aggregate (+1½ inch) ²	W	W	--	--	--	--	--	--
Coarse aggregate, graded ³	--	--	--	--	W	W	--	--
Coarse and fine aggregates ⁴	W	W	--	--	W	W	--	--
Other construction materials	--	--	--	--	57	592	--	--
Agricultural ⁵	--	--	--	--	W	W	--	--
Chemical and metallurgical ⁶	W	W	--	--	W	W	--	--
Special ⁷	--	--	--	--	(8)	(8)	--	--
Unspecified:⁹								
Reported	111	662	351	1,890	5	29	1,230	6,110
Estimated	2,100	11,000	72	389	2,200	12,000	--	--
Total	4,650	27,000	423	2,280	5,750	33,900	1,230	6,110

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes riprap and jetty stone.

³Includes bituminous aggregate (coarse).

⁴Includes graded road base or subbase, terrazzo and exposed aggregate, and other coarse and fine aggregates.

⁵Includes poultry grit and mineral food.

⁶Includes cement and lime manufacture.

⁷Includes other fillers or extenders.

⁸Less than ½ unit.

⁹Reported and estimated production without a breakdown by end use.

TABLE 5
ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 2005,
BY MAJOR USE CATEGORY¹

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Concrete aggregate (including concrete sand)	16,000	\$97,400	\$6.08
Concrete products (blocks, bricks, pipe, decorative, etc.) ²	529	6,310	11.92
Asphaltic concrete aggregates and other bituminous mixtures	3,370	23,200	6.89
Road base and coverings	8,550	43,500	5.09
Fill	1,200	5,360	4.48
Railroad ballast	15	218	14.38
Filtration	596	3,620	6.07
Other miscellaneous uses ³	1,640	19,000	11.62
Unspecified: ⁴			
Reported	42,100	252,000	6.00
Estimated	10,900	64,900	5.95
Total or average	84,900	516,000	6.08

¹Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

²Includes plaster and gunite sands.

³Includes snow and ice control.

⁴Reported and estimated production without a breakdown by end use.

TABLE 6
ARIZONA: CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN 2005,
BY USE AND DISTRICT¹

(Thousand metric tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Concrete aggregate (including concrete sand)	1,040	8,580	558	4,170	14,300	84,200
Concrete products (blocks, bricks, pipe, decorative, etc.) ²	W	W	W	W	213	2,260
Asphaltic concrete aggregates and other bituminous mixtures	284	1,930	W	W	2,520	17,500
Road base materials	863	4,770	425	2,840	5,080	25,400
Fill	71	362	35	247	1,090	4,750
Other miscellaneous uses ³	377	4,630	253	2,730	2,150	21,700
Unspecified: ⁴						
Reported	5,000	30,200	791	4,820	35,300	215,000
Estimated	2,050	12,200	809	4,820	8,050	47,900
Total	9,690	62,700	2,870	19,600	68,700	419,000
	Unspecified district					
	Quantity	Value				
Concrete aggregate (including concrete sand)	94	509				
Concrete products (blocks, bricks, pipe, decorative, etc.) ²	--	--				
Asphaltic concrete aggregates and other bituminous mixtures	W	W				
Road base materials	2,180	10,500				
Fill	--	--				
Other miscellaneous uses ³	356	1,580				
Unspecified: ⁴						
Reported	968	1,870				
Estimated	--	--				
Total	3,590	14,400				

W Withheld to avoid disclosing company proprietary data; included in "Other miscellaneous uses." -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes plaster and gunite sands.

³Includes filtration, railroad ballast, and snow and ice control.

⁴Reported and estimated production without a breakdown by end use.