

# Strategic Freight Transportation Analysis

## 2005 Transportation of Mining/Mineral Survey Summary Report

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**Research Report # 21**

**January 2007**

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**January 2007**

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**SFTA Research Reports:  
Background and Purpose**

This is the 21<sup>st</sup> report in a series of research studies prepared as part of the Strategic Freight Transportation Analysis (SFTA) study. SFTA is a six year comprehensive research and implementation analysis that will provide information (data and direction) for local, state and national investments and decisions designed to achieve the goal of efficient and seamless freight transportation.

The overall SFTA scope includes the following goals and objectives:

- Improving knowledge about freight corridors.
- Assessing the operations of roadways, rail systems, ports and barges – freight choke points.
- Analyze modal cost structures and competitive mode shares.
- Assess potential economic development opportunities.
- Conduct case studies of public/private transportation costs.
- Evaluate the opportunity for public/private partnerships.

The five specific work tasks identified for SFTA are:

- Work Task 1 - Scoping of Full Project
- Work Task 2 - Statewide Origin and Destination Truck Survey
- Work Task 3 - Shortline Railroad Economic Analysis
- Work Task 4 - Strategic Resources Access Road Network (Critical State and Local Integrated Network)
- Work Task 5 - Adaptive Research Management

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by Eric L. Jessup

### **Report 2**

*Freight Truck Origin and Destination Study: Methods, Procedures, and Data Dictionary*

by Michael L. Clark

### **Report 3**

*Value of Modal Competition for Transportation of Washington Fresh Fruits and Vegetables*

by Ken L. Casavant & Eric L. Jessup

### **Report 4**

*Transportation Usage of the Washington Wine Industry*

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# Transportation of Mining/Mineral Survey

## Summary Report

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## INTRODUCTION

The aggregates industry in Washington is a major provider of construction materials such as sand and gravel, crushed stone and, as such, plays vital role in the state's infrastructural development. Availability of aggregates in general can affect the support for regional economic development since one of the biggest consumers of the aggregates industry is the transportation industry. High quality aggregates are used for maintenance and repair of state highways to increase the durability, as well as for the development of new roads. Today, one mile of interstate highway construction consumes about 20,000 tons of aggregate per lane (Zettler, Rick)<sup>1</sup>. With the growing traffic volume on state highways and increasing durability standards, the demand for construction aggregate continues to grow.

As a part of a six year comprehensive research project, Strategic Freight Transportation Analysis (SFTA), this study investigates needs of the mining industry as they pertain to Washington's road networks. Data collected from this survey that was designed to investigate the transportation and operational characteristics of Washington's mined products will help to inform both the location and type of need for road maintenance and improvements. To achieve that purpose, Geographic Information Systems (GIS) is used as an analytical tool to create desired maps and to analyze spatial relationship between mine locations and road system. Maps containing locations of mines were created based a GIS coverage file provided by Washington State Department of Natural Resources (DNR) Division of Geology and Earth

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<sup>1</sup> Note that 94% of the asphalt and 80% of concrete pavements consist of construction aggregate (National Stone, Sand and Gravel Association).

Resources (DGER). County and highway system GIS files were obtained from the WSDOT GeoData Distribution Catalog.

Further, the survey data is used to investigate the spatial relationships between construction aggregate shipment and the trucks' payload weight as it pertains to highway deterioration in the State of Washington.

## **1. The Survey Objective**

The main objective of the survey was to examine transportation characteristics of mining Washington's aggregates and to analyze spatial relationship between mine locations and road network. Because the transportation of mined products underlies the state's economy and regional operations, better understanding of the mining industry needs (as they pertain to the road network) is very useful. The majority of the first phase of the survey was accomplished in 2006. The second mailing of the survey, designed for non-responder companies, followed after about two weeks, in late January, 2006. The initial mailing of the survey resulted in a 20.4% response rate (mining sites), which increased to 47.2% at the end of the second mailing.

## **2. Mining in Washington**

### **2.1 Mining Industry**

The State of Washington is one of the top 10 aggregates producer states in the United States (Wallace P. Bolen, USGS Construction Sand and Gravel Statistics and Information, 2004). Its mineral industry produced an average of 42.2 million tons of construction sand and gravel and 13.7 million tons of crushed stone annually from 2001 to 2003 (Table 2.1.1).



**Table 2.1.1** Nonfuel Raw Mineral Production in Washington<sup>2</sup> (Thousand metric tons and thousand dollars unless otherwise specified)<sup>1, 2</sup>

Mineral	2001		2002		2003 <sup>p</sup>	
	Quantity	Value	Quantity	Value	Quantity	Value
Clays, common	89	258	89	169	89	169
Gemstones	N/A	25	N/A	29	N/A	29
Gold <sup>3</sup> (kilograms)	1,700	14,900	980	9,810	--	--
Sand and gravel, construction	41,400	220,000	43,200	223,000	42,000	218,000
Silver <sup>3</sup> (kilograms)	--	--	729	108	--	--
Stone, crushed	14,100	84,300	13,700	79,900	13,400	79,100
Combined values of cement (portland), diatomite, lime, magnesium metal(2001), olivine, peat, sand and gravel (industrial), and stone (dimension miscellaneous)	XX	178,000	XX	124,000	XX	133,000
Total	XX	498,000	XX	437,000	XX	430,000

<sup>p</sup>Preliminary. NA Not available. XX Not applicable. -- Zero.

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

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

<sup>3</sup>Recoverable content of ores, etc.

The table was adopted from *The Mineral Industry of Washington 2003*, U.S. Geological Survey, USGS Minerals Yearbook 2003.

The two main sources of natural aggregates, construction sand and gravel and crushed stone, are the most extractable and most demanded natural resources (Wallace P. Bolen, USGS Construction Sand and Gravel Statistics and Information, 2004). Defined as Aggregates, those represent about 96 % of Washington's mined minerals volume (Transportation of Mining/Mineral Survey results). However, in order to develop more comprehensive information on the mining industry from this study, 12

2 Nonfuel indicates the difference from fuel minerals, which represent any materials/minerals that release energy as a result of changing or converting their chemical or physical structure – (coal, peat, etc.)

types of minerals were included: sand and gravel, rock or stone, coal, carbonate, clay, peat, metals, ash, diatomite, silica sand, soil and gold.

Below are definitions of aggregate types that are broadly discussed in this study.

- Natural aggregates can be defined as materials that are composed of rock fragments and are used in their natural condition except for such operations as crushing, sizing and washing.
- Rocks are solid, consolidated materials derived from the earth and usually have relatively small size.
- Gravel is a granular material mostly retained on the No. 4 (4.75 mm) sieve that is received from natural disintegration and abrasion of rock or processing of weakly bound conglomerates.
- Crushed gravel results from the artificial crushing of gravel or small cobblestones with substantially all fragments having at least one face resulting from fracture.
- Crushed stone results from the artificial crushing of rock, boulders, or large cobblestones, (all faces result from crushing operation).
- Coarse aggregate is composed of mainly gravel-size particles and predominantly retained on the No. 4 (4.75 mm) sieve.
- Fine aggregate mainly composed of sand-size particles (passing the 3/8 inch (9.5 mm) and No. 4 (4.75 mm) sieves).
- Sand is a granular material passing the 3/8 inch (9.5 mm) sieve, almost entirely passing the No. 4 (4.75 mm) sieve, and mainly retained on the No. 200 (75  $\mu$ m) sieve that is received from natural disintegration and abrasion of rock or processing of completely friable sandstone.
- Sand and gravel aggregate is a mixture (or aggregation) of sand and gravel where gravel is accounted for 25% or more of the mixture (McLaughlin, et al. 1960).

The transportation industry proves to be the biggest consumer of Washington's aggregates industry based on volumes of sand and gravel and crushed stone sold or used in 2002 by major category, (Table 2.1.2). The use, consisting of end-use<sup>3</sup> categories such as road base and coverings, road stabilization (cement), fill, snow and ice control, railroad ballast, consumed a significant portion of aggregates industry's production (USGS Minerals Yearbook 2003, The Mineral Industry of Washington 2003). Shown in Tables 2.1.2 and 2.1.3 are volumes of various uses of aggregates by major category in 2002.

**Table 2.1.2** Washington's construction sand and gravel sold or used in 2002, by major use category <sup>a</sup>

Use	Quantity (thousand metric tons)	Value (thousands)	Value (per ton)
Concrete aggregate (including concrete sand)	7,810	\$53,000	\$6.78
Concrete products (blocks, bricks, pipe, decorative, etc.) <sup>b</sup>	152	1,710	11.24
Asphaltic concrete aggregates and other bituminous mixtures	1,840	10,100	5.49
Road base and coverings	7,700	36,100	4.68
Fill	6,740	23,000	3.41
Snow and ice control	105	449	4.28
Railroad ballast	139	774	5.57
Other miscellaneous uses	220	1,340	6.09
Unspecified: <sup>c</sup>			
Reported	8,220	40,400	4.92
Estimated	10,000	56,000	5.47
Total or average	43,200	223,000	5.16

<sup>a</sup> Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

<sup>b</sup> Includes plaster and gunite sands.

<sup>c</sup> Reported and estimated production without a breakdown by end use.

The table was adopted from *The Mineral Industry of Washington 2003*, U.S. Geological Survey, Minerals Yearbook 2003.

<sup>3</sup> End-use is defined as the use of mineral commodity in a particular industry sector.

**Table 2.1.3** Washington's crushed stone sold or used by producers in 2002, by use category<sup>1</sup>

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
<b>Construction:</b>			
Coarse aggregate (+1 1/2 inch):			
Macadam	W <sup>2</sup>	W	\$8.59
Riprap and jetty stone	64	\$511	7.98
Filter stone	12	93	7.75
Other coarse aggregates	122	774	6.34
Total or average	198	1,380	6.96
Coarse aggregate, graded:			
Concrete aggregate, coarse	(2)	(2)	4.19
Bituminous aggregate, coarse	(2)	(2)	8.27
Bituminous surface treatment aggregate	(2)	(2)	4.24
Railroad ballast	48	276	5.75
Other graded coarse aggregates	25	126	5.04
Total or average	104	609	5.86
Fine aggregate (-3/8 inch):			
Stone sand, concrete	(2)	(2)	3.69
Screening, undesignated	(2)	(2)	5.15
Other fine aggregates	9	53	5.89
Total or average	82	413	5.04
Coarse and fine aggregate:			
Graded road base or subbase	641	2,780	4.33
Unpaved road surfacing	331	1,820	5.49
Terrazzo and exposed aggregate	W	W	9.92
Crusher run or fill or waste	102	444	4.37
Other coarse and fine aggregates	764	3,240	4.23
Total or average	1,840	8,270	4.50
Other construction materials	91	840	9.23
<b>Agricultural</b>	5	21	4.20
<b>Chemical and metallurgical</b>	69	847	12.28
<b>Special</b>	135	1,420	10.53
<b>Other miscellaneous uses</b>	(7)	(7)	6.50
Unspecified <sup>3</sup>	11,100	65,700	5.91
Grand total or average	13,700	79,900	5.82

W Withheld to avoid disclosing company proprietary data; included with "Other."

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

<sup>2</sup>Withheld to avoid disclosing company proprietary data; included in "Totals."

<sup>3</sup>Reported and estimated production without a breakdown by end use.

The table was adopted from *The Mineral Industry of Washington 2003*, U.S. Geological Survey, Minerals Yearbook 2003.

Residential and commercial construction industries are other consumers of the aggregates, given that 80% of concrete is construction aggregate. As an example, the average home construction requires about 400 tons of construction aggregates (National Stone, Sand and Gravel Association). Recently, the average level of annual aggregate consumption in the US reached 10 tons per person, which is 80 times of the volume consumed in early 1900s. Concurrently, increasing demand for extraction of aggregates results in growing pressures from environmental agencies and local communities (Zettler, Rick).

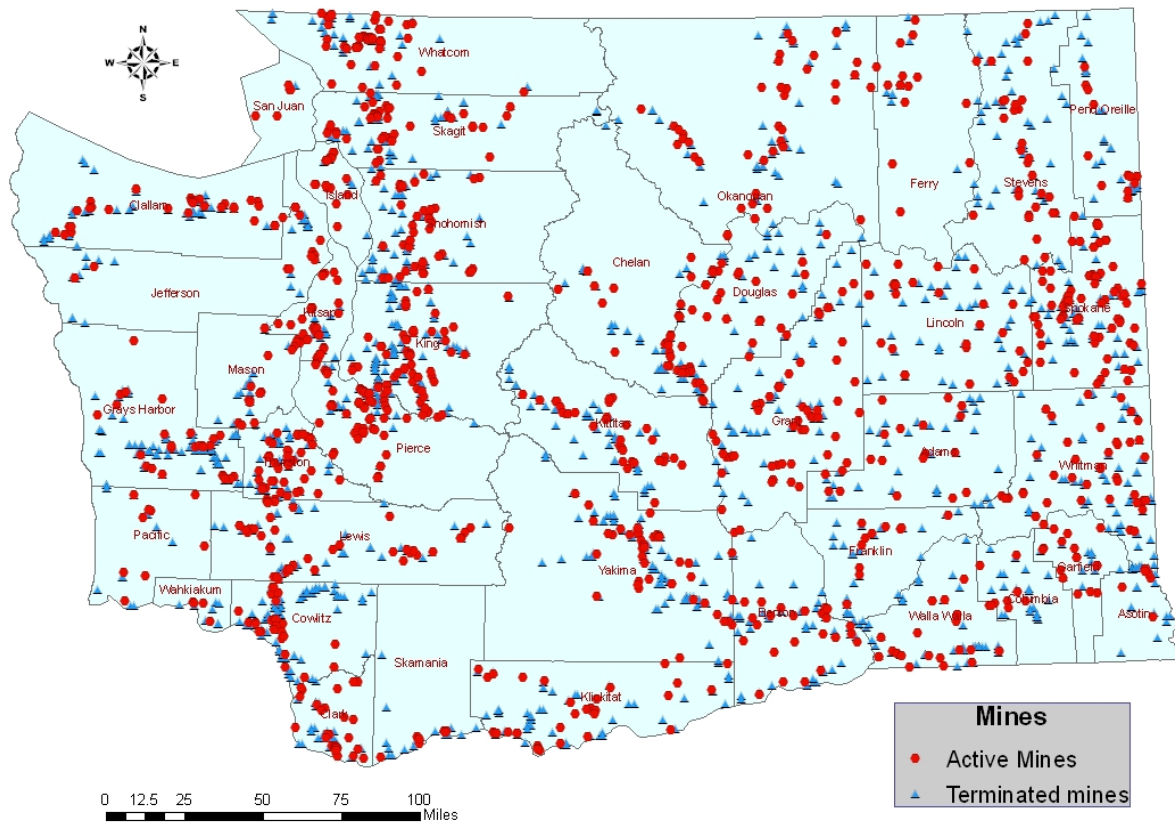
*The Aggregates Industry in Washington* study conducted by Pacific Lutheran University in 2000 found about 52% of aggregates and ready mix was used by the transportation industry. Projects were classified as road maintenance, street & runway construction and bridges. About twenty two percent was attributed to residential, 18.5% to commercial and offices, and 7.5% to public sectors' uses (B. Finnie, J. Peet 2003).

There were 2,807 surface mines in the state of Washington, 1,645 of which are currently terminated (Norman, D., Figure 2.1.1). Terminated status represents mines that were depleted and fully reclaimed. Active mines<sup>4</sup> can be further categorized as currently operational or non-operational. Non-operational represents mines that are not operating because of various obstacles such as high transportation costs or absence of construction projects in the economically feasible region, or mines that are kept as a reserve for further use.

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<sup>4</sup> Hereafter, "mines" refers to "surface mines."

**Figure 2.1.1** State of Washington Active and Terminated Mines



Data Sources: Geographic site information was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources. County GIS files were downloaded from the WSDOT GeoData Distribution Catalog.

## 2.2 Mining Regulations

Reclamation permits for Washington's mines are issued by Department of Natural Resources (DNR), which has exclusive authority to endorse reclamation plans (DNR Division of Geology and Earth Resources (DGER)). As such, the DNR DGER carries responsibility for ensuring reclamation of the active (approximately 1,200) permitted mines.

The main objective of reclamation at terminated mines is to reestablish the vegetative cover, soil stability, and water conditions at the site (Surface Mining Reclamation Program, DNR DGER). *The Surface Mining Reclamation Act* requires a reclamation permit for each mine in State of Washington that has the following three characteristics: results in 3 or more acres of mine-related disturbance, or has a high-wall that is higher than 30 feet and steeper than 45 degrees (Surface Mining Reclamation Program).

Each of the mining permit holders must have a quality reclamation plan, which is required to be periodically reviewed and updated (DNR DGER). Detailed reclamation plans that include contouring of land, placement of topsoil and reseeding with native vegetation/crops/trees, must be approved by government officials and local permitting groups before mining begins. As a result reclaimed mine sites are returned to productive uses such as recreational parks, golf courses or wildlife areas, which is sometimes better than their original conditions (National Mining Association).

All other mine-related activities are permitted by local governments or state and federal agencies. Particularly, local governments must officially approve the location and use of mine sites (Surface Mining Reclamation Program, RCW 78.44.091) before they receive a reclamation permit from the DNR.

## 2.3 Transportation of Minerals

Aggregates industry is highly affected by transportation in terms of high cost of movement. More than 90% of transported mined commodities were hauled using trucks as a mode of transportation from mine pit to points of sale or processing plant, 3% used



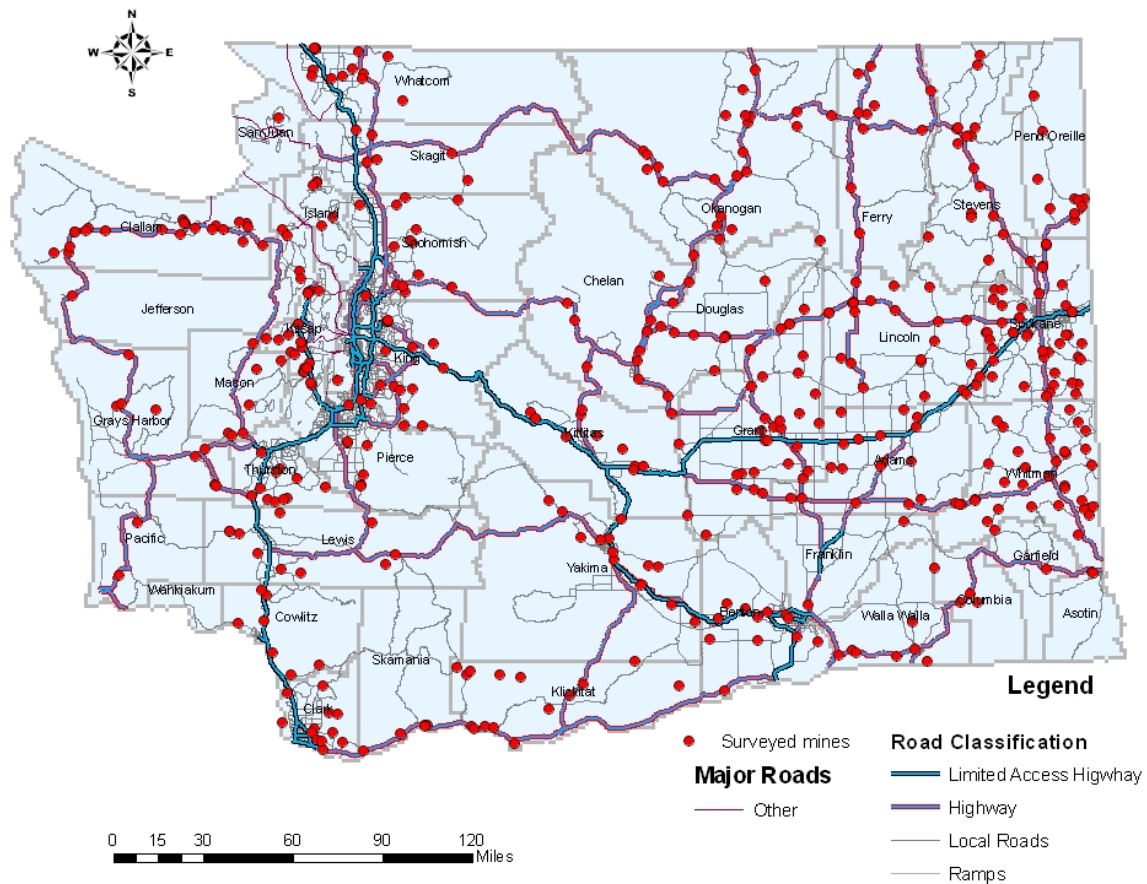
waterway and 1% used rail (Wallace P. Bolen, USGS Construction Sand and Gravel Statistics and Information, 2004, Table 1, Appendix A).

Looking generally, the location pattern of active mines in the study area seems reasonably dispersed. However, closer investigation of mine locations, road network and highly urbanized areas showed local clustering, emphasized in Figure 2.3.1. This is explained by high concentration of highway, home and office construction in urban areas.

The opening of a new mine site usually changes the pattern of transportation of aggregates in the region. If aggregate producers and construction sites are transportation cost minimizing, the new path of aggregates transportation from a new site will require less truck transport than the pattern of transportation used to haul from other mine sites (Berck, Peter, 2005).

Considering weight to value ratio, aggregates are inexpensive products, but adding the transportation costs may increase the unit price significantly for each additional hauling distance. The total cost of transportation and production may explain a high correlation between mine and construction sites locations.

**Figure 2.3.1** Washington's active mines and road network

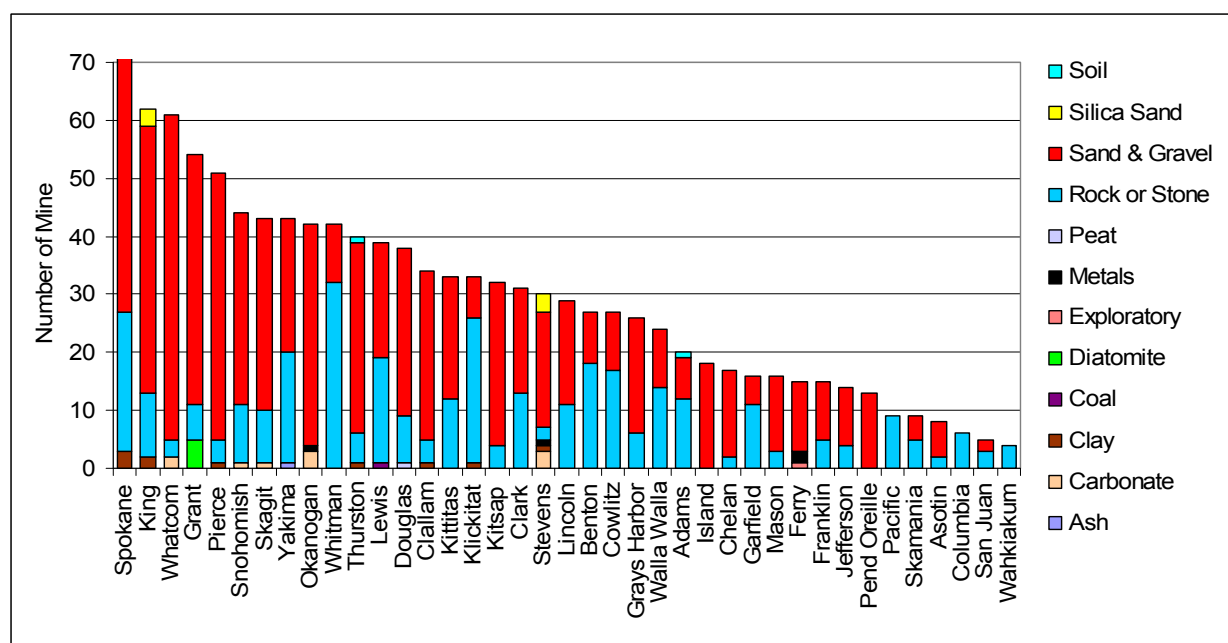


Data Sources: Geographic site information was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources. County and highway system GIS files were downloaded from the WSDOT GeoData Distribution Catalog.

### **3. Survey/Questionnaire Description**

Mining companies were included in the survey based on the permit holder list provided by DNR DGER. The initial survey population was more than 500 companies that owned in total more than 1,100 mine sites. The number of mines on the initial list ranged from 4 to 72 mines per county, with an average of 29 mines per county. Descriptive/initial information about number of mines and types of commodities for surveyed mines classified as active is presented in Figure 3.1. Information sought via the survey questionnaire included mining site location, commodity type mined, annual tons of production, highway usage by specific mine, distance of shipment and transportation mode used, shipment destinations, factors influencing monthly shipments, seasonality of mine operations and mineral shipments, average payload weight of outbound truck shipments, number of axles of trucks, as well as information on daily and monthly operations. (For a full version of the questionnaire refer to Appendix E).

**Figure 3.1** Total numbers of surveyed mines by type per county



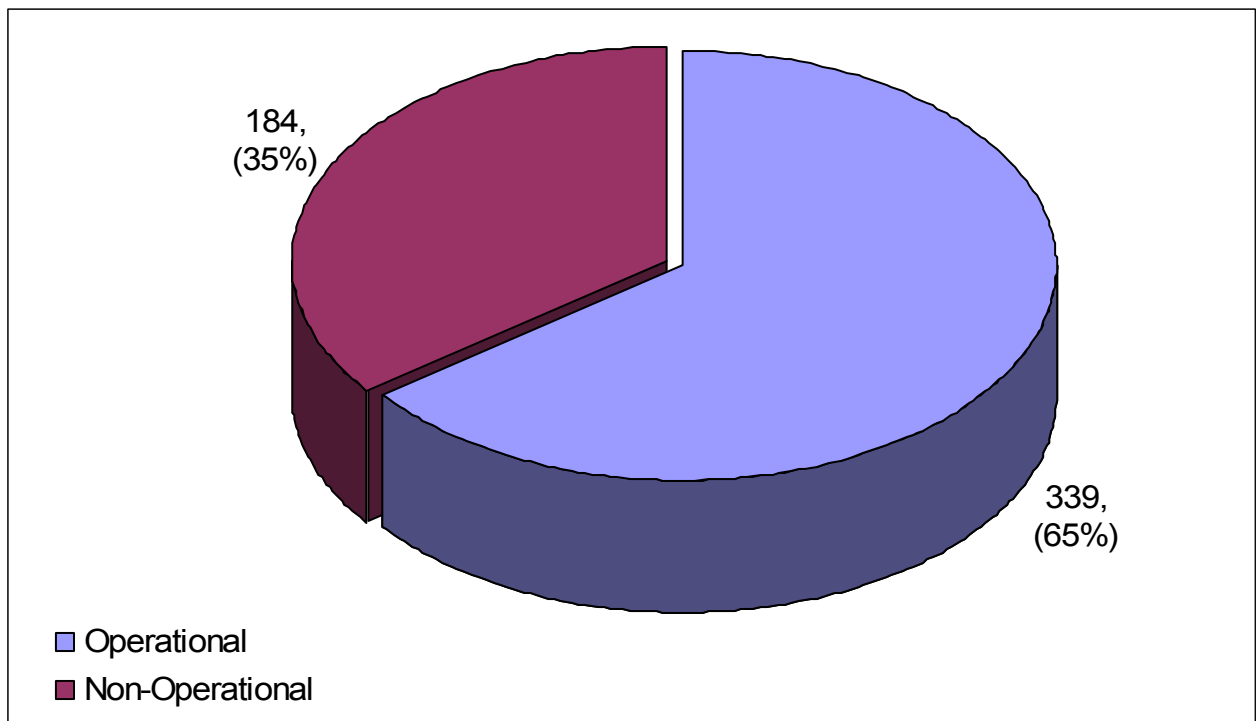
Data Source: Donald T. McKay, Jr., et al, Directory of Washington Mines 2001, Department of Natural Resources, Division of Geology and Earth Resources.

## 4. Study Results

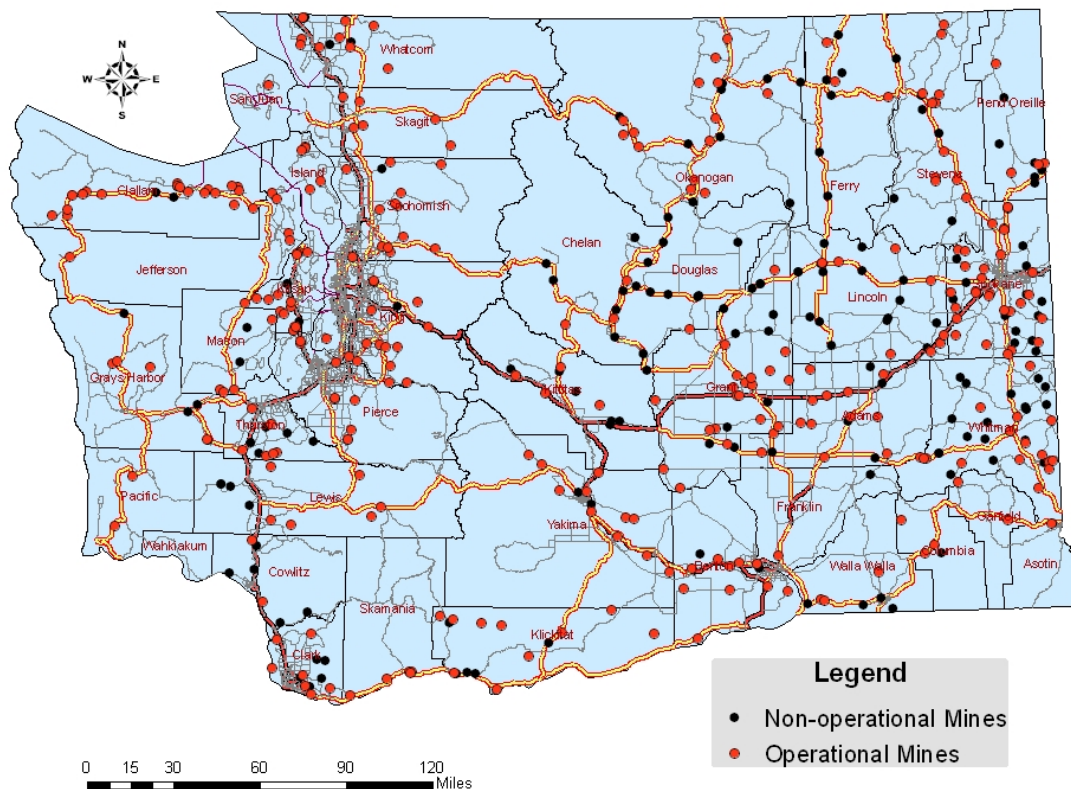
### 4.1 Mines and Volumes of Production

Responses were received from 194 companies, 39% of the total number of companies. Those 194 companies provided information for 523 mines, which was 47.2% of the total number of mines in the state. As it was stated earlier active mines were divided into two categories; consequently, information was categorized into operational and non-operational mines. Out of the 523 mine sites 184 (or 35%) are non-operational, and remaining 339 (65%) are in operation (Figures 4.1.1 and 4.1.2).

**Figure 4.1.1** Study responses: operational and non-operational mines



**Figure 4.1.2** Study responses: operational and non-operational mines



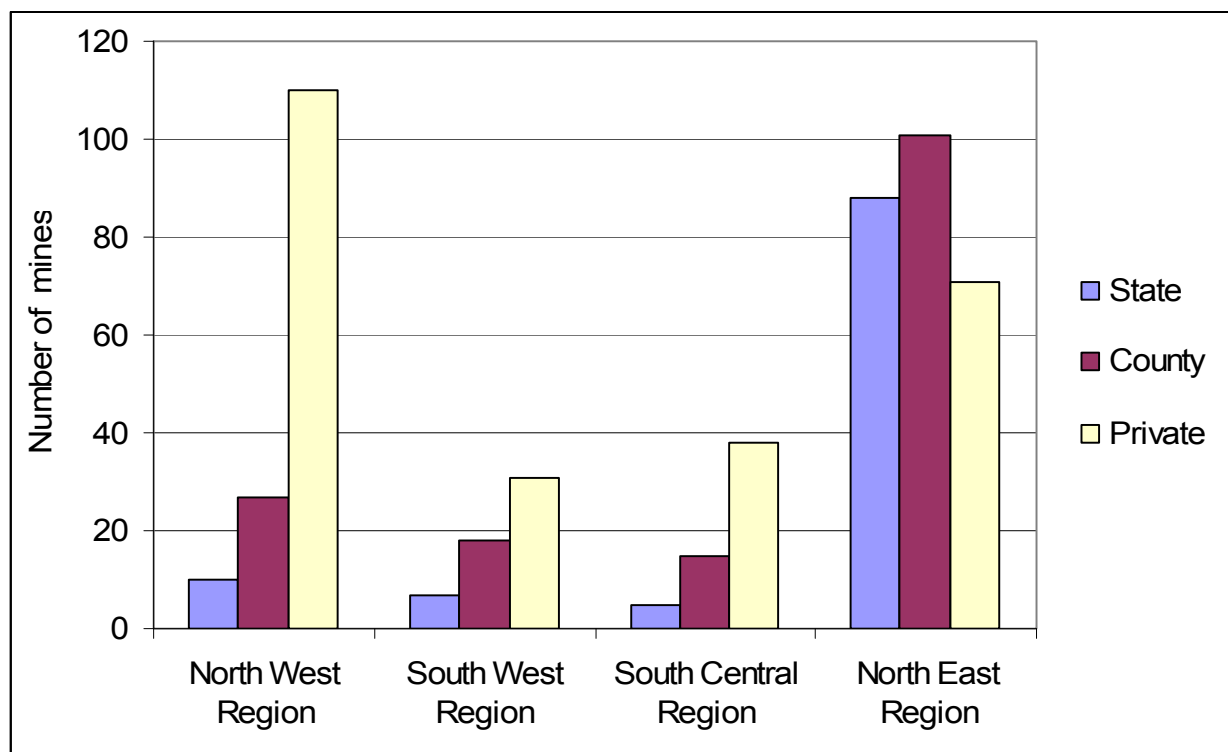
Data Sources: Geographic site information was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources. County and highway system GIS files were downloaded from the WSDOT GeoData Distribution Catalog.

The ownership of mines is divided into state, county and privately owned. Survey results showed that most of the mines in the State of Washington are owned by private firms (48%). WSDOT or DNR owned mines represent about 21% of study responses and the remaining (31%) are owned by local governments.

Spatial investigation of the ownership data exhibited variability across the state. The proportion of state owned mines (mostly located in the North East Region) varies

from as low as 7% in the North West Region to 34% in the North East Region of the state. In contrast, privately owned mines are found more in the North West Region (75%), South Central Region (65.5%) and South West Region (55%). The proportion of mines owned by Counties ranges from 18% in the North West Region of the state to 39% in the North East (Figure 4.1.3 and Table 4.1.1).

**Figure 4.1.3** Study responses: ownership of mines by category<sup>5</sup>



<sup>5</sup> The geographic split is based on WSDOT Regions, such that DOT's Olympic and North West regions form North West region/part for this study, North Central and North East regions form North East part. South West and South East separations for the study coincide with the geographical boundaries of DOT's homonymous regions.

WSDOT Regions:

**Southwest Region** - Pacific, Lewis, Wahkiakum, Cowlitz, Clark, Skamania and Klickitat counties.

**Olympic Region** - Clallam, Jefferson, Grays Harbor, Mason, Thurston, Kitsap and Pierce counties.

**Eastern Region** - Pend Oreille, Ferry, Stevens, Lincoln, Spokane, Adams and Whitman counties.

**Northwest region** - San Juan, Island, Whatcom, Skagit, Snohomish and King counties.

**North Central Region** - Okanogan, Chelan, Douglas and Grant counties.

**South Central Region** - Kittitas, Yakima, Benton, Franklin, Walla Walla, and Columbia counties.



**Table 4.1.1** Study responses: ownership of mines global vs. regional

	North West Region		South West Region		South Central Region		North East Region		Global Results	
	mines	%	mines	%	mines	%	mines	%	mines	%
State	10	7%	7	13%	6	8.6%	88	34%	111	21%
County	27	18%	18	32%	14	25.9%	101	39%	160	31%
Private	110	75%	32	55%	39	65.5%	71	27%	252	48%
Total	147		56		58		260		523	

Ten counties each produce annually more than 1million tons of minerals, 12 counties produce between 300,000 and 950,000 tons, and remaining counties produce less than 300,000 tons per year. The number of mines ranged from 2 to 48 mines (with the average of 15 mines) per county. As expected from the number of responses of total mine site responses (47.2%), these numbers closely represent about half of the statistics of the original listing (*min 4, max 72, and average 29*). A list of counties with total annual production across all types of minerals included in the survey is presented in table 4.1.2.

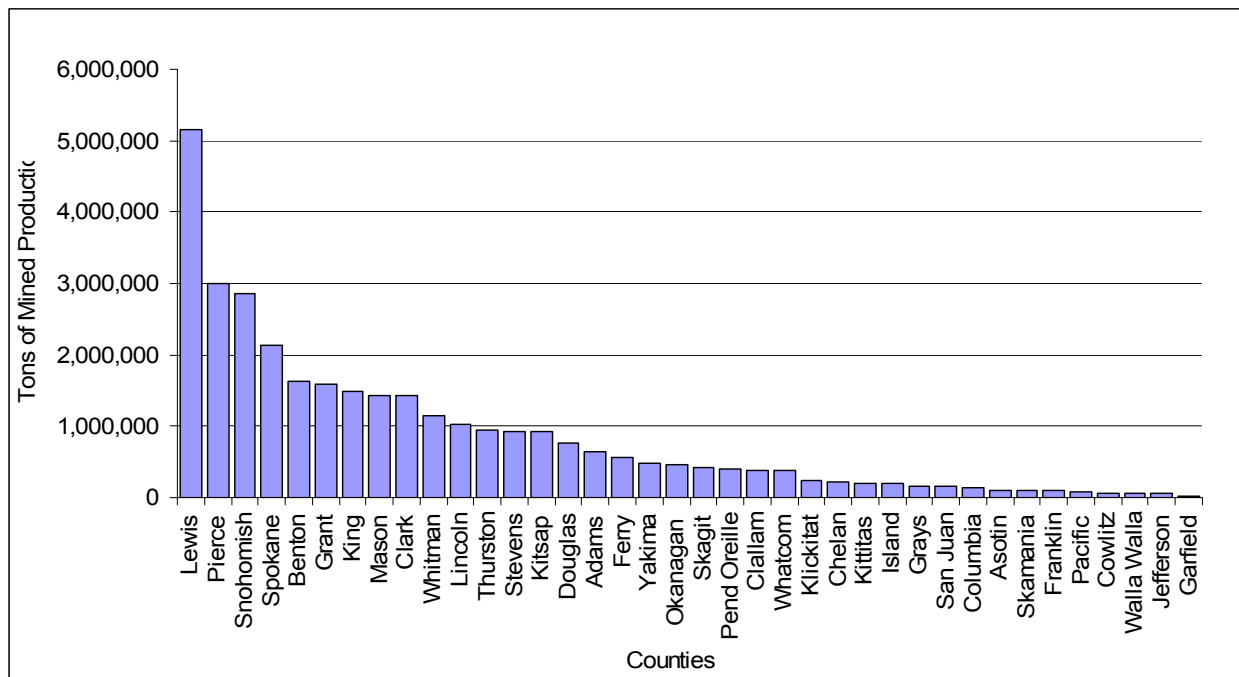
**Table 4.1.2** Study responses: mines' annual production volumes by county

County	Tonnage	As % of total production	County	Tonnage	As % of total production
Lewis	5,260,000	16.1%	Skagit	425,000	1.3%
Pierce	3,010,000	9.4%	Pend Oreille	411,500	1.3%
Snohomish	2,865,711	8.9%	Clallam	383,480	1.2%
Spokane	2,130,000	6.6%	Whatcom	375,030	1.2%
Benton	1,640,000	5.1%	Klickitat	250,000	0.8%
Grant	1,582,750	4.9%	Chelan	213,000	0.7%
King	1,481,000	4.6%	Kittitas	208,500	0.6%
Mason	1,434,050	4.5%	Island	197,013	0.6%
Clark	1,425,200	4.4%	Grays Harbor	160,200	0.5%
Whitman	1,140,003	3.5%	San Juan	153,000	0.5%
Lincoln	1,020,000	3.2%	Columbia	140,000	0.4%
Thurston	950,100	3.0%	Asotin	105,000	0.3%
Stevens	933,152	2.9%	Skamania	105,000	0.3%
Kitsap	920,000	2.9%	Franklin	100,000	0.3%
Douglas	761,000	2.4%	Pacific	85,000	0.3%
Adams	650,000	2.0%	Cowlitz	70,100	0.2%
Ferry	567,550	1.8%	Walla Walla	66,000	0.2%
Yakima	479,673	1.5%	Jefferson	51,500	0.2%
Okanagan	453,300	1.4%	Garfield	25,000	0.1%
Total tons					32,227,812
Max					5,260,000
Min					25,000
Average					848,100

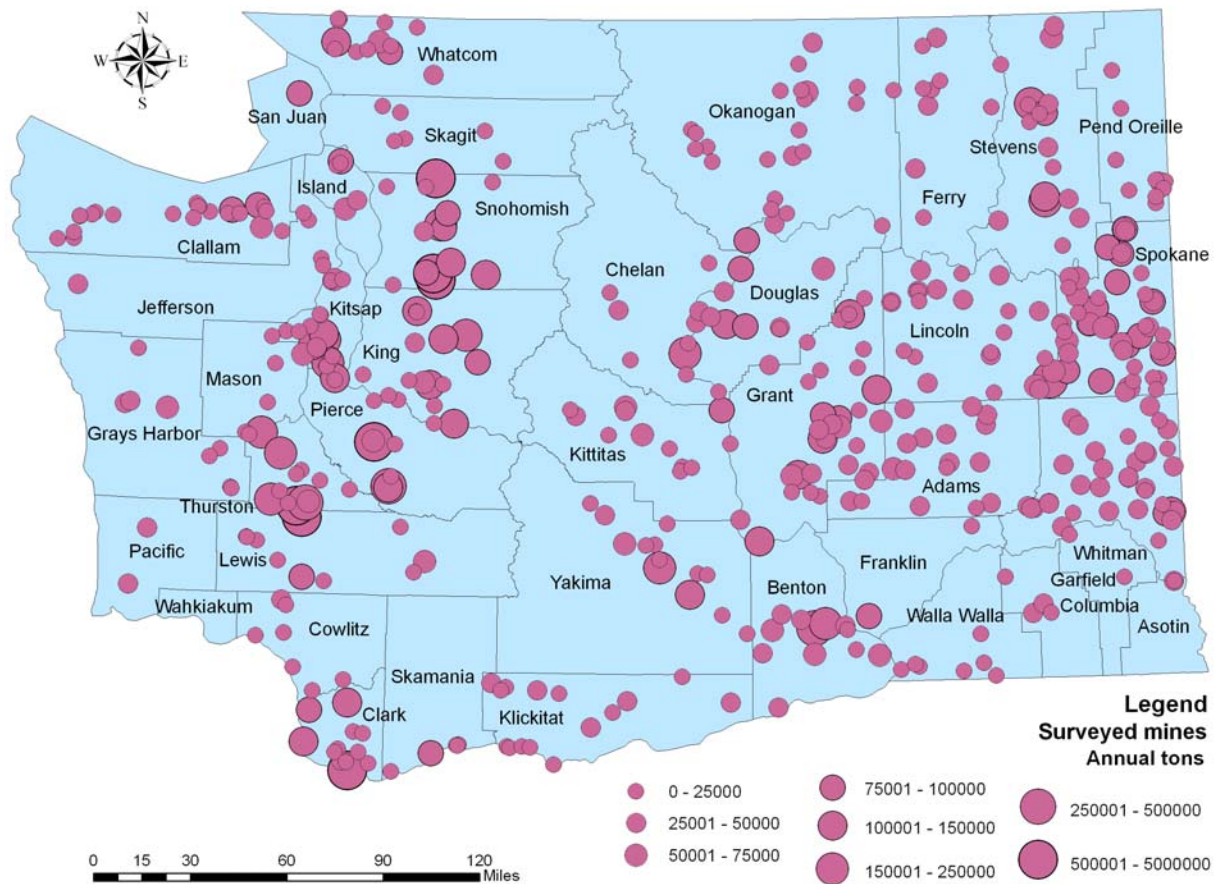
The top 10 county mineral producers by annual volume were: Lewis, Pierce, Snohomish, Spokane, Benton, Grant, King, Mason, Clark and Whitman, with the average of 2,196,871 tons (for top 10) each year. The top five counties produce 46% of the total volume. On average individual Washington counties produce 848,100 tons of minerals per year, ranging from 25,000 to 5,260,000 tons. Detailed information for each

county's number of mines, types of minerals mined and annual production volumes can be found in Figures 4.1.4, 4.1.5 and Table 2, 3 (Appendix A).

**Figure 4.1.4** Study responses: annual production volumes of mines by county



**Figure 4.1.5** Study responses: mine sites by annual production volume



Data Sources: Geographic site information was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources. County and highway system GIS files were downloaded from the WSDOT GeoData Distribution Catalog.

The data were then examined separately among WSDOT Regions (table 4.1.2). WSDOT Southwest, Olympic, Northwest and Eastern regions each produce about the same level of North Central and South Central regions' production volumes combined. Regional production volumes can be useful for examining the highway or local roads usage by mineral hauling trucks in the region, given average hauling distances. However, on-site use of mined minerals has to be considered as well. Although the

Southwest Region is listed with the highest annual production level, it is not considered to be the largest user of the highway or local road system, due to the coal mine located in that region, which has on-site use of about 5 million tons of annual production. To investigate this relationship further, maps for each of the WSDOT Regions were created using mine sites location information joined with annual production volumes and types of minerals mined (Appendix B).

In order to determine segments of highways used for hauling minerals, this information was linked with the average shipment distances and discussed more in the section 4.12 (“Shipment Distances by Volume and Road Network Used”). Further, to assess the overall effect by truck movements, the frequency of those highways used by the mines is discussed in the same section. For closer investigation of highway segments, maps were created at county level, each with corresponding highway usage frequency tables.

**Table 4.1.3** Study responses: mines' annual production volumes by Washington State Department of Transportation regions

DOT region	Annual Production (Tons)	As % of total production
Southwest Region <sup>6</sup>	7,195,300	22.3%
Olympic Region	6,909,330	21.4%
Eastern Region	6,852,205	21.3%
Northwest Region	5,496,754	17.1%
North Central Region	3,010,050	9.3%
South Central Region	2,764,173	8.6%
Total	32,227,812	
Max	7,195,300	
Min	2,764,173	
Average	5,371,302	

## 4.2 Mines and Types of Commodities

Fifty nine percent of mined minerals is represented by the sand and gravel commodity, and 35.5%<sup>7</sup> is accounted for by rock or stone. The remaining 5.5% is divided among the rest of the types of mines (Figure 4.2.1 and 4.2.2).

The high percentage of this most extractable and demanded natural resources is explained by its multipurpose and diverse use. Accounting for 94% of the asphalt and 80% of concrete pavements, construction aggregates are used for highway, residential

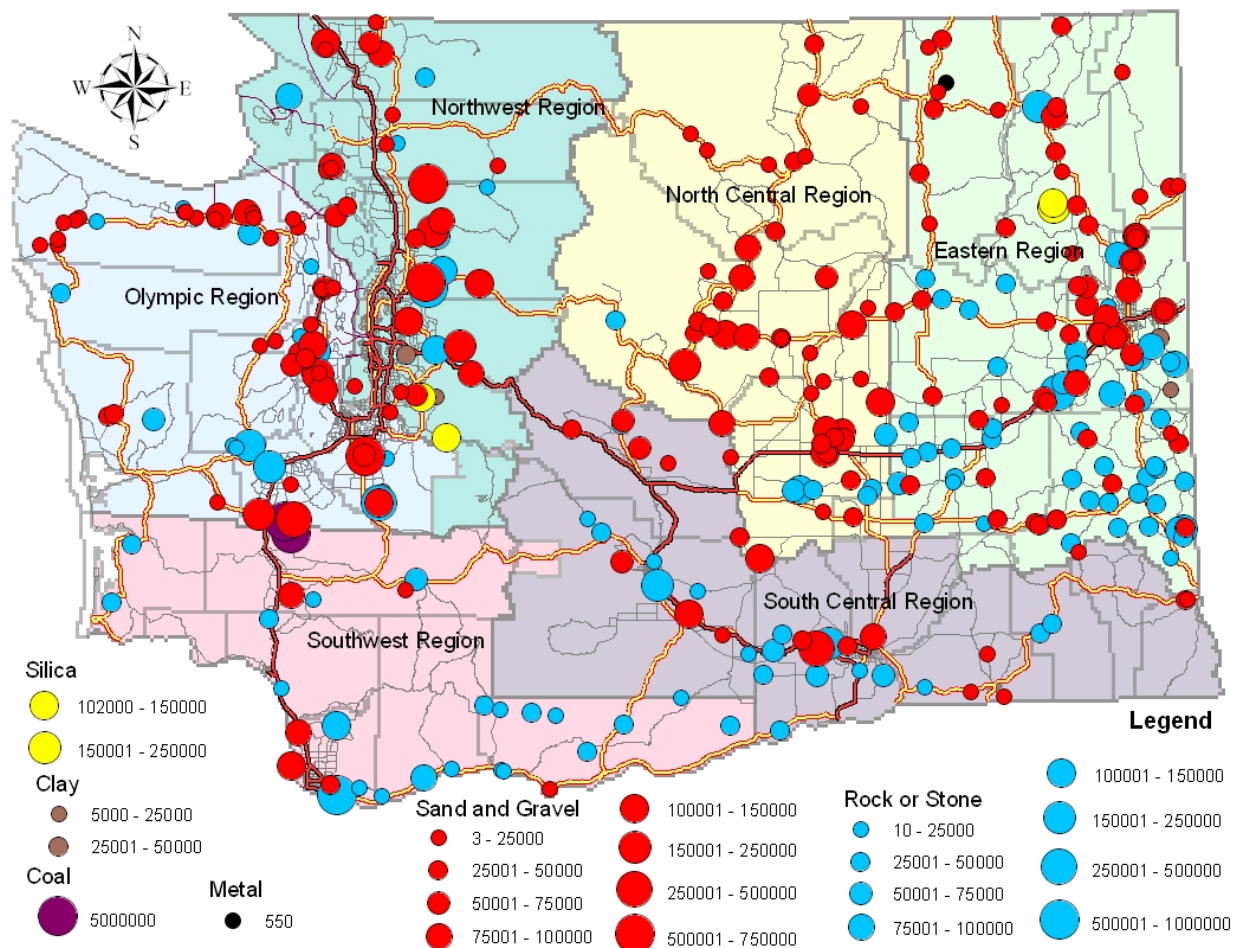
<sup>6</sup> WSDOT **Southwest Region** includes Pacific, Lewis, Wahkiakum, Cowlitz, Clark, Skamania and Klickitat counties. **Olympic Region** – Clallam, Jefferson, Grays Harbor, Mason, Thurston, Kitsap and Pierce counties, **Eastern Region** – Pend Oreille, Ferry, Stevens, Lincoln, Spokane, Adams and Whitman counties, **Northwest region** – San Juan, Island, Whatcom, Skagit, Snohomish and King counties, **North Central Region** – Okanogan, Chelan, Douglas and Grant counties, **South Central Region** – Kittitas, Yakima, Benton, Franklin, Walla Walla, Columbia.

<sup>7</sup> According to National Stone, Sand and Gravel Association about two-thirds of the non-fuel minerals mined each year in the U.S. are aggregates.

or commercial constructions, as well as for public works (hospitals, airports, water treatment plants, schools, etc.).

**Figure 4.2.1** Study responses: number of mines by type

**Figure 4.2.2** Survey responses: mines by type and production volume in relation to Washington State Department of Transportation regions



Data Sources: Geographic site information was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources. County and highway system GIS files were downloaded from the WSDOT GeoData Distribution Catalog.

#### 4.2.1 Washington State Department of Transportation Owned Mines

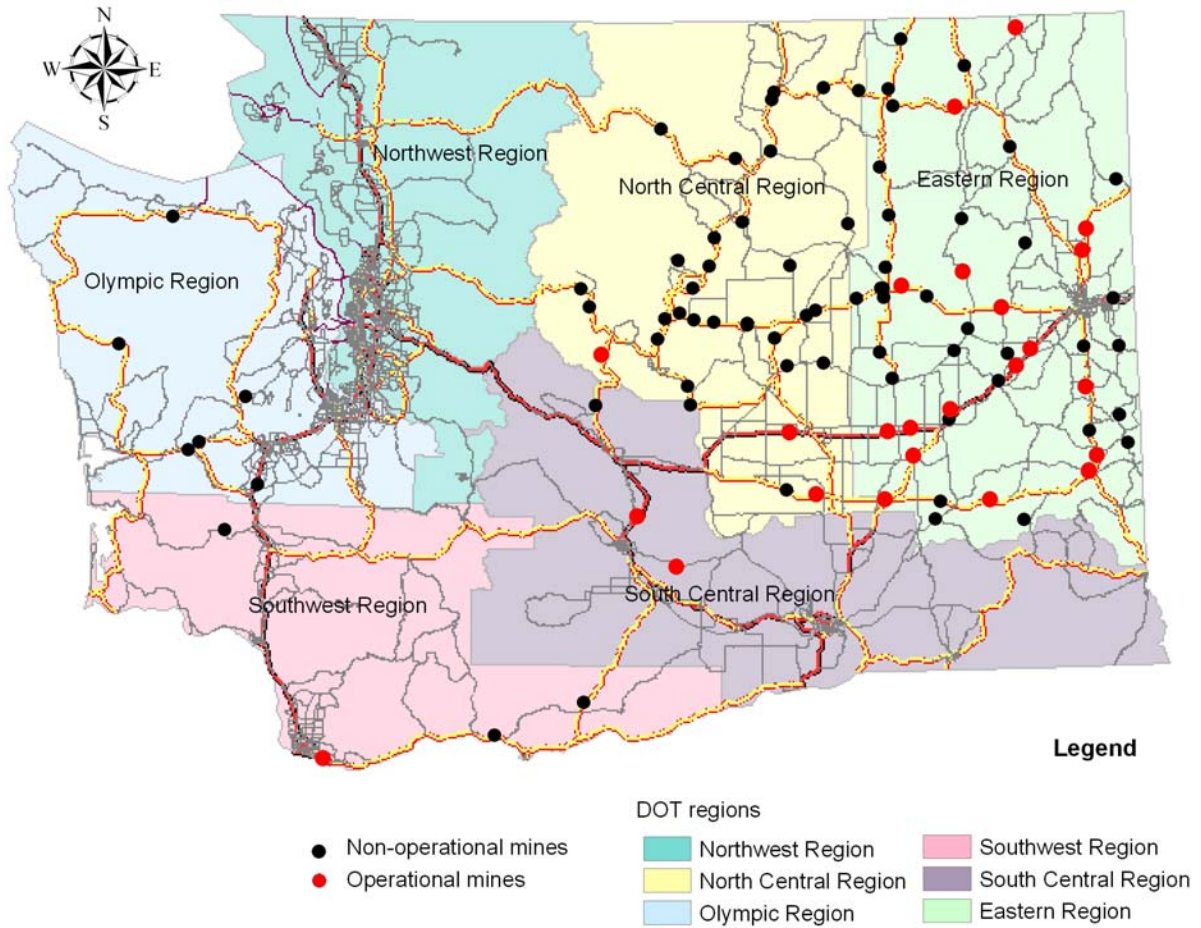
More than 10% of Washington's active mines are permitted to the WSDOT. Sixty-nine percent of these mines produce sand and gravel and the remaining (31%) mines are rock or stone. However, a number of the WSDOT owned mines have not



been used for many years. According to the survey responses, a large proportion of mines listed for the WSDOT South Central Region has not been used for the last 13-45 years. As an alternative or reserve resource, those mines can be utilized in the future for the WSDOT highway construction and improvement projects, especially by the construction contractors who do not have their own supply of aggregate. Only about 26% of State owned permitted mines are currently in operation. Figures 4.2.3 and 4.2.4 show locations of the WSDOT owned operational (26%) and non-operational (74%) mines, as well as types of minerals and production volumes for each mine. Geographic distribution of operational mines suggests a high degree of availability of construction sand and gravel or crushed stone in the WSDOT Eastern Region.

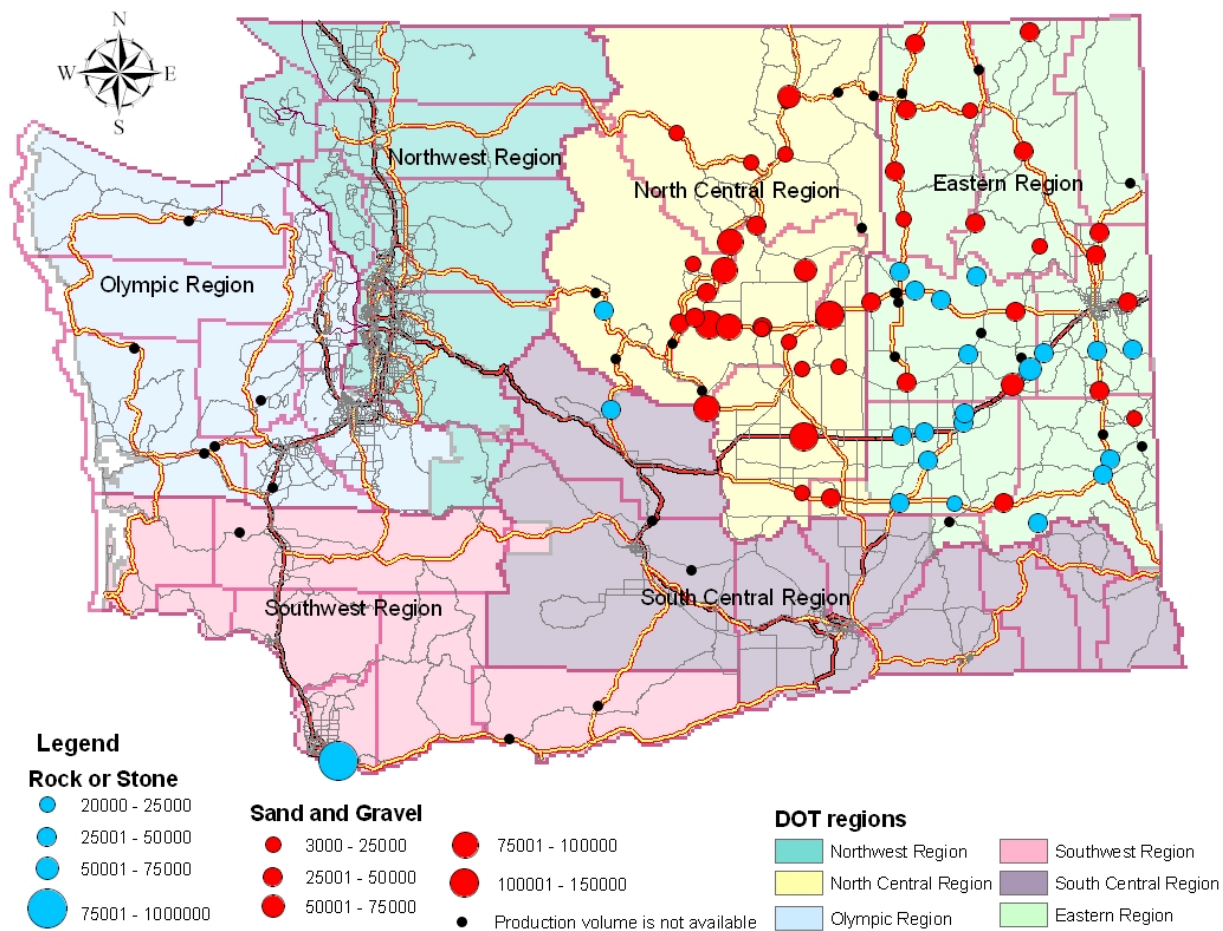
High transportation cost of construction materials such as sand and gravel or crushed stone is the largest component in determining the cost of materials in highway construction, which makes the proximity of the mine to the construction site a strong economic issue. As demonstrated in Figure 4.2.3, WSDOT owned operational and non-operational mines are heavily located adjacent to highways. Another related concern with the proximity of the mine to the point of use for highway construction is the potential deterioration of the highway segments used for hauling construction materials.

**Figure 4.2.3** Washington State Department of Transportation owned mines: Operational vs. Non-operational



Data Sources: Geographic site information was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources. County and highway system GIS files were downloaded the WSDOT GeoData Distribution Catalog.

**Figure 4.2.4** Washington State Department of Transportation owned mines by type of mineral and production volume



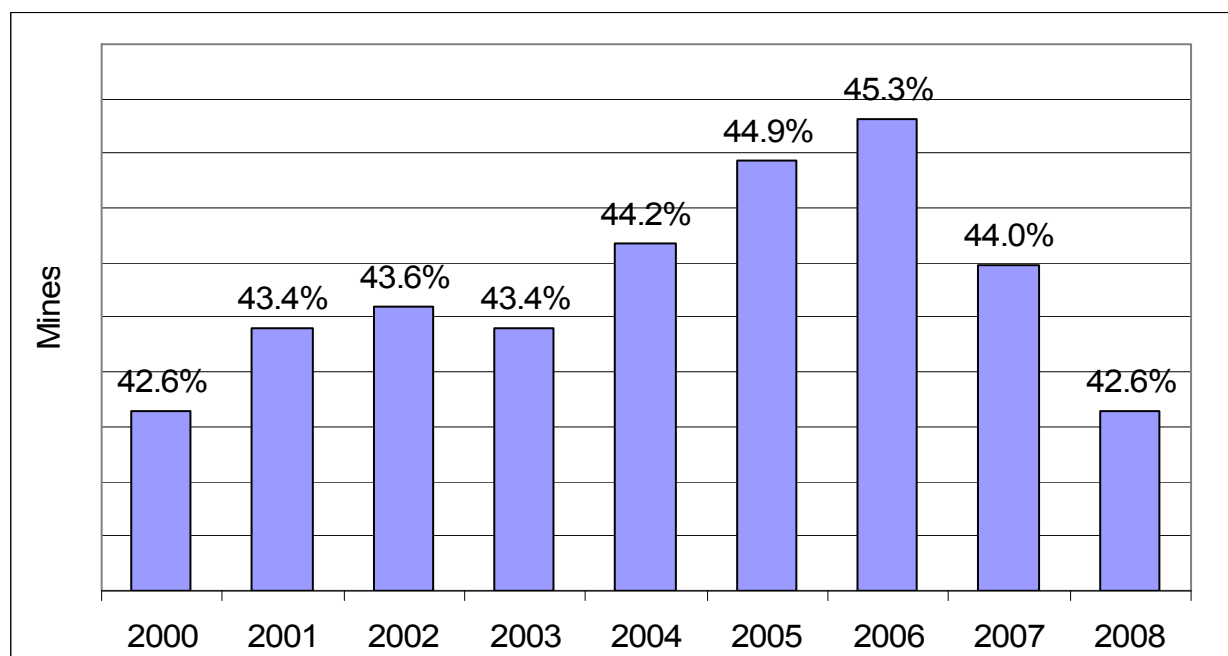
Data Sources: Geographic site information was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources. County and highway system GIS files were downloaded from the WSDOT GeoData Distribution Catalog.

### 4.3 Years of Operation

The study requested information over a 9 year period of mining operations from 2000 to 2008. From 2000 to 2006 the number of permitted mines in operation has shown small but steady growth (except 2003) over that period. However, according to surveyed company responses (Figure 4.3.1), projected number of mines to be in

operation will be decreased about 2% between 2006 and 2008, reaching the level of mines in 2000. According to the Washington State Office of Financial Management, Washington's population is expected to grow by 30% between 2000 and 2020 (Washington State Office of Financial Management). Urbanization is usually positively related with aggregates consumption. Thus, with increasing population growth, the demand for aggregates will also be increased (Zettler, Rick). Potential for increasing aggregates use/demand, plus numerous concerns received from mining companies about various restrictions and obstacles for production (supply constraints) suggest careful monitoring of the industry's performance and needs would be appropriate.

**Figure 4.3.1** Mines in operation from 2000 and projections for the next two years

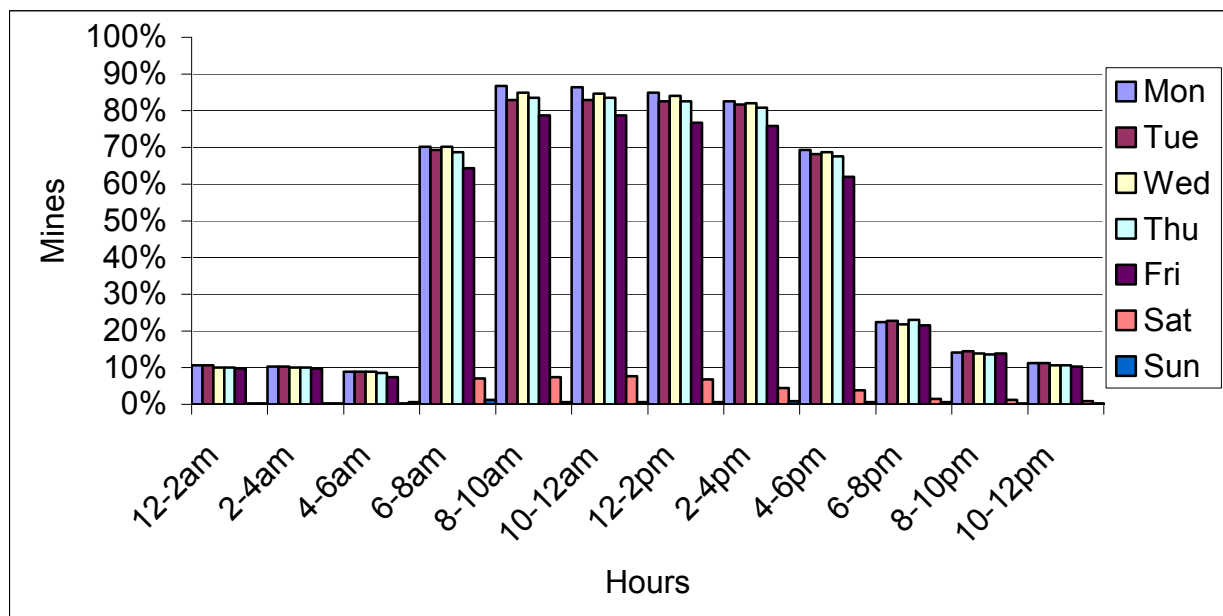


Source: Transportation of Mining/Mineral Survey results

#### 4.4 Operational Times

While most mines operate on usual business day basis, there are some that operate 16 or up to 24 hours a day. About 65-85% of mines operate Monday through Friday from 6-8 am to 4-6 pm. Slightly more than twenty percent of the total mines stay opened from 6-8pm. The rest of operational hours after 8 pm to 6 am (the night shift) was used by around 10% of the mines. The proportion of mines operating on the weekend is less than 8% for Saturday and less than 1.5% for Sunday, mostly from 6 am to 6 pm. This information is potentially useful in assessing any addition of mining trucks to the rest of the traffic on Washington's road system (Figure 4.4.1).

**Figure 4.4.1** Mines' operations by days and hours (global)



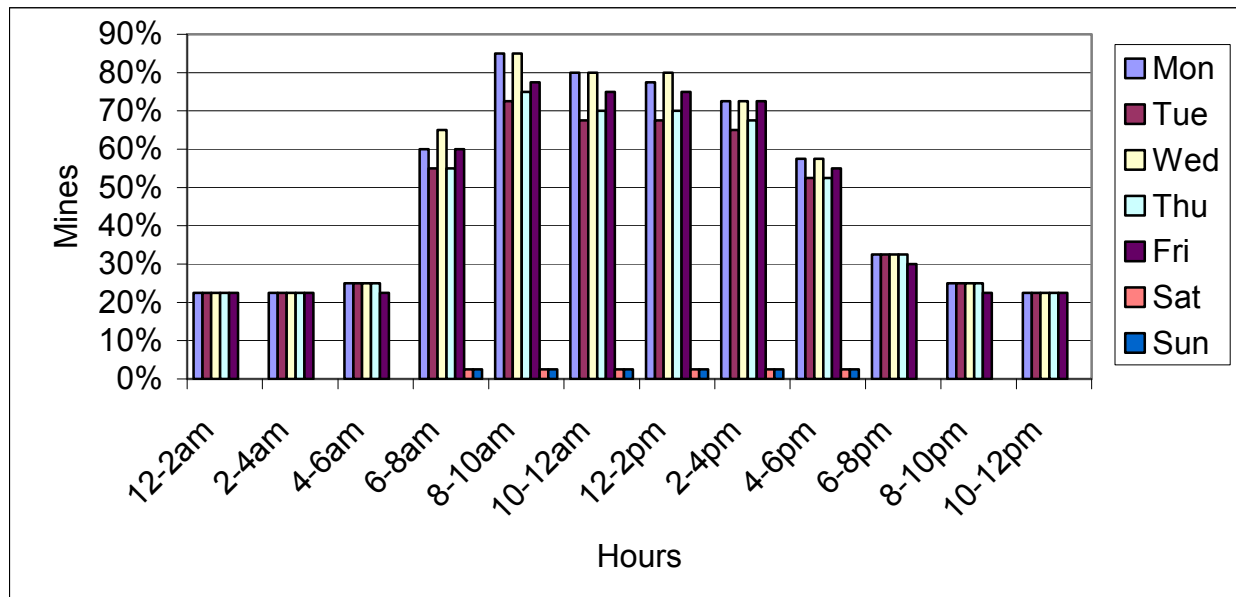
Source: Transportation of Mining/Mineral Survey results

In order to determine spatially varying relationships over the study area the state was split into four parts: North East, North West, South Central and South West. In this

case, to better understand effects of mine sites' operational hours at different locations of the state, the data for each of the regions were examined separately. The geographic split is based on WSDOT Regions, such that DOT's Olympic and North West regions form the North West region/part for this study, and the North Central and North East regions form North East part. South West and South East separations for the study coincide with the geographical boundaries of DOT's regions. The same operational pattern was observed for all regions except for South Central, where in comparison with other regions or global pattern (much less than 20%) the number of mines operating a night shift is between 20 and 30% (Figure 4.4.2).

Sometimes mines' operational times can be affected by the local governments that are taking responsibility of noise control and abatement (Noise Control Act, Chapter 70.107 RCW). In addition to state regulations, local governments can enforce their own more restrictive regulations on noise standards, which can be construed as an additional constraint for mines operation. This suggests that 20-30% of mining sites located in the South Central regions may be affected more from local regulations than those located in other parts of the state. Alternatively, this may imply more volume or more availability of day-around supply of aggregates for construction sites located in the South Central part of the state, which will give more flexibility to the construction firms' operations. This discussion will be revisited in the "Seasonality of aggregate shipments and mine operations" section where the link between operational hours and operational/shipment months will be investigated.

**Figure 4.4.2** Mines' operations by days and hours (South Central region)



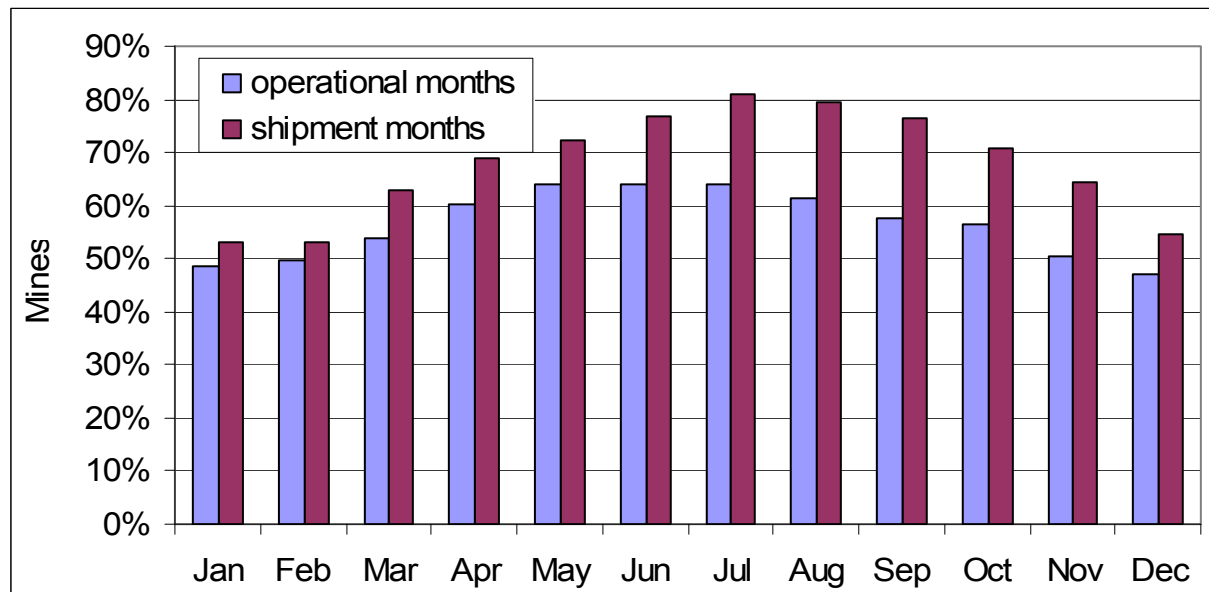
Source: Transportation of Mining/Mineral Survey results

#### 4.5 Seasonality of Aggregates Shipments and Mine Operations

Seasonality of shipments and mine operations also affects traffic flows and infrastructure needs. As shown in Figure 4.5.1, operational months peaked in April to August months. A similar pattern can be observed for the months when shipments occur with July as the peak of operations. When analyzed in relation to number of hauling trucks, the pattern of shipment months may suggest relatively less number of trucks in November, December, January and February. Generally, as the study found out (when analyzing factors influencing shipments), variations in demand and weather conditions were most the most important factors affecting shipment operations. Linking this with operations and shipments characteristics allows two inferences: first, decreasing operations cause less shipment in the winter period (as the pattern shows in

Fig. 4.5.1); secondly, decreases in shipments from November to March period increases mine sites' inventories and causes slow down in operations<sup>8</sup>.

**Figure 4.5.1** Seasonality of mine operations and aggregate shipments (global)



Source: Transportation of Mining/Mineral Survey results

This overall average relationship (global form), however, may hide some interesting and important local variations. For example in the Western regions, the availability of many construction projects (demand) or favorable weather conditions may lead to a higher percentage of mines to be in operation than it would be in the Eastern part of the state. This variability caused a deeper look at the data, using local forms of spatial analysis in the research study.

Received pattern, by region, showed differences in operational and shipment patterns between Western and Eastern regions<sup>9</sup>. The Western region showed about

<sup>8</sup> As shown in Table 2.1.2, the use of aggregates (gravel) for snow and ice control purposes accounted for only small portion of the total use.



twice as many operating mines from November to February. In addition, from March through October, on average 34% more mines were operating in the Western region (Figures 4.5.2 and 4.5.3).

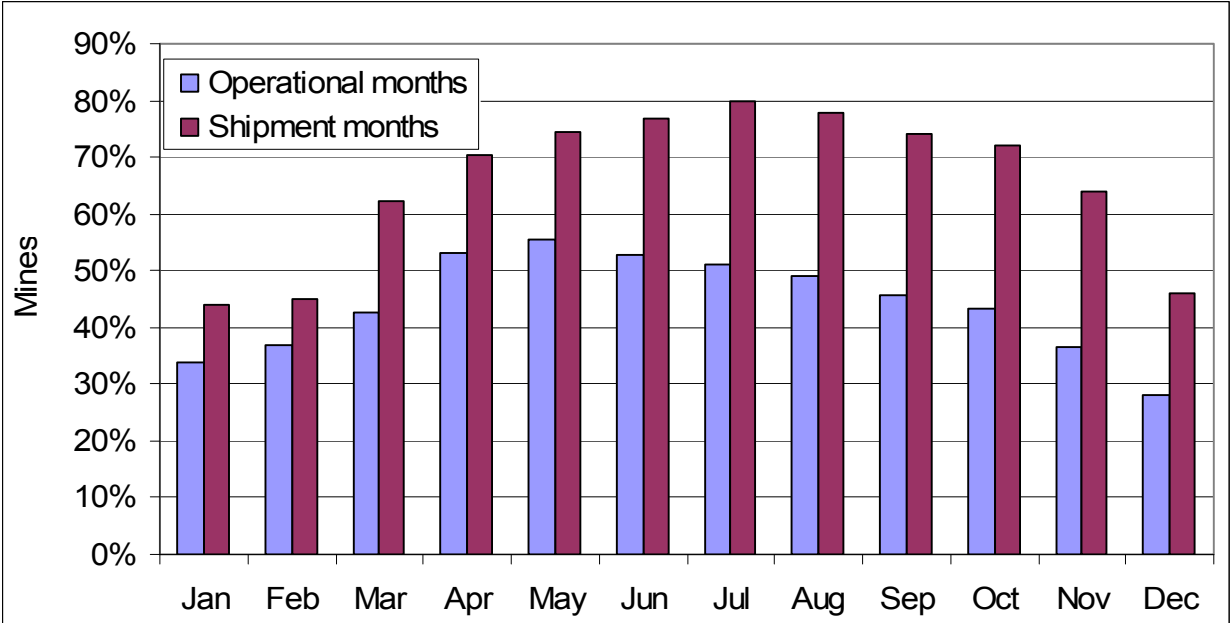
As it was noticed in the “Operational Times” section earlier, mines in the South Central region (which was included in the Eastern region in this section) had longer operational hours for the night shift than mines in the rest of the regions, which could affect the seasonality of operational months pattern of the entire Eastern region. It does appear that weather conditions in the Eastern Washington can be less favorable for mining operations.

While the higher percentage of mines shipping during winter months provides more stability and flexibility to construction sites/projects in the Western region, it also generates increased usage of the state road system. The relationship between trucks payload and shipment distances will be discussed later in the study.

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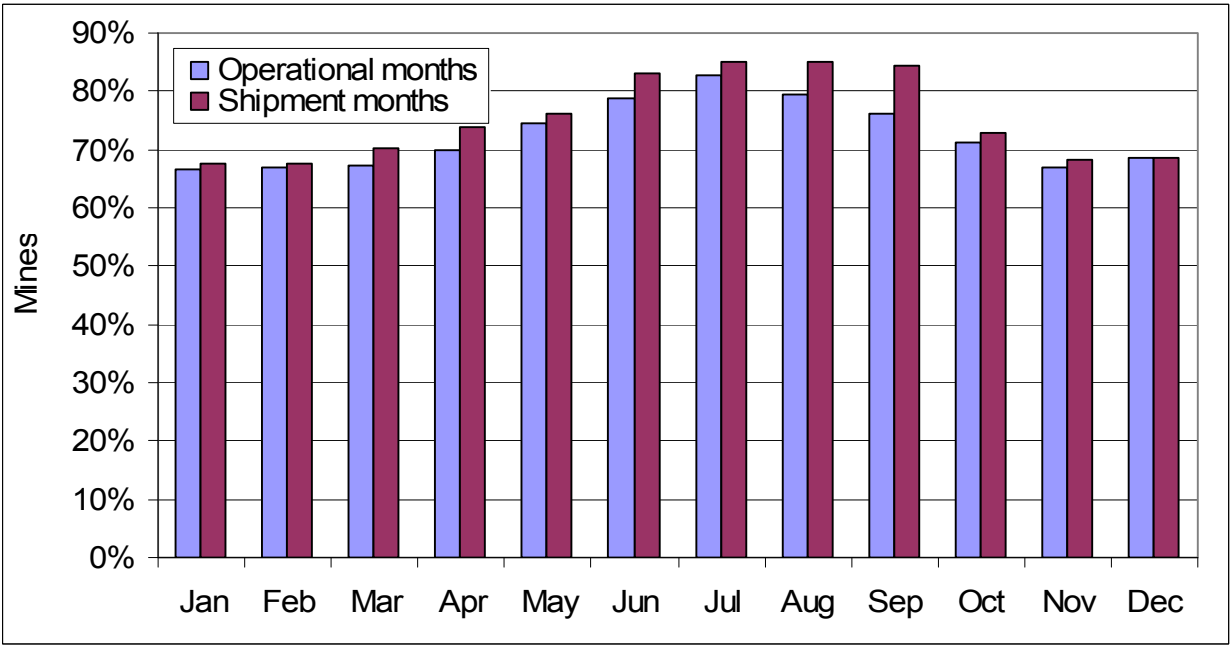
<sup>9</sup> Because North West and South West data formed similar pattern, as well as that of North East and South Central regions, in this section the split of the data will be examined as Western and Eastern regions.

**Figure 4.5.2** Eastern region’s seasonality of mine operations and aggregate shipments



Source: Transportation of Mining/Mineral Survey results

**Figure 4.5.3** Western region’s seasonality of mine operations and aggregate shipments

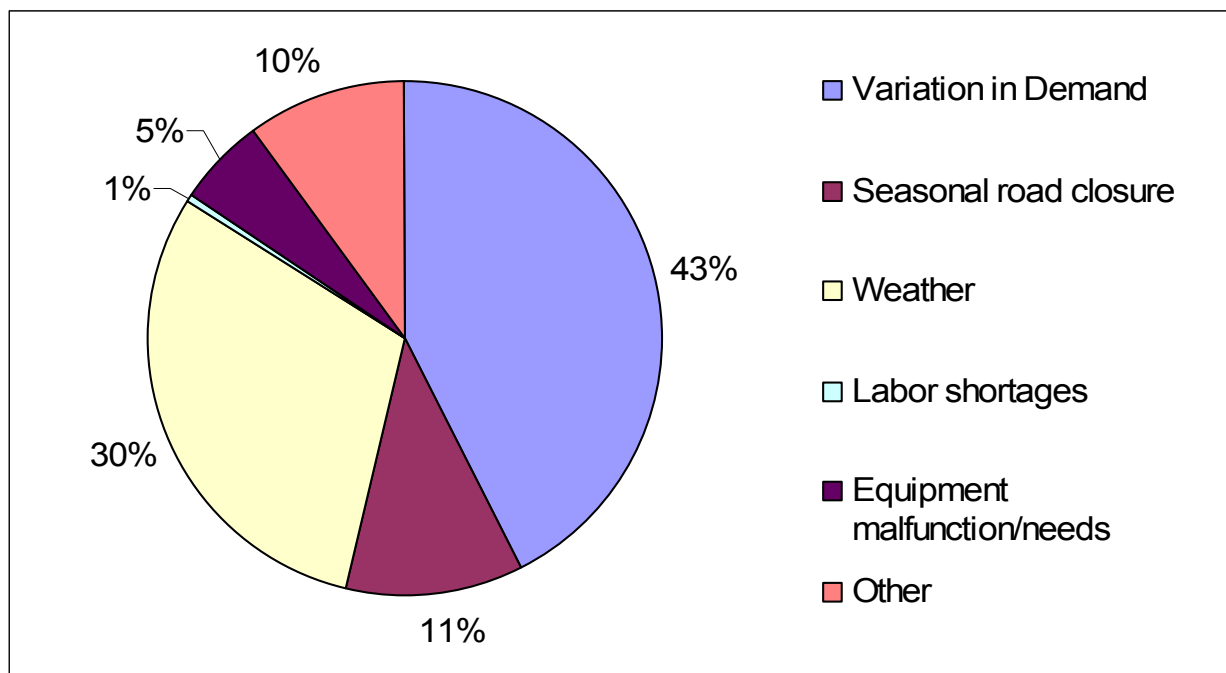


Source: Transportation of Mining/Mineral Survey results

## 4.6 Factors Influencing Shipments

Many factors influence shipments of mined minerals. As expected the largest source of influence is explained by the demand for the product. Forty three percent of the companies identified variation in demand as the main factor influencing their monthly shipments. “Weather conditions” accounted for 30% of responses. Seasonal road closure and “other” category were considered as next two factors with 11% and 10% of responses accordingly. “Other” category include identified factors such as competition, contractors’ schedule, county limitations on number of trips, permit problems, construction project schedule, highway rehabilitation projects, and road maintenance projects. Equipment malfunction/needs and labor shortages affect mine commodities shipments by 5% and 1% accordingly (Figure 4.6.1).

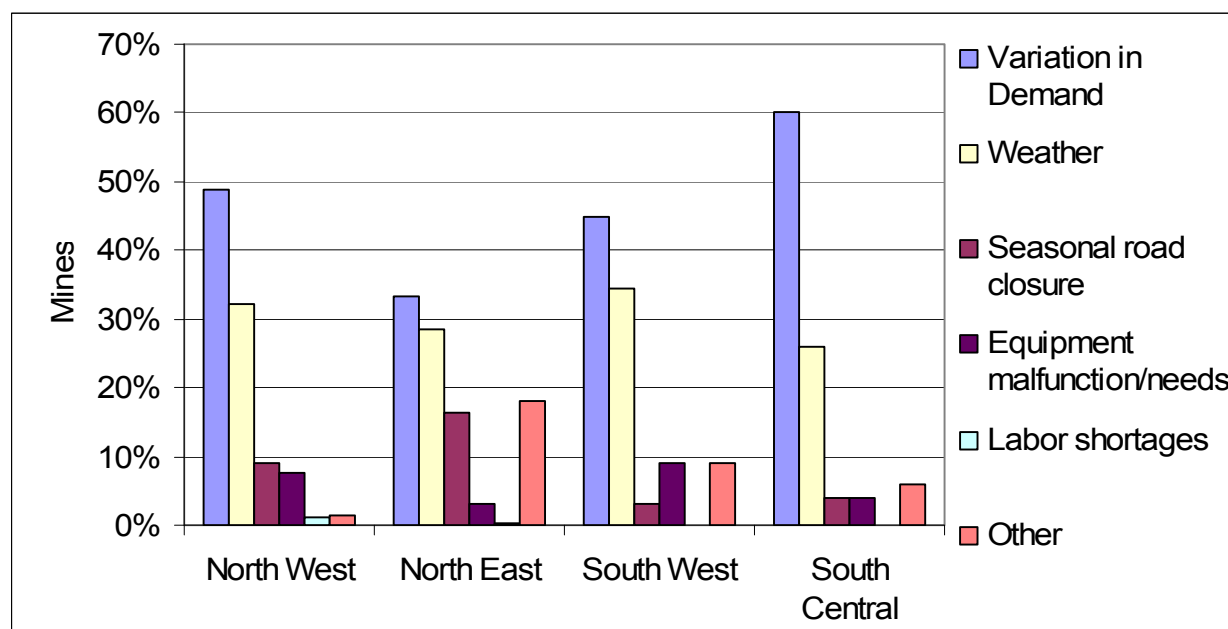
**Figure 4.6.1** Factors affecting mined commodities shipments (global)



Source: Transportation of Mining/Mineral Survey results

However, global statistics described above are again very general. In contrast, local statistics emphasize the differences across areas, and it was found that variation in demand ranged across the state from 34% to 60%. Mines in South Central region are more dependent on demand availability than mines in the North East. In contrast, North East is more dependent on weather, seasonal road closures. Western regions had similar pattern of responses for factors influencing shipments except for seasonal road closures, which were higher for the mines located in the North West (Figure 4.6.2).

**Figure 4.6.2** Factors affecting mined commodities shipments (split data)



Source: Transportation of Mining/Mineral Survey results

#### 4.7 Shipment Destinations by Type (instate)

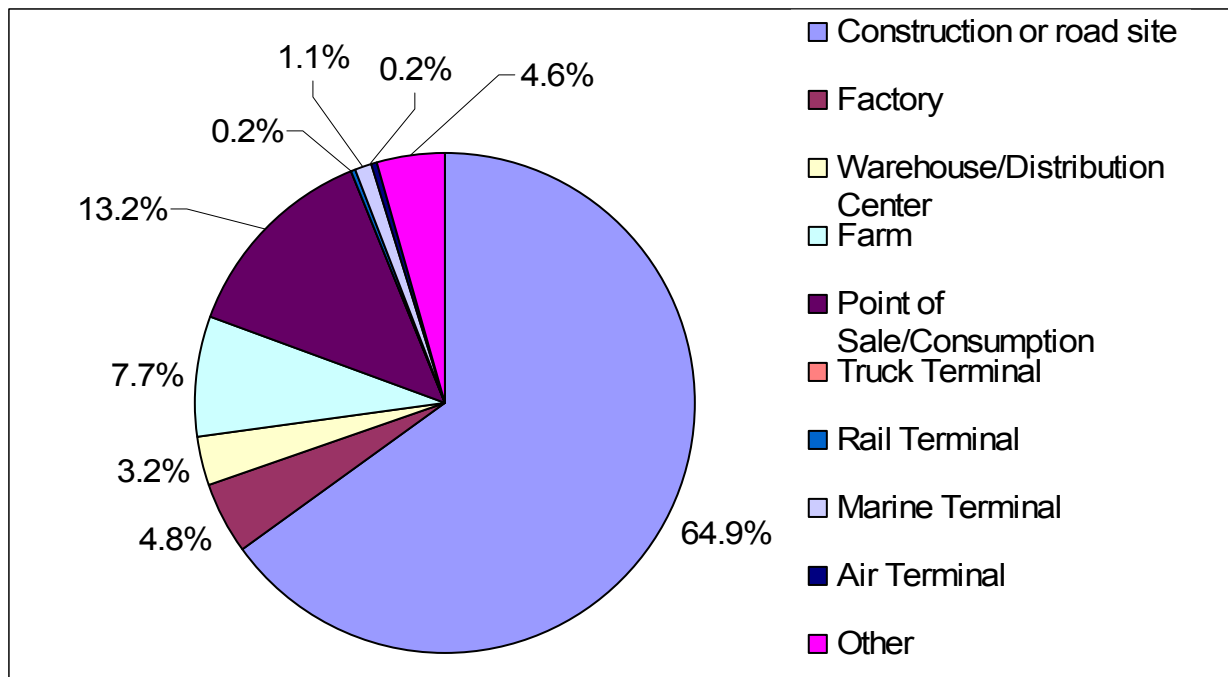
Instate shipments were divided into destination types in order to investigate end points and usage of aggregates shipments. The question was designed to collect relative proportional information about shipments destinations such as construction or

road site, factory, warehouse/distribution center, farm, point of sale/consumption, truck terminal, rail terminal, marine terminal, air terminal and other destinations. Again as expected, the category, construction or road sites, was the destination (65%) for most of the shipments (Figure 4.7.1). Other destinations were:

- Point of Sale/Consumption 13%
- Farm 8%
- Factory 5%
- Warehouse/Distribution Center 3%
- Marine Terminal 1%
- Other 5% (logging roads, lumber log/storage yards, forestry, refinery, concrete plants and mine sites)

To analyze the relationship of proximity and various types of destinations from mines, the data was linked with the data collected on shipment distances. As is noticed later in the “Shipment Distances” section, aggregates were mostly (56%) shipped within 10 miles from mines. Sixty five percent of that volume was consumed by only construction or road sites that were located within 10 miles from mines, 13% was attributed to point of sales or consumption destination , 8% and 5% to farm and factory destinations.

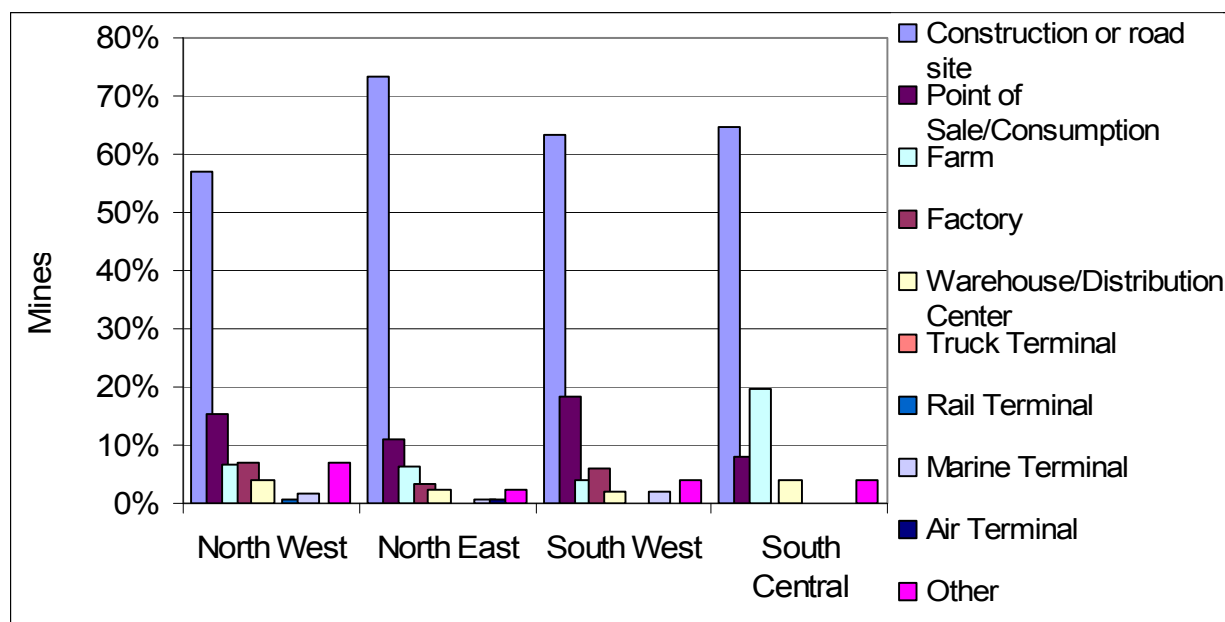
**Figure 4.7.1** Shipment destinations by type (global)



Source: Transportation of Mining/Mineral Survey results

Variations were found as to several destination types across regions. “Construction or road site” destination ranged from 57% in the North West region to 73.4% in the North East, and “point of sale/consumption” ranged 7.8% in South Central to 18.4% in the South West regions. Variations in shipments to “farm” category were also noted, ranging from 4.1% in the South West to 19.6% in the South Central region (Figure 4.7.2).

**Figure 4.7.2** Shipment destinations by type (split data)

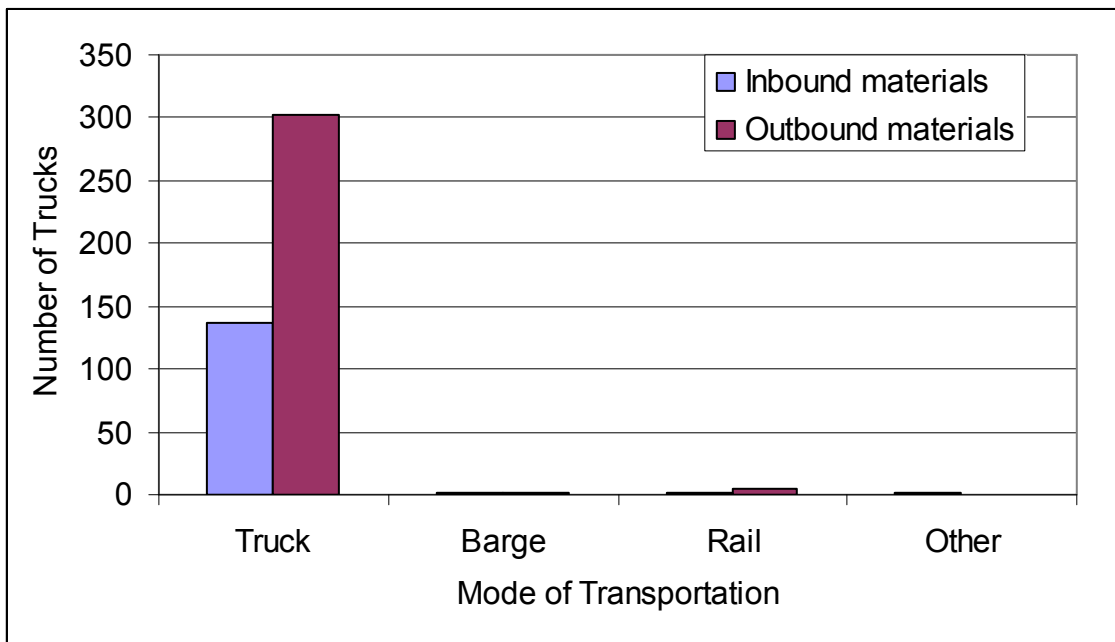


Source: Transportation of Mining/Mineral Survey results

#### 4.8 Modal Usage

Information on the use of alternative transportation modes was sought for both inbound and outbound shipments. Ninety seven percent of inbound and 98.4% of outbound shipments relied on trucks for aggregates shipments (Figure 4.8.1). Only 33% of mines were found to have inbound shipments. Major materials shipped into mines consist of liquid asphalt, cement, soil, fine sand, recycled asphalt, topsoil, sand, dirt, crushed rock-concrete for recycle, rock phosphate, gypsum, coal, asphalt grindings, sand and gravel, waste soil, fuel, round rock, inert soil or wood ash, explosives and other supplies.

**Figure 4.8.1** Shipments by mode



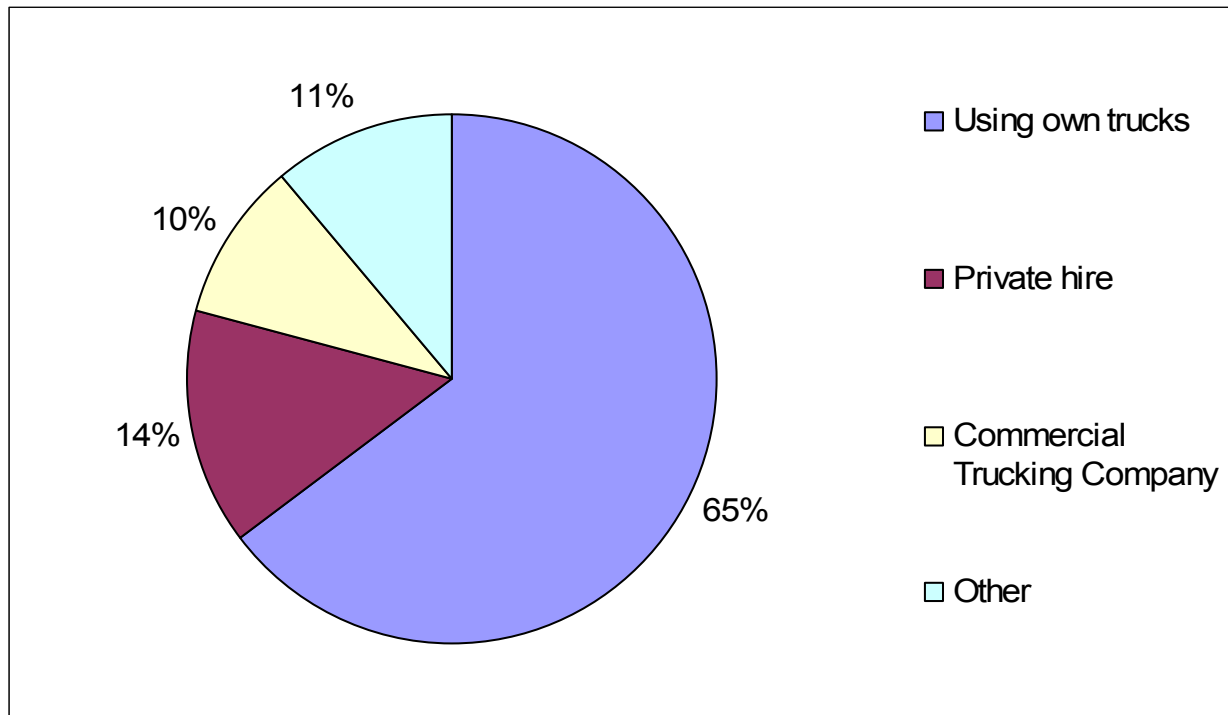
Source: Transportation of Mining/Mineral Survey results

#### 4.9 Ownership of Trucks

Some mines do use their own fleet of trucks, ranging from a low of 1 up to 47 trucks. The average number of trucks owned by mining firms was 16.5 with mode of 35. Companies owning their own trucks accounted for 65% of the total, with the remaining 35% being operated as private trucks for hire, as commercial trucking services or by other types of trucking options (Figure 4.9.1). Fourteen percent of companies use private trucks for hire, 10 % as commercial hire, and 11% make use of other options which include contractors, tenants at port site, consumers with their own trucks, affiliated company, state timber sale purchaser, county public works, DOT, governmental and lessee.



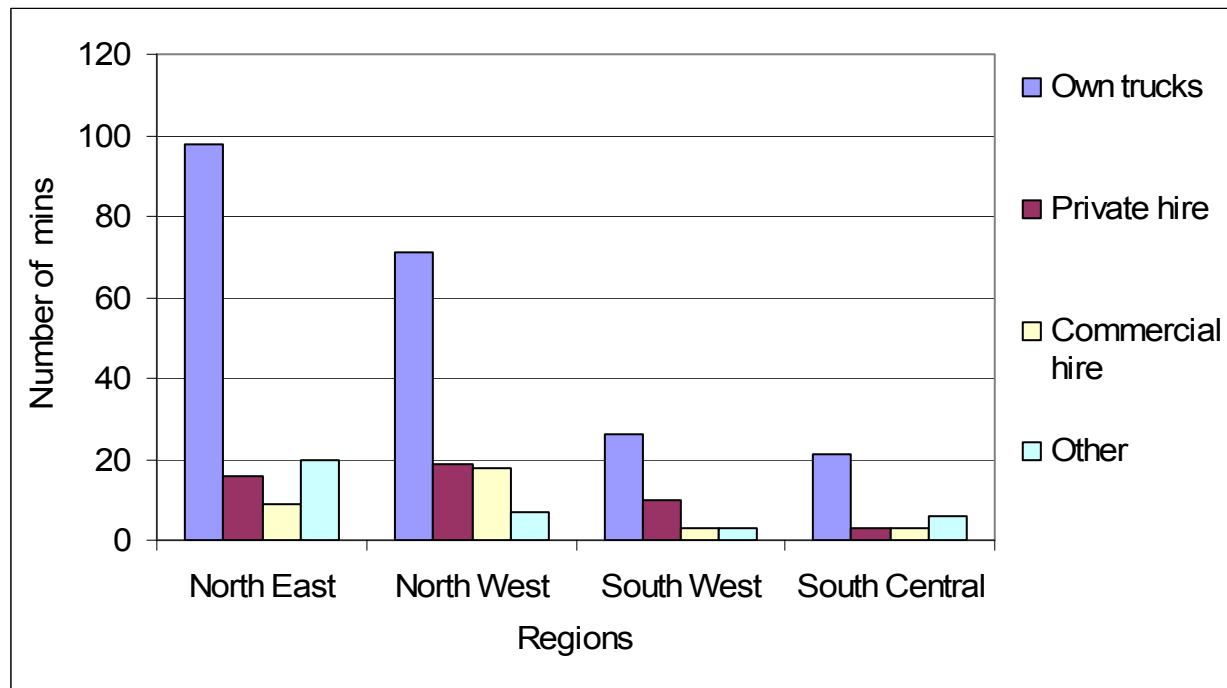
**Figure 4.9.1** Ownership of trucks



Source: Transportation of Mining/Mineral Survey results

Regions displayed considerable differences in truck ownership characteristics across the study area (Fig. 4.9.2). The North East and North West regions had a substantial amount of mines that operate with their own fleet of trucks. This could be partially explained by the higher volumes of mineral shipments for longer distances in the North West and North East regions (mentioned in the "Shipment Distances by Volume and Road Network Used" section, Fig. 4.12.2).

**Figure 4.9.2** Ownership of trucks (split data)



Source: Transportation of Mining/Mineral Survey results

**Table 4.9.1** Variation of truck ownership information across regions (number of trucks)

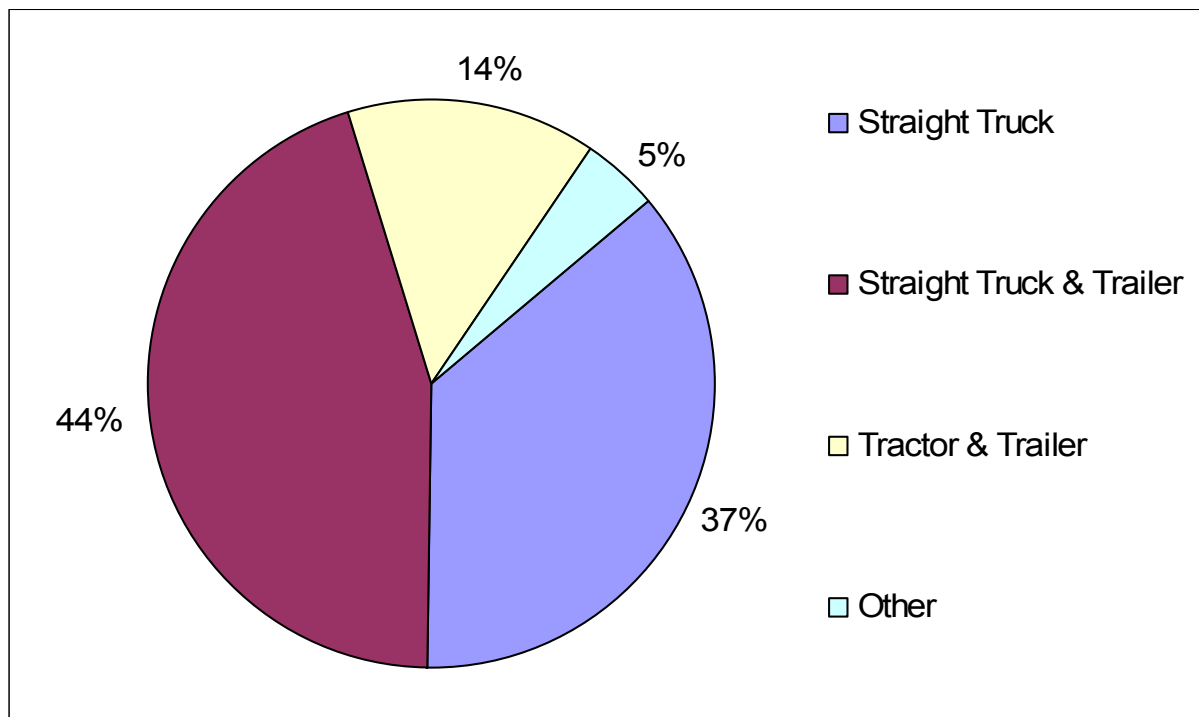
	North East Region	North West Region	South West Region	South Central Region
Average	19.8	14.8	12	12.8
Mode	35	12	17	20
Total	1800	992	300	257

Source: Transportation of Mining/Mineral Survey results

#### 4.10 Truck Configurations, Payload Weight and Axles on Ground

The configuration of the trucks, which can be affected by road availability and usage, as well as a desire for overall efficiency, were straight truck, straight truck & trailer, tractor & trailer and other. About 37% of aggregates are moved by straight truck, 44% by straight truck & trailer, and 14% by tractor & trailer. The remaining portion is shipped using dump trucks, train tractor & two trailers, tractor & double trailers, and truck & transfers (Figure 4.10.1).

**Figure 4.10.1** Truck configurations used for aggregates hauling



Source: Transportation of Mining/Mineral Survey results

Payload weight for outbound truck shipments in this study ranged from 3.5 to 50 tons of aggregates. The average payload is 23.2 tons and the mode is 30 tons. Allowable weights for trucks driving on Washington road networks are set by the state

legislature and regulated by Washington State DOT and Washington State Patrol, based on tire size, the number of axles, and the spacing of axles (or axle groups). However, weights are also subject to further limitations at the county level, which are sometimes more restrictive than state rules, especially during varying weather conditions.

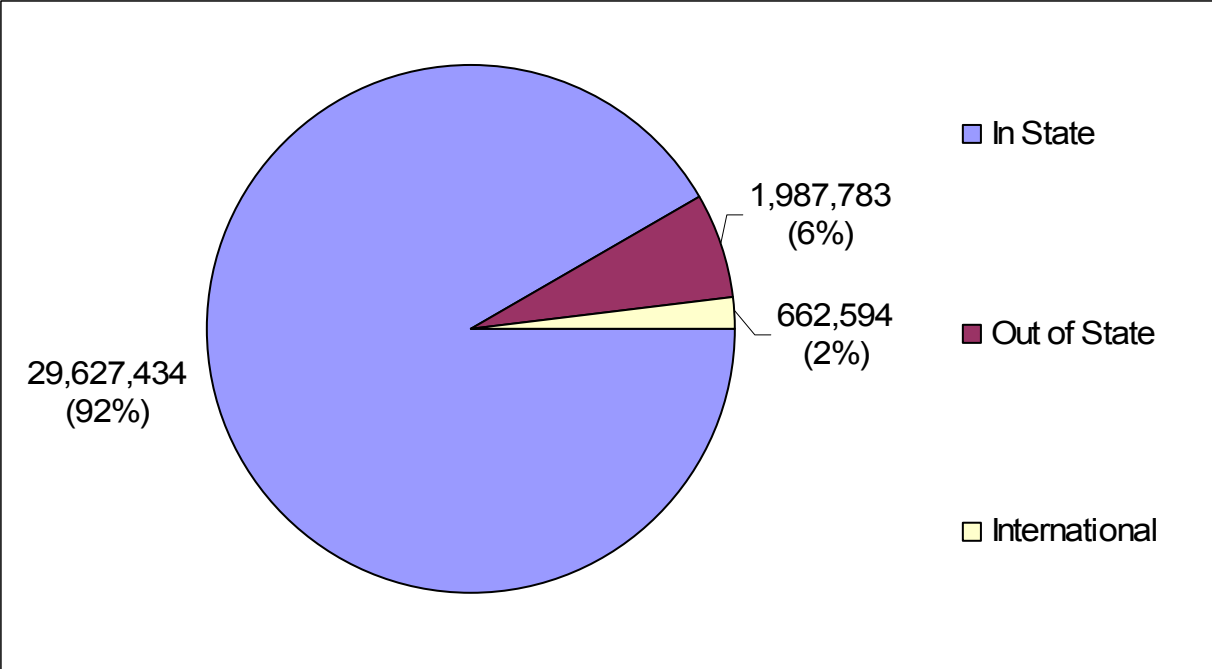
Since the damage to pavements is closely related to the weight on each axle of the trucks, the survey questionnaire included questions to determine number of axles on the ground for the trucks leaving mining facilities. Number of axles typically on the ground varies depending on the type of a truck. According to survey results the number of axles that are typically on the ground ranges from 2 to 6 for trucks, with the average of 3.4 and mode of 3 axles. Trailer axles on the ground ranged from 2 up to 7 axles, with an average and mode of 3. Total number of axles for truck or tractor ranges from 2 to 9, with average of 3.6 axles. With an average of 3 axles, the total number of axles on 1<sup>st</sup> trailer varies from 2 to 5 axles.

#### 4.11 Shipment Destinations

Three main destinations of shipments of interest were in-state, out-of-state and international. Not surprisingly, 92% of mined product is shipped within the State of Washington. The geography of shipments is probably explained mainly by high transportation cost of the low cost aggregates. Six percent of the shipments were out-of-state destinations and the remaining 2% was shipped out-of-country, mostly to Canada (Figure 4.11.1). The small portion of international and out of state shipments corresponds to the 2% of responses indicated for shipments over 100 miles in the “Shipment Distances by Volume and Road Network Used” section. It also supports the

statement that aggregates industry is highly affected by transportation in terms of high cost of shipments and emphasizes that proximity of mine site location to the construction site or any other end use location is important, maybe even critical.

**Figure 4.11.1** Mined products shipment destinations by production volumes (tons)



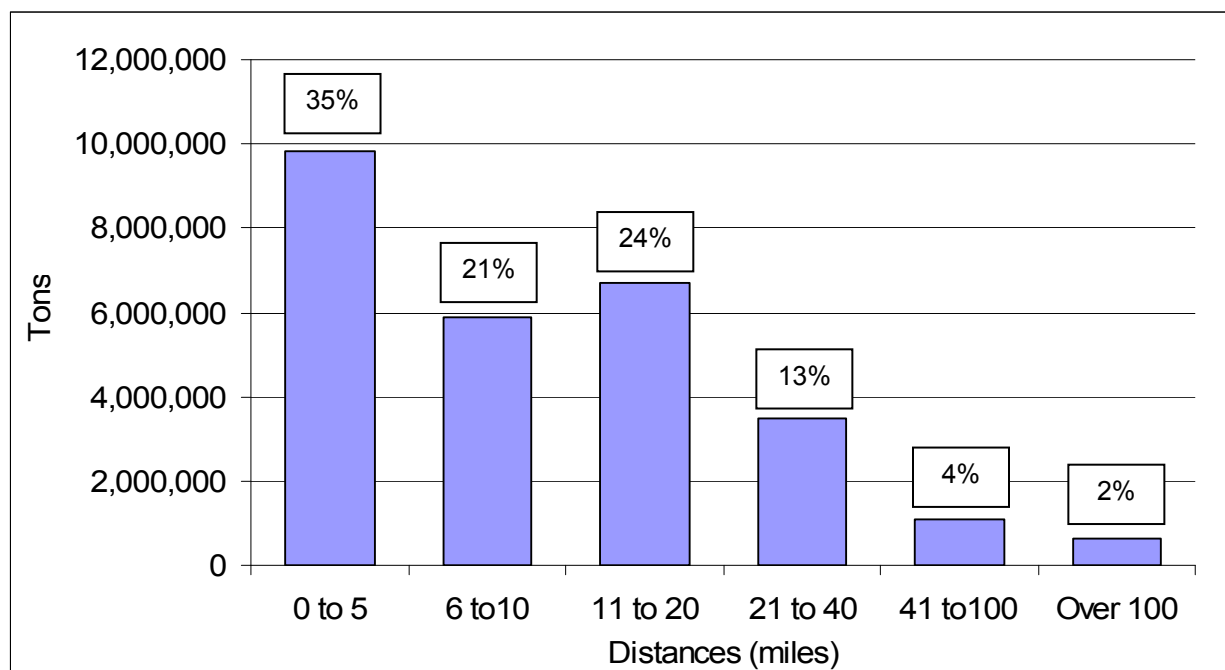
Source: Transportation of Mining/Mineral Survey results

#### 4.12 Shipment Distances by Volume and Road Network Used

It was found most aggregate is hauled within close distances from its origin. Survey results showed 80% of total production (78% of mine sites) was hauled within 20 miles or less from the mine location. In highway construction the cost of construction materials plays a vital role in meeting a construction project’s schedule and budget constraints (WSDOT, State Construction Office). An important cost component of the projects can be considered the delivery of construction materials to the sites. This

relationship is supported by high proportion of shipments within 5, 10 and 20 mile distances from mine locations (Figure 4.12.1).

**Figure 4.12.1** Aggregates shipment distances by production volume<sup>10</sup>



Source: Transportation of Mining/Mineral Survey results

Despite its low value per ton characteristic, an aggregate is heavy, which makes truck hauling very costly. Taking into account an average payload weight of 23 tons (survey results) and average transportation costs of \$80 - \$110 for an hour length haul, every additional 25 mile distance will add approximately \$40 - \$55 per truck<sup>11</sup>. Given 20,000 tons of aggregate per lane mile demand for a rural segment of interstate construction, every additional 25 mile distance of approximately 869 hauls (20,000/23 tons) will add about \$41,000 per lane mile construction. Additionally, road deterioration

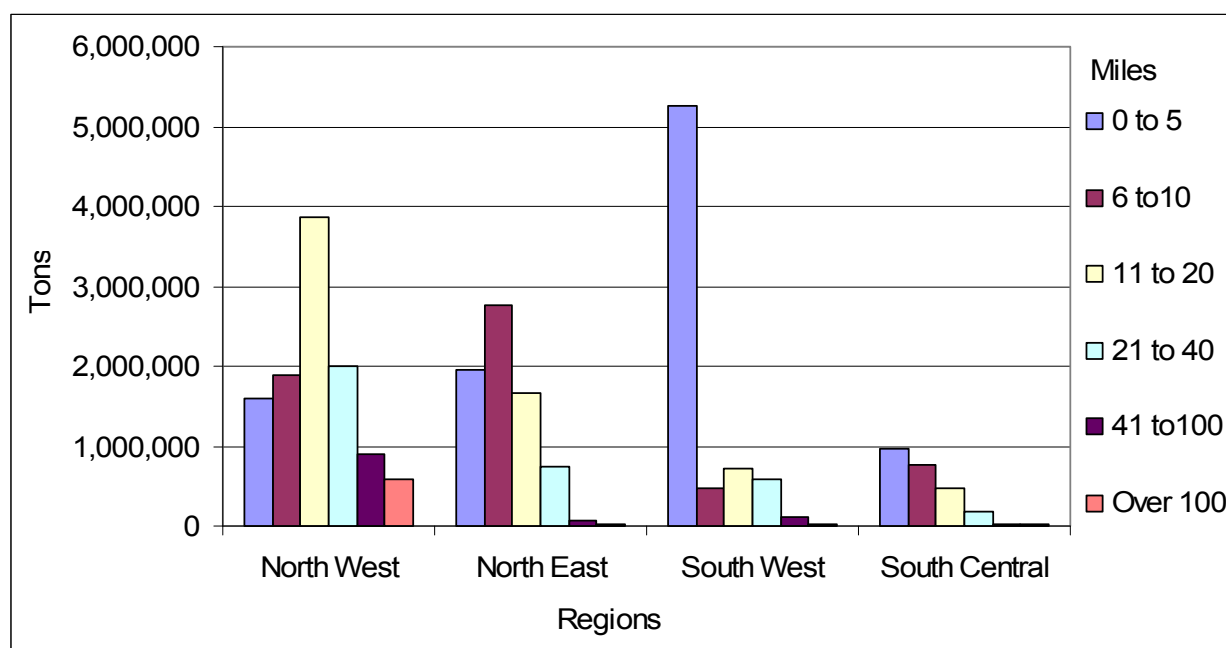
<sup>10</sup> Due to on-site use of mined production at several mine sites, the volumes indicated in this chart may differ from total production volumes.

<sup>11</sup> Trucking rates were averaged from phone interviews with mining firms.

level resulting from the trucks hauling the material also has to be carefully considered for projects planning, another topic investigated later in this report.

Comparison of regional statistics showed high volume of longer distance shipments for the mines in the North West region of the state. The South West region was differentiated by a high volume of shipments within 5 mile distances. Although local pattern of shipment distances varies across regions, generally most of the aggregates were hauled within 20 mile distances (Fig. 4.12.2). Shipment volumes over 40 miles were much higher in the North West region.

**Figure 4.12.2** Variation of aggregates shipment distances across regions by production volume (split data)



Source: Transportation of Mining/Mineral Survey results

In order to assess the usage of roads by the mining trucks, mining firms were indicated routes of state highways used for transportation (Appendix D). As stated earlier, with the average payload of 23 tons, 81% of the total mining production was

hauled within 20 mile distances of identified state highways and 57% of the total production within 10 mile distances. Appendix C represents maps created at specific county level with corresponding highway usage frequency tables.



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**Appendix A**  
**Mining/Mineral Production Data**

**Table 1.** Construction sand and gravel sold or used by producers in the United States in 2004, by geographic division and method of transportation (Thousand metric tons)

Region/division	Truck	Rail	Water	Other	Not transported	Not specified	Total
Northeast:							
New England	12,700	353	--	20	3,530	33,400	50,000
Middle Atlantic	23,000	18	--	1,200	3,860	45,200	73,300
Midwest:							
East North Central	77,200	406	4,930	141	10,900	137,000	231,000
West North Central	37,600	538	2,620	204	10,700	83,400	135,000
South:							
South Atlantic	41,300	351	14	--	4,700	42,600	89,000
East South Central	13,900	239	3,440	46	751	28,500	46,900
West South Central	45,900	1,260	92	--	12,600	62,500	122,000
West:							
Mountain	68,600	254	--	86	16,500	166,000	251,000
Pacific	117,000	2,820	2,470	1,260	22,800	92,500	239,000
Total	437,000	6,240	13,600	2,960	86,300	691,000	1,240,000

The table was adapted from U.S. Geological Survey *Construction Sand and Gravel Statistics and Information*, 2004 publication

**Table 2.** Number of surveyed mines, annual production volumes and types of commodities by county

	Sand & Gravel	Rock or Stone	Coal	Carbonate	Clay	Peat	Metals	Ash	Diatomite	Silica Sand	Soil	Gold	Other	Total	# of mines as %	Annual Production (tons)
Adams	16	17									1			34	6%	650,000
Asotin	1	1												2	0%	105,000
Benton	11	11												22	4%	1,640,000
Chelan	5	4												9	2%	213,000
Clallam	20	4			1									25	5%	383,480
Clark	7	7												14	3%	1,425,200
Columbia	2	4												6	1%	140,000
Cowlitz	3	6			1								1	11	2%	70,100
Douglas	10	5												15	3%	761,000
Ferry	9						1					1		11	2%	567,550
Franklin	2													2	0%	100,000
Garfield		1						1						2	0%	25,000
Grant	35	3											1	39	7%	1,582,750
Grays Harbor	6	2												8	1%	160,200
Island	5													5	1%	197,013
Jefferson	4	2												6	1%	51,500
King	10	3			2					2			1	18	3%	1,481,000
Kitsap	12	3												15	3%	920,000
Kittitas	8	8												16	3%	208,500
Klickitat	3	13												16	3%	250,000
Lewis	3	4	1											8	1%	5,260,000
Lincoln	23	14												37	7%	1,020,000
Mason	6	4												10	2%	1,434,050
Okanagan	22	1		2										25	5%	453,300
Pacific		2												2	0%	85,000
Pend Oreille	5	3												8	1%	411,500
Pierce	5	3			1						3			12	2%	3,010,000
San Juan		3												3	1%	153,000
Skagit	4	3												7	1%	425,000
Skamania	3	4												7	1%	105,000
Snohomish	10	8									2			20	4%	2,865,711
Spokane	22	23			3									48	9%	2,130,000
Stevens	14	6								2			1	23	4%	933,152
Thurston	6	2			1									9	2%	950,100
Walla Walla	3	3												6	1%	66,000
Whatcom	6	1												7	1%	375,030
Whitman	24	12												36	6%	1,140,003
Yakima	4	7												11	2%	479,673
<b>Total</b>	<b>329</b>	<b>197</b>	<b>1</b>	<b>2</b>	<b>9</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>4</b>	<b>6</b>	<b>1</b>	<b>4</b>	<b>555</b>		<b>32,227,812</b>
Comm as %	59%	35%	0%	0%	2%	0%	0%	0%	0%	1%	1%	0%	1%			
Max														48		5,260,000
Min														2		25,000
Average														15		848,100

Data Source: Transportation of Mining/Mineral Survey results

**Table 3. Operational mines' annual production volumes and types of commodities by county**

County	Sand/ Gravel		Rock/ Stone		Clay		Silica		Coal		Total
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons
Lewis	120,000	2%	90,000	2%					5,000,000	96%	5,210,000
Snohomish	1,725,000	60%	1,140,711	40%							2,865,712
Spokane	1,315,000	66%	620,000	31%	50,000	3%					1,985,001
Pierce	1,080,000	71.52%	425,000	28.15%	5,000	0.33%					1,510,001
Clark	274,000	20%	1,121,200	80%							1,395,200
Grant	887,000	77%	268,750	23%							1,155,751
Benton	600,000	56%	475,000	44%							1,075,001
Thurston	700,100	74%	250,000	26%							950,101
Kitsap	656,000	72%	260,000	28%							916,001
King	499,000	60%			62,000	7%	270,000	32%			831,001
Stevens	394,605	48%	168,647	21%			254,000	31%			817,253
Lincoln	140,000	22%	500,000	78%							640,001
Adams	175,000	34%	345,000	66%							520,000
Whitman	70,003	14%	445,000	86%							515,004
Yakima	176,520	39%	273,153	61%							449,674
Clallam	285,480	76%	91,000	24%							376,481
Whatcom	310,030	86%	50,000	14%							360,031
Mason	76,000	23%	255,050	77%							331,051
Klickitat	24,000	10%	221,000	90%							245,001
Island	197,013	100%									197,014
Douglas	180,000	100%									180,001
Grays Harbor	90,200	56%	70,000	44%							160,201
Okanogan	112,000	100%									112,001
Skamania	0		105,000	100%							105,001
Franklin	100,000	100%									100,001
San Juan			95,000	100%							95,001
Kittitas	90,500	100%									90,501
Pacific			85,000	100%							85,001
Pend Oreille	71,500	100%									71,501
Columbia			60,000	100%							60,000
Jefferson	10,500	20%	41,000	80%							51,500
Cowlitz	50,100	100%									50,101
Ferry	46,000	100%									46,001
Chelan	40,000	100%									40,001
Walla Walla	20,000	50%	20,000	50%							40,001
Asotin	30,000	100%									30,001
Skagit	24,000	96%	1,000	4%							25,001
Garfield	0										0
Total	10,569,551		7,476,511		117,000		524,000		5,000,000		23,687,093

Data Sources: Transportation of Mining/Mineral Survey

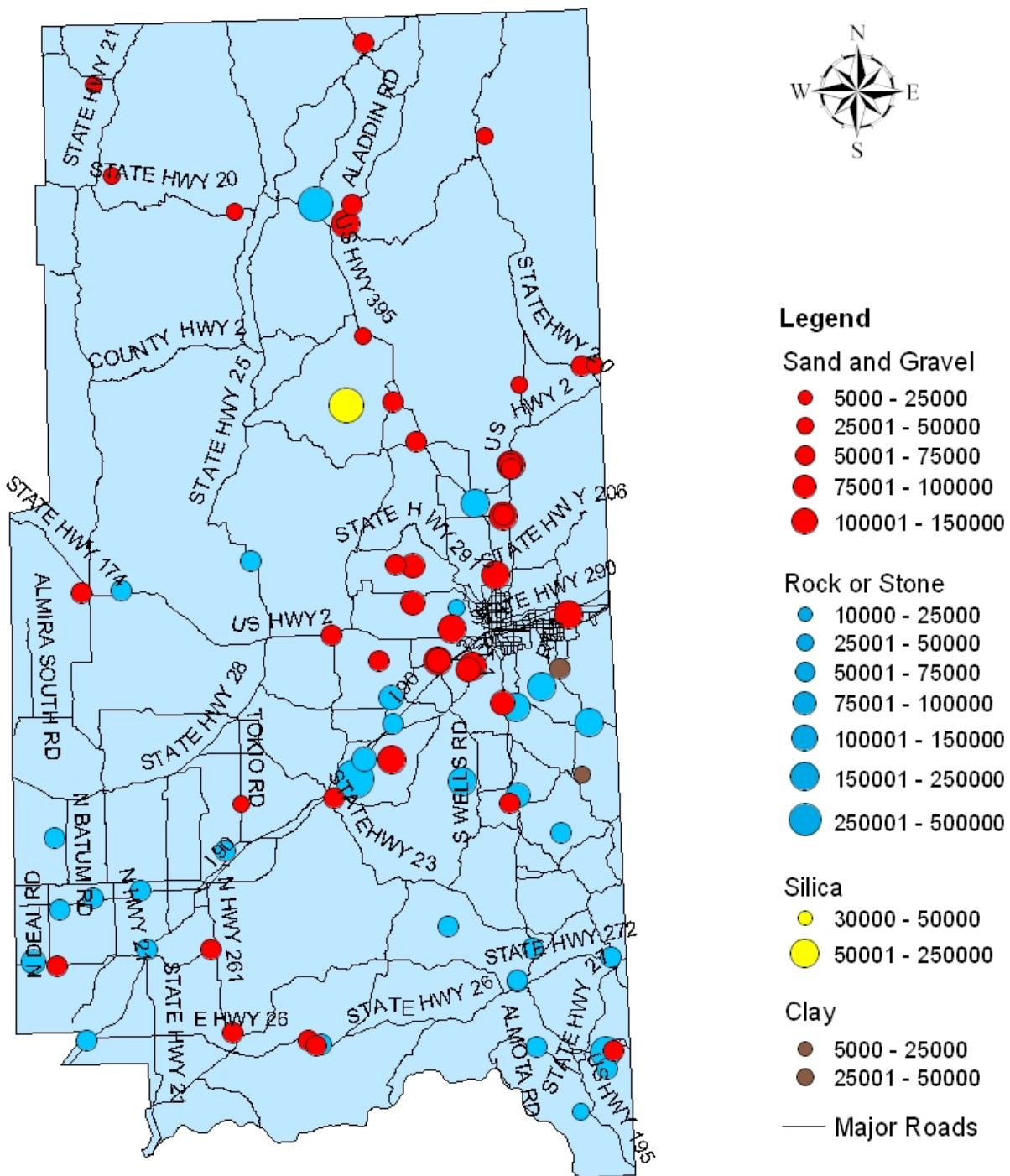
## **Appendix B**

### **Operational Mines' Locations and Data (by WSDOT Regions)**

#### Data Sources:

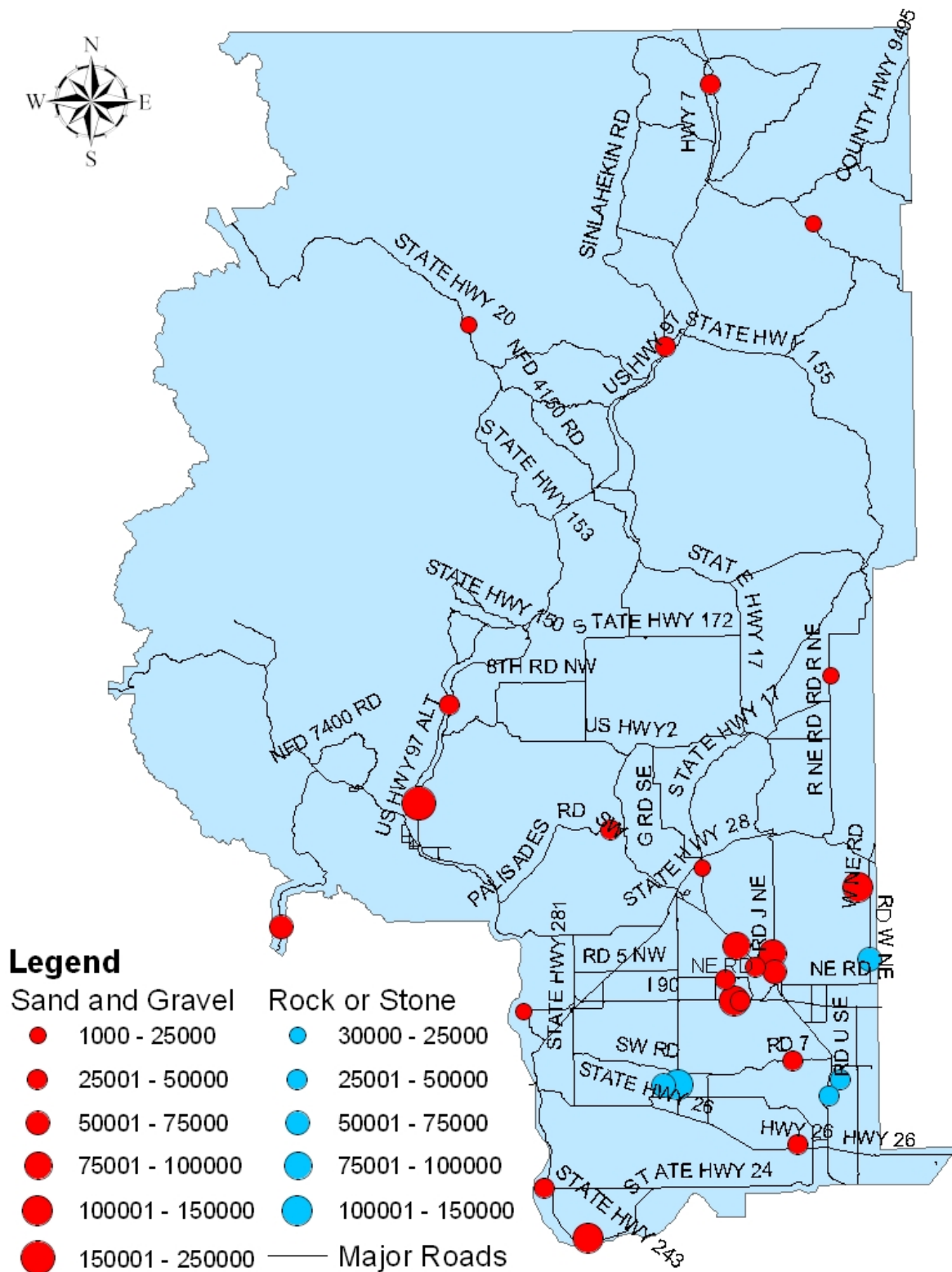
- Transportation of Mining/Mineral Survey
- Geographic site information for all figures was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources.
- County and highway system GIS files were provided by the WSDOT GeoData Distribution Catalog.

**Figure 1.** Washington State Department of Transportation Eastern Region: mines by type and production level in relation to highway system

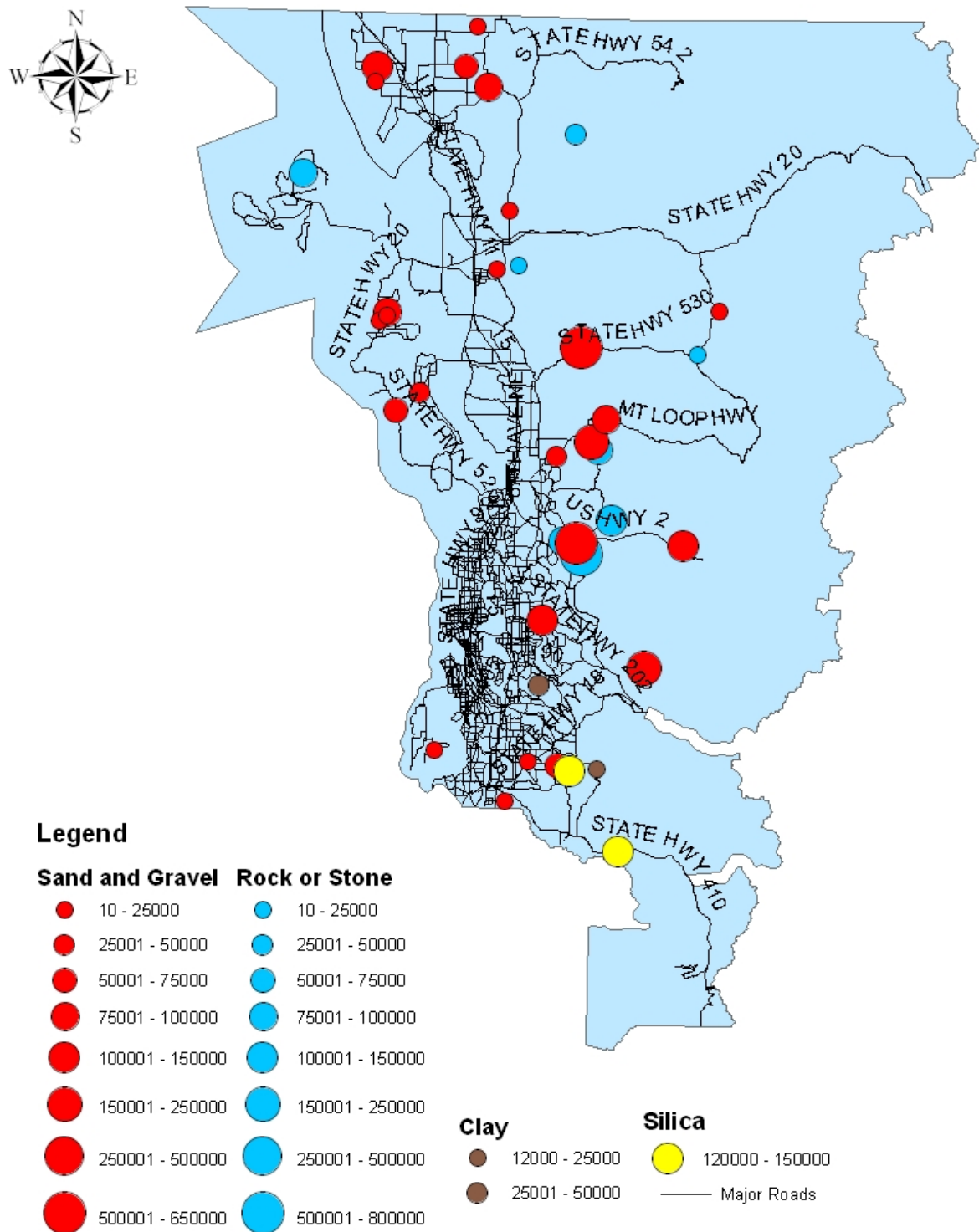




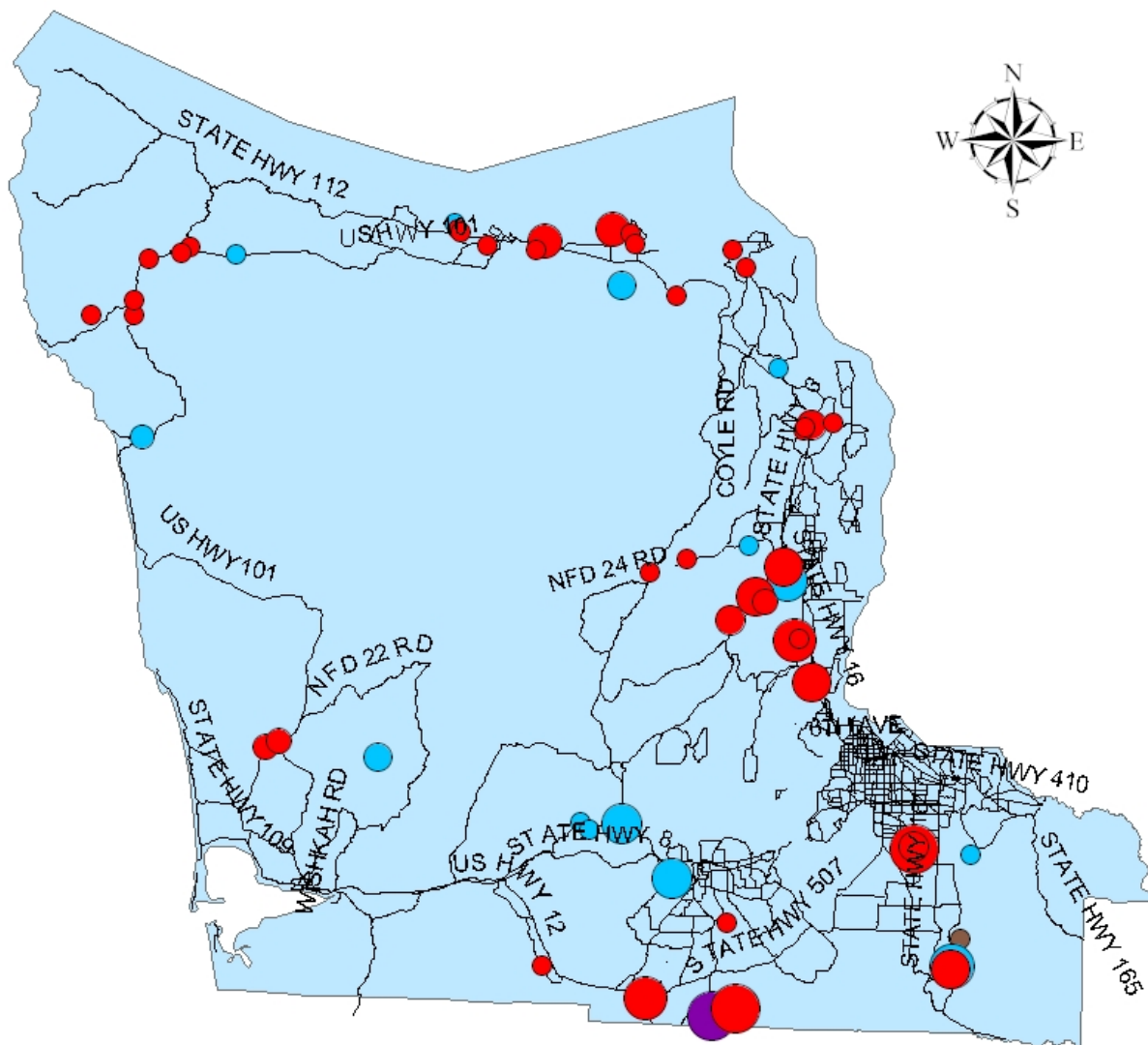
**Figure 2.** Washington State Department of Transportation North Central Region: mines by type and production level in relation to highway system



**Figure 3.** Washington State Department of Transportation Northwest Region: mines by type and production level in relation to highway system

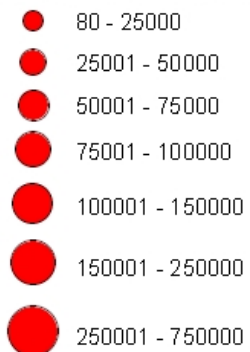


**Figure 4.** Washington State Department of Transportation Olympic Region: mines by type and production level in relation to highway system

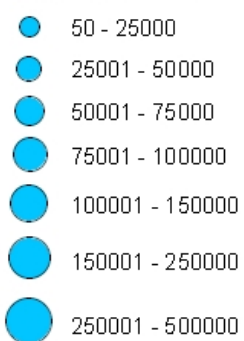


### Legend

#### Sand and Gravel



#### Rock or Stone



#### Coal

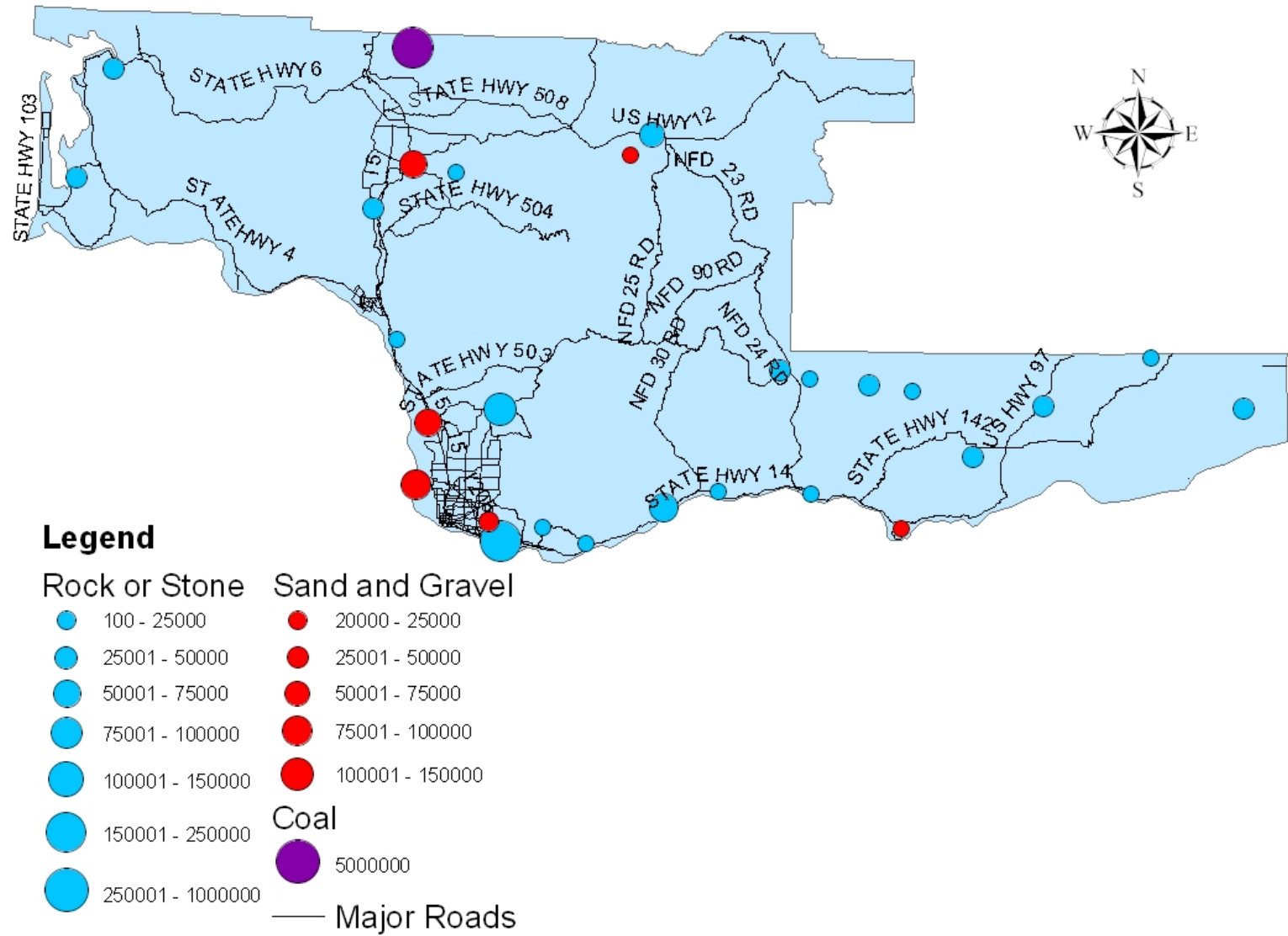


#### Clay

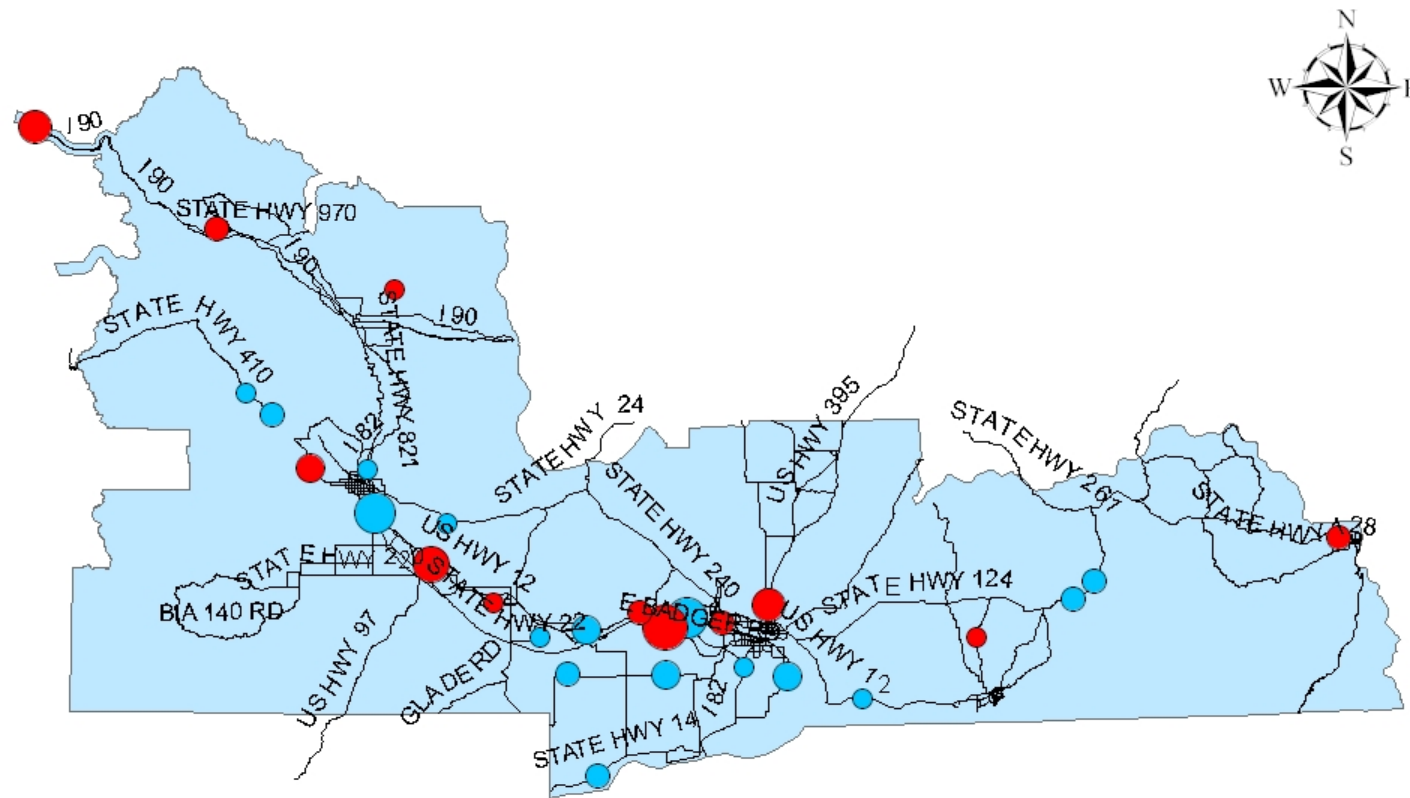


#### Major Roads

**Figure 5.** Washington State Department of Transportation Southwest Region: mines by type and production level in relation to highway system

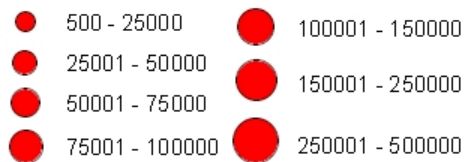


**Figure 6.** Washington State Department of Transportation South Central Region: mines by type and production level in relation to highway system

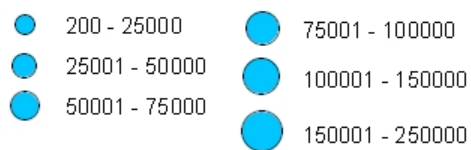


### Legend

#### Sand and Gravel



#### Rock or Stone



— Major Roads

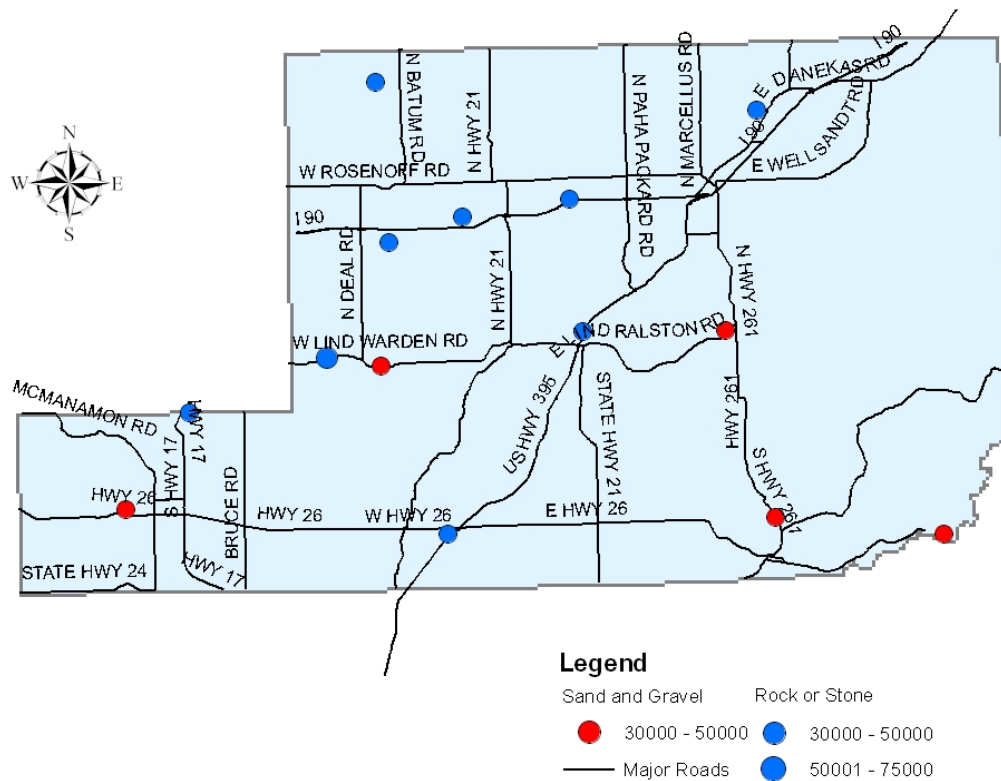
## **Appendix C**

### **Operational Mines' Locations and Data (by County)**

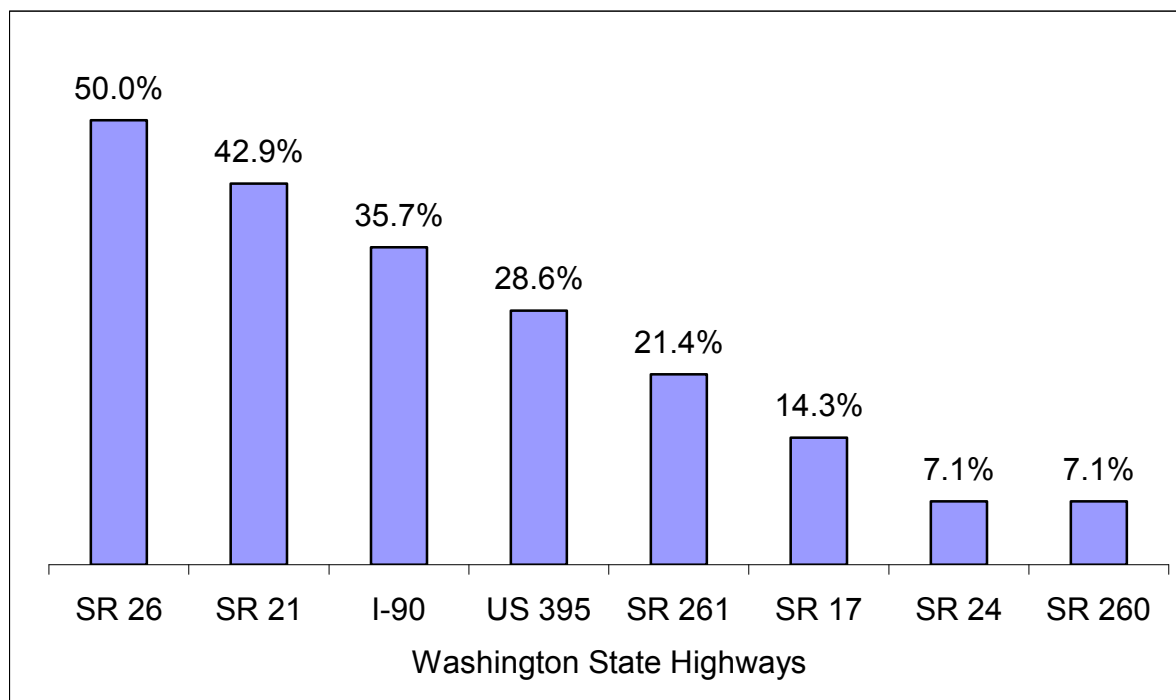
#### Data Sources:

- Transportation of Mining/Mineral Survey
- Geographic site information for all figures was obtained from Washington Department of Natural Resources, Division of Geology and Earth Resources.
- County and highway system GIS files were provided by the WSDOT GeoData Distribution Catalog.

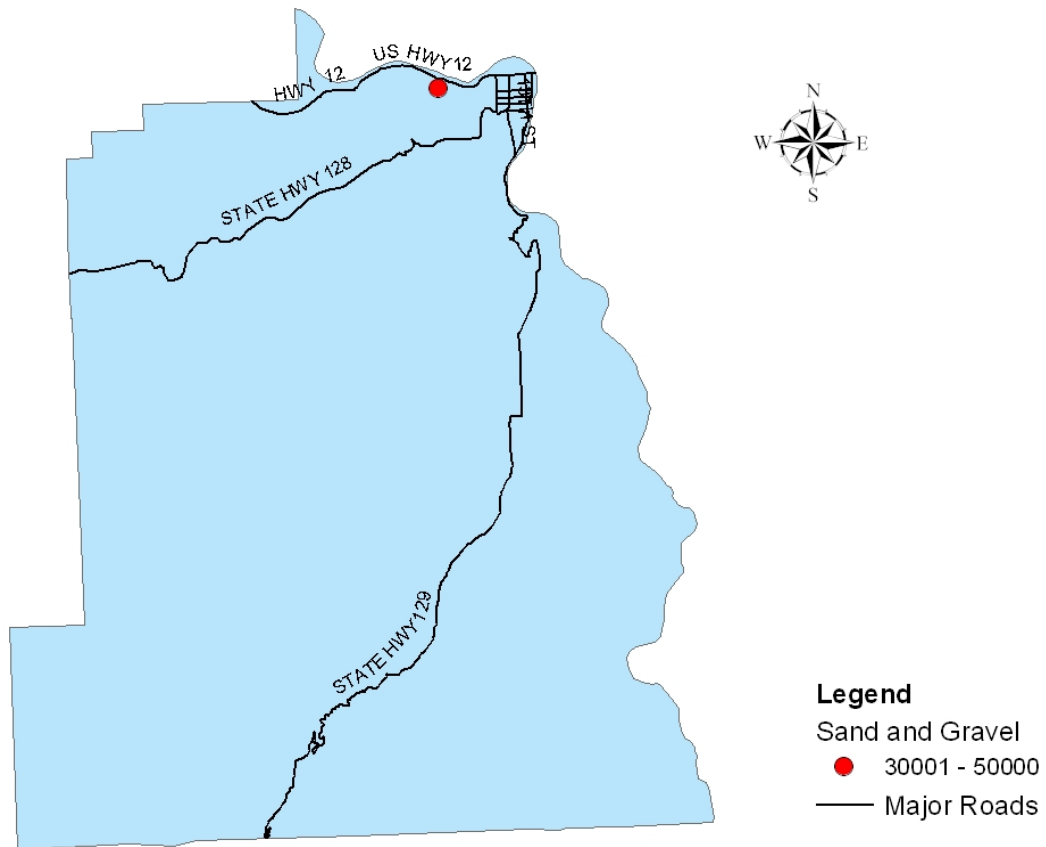
**Figure 1.** Adams County mines by type and production level in relation to highway system



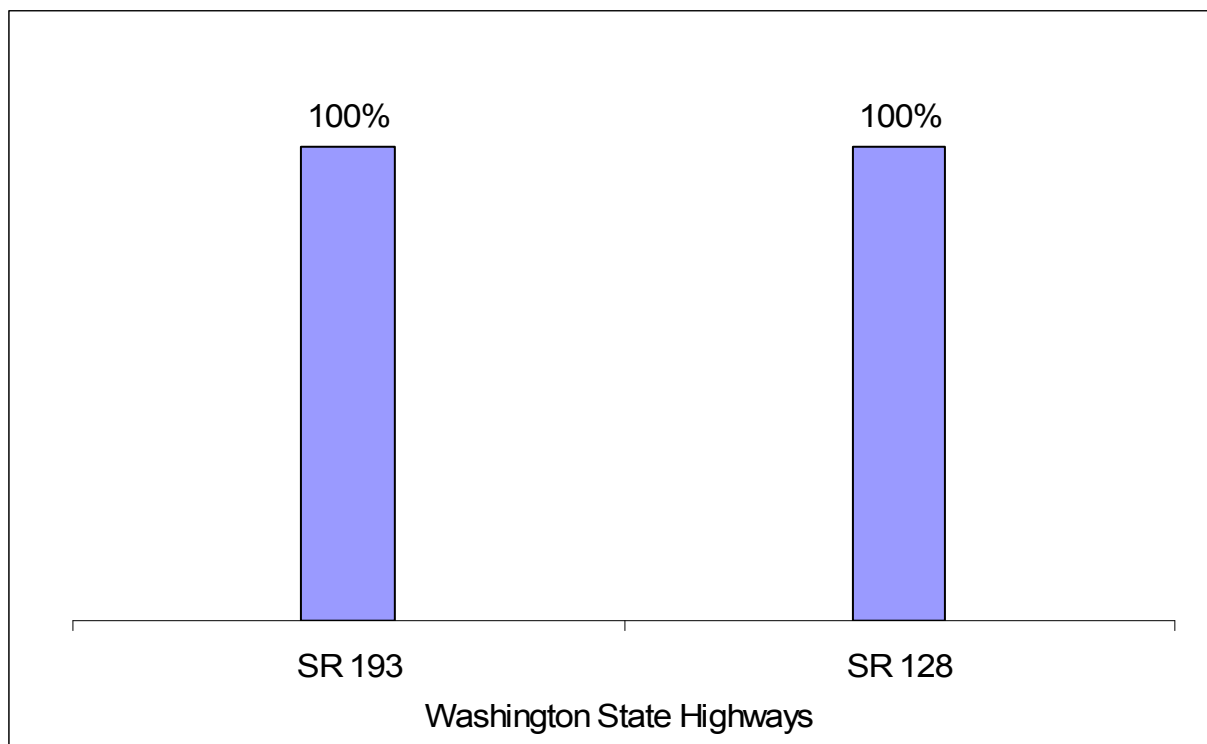
**Figure 2.** Frequency of roads used for aggregates hauling in Adams County



**Figure 3.** Asotin County mines by type and production level in relation to highway system

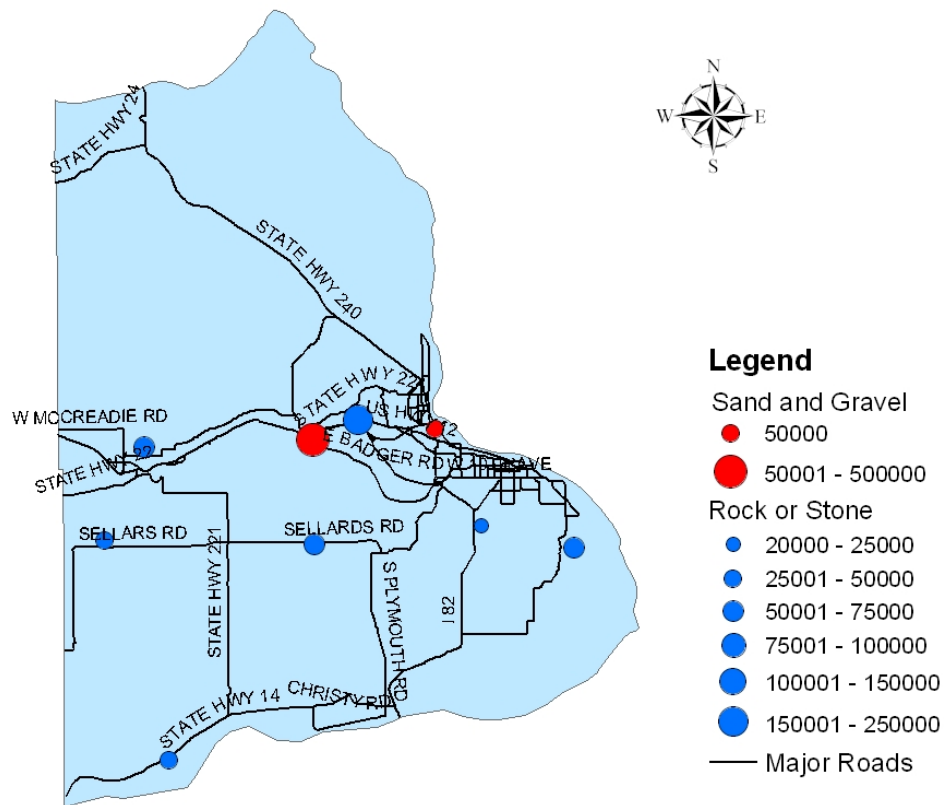


**Figure 4.** Frequency of roads used for aggregates hauling in Asotin County

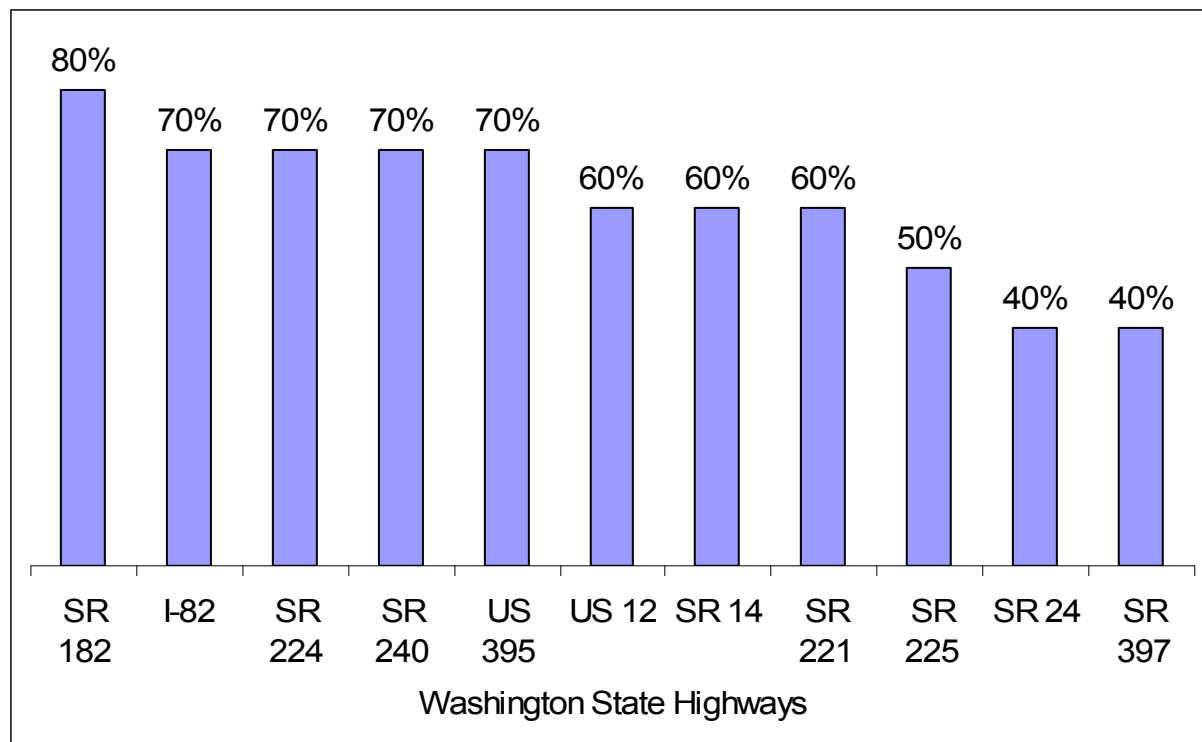




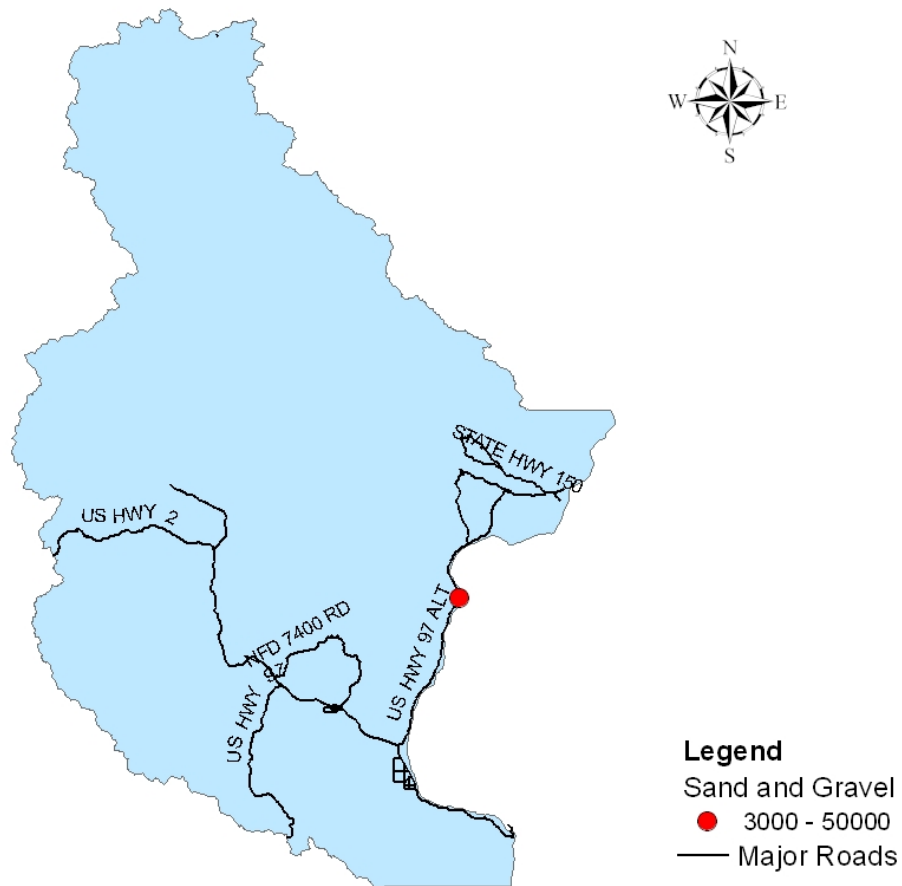
**Figure 5.** Benton County mines by type and production level in relation to highway system



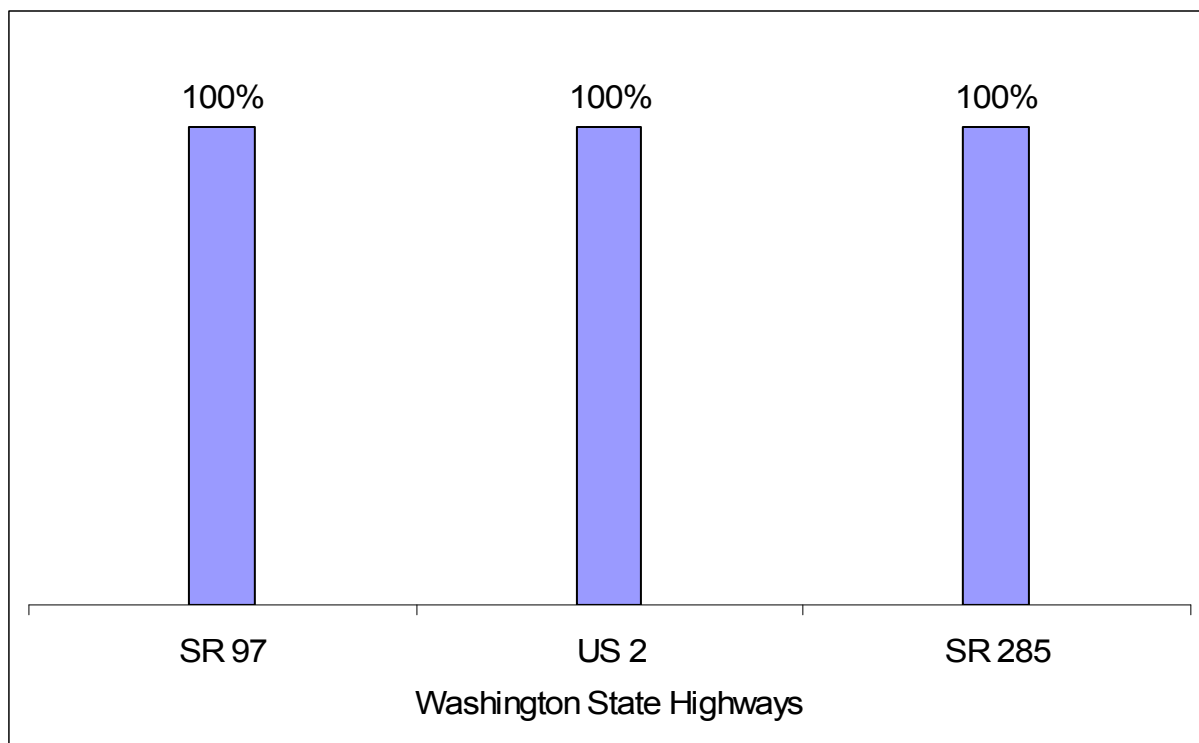
**Figure 6.** Frequency of roads used for aggregates hauling in Benton County



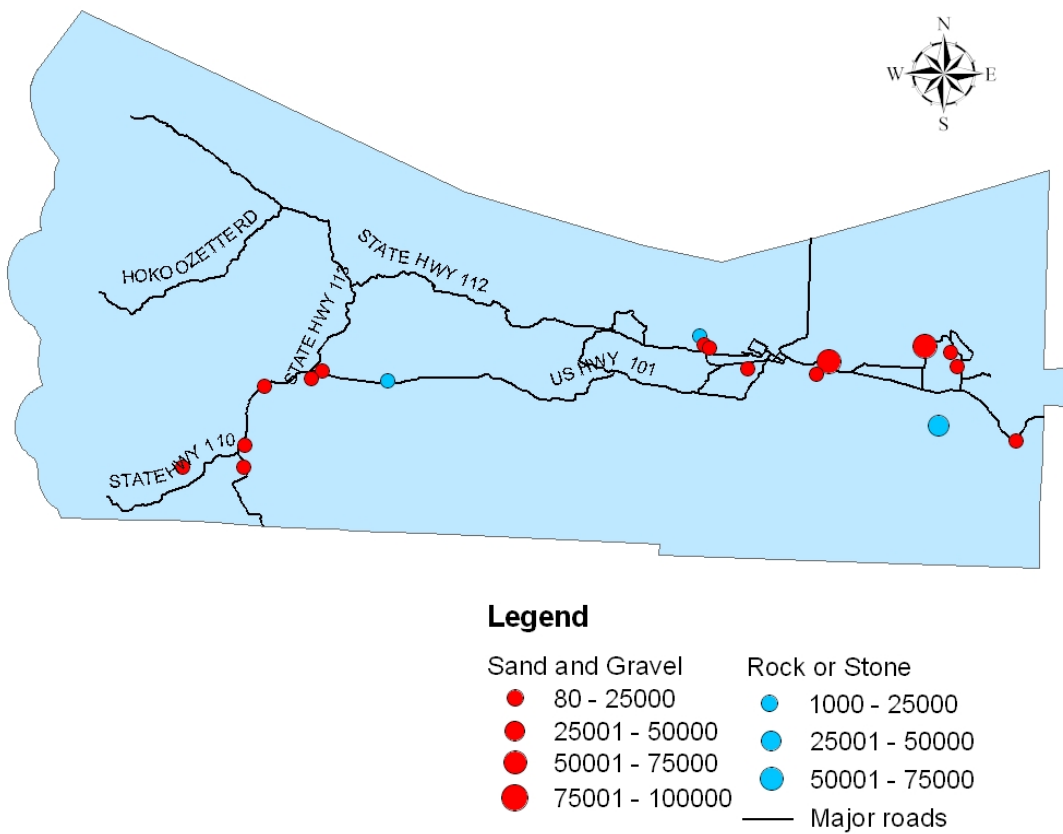
**Figure 7.** Chelan County mines by type and production level in relation to highway system



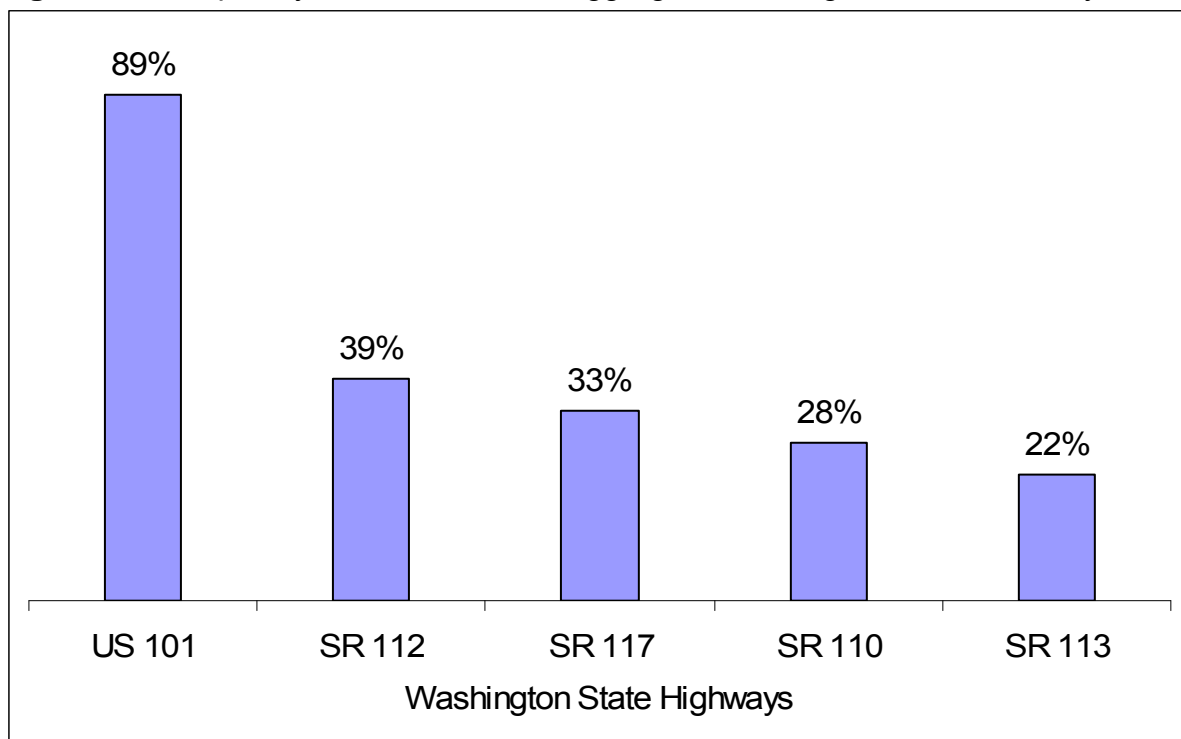
**Figure 8.** Frequency of roads used for aggregates hauling in Chelan County



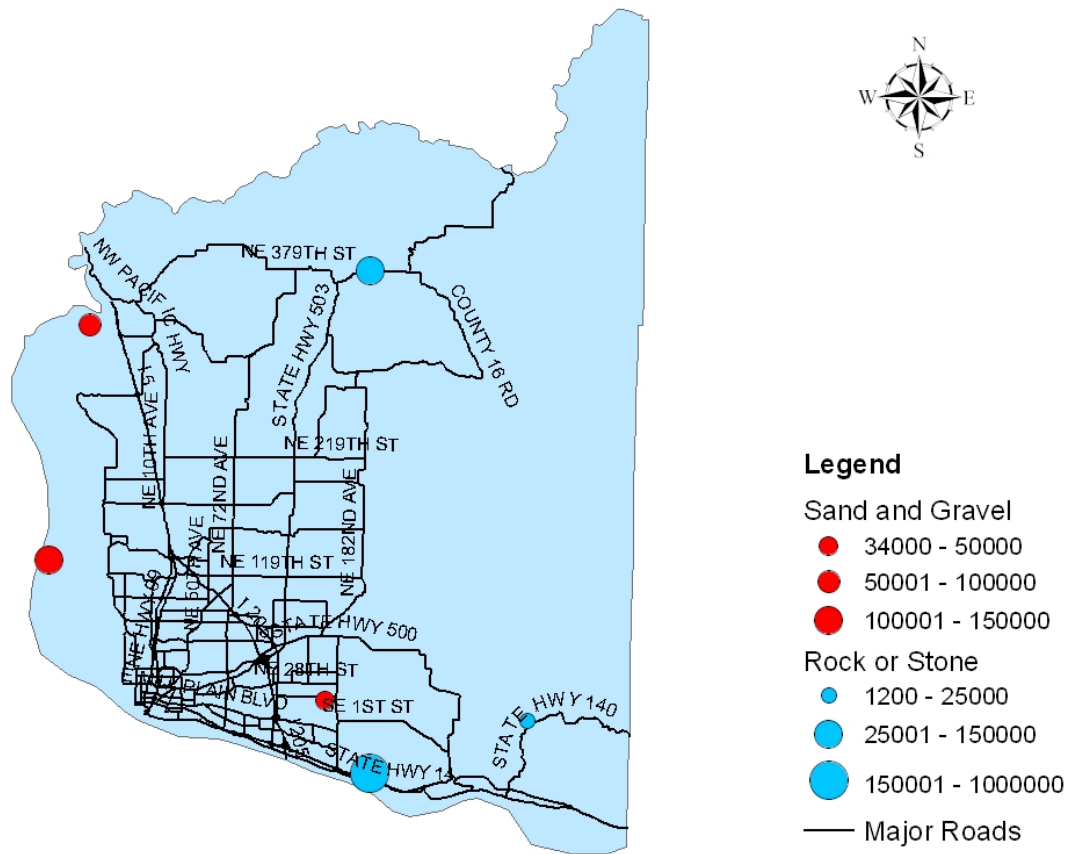
**Figure 9.** Clallam County mines by type and production level in relation to highway system



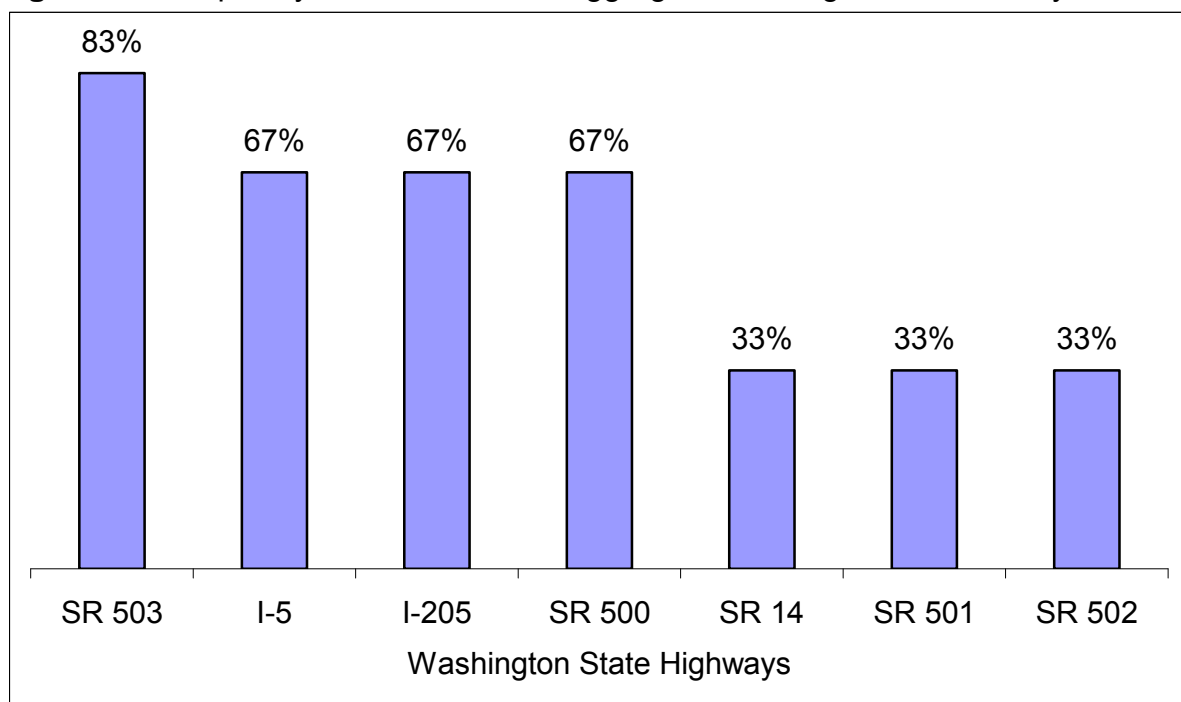
**Figure 10.** Frequency of roads used for aggregates hauling in Clallam County



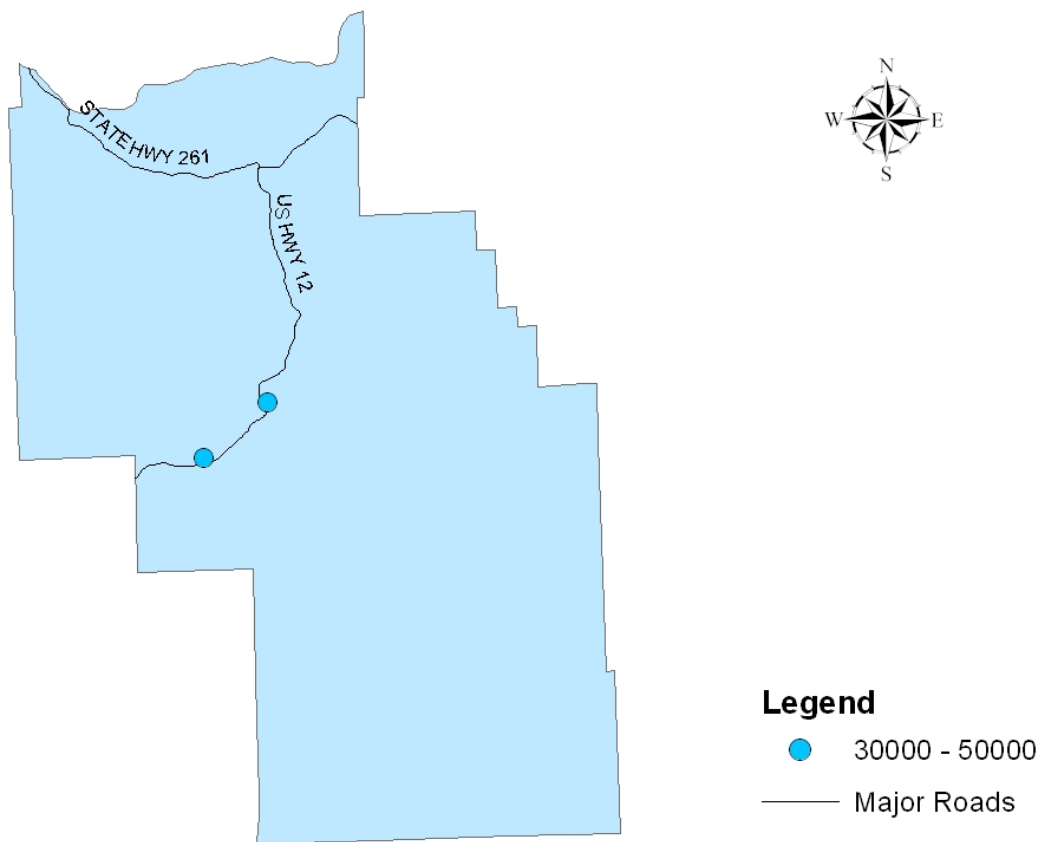
**Figure 11.** Clark County mines by type and production level in relation to highway system



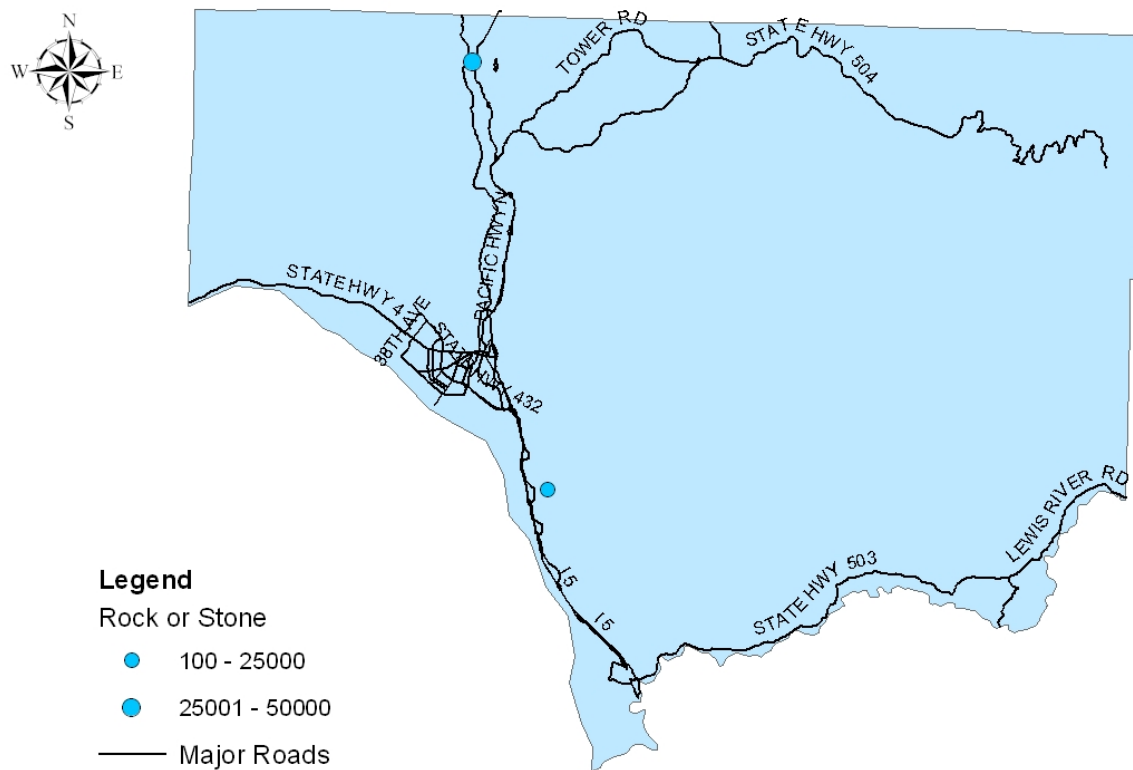
**Figure 12.** Frequency of roads used for aggregates hauling in Clark County



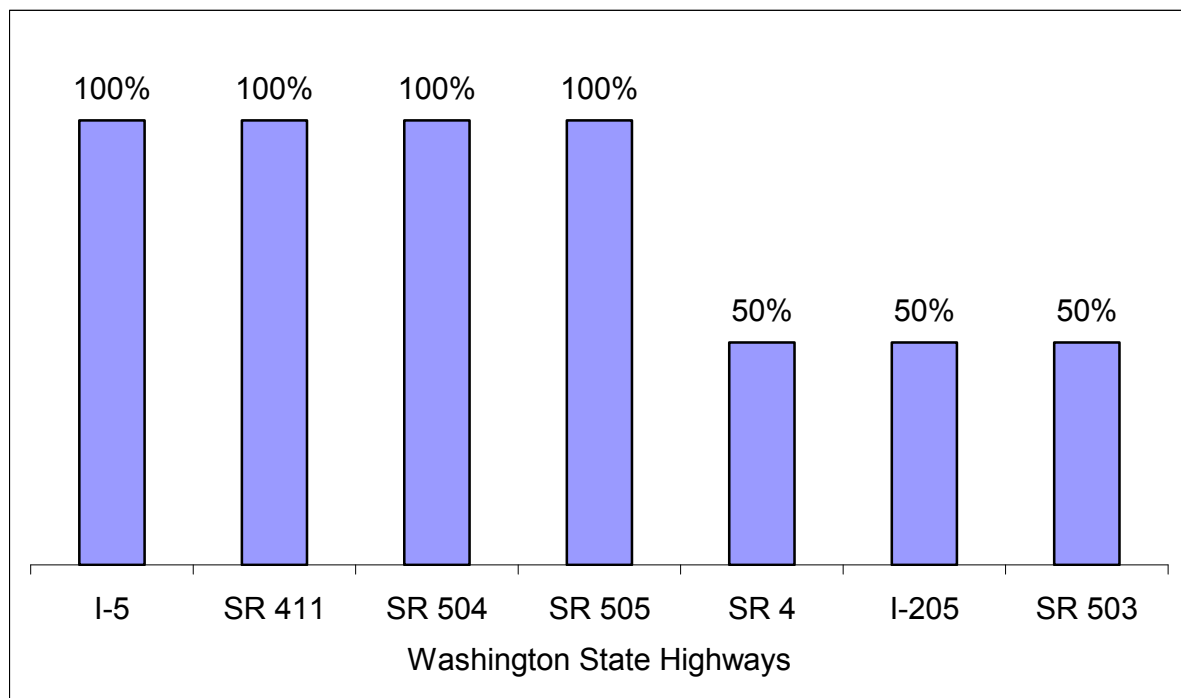
**Figure 13.** Columbia County mines by type and production level in relation to highway system



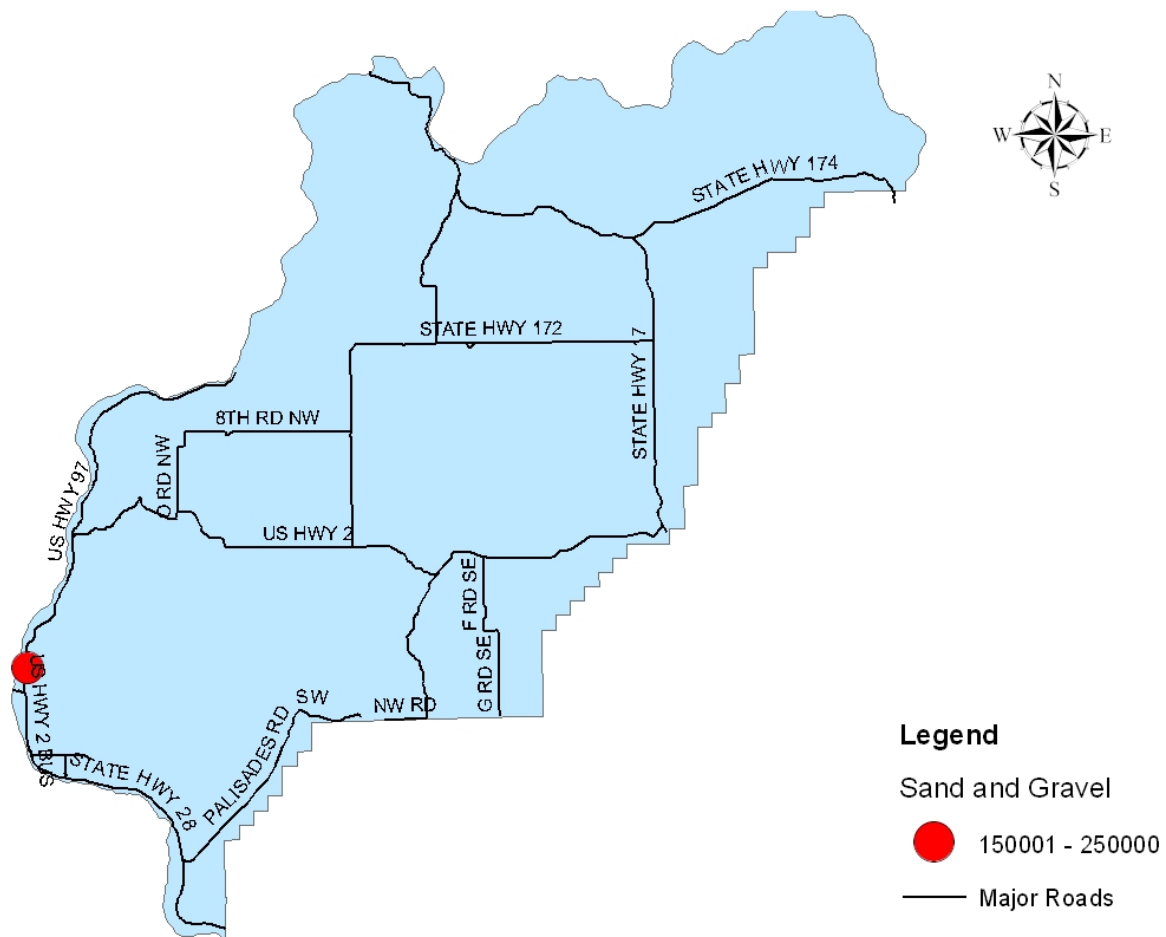
**Figure 14.** Cowlitz County mines by type and production level in relation to highway system



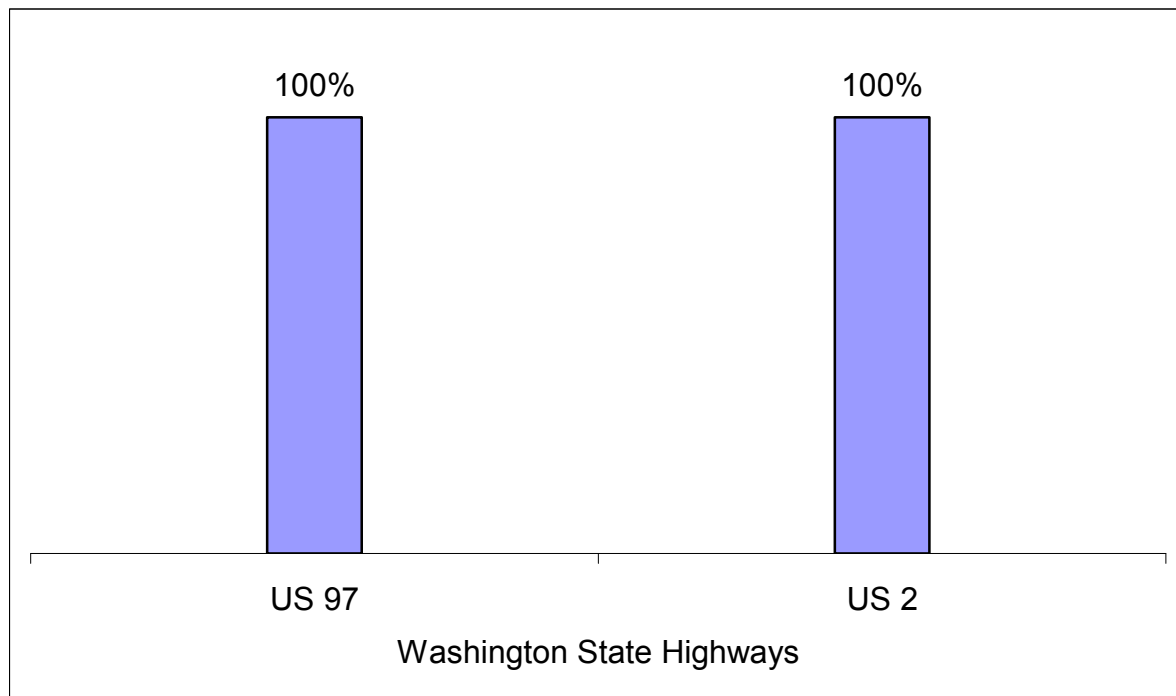
**Figure 15.** Frequency of roads used for aggregates hauling in Cowlitz County



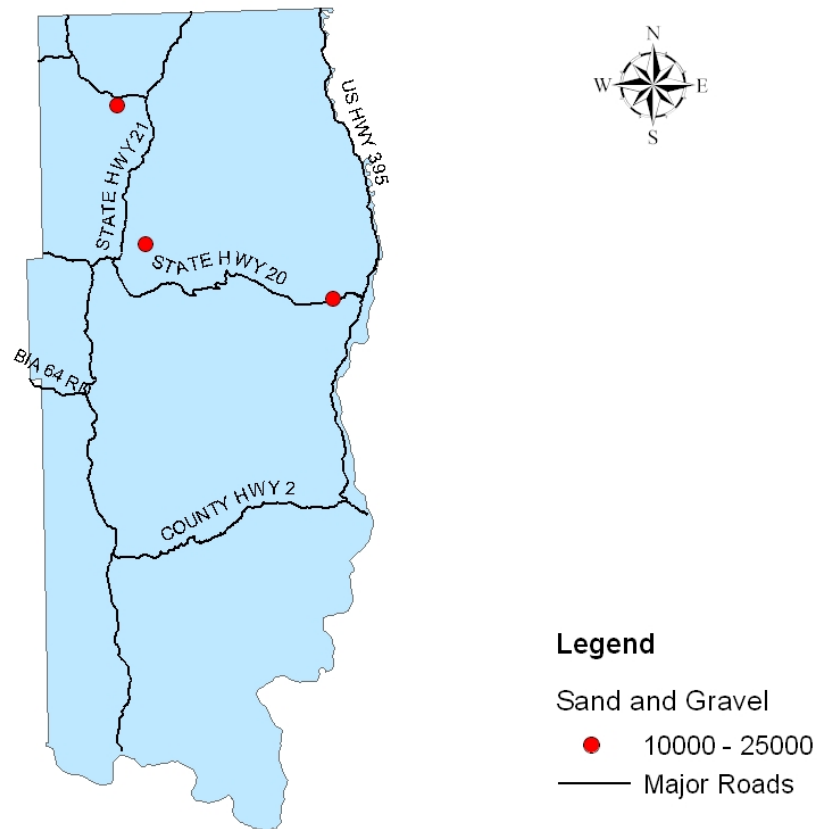
**Figure 16.** Douglas County mines by type and production level in relation to highway system



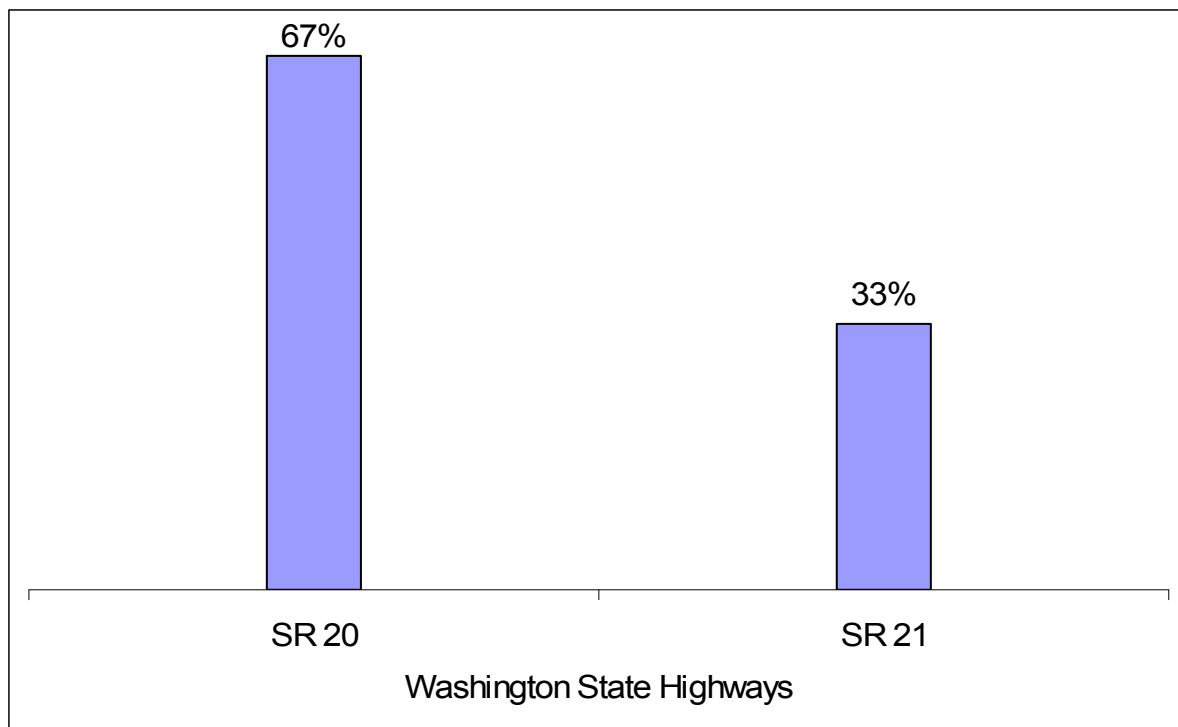
**Figure 17.** Frequency of roads used for aggregates hauling in Douglas County



**Figure 18.** Ferry County mines by type and production level in relation to highway system

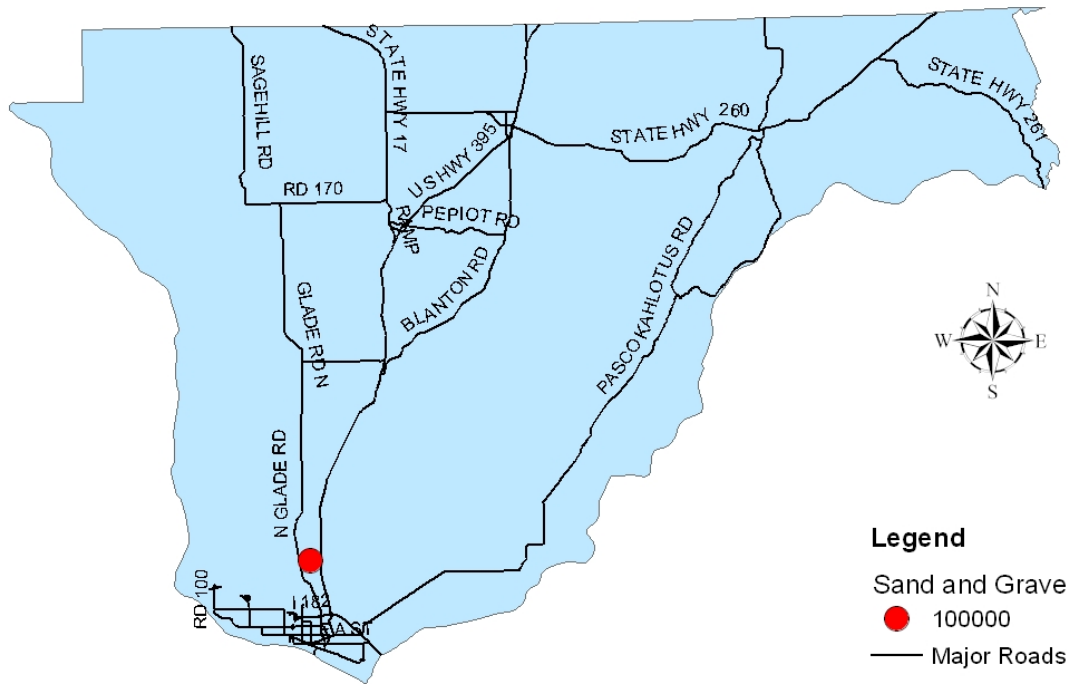


**Figure 19.** Frequency of roads used for aggregates hauling in Ferry County

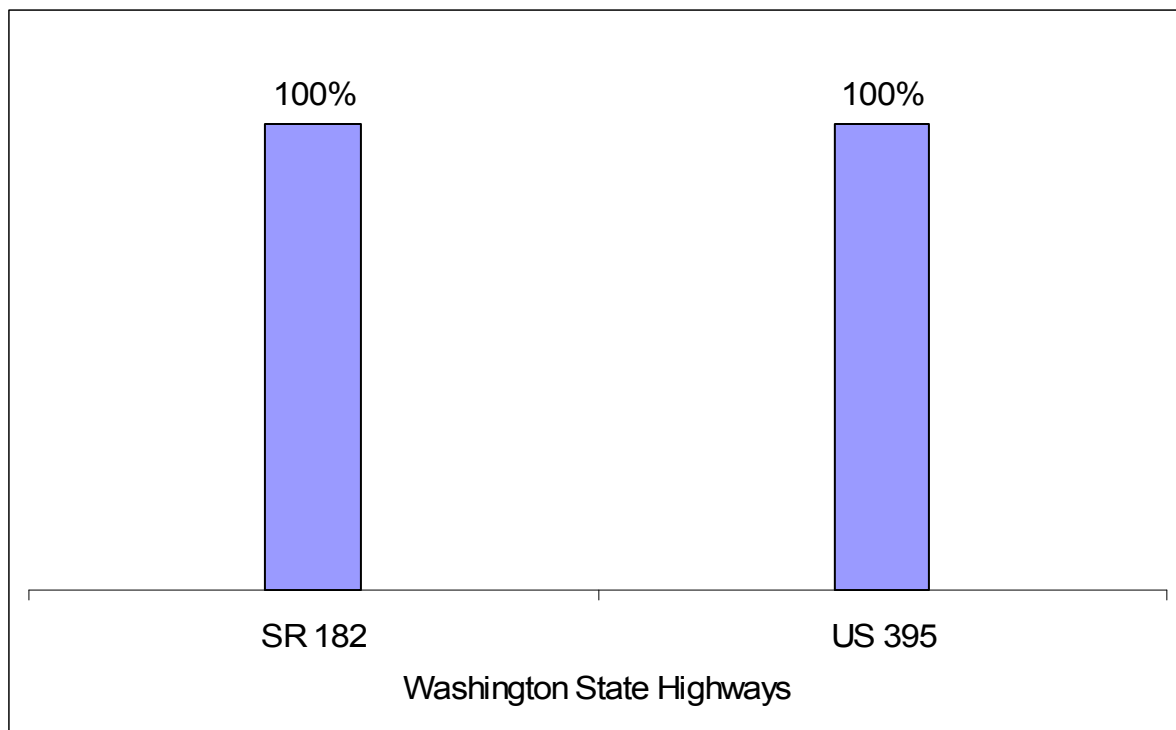




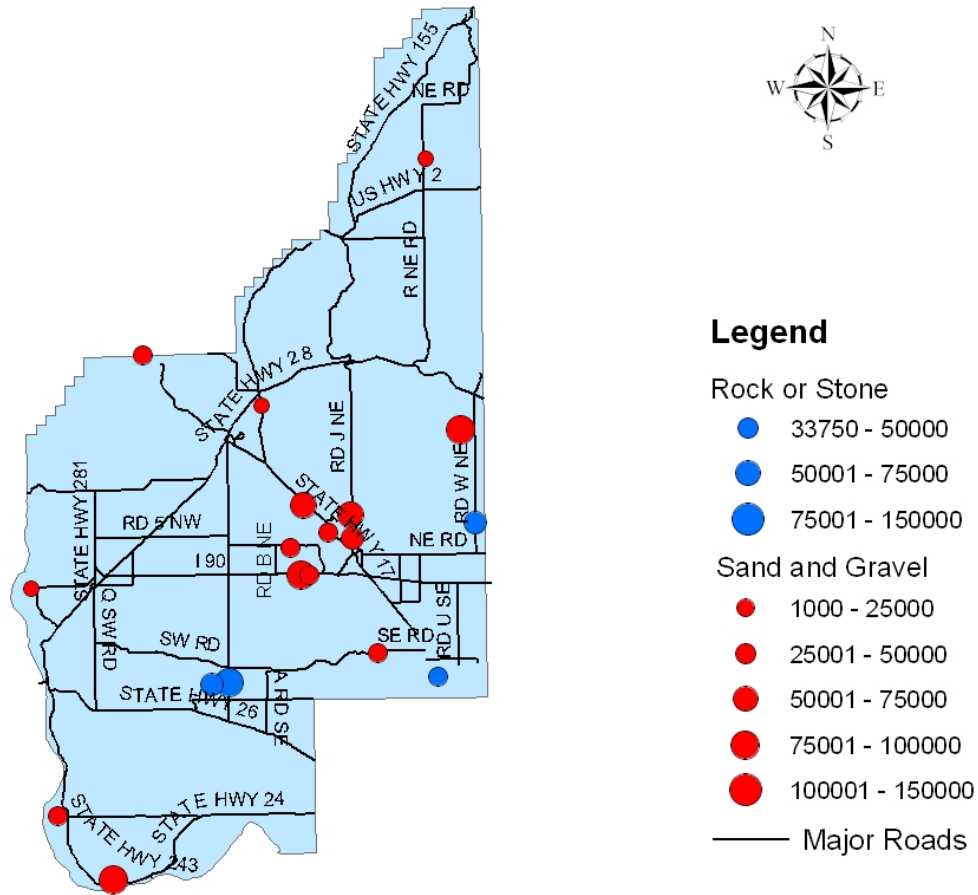
**Figure 20.** Franklin County mines by type and production level in relation to highway system



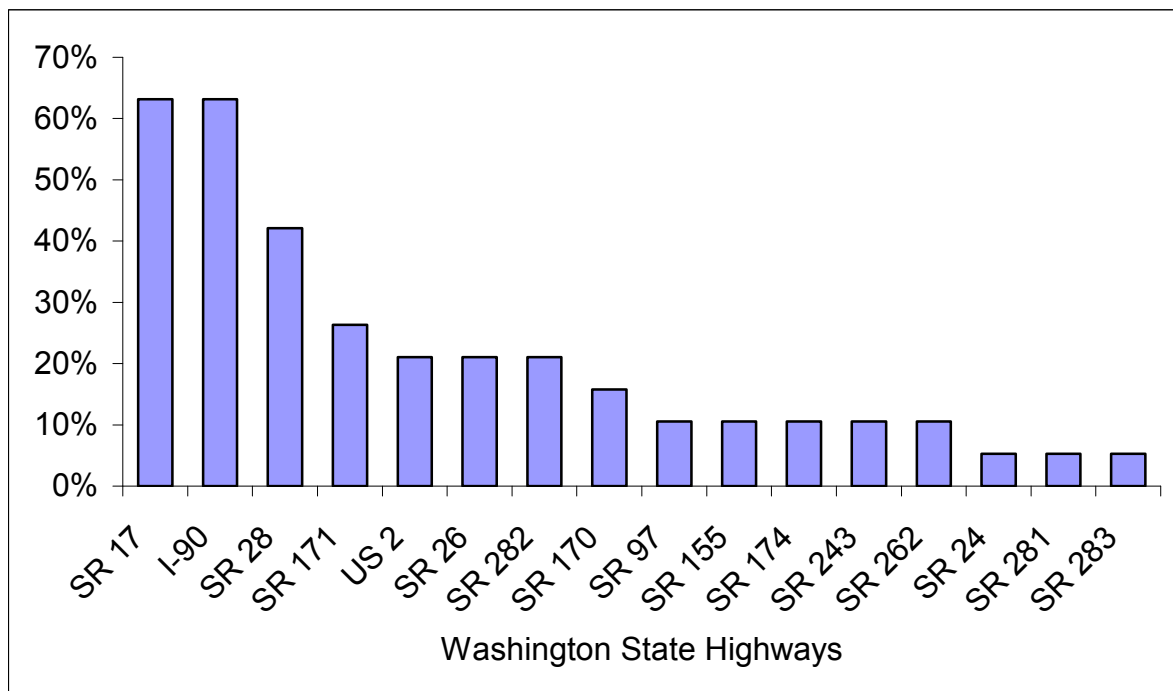
**Figure 21.** Frequency of roads used for aggregates hauling in Franklin County



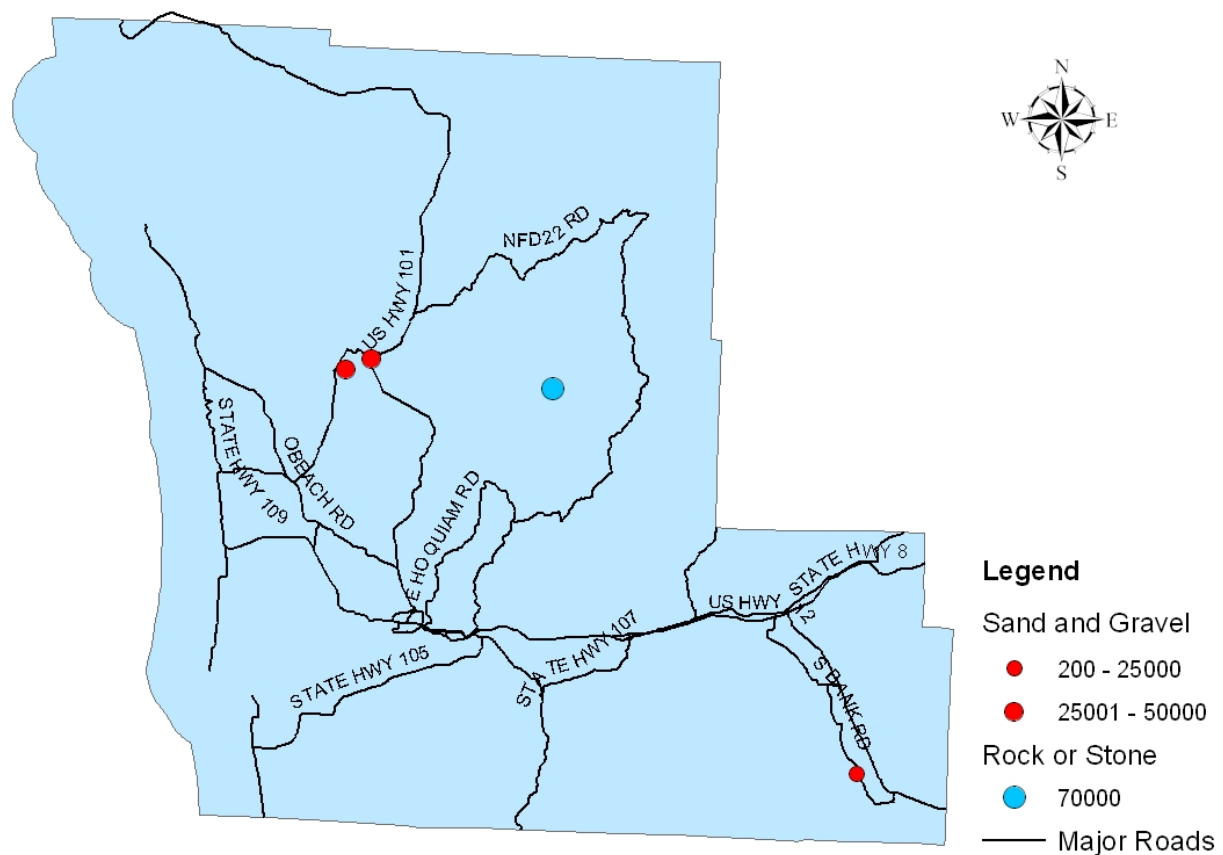
**Figure 22.** Grant County mines by type and production level in relation to highway system



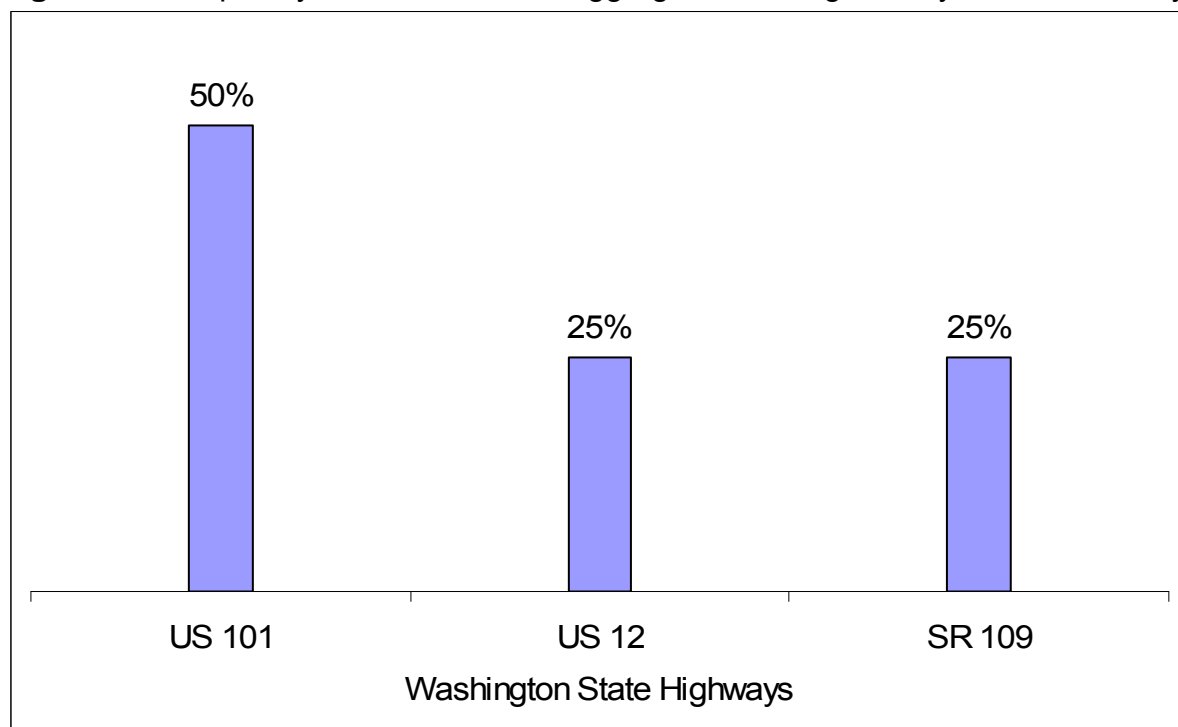
**Figure 23.** Frequency of roads used for aggregates hauling in Grant County



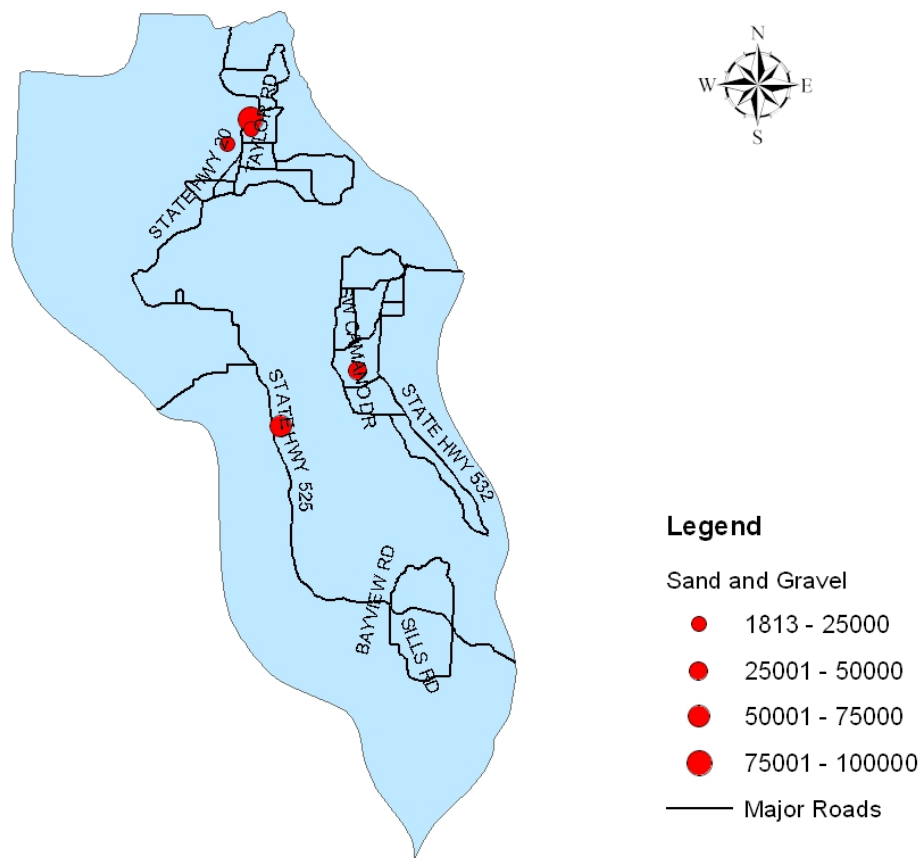
**Figure 24.** Grays Harbor County mines by type and production level in relation to highway system



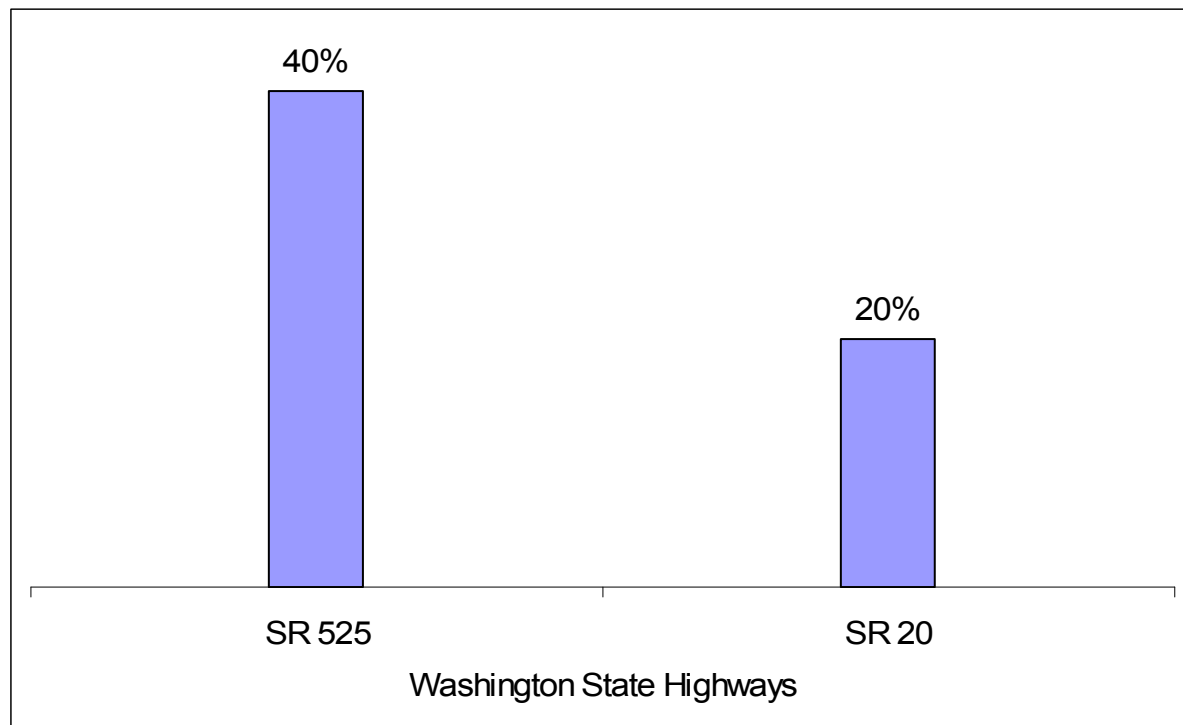
**Figure 25.** Frequency of roads used for aggregates hauling in Grays Harbor County



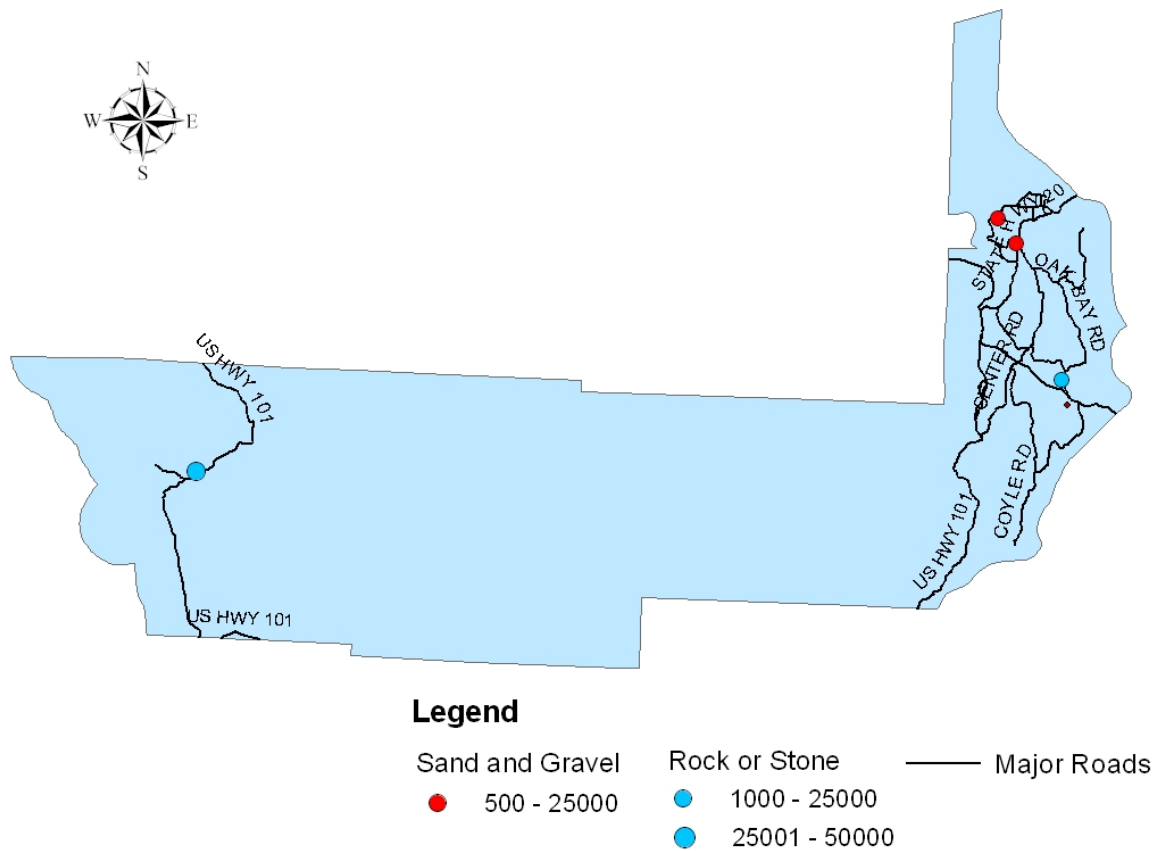
**Figure 26.** Island County mines by type and production level in relation to highway system



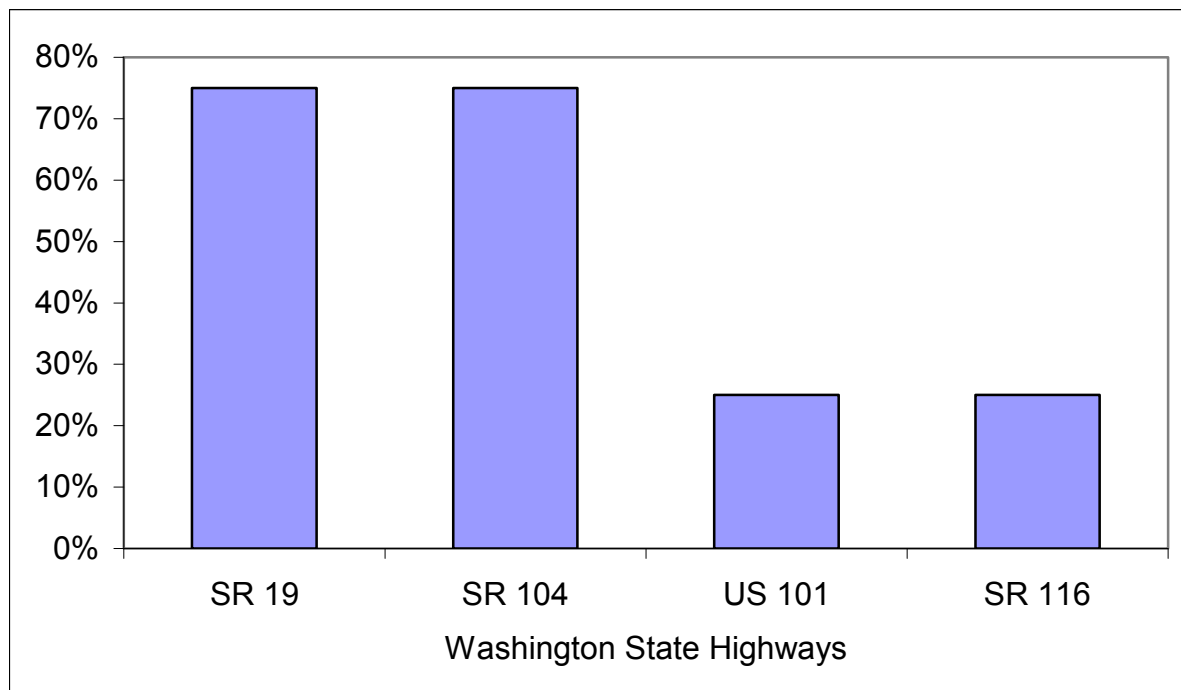
**Figure 27.** Frequency of roads used for aggregates hauling in Island County



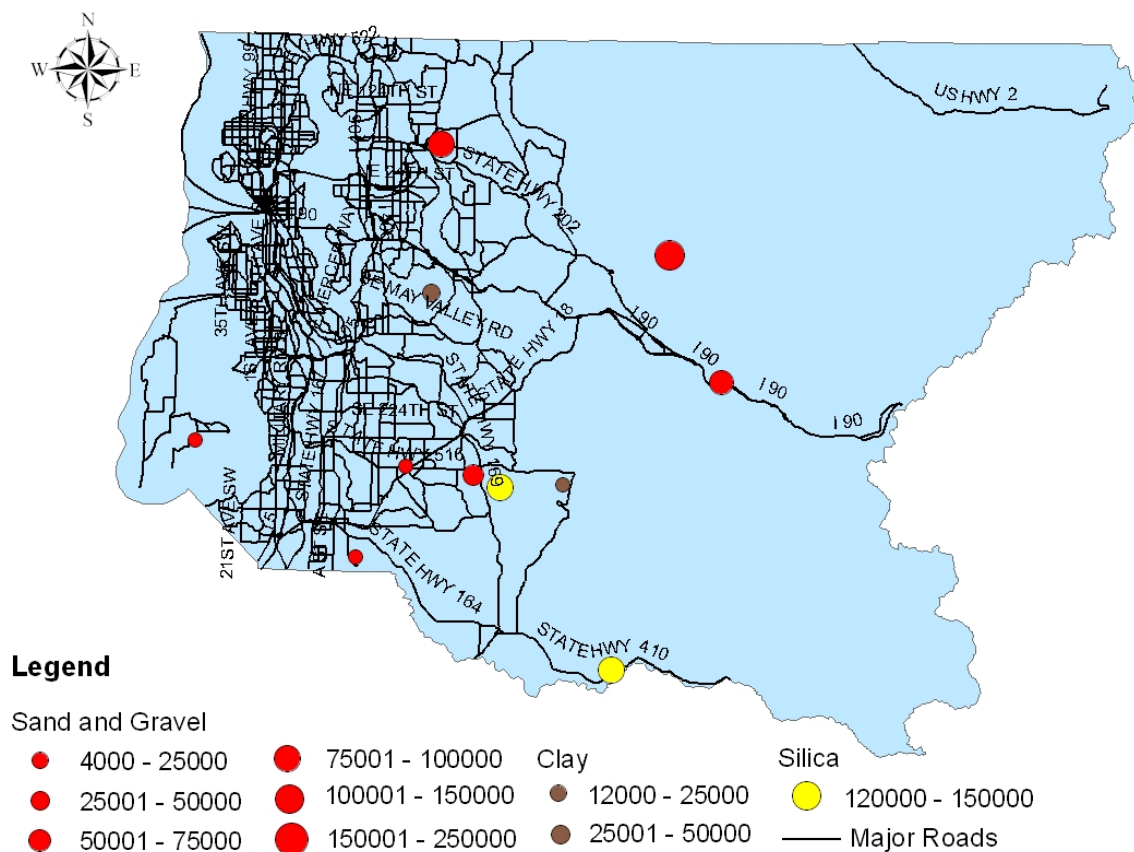
**Figure 28.** Jefferson County mines by type and production level in relation to highway system



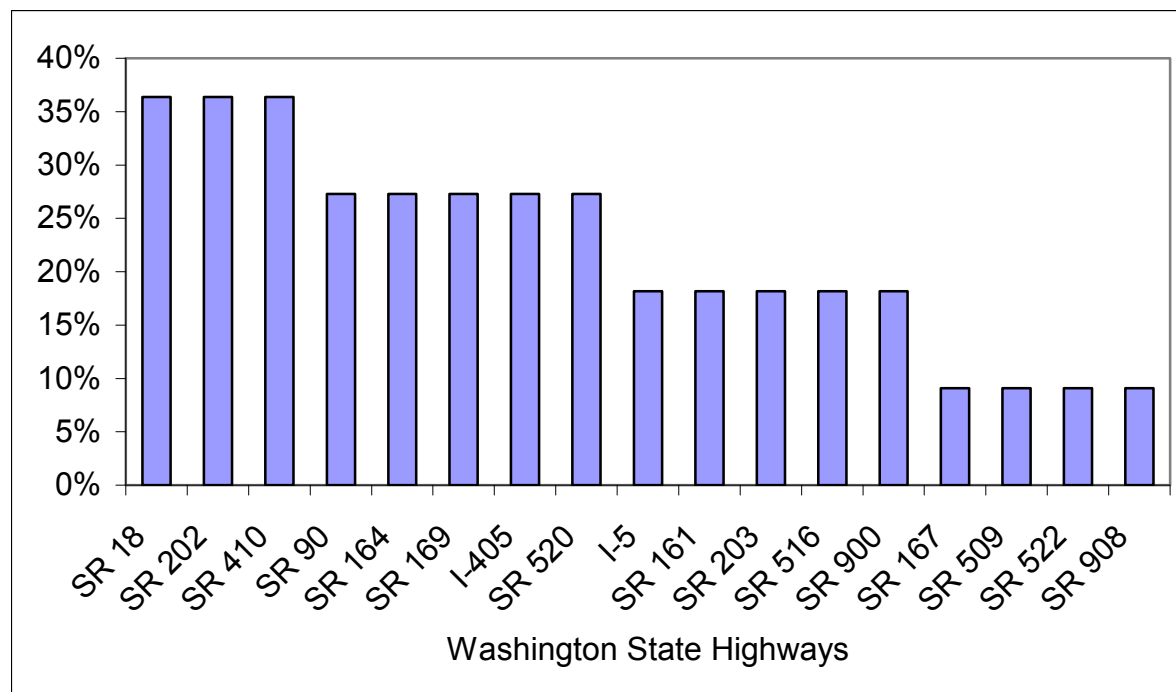
**Figure 29.** Frequency of roads used for aggregates hauling in Jefferson County



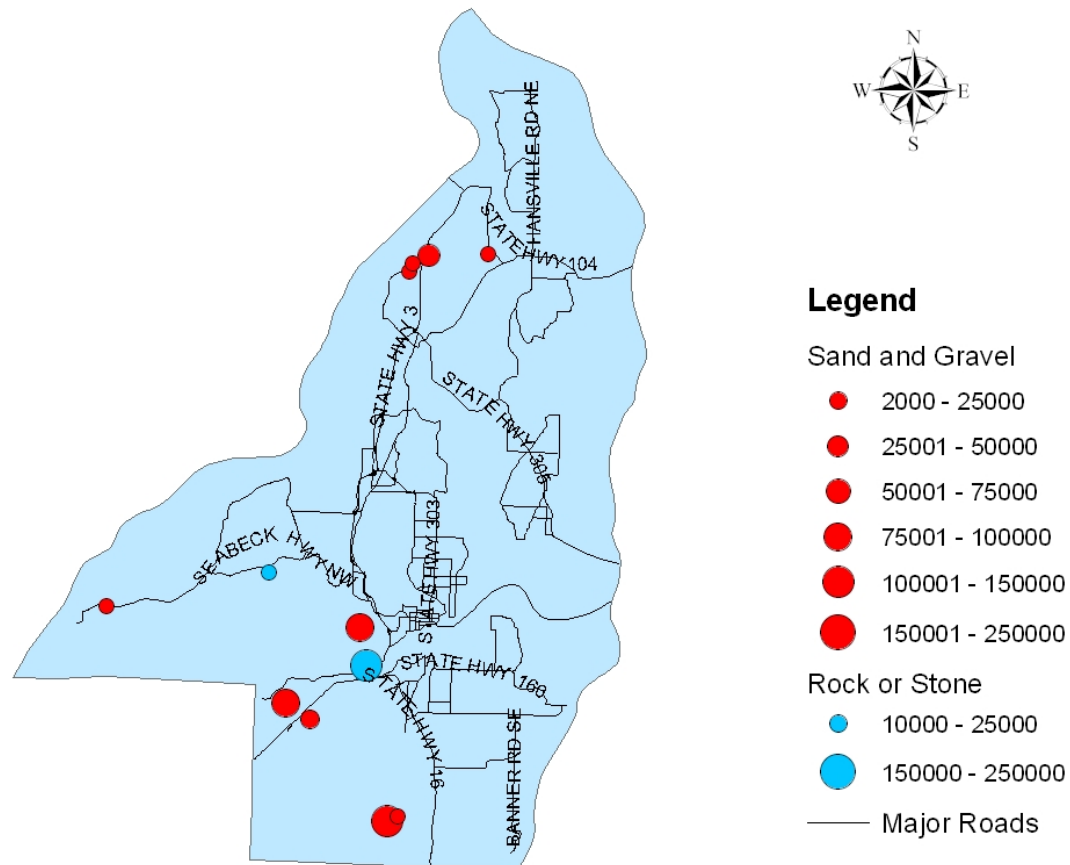
**Figure 30.** King County mines by type and production level in relation to highway system



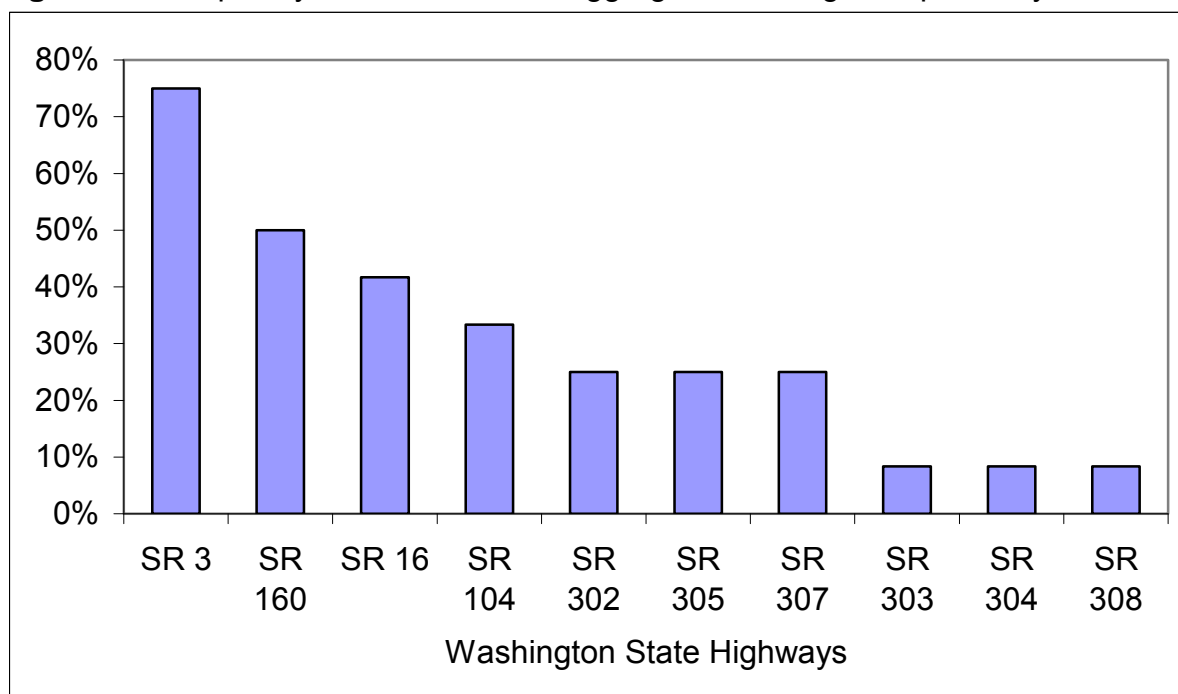
**Figure 31.** Frequency of roads used for aggregates hauling in King County



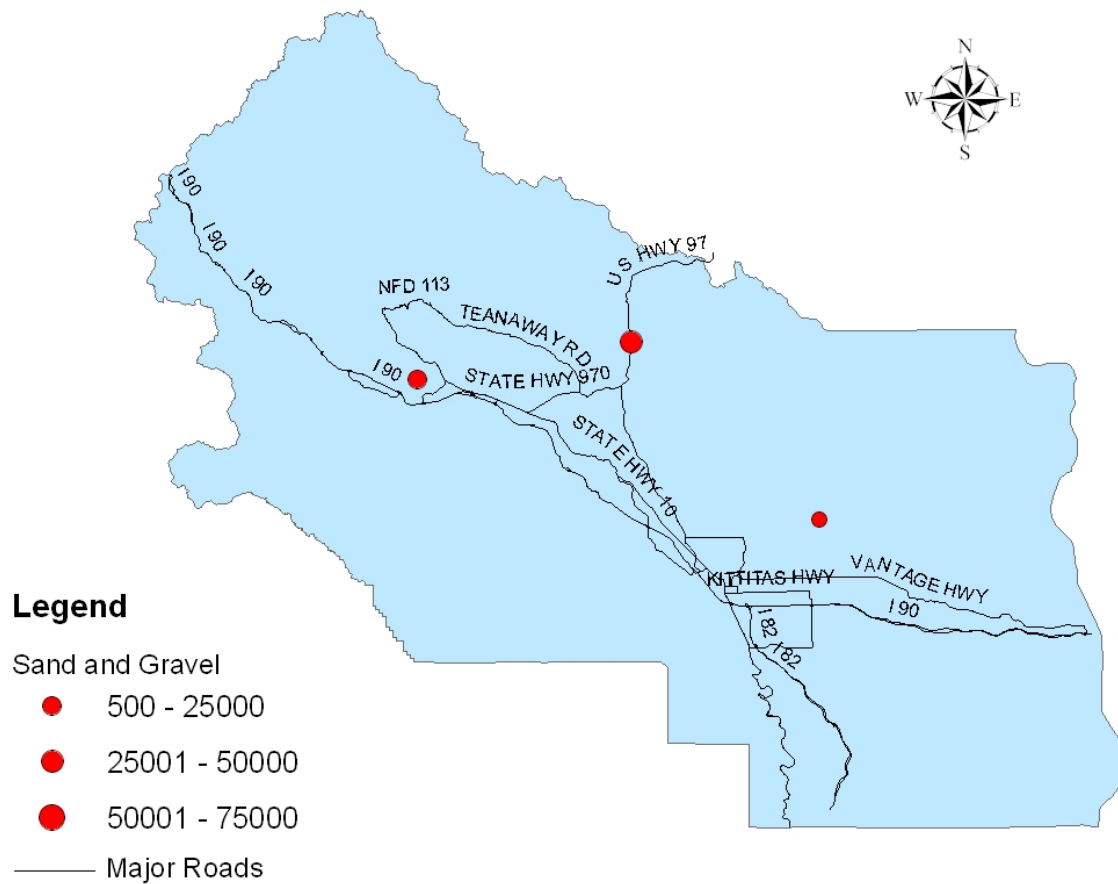
**Figure 32.** Kitsap County mines by type and production level in relation to highway system



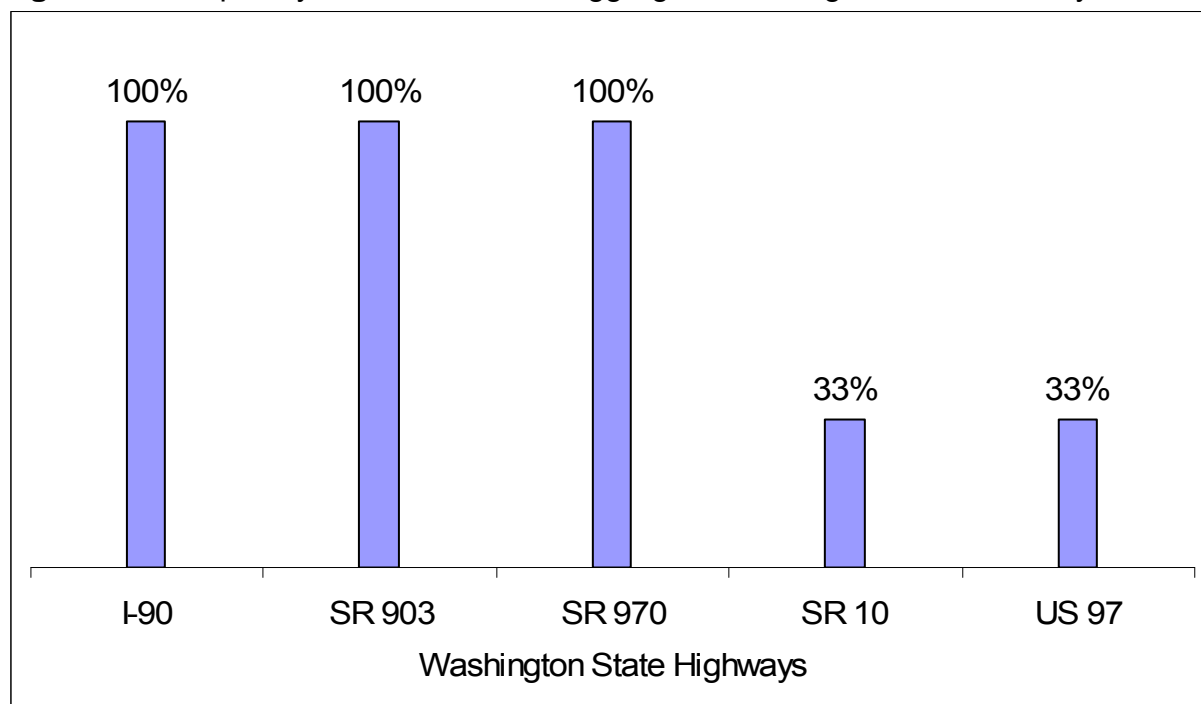
**Figure 33.** Frequency of roads used for aggregates hauling Kitsap County



**Figure 34.** Kittitas County mines by type and production level in relation to highway system

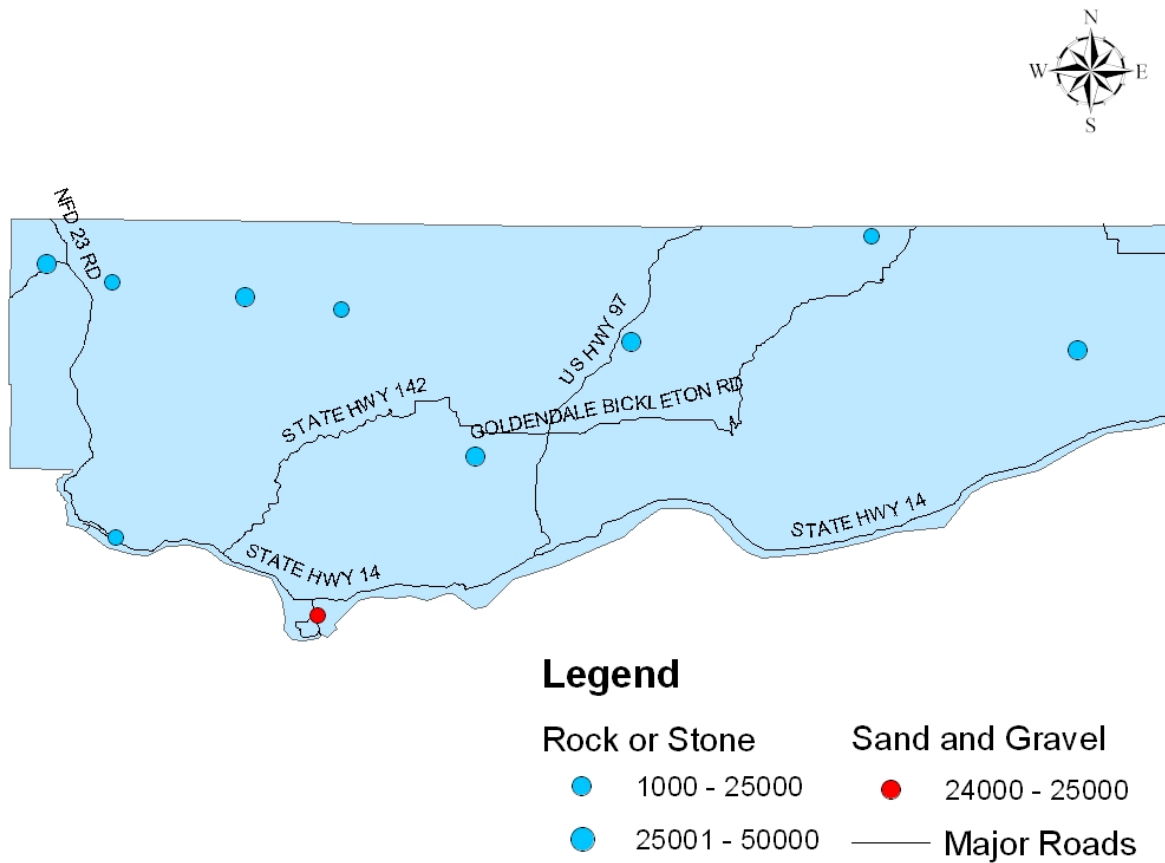


**Figure 35.** Frequency of roads used for aggregates hauling in Kittitas County

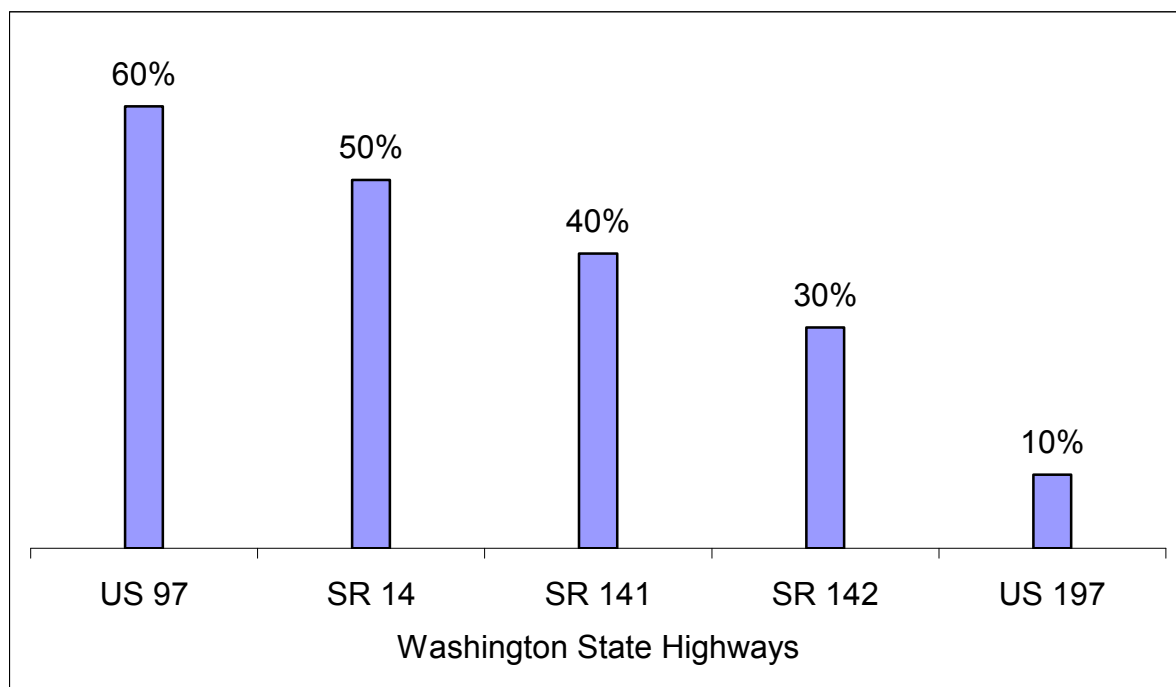




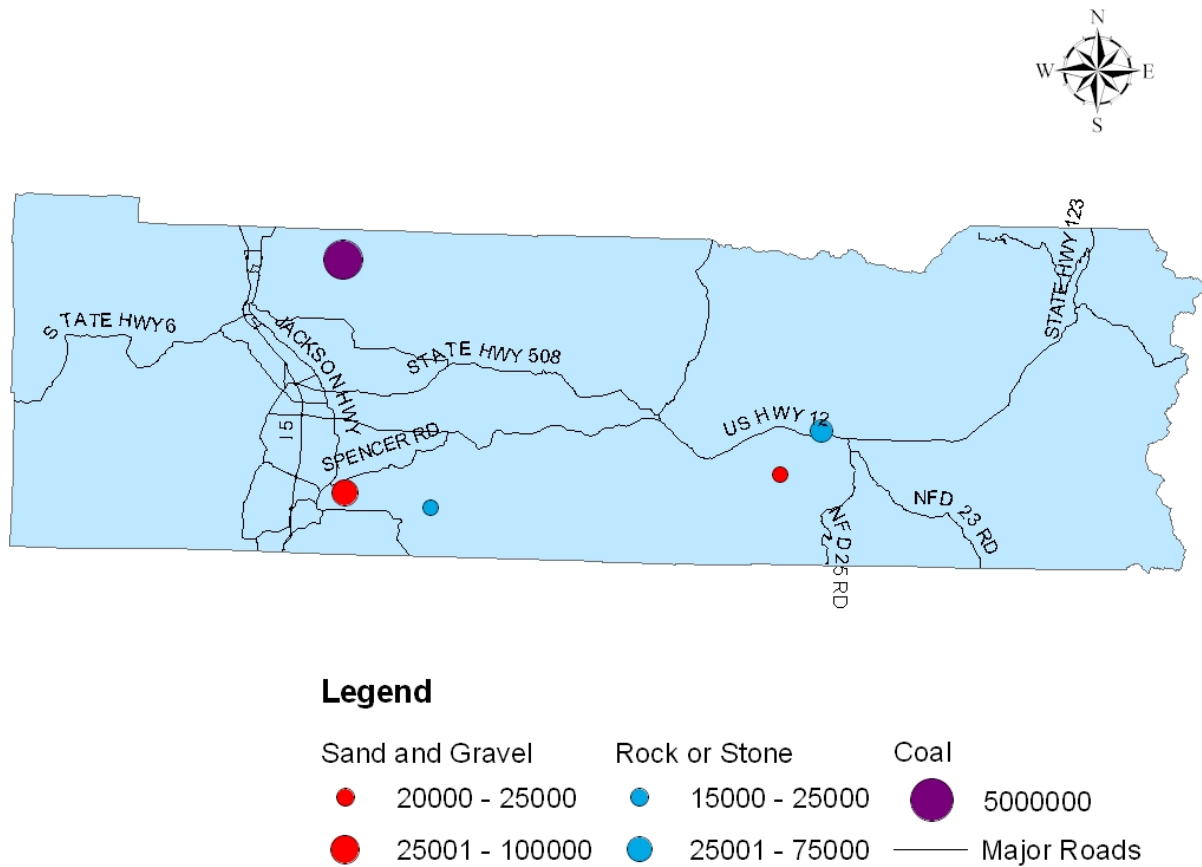
**Figure 36.** Klickitat County mines by type and production level in relation to highway system



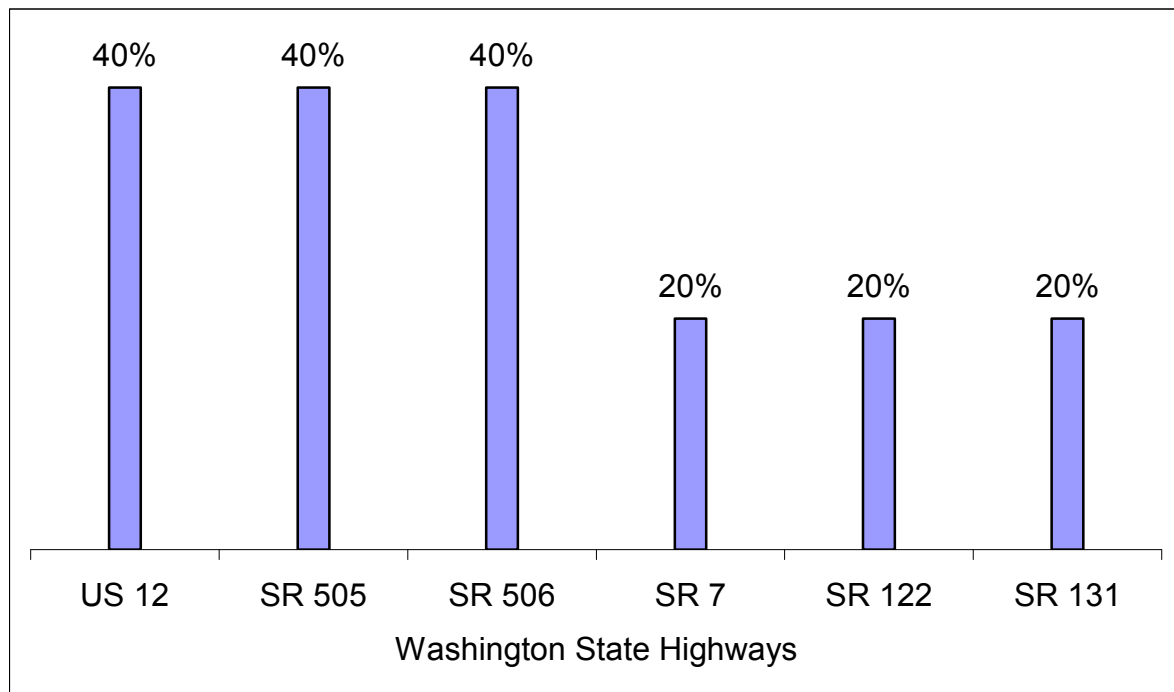
**Figure 37.** Frequency of roads used for aggregates hauling in Klickitat County



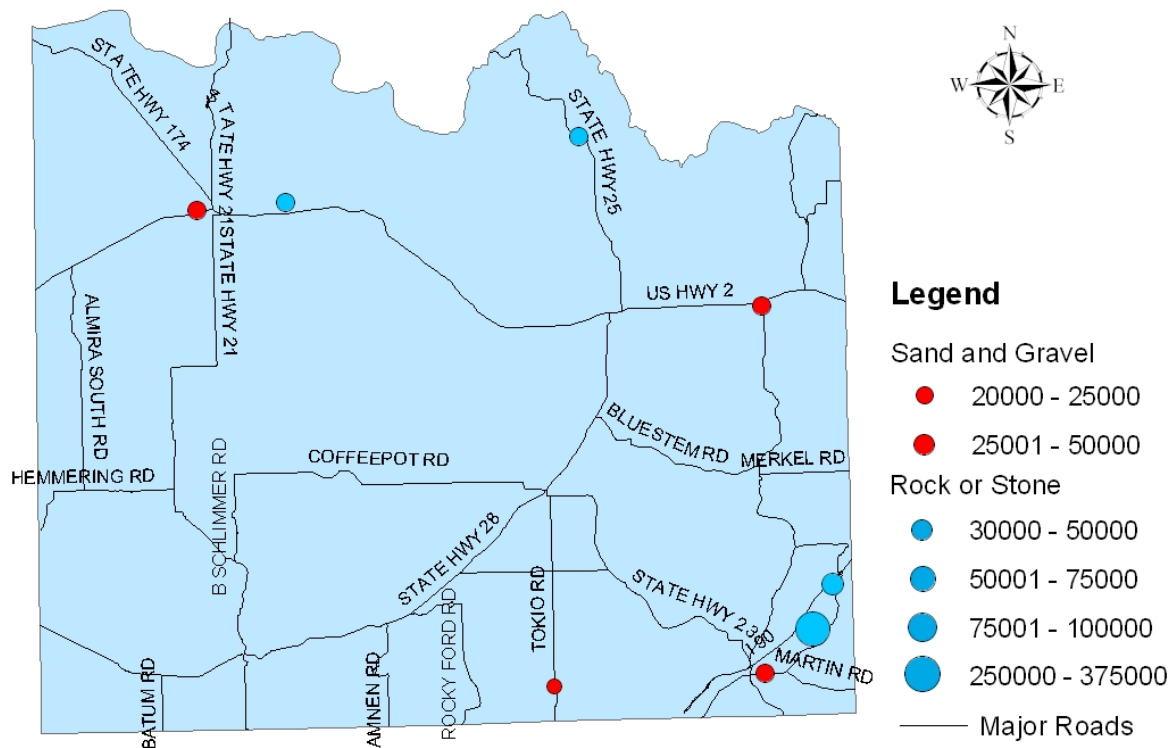
**Figure 38.** Lewis County mines by type and production level in relation to highway system



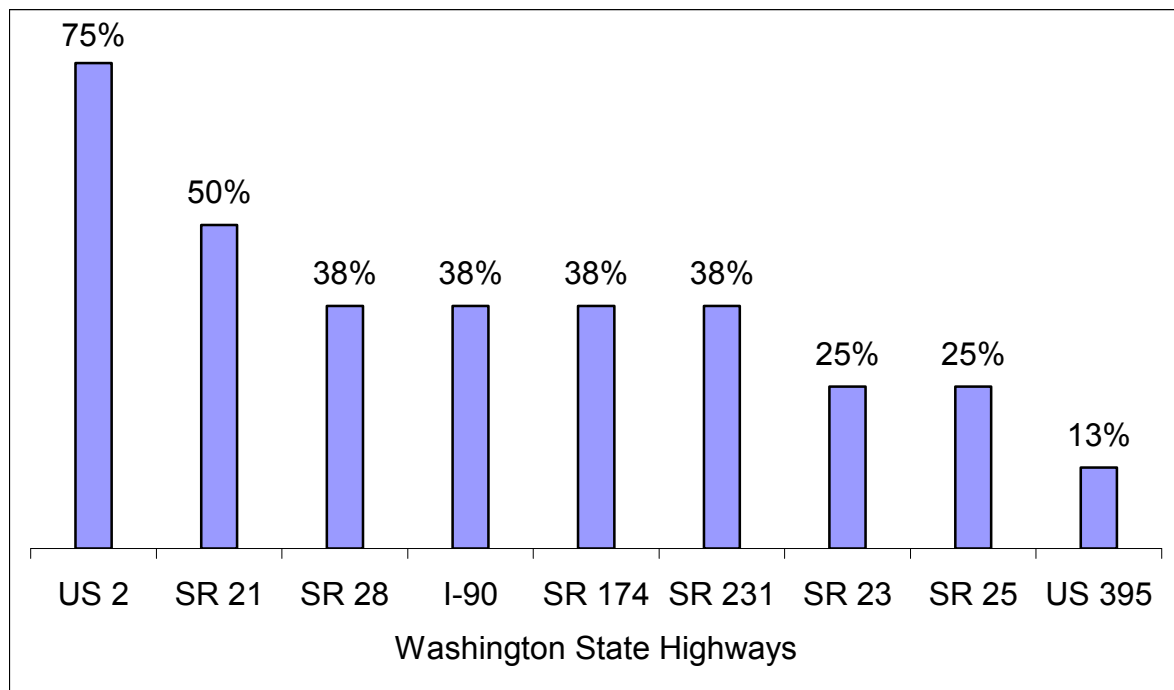
**Figure 39.** Frequency of roads used for aggregates hauling in Lewis County



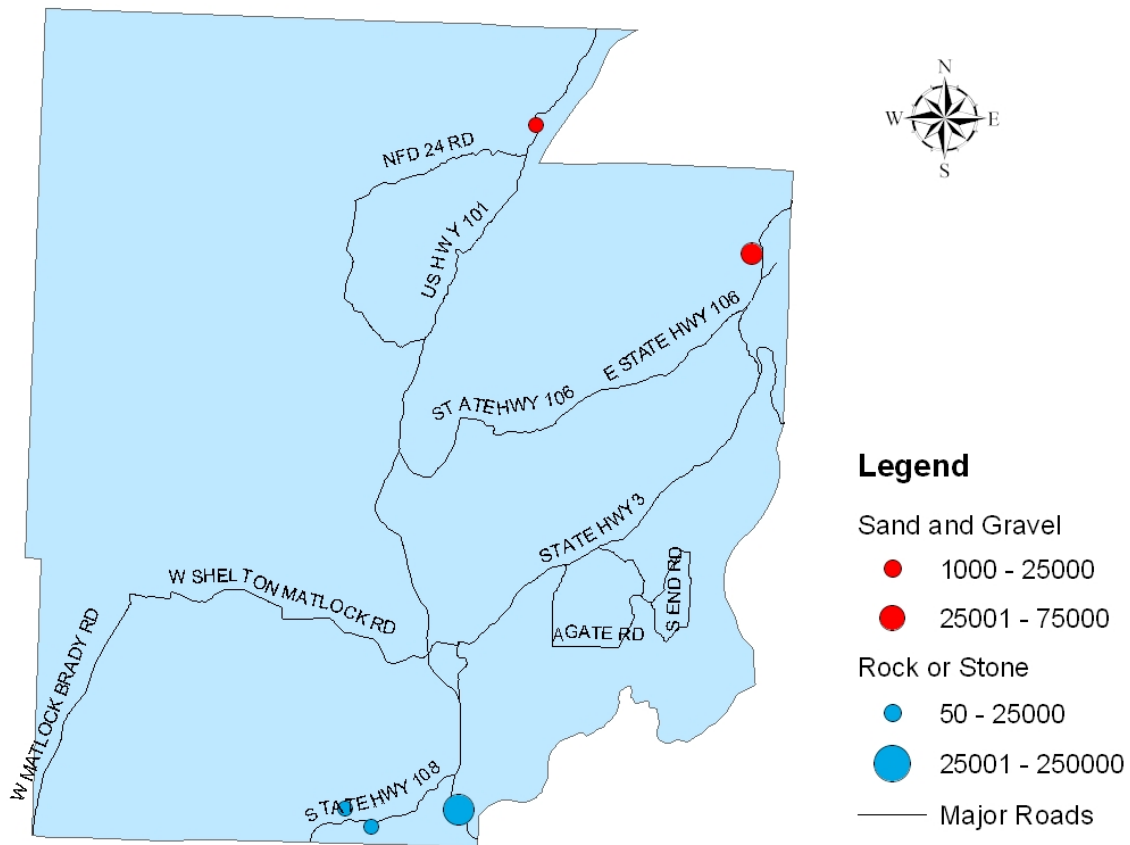
**Figure 40.** Lincoln County mines by type and production level in relation to highway system



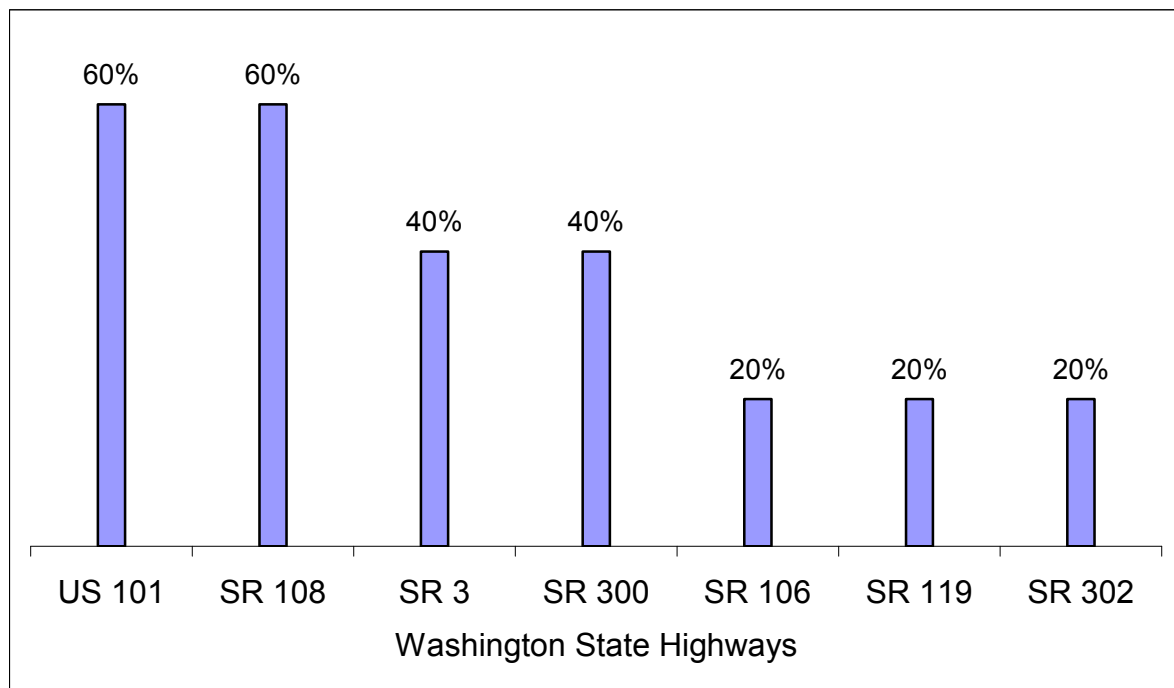
**Figure 41.** Frequency of roads used for aggregates hauling in Lincoln County



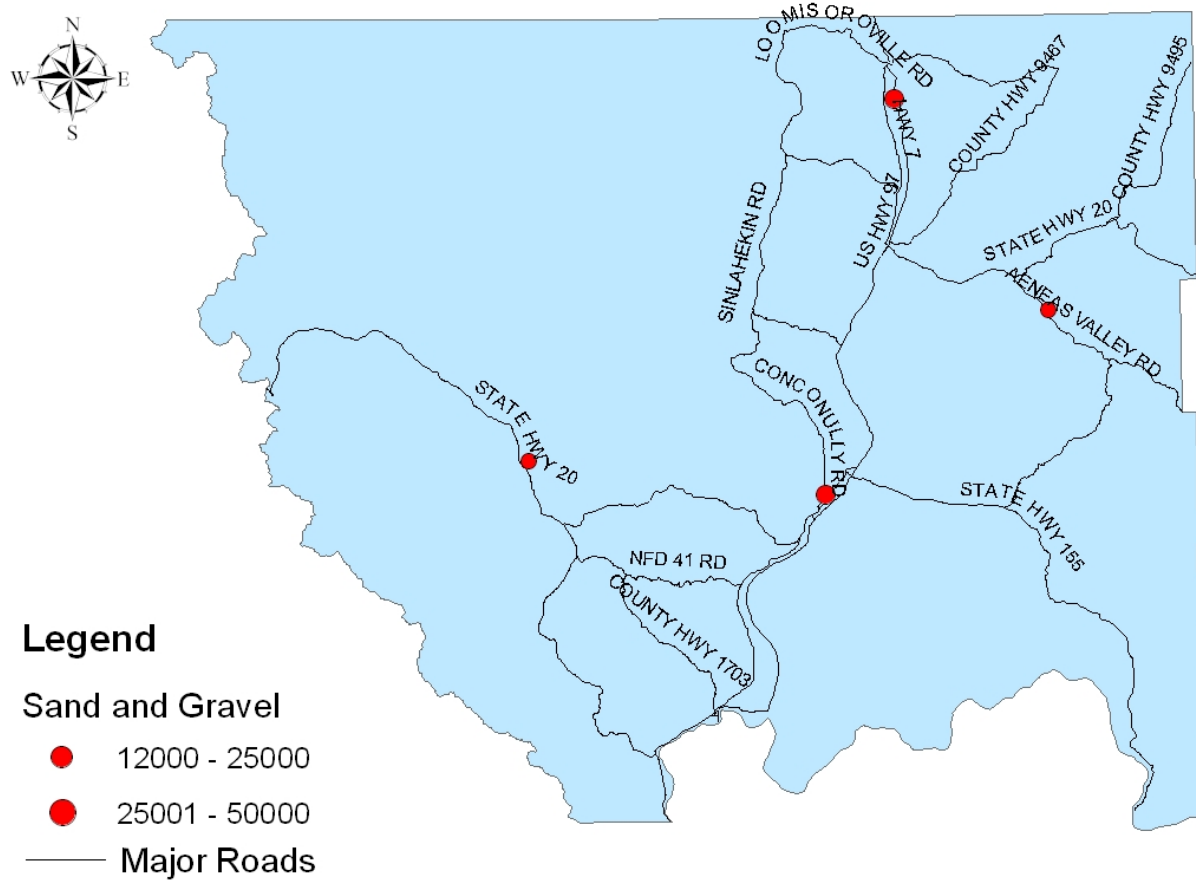
**Figure 42.** Mason County mines by type and production level in relation to highway system



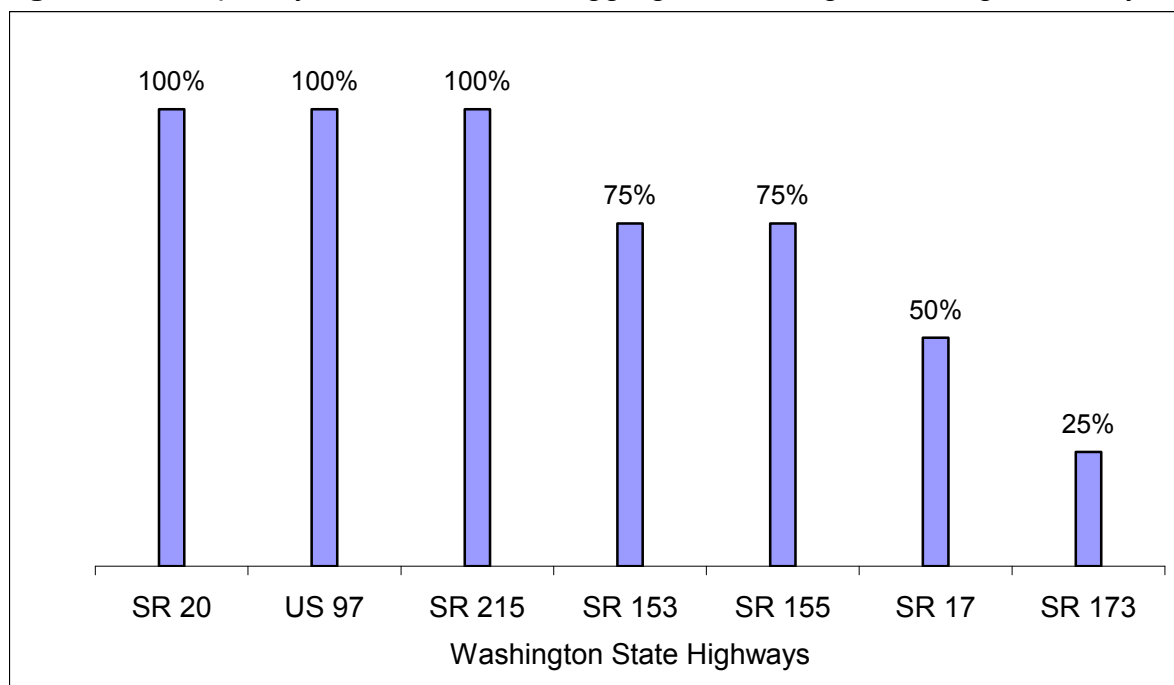
**Figure 43.** Frequency of roads used for aggregates hauling Mason County



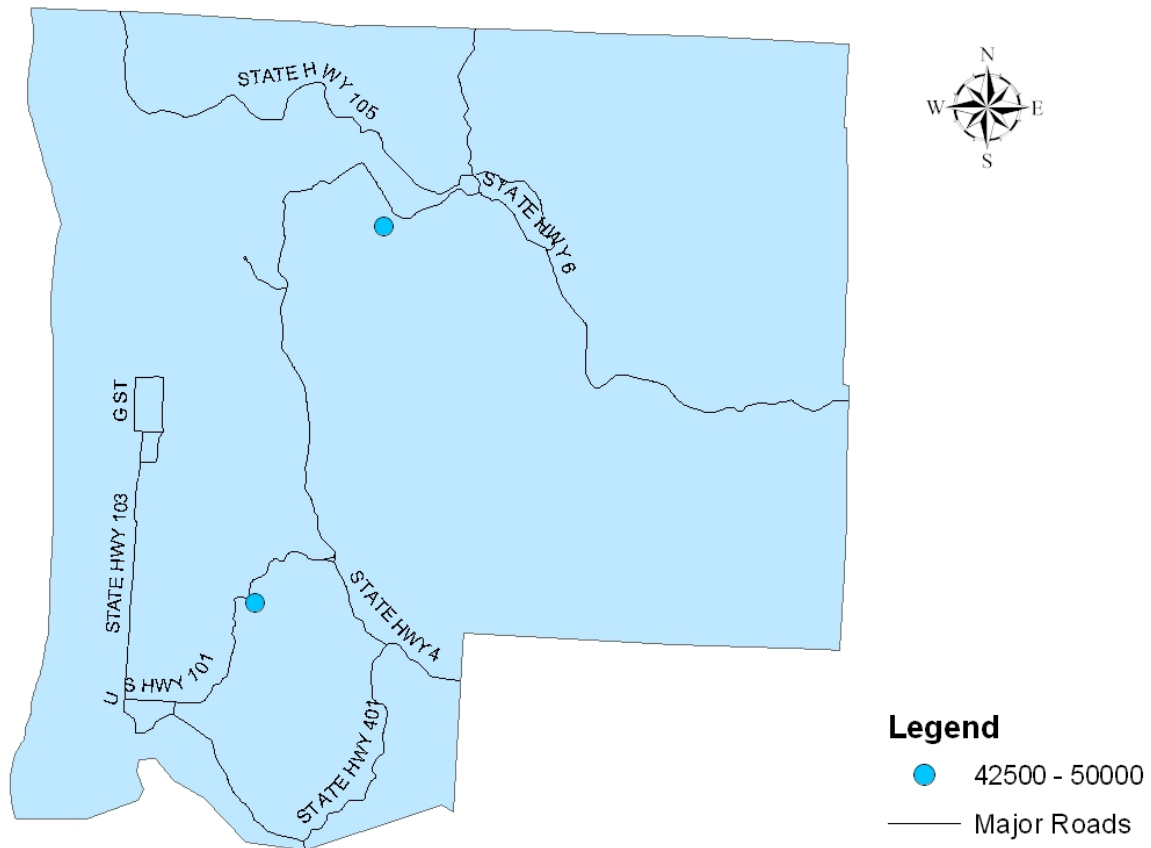
**Figure 44.** Okanogan County mines by type and production level in relation to highway system



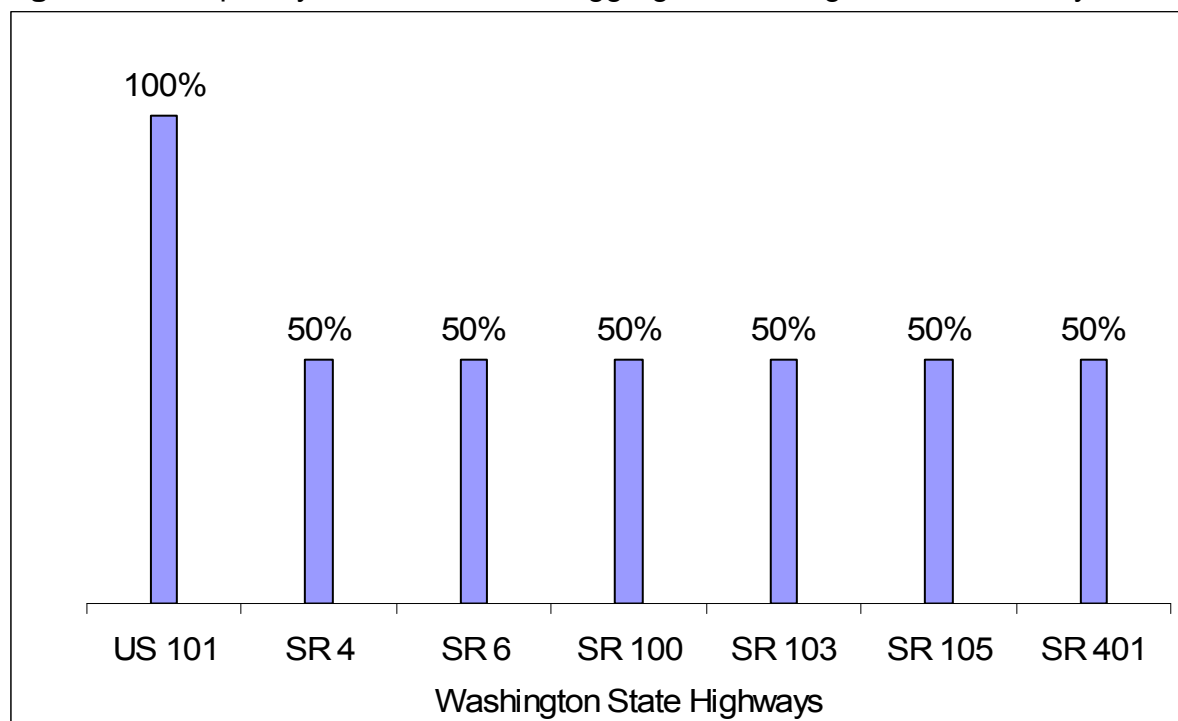
**Figure 45.** Frequency of roads used for aggregates hauling in Okanogan County



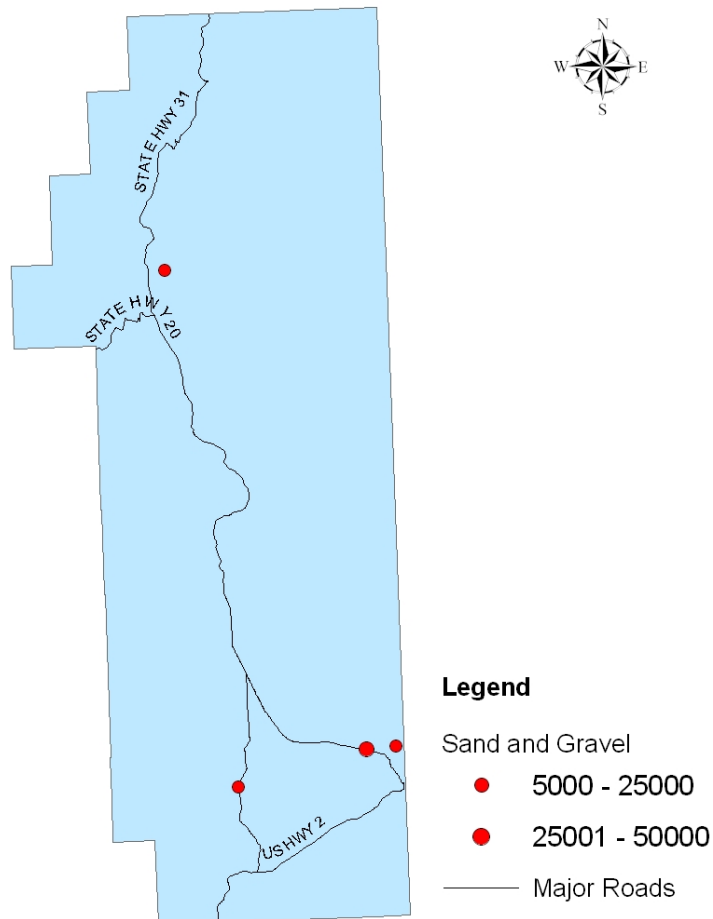
**Figure 46.** Pacific County mines by type and production level in relation to highway system



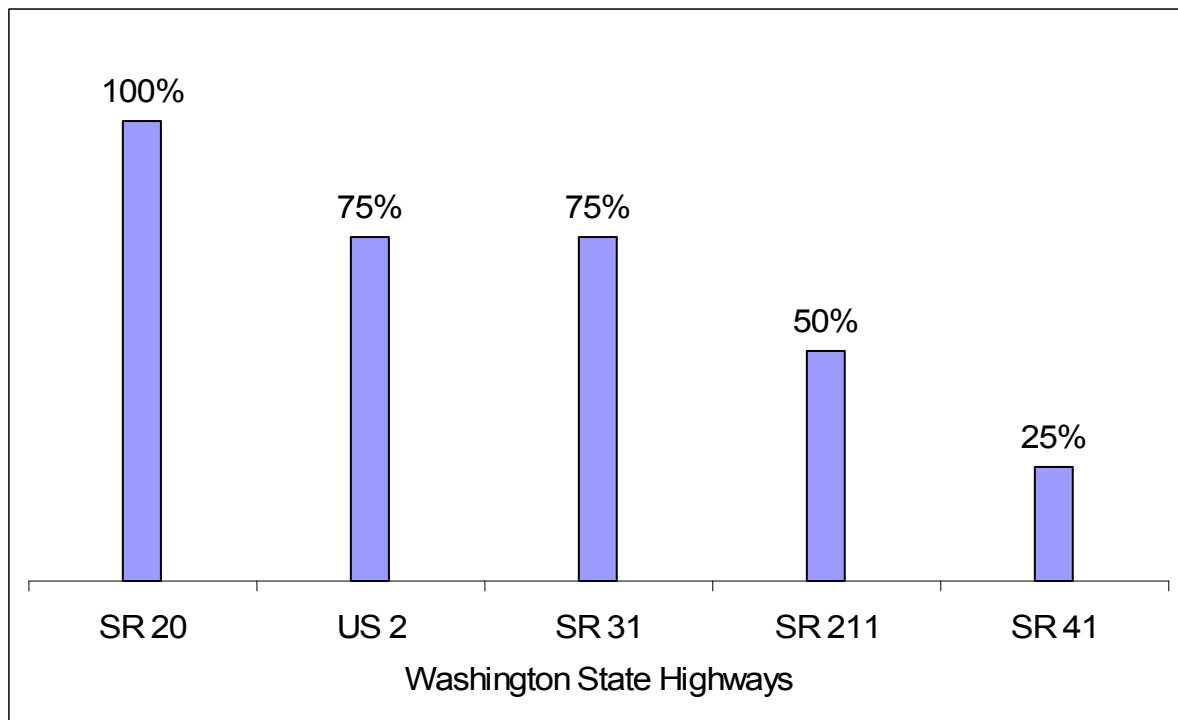
**Figure 47.** Frequency of roads used for aggregates hauling in Pacific County



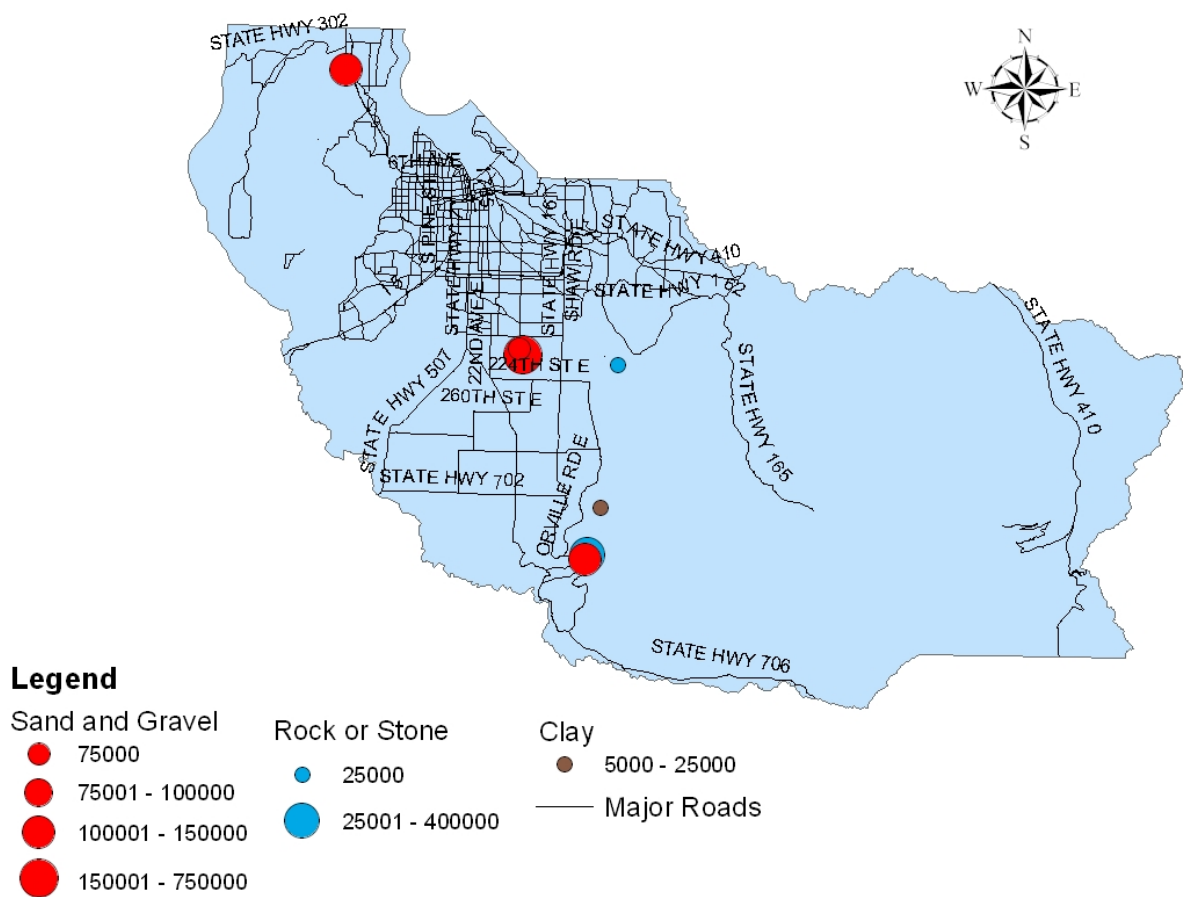
**Figure 48.** Pend Oreille County mines by type and production level in relation to highway system



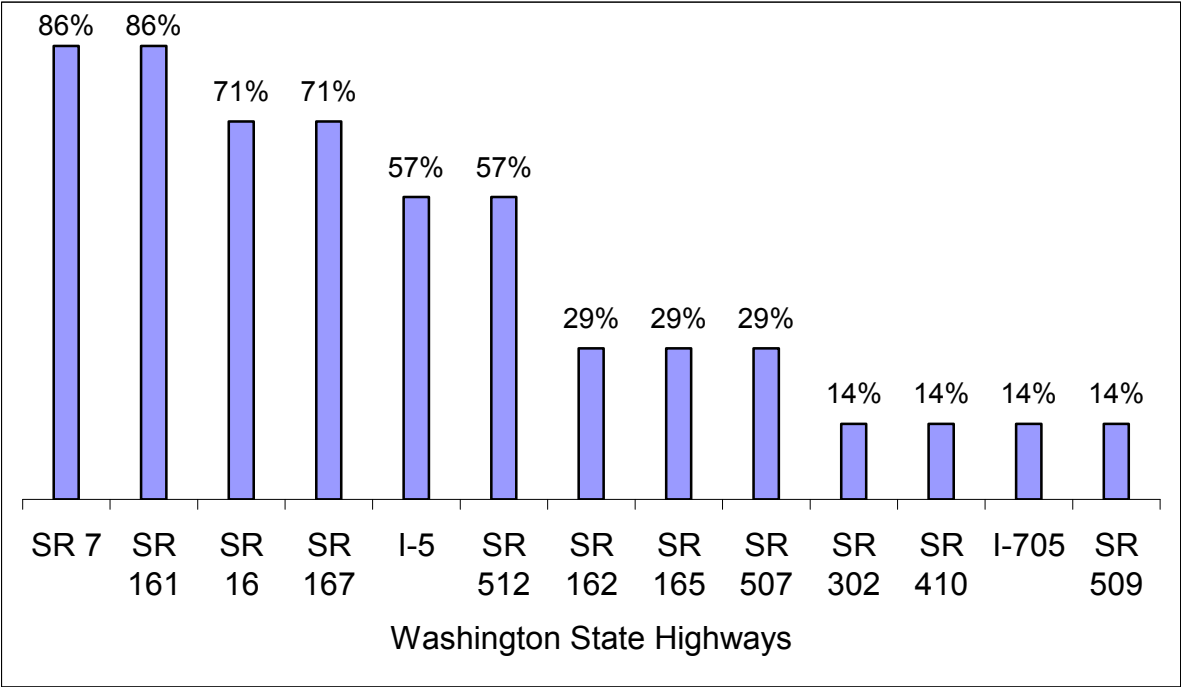
**Figure 49.** Frequency of roads used for aggregates hauling in Pend Oreille County



**Figure 50.** Pierce County mines by type and production level in relation to highway system

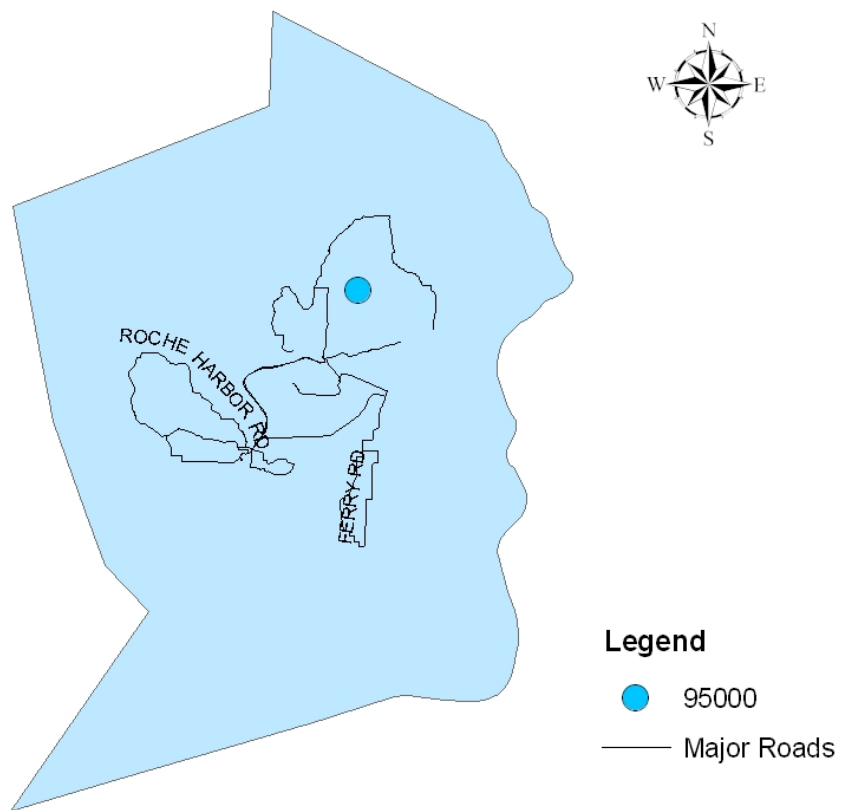


**Figure 51.** Frequency of roads used for aggregates hauling in Pierce County

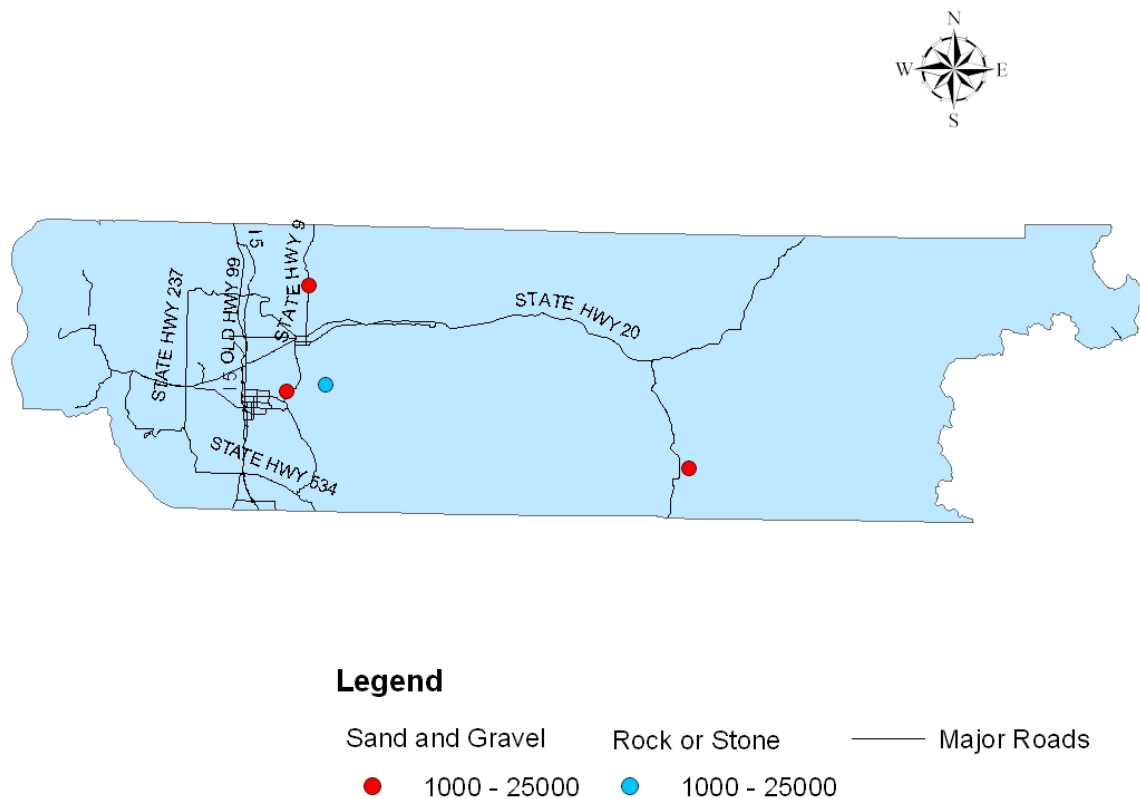




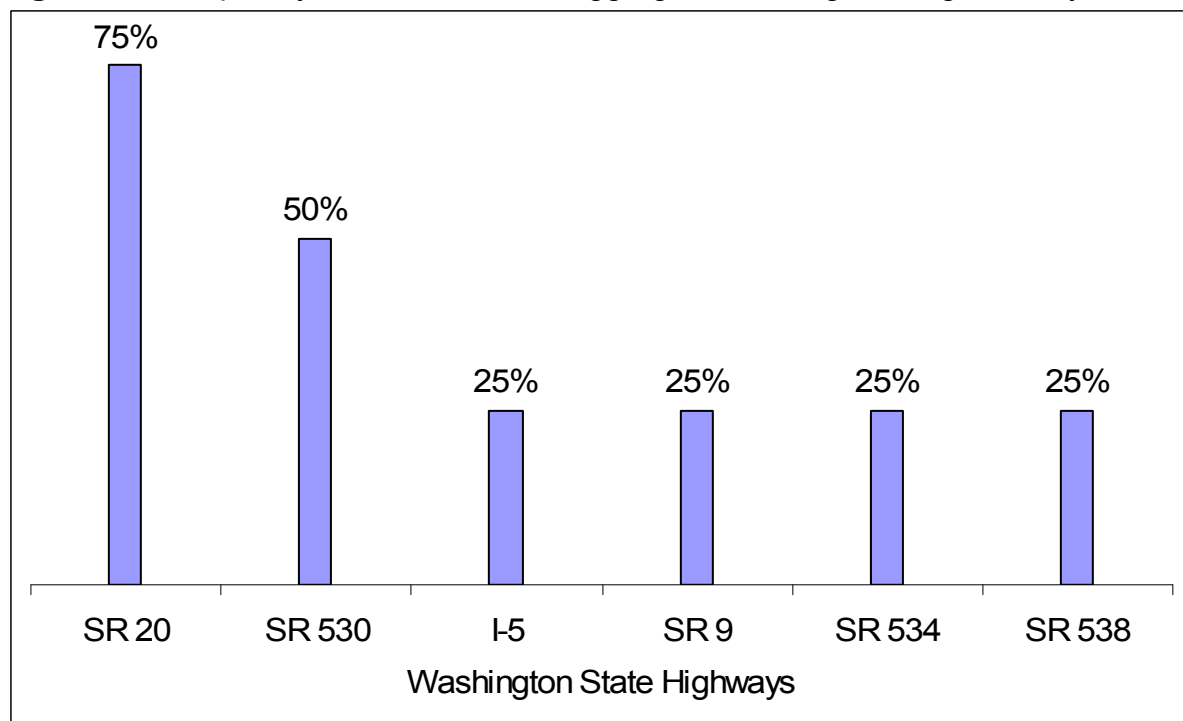
**Figure 52.** San Juan County mines by type and production level in relation to highway system



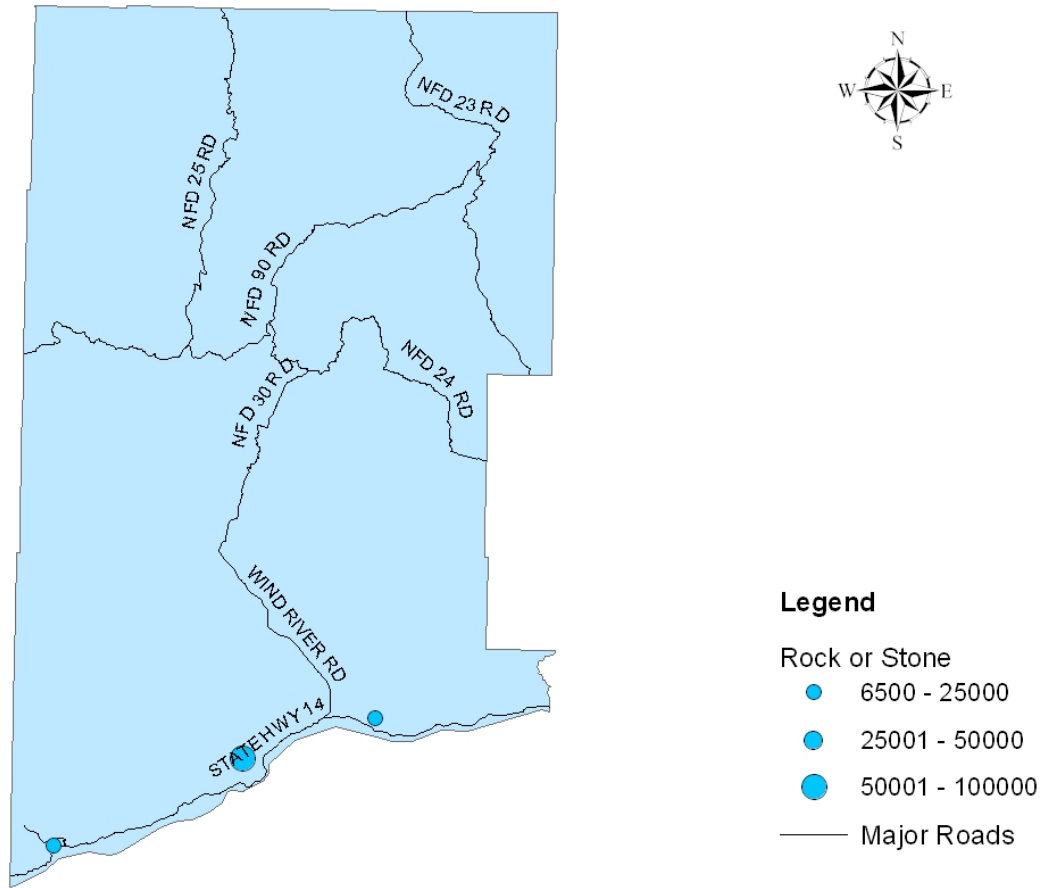
**Figure 53.** Skagit County mines by type and production level in relation to highway system



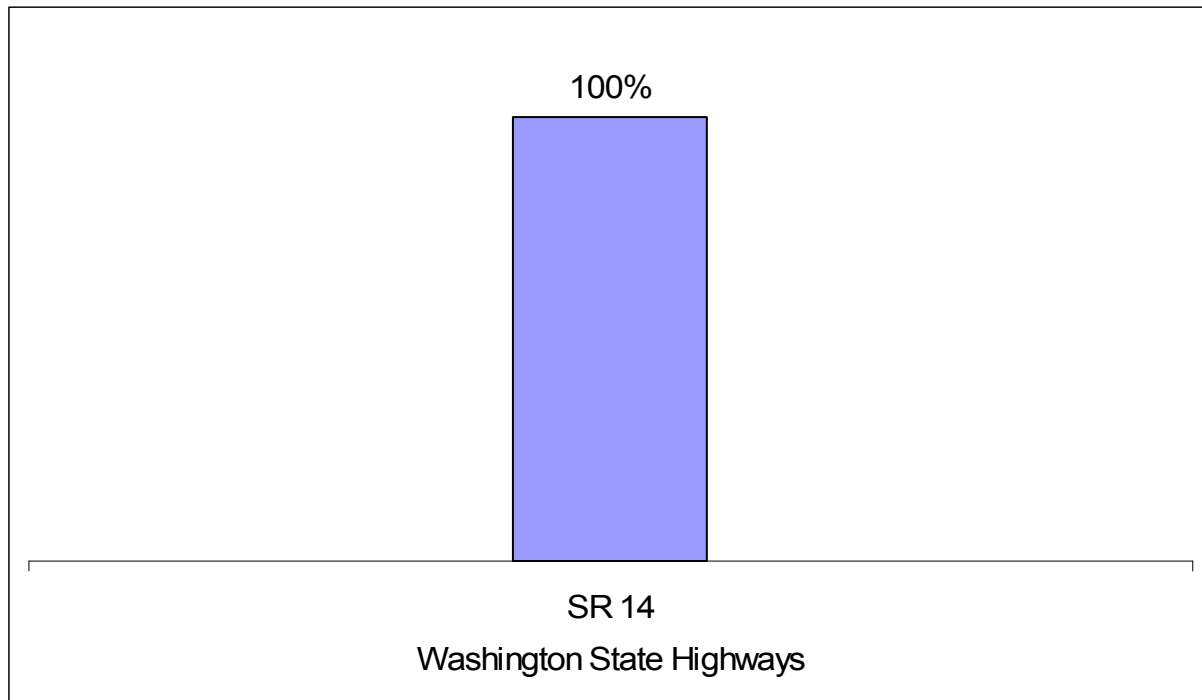
**Figure 54.** Frequency of roads used for aggregates hauling in Skagit County



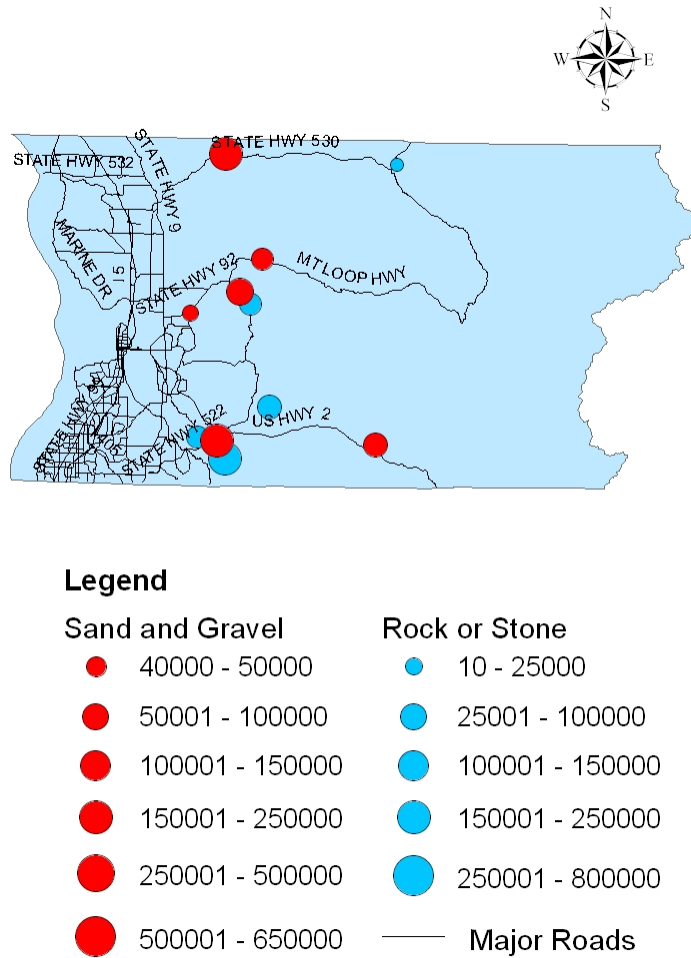
**Figure 55.** Skamania County mines by type and production level in relation to highway system



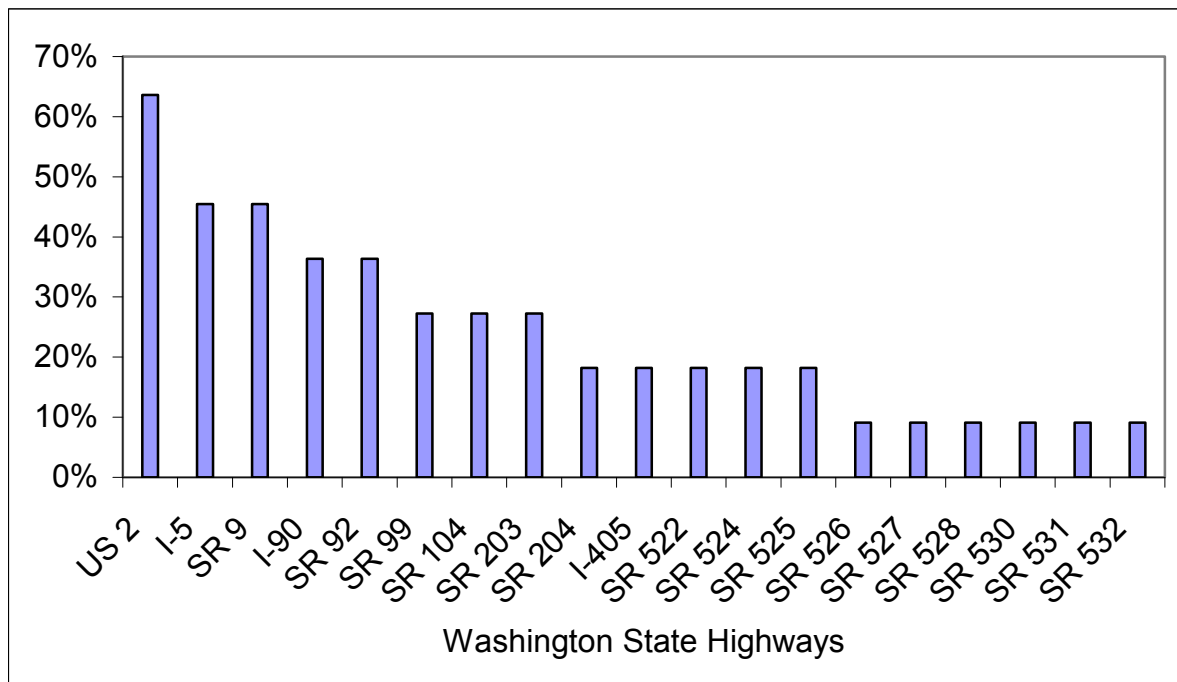
**Figure 56.** Frequency of roads used for aggregates hauling in Skamania County



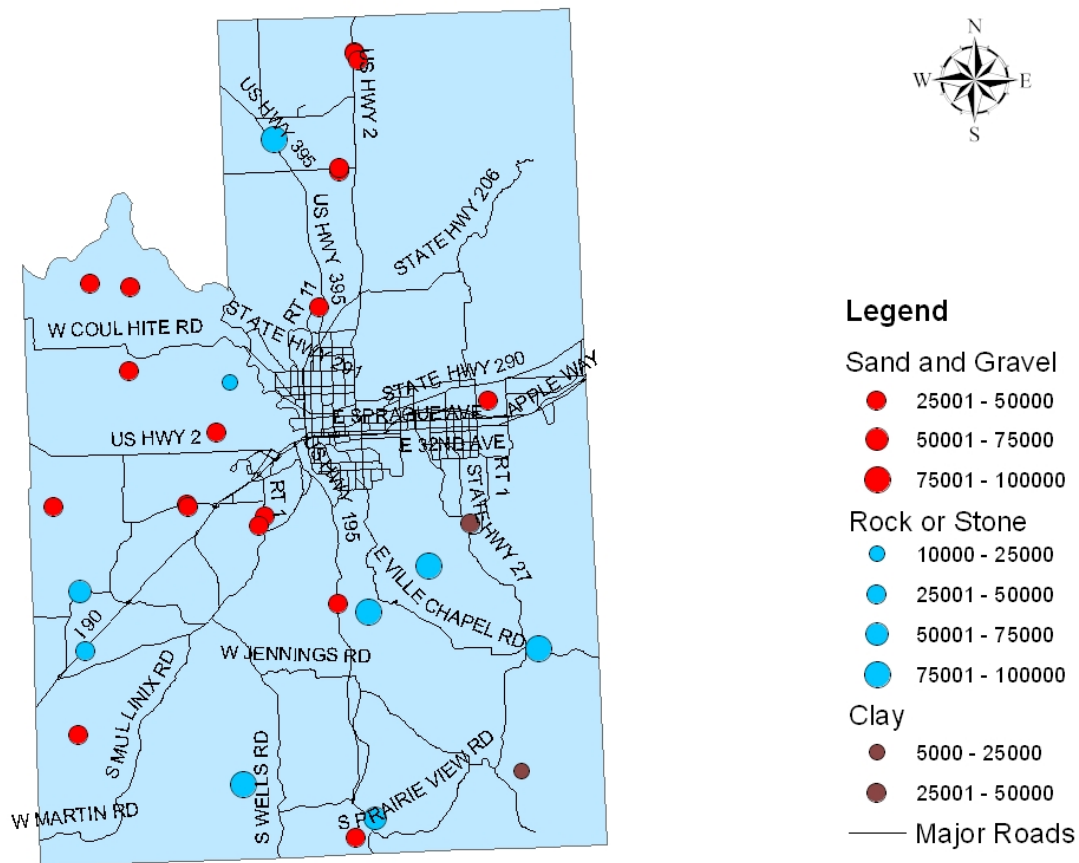
**Figure 57.** Snohomish County mines by type and production level in relation to highway system



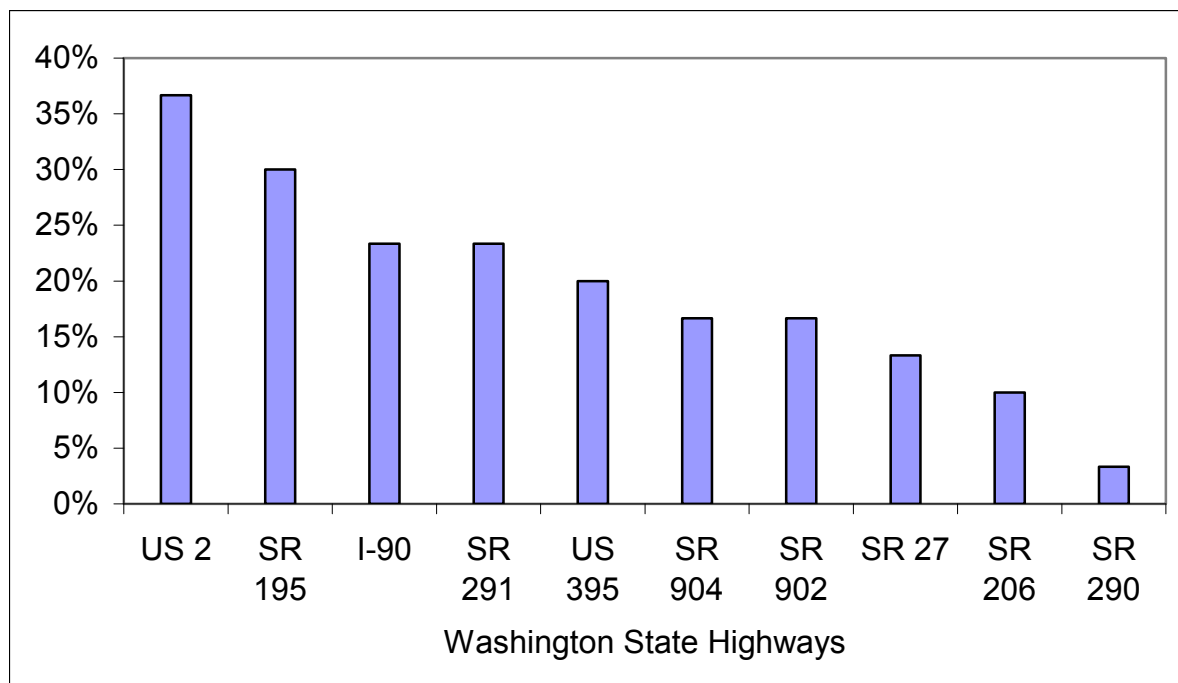
**Figure 58.** Frequency of roads used for aggregates hauling in Snohomish County



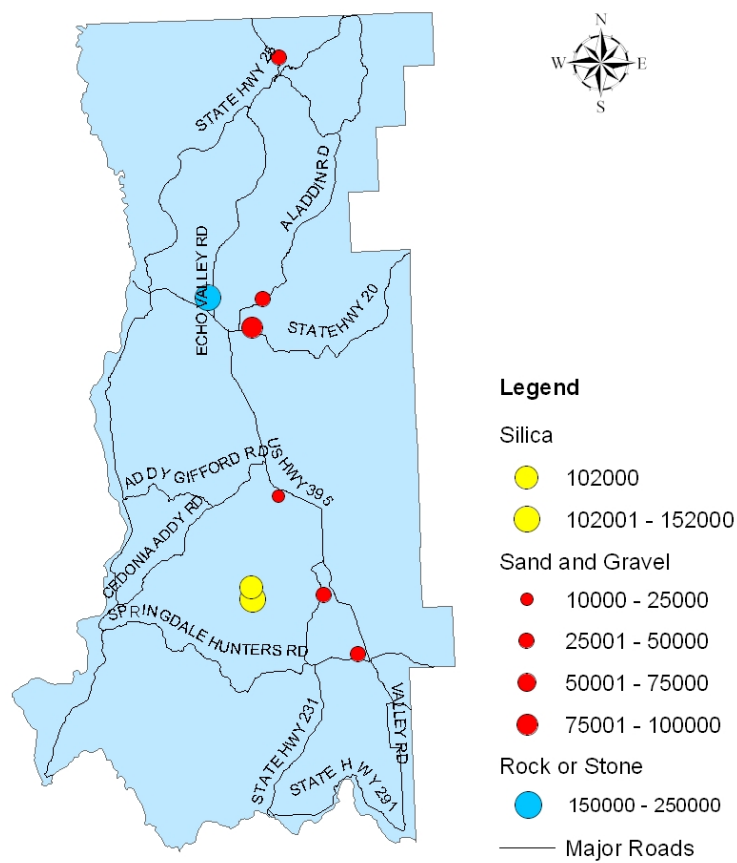
**Figure 59.** Spokane County mines by type and production level in relation to highway system



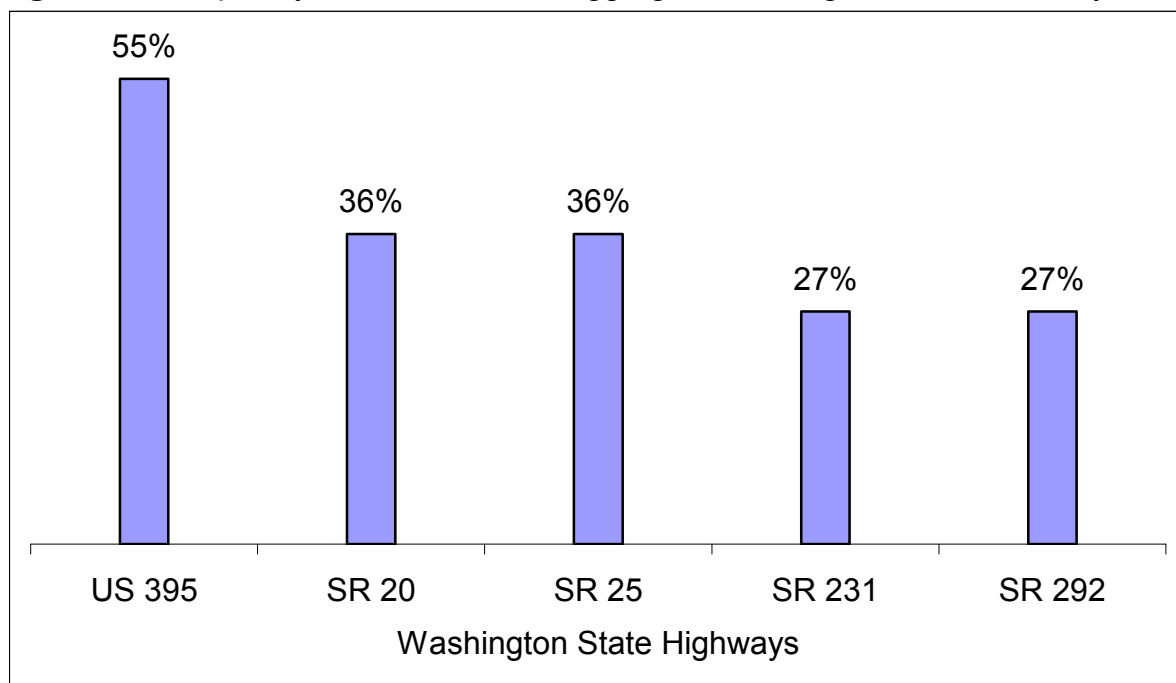
**Figure 60.** Frequency of roads used for aggregates hauling in Spokane County



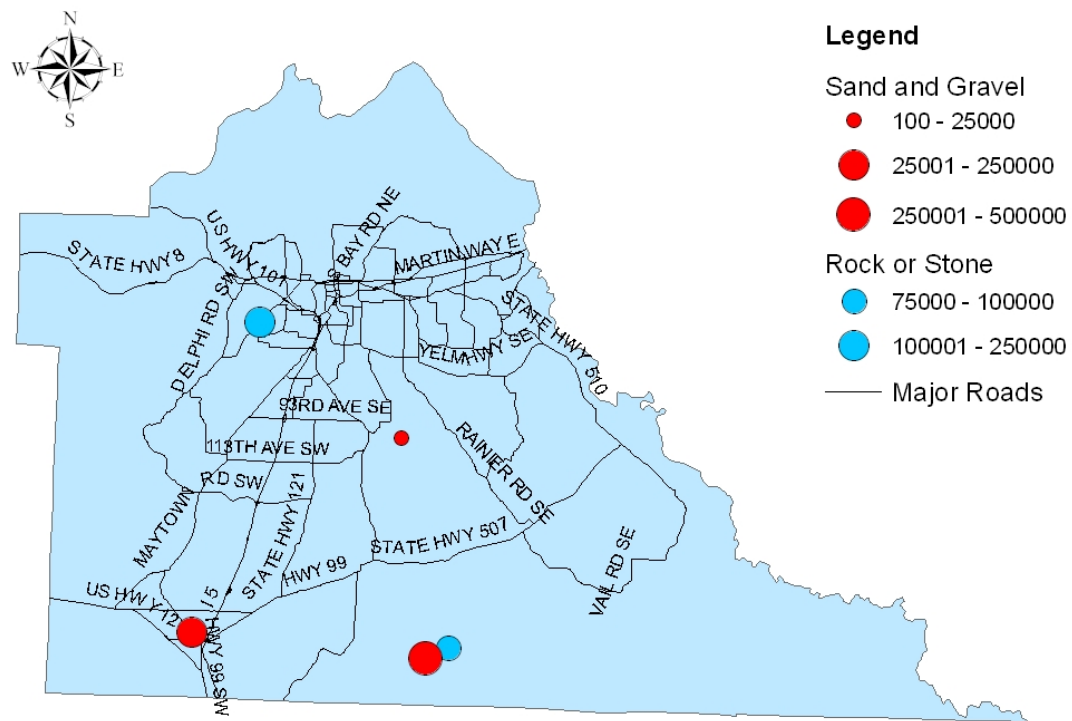
**Figure 61.** Stevens County mines by type and production level in relation to highway system



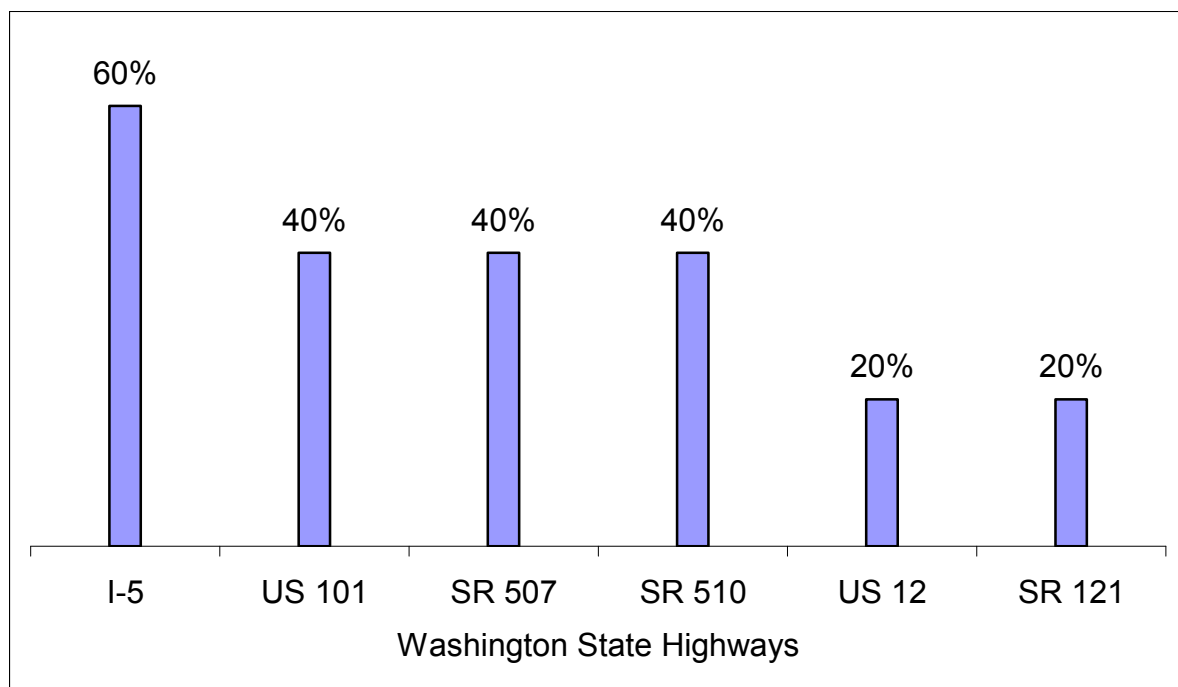
**Figure 62.** Frequency of roads used for aggregates hauling in Stevens County



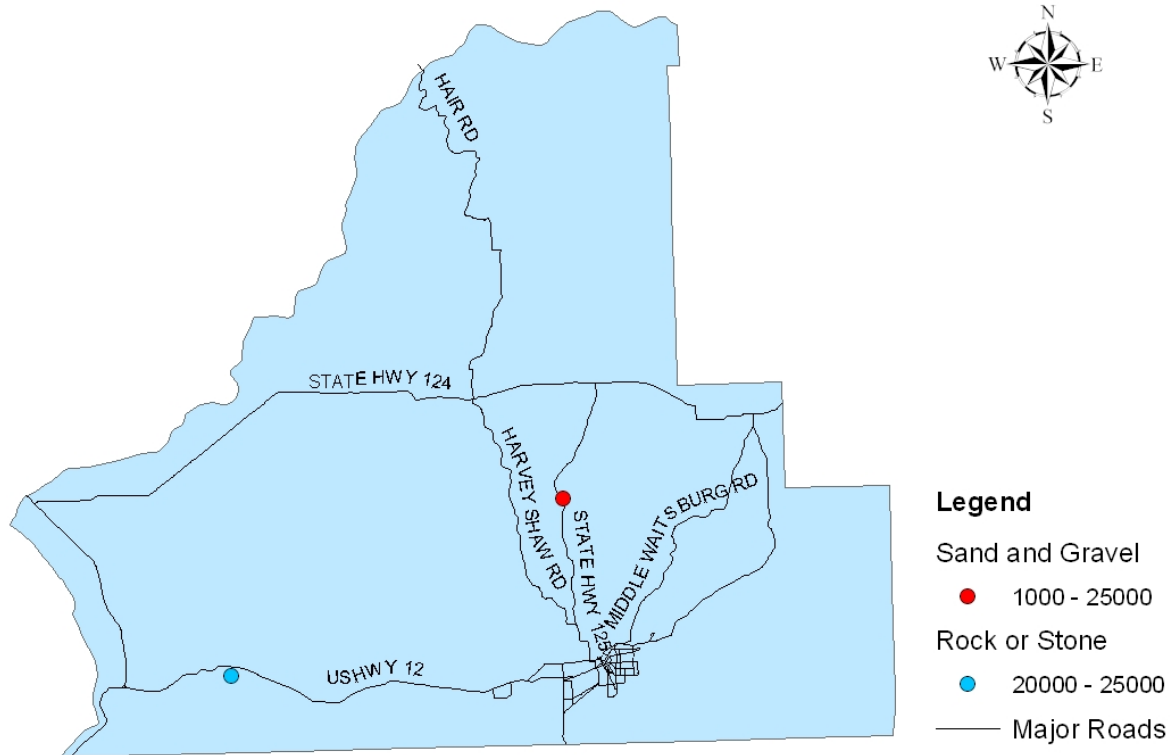
**Figure 63.** Thurston County mines by type and production level in relation to highway system



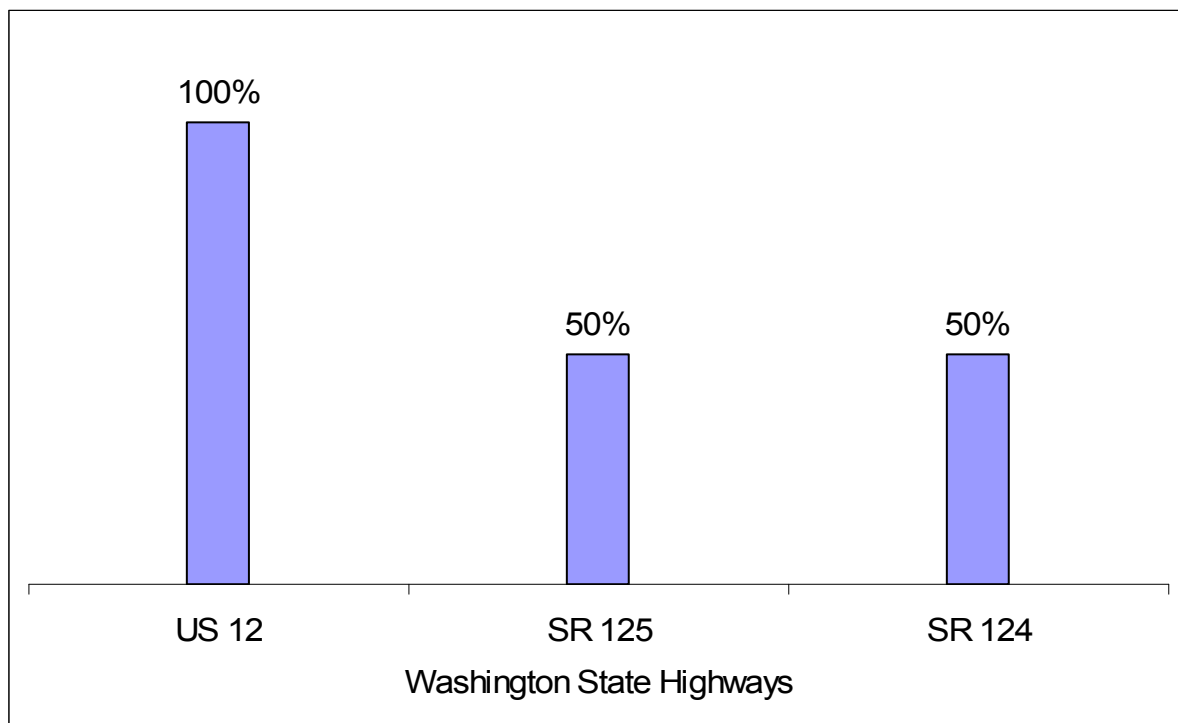
**Figure 64.** Frequency of roads used for aggregates hauling in Thurston County



**Figure 65.** Walla Walla County mines by type and production level in relation to highway system

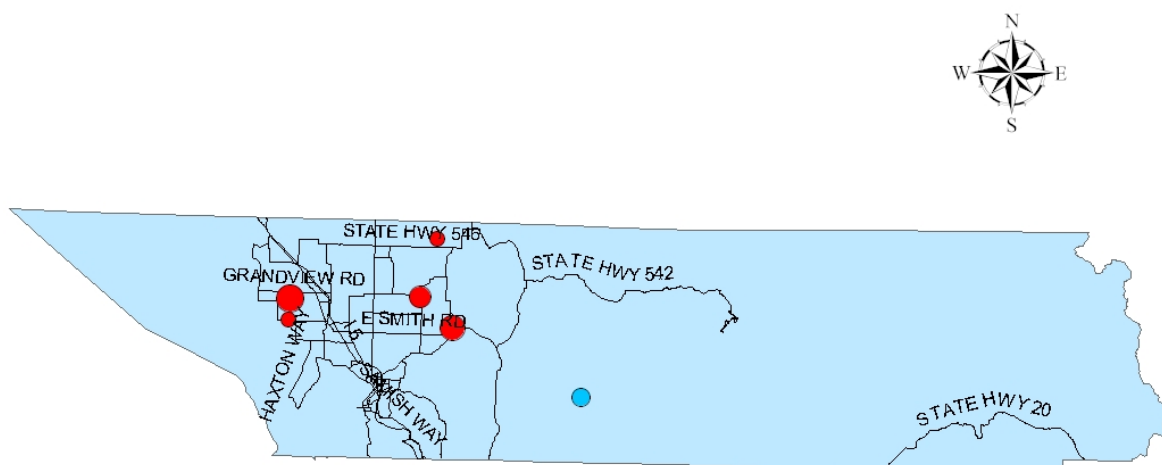


**Figure 66.** Frequency of roads used for aggregates hauling in Walla Walla County

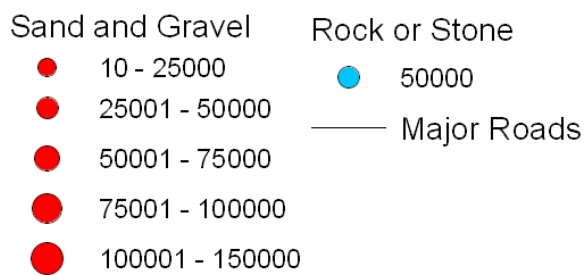




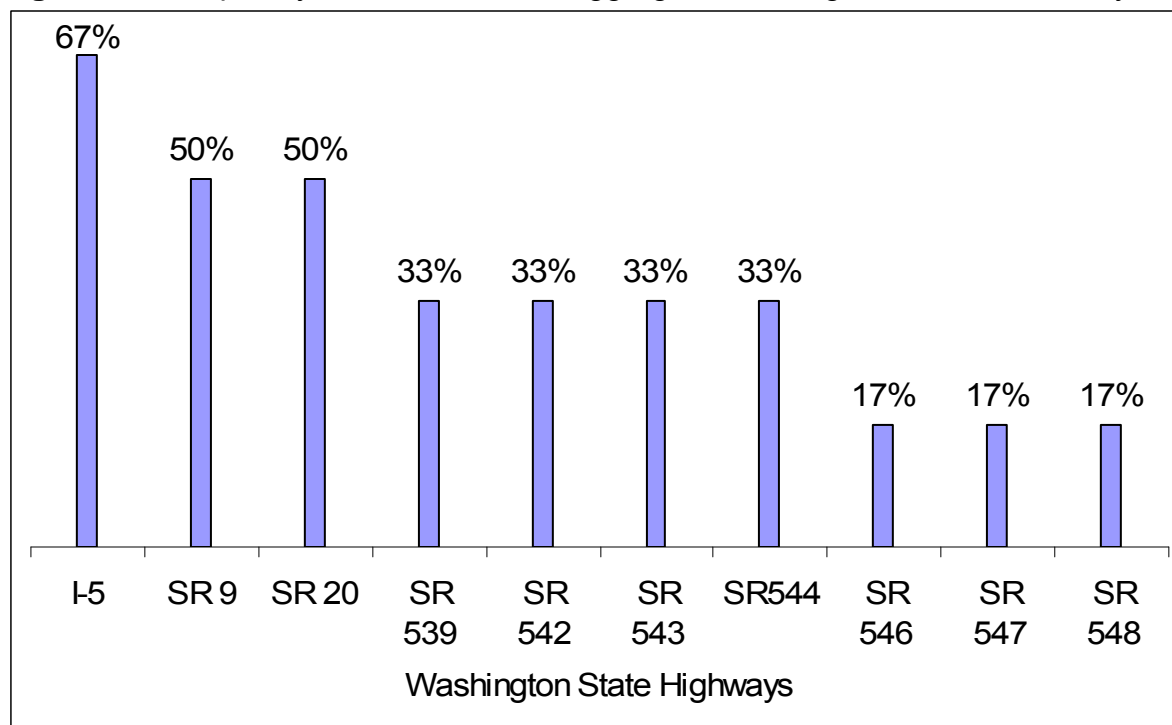
**Figure 67.** Whatcom County mines by type and production level in relation to highway system



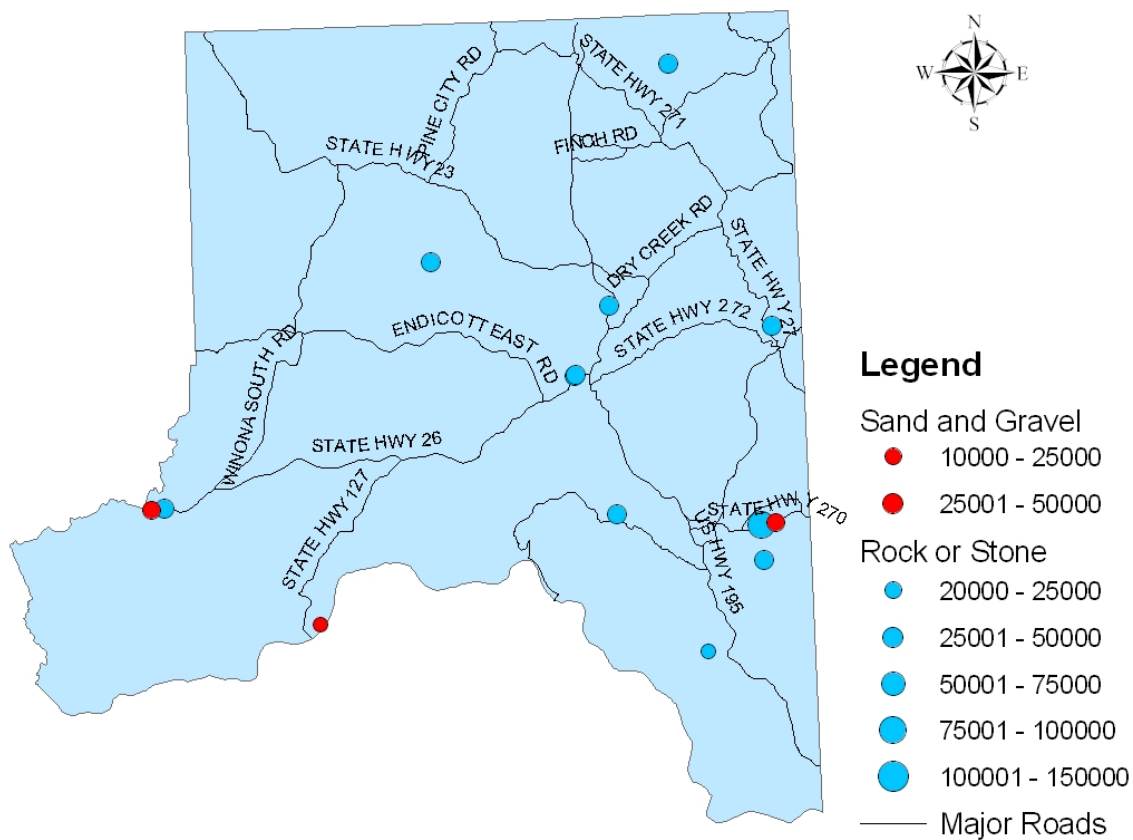
### Legend



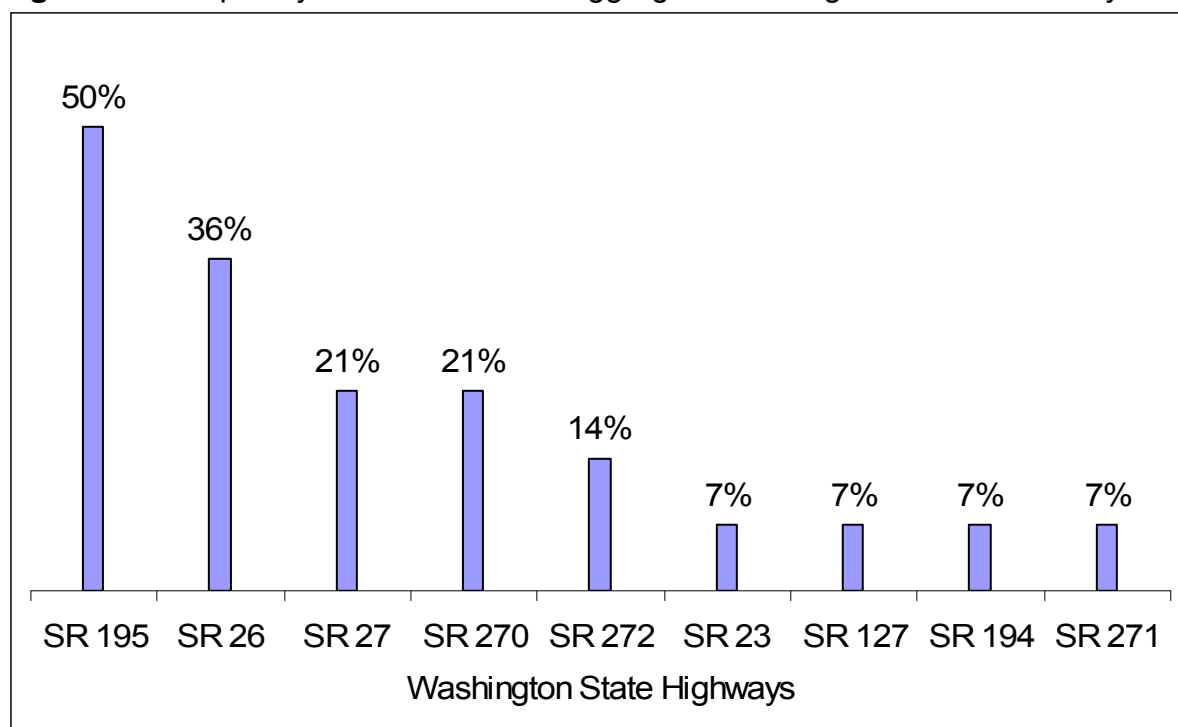
**Figure 68.** Frequency of roads used for aggregates hauling in Whatcom County



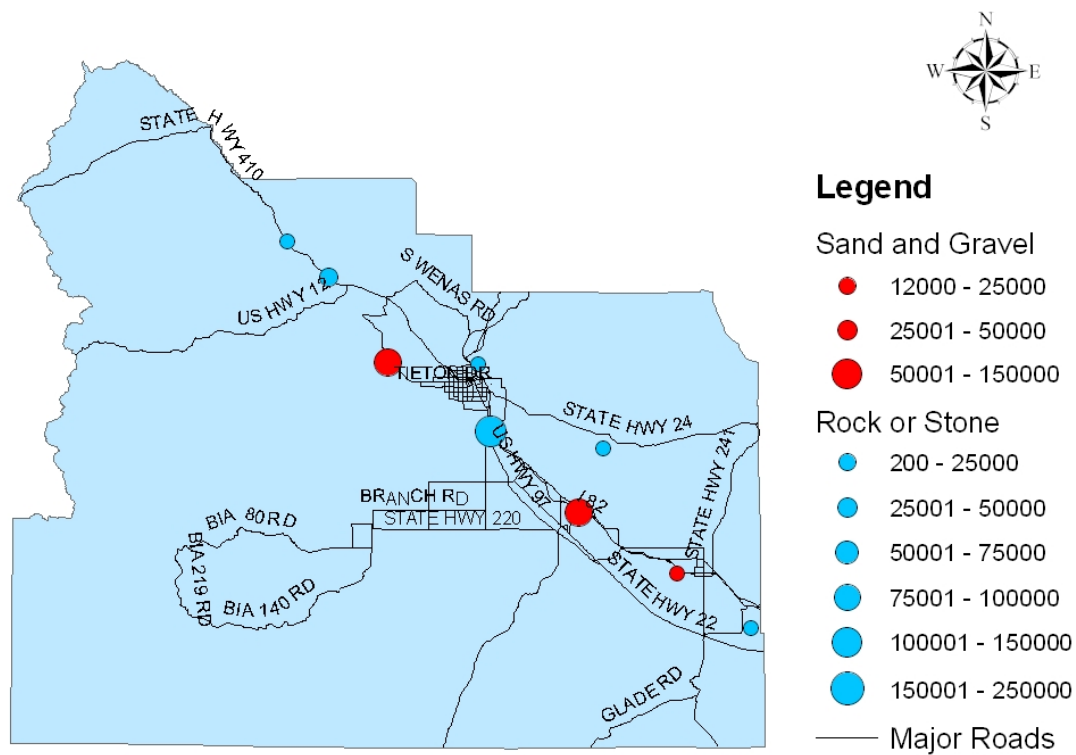
**Figure 69.** Whitman County mines by type and production level in relation to highway system



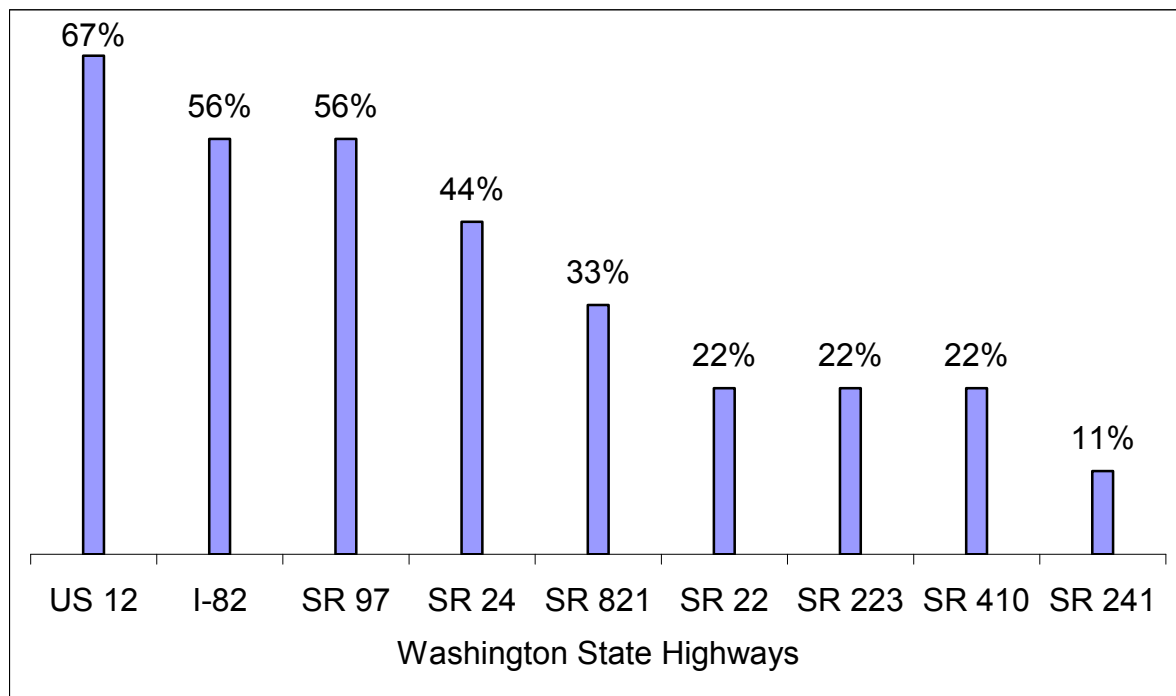
**Figure 70.** Frequency of roads used for aggregates hauling in Whitman County



**Figure 71.** Yakima County mines by type and production level in relation to highway system



**Figure 72.** Frequency of roads used for aggregates hauling in Yakima County



## Appendix D

### Washington State highways used for mineral hauling

Interstate	US	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR
5	2	3	21	100	119	161	193	225	283	410	512	534	883
82	12	4	22	102	121	162	194	231	285	411	516	538	900
90	97	6	23	103	122	163	195	240	292	500	518	539	903
205	197	7	24	104	124	164	202	241	300	501	520	542	904
405	101	8	25	105	125	165	203	243	302	502	522	543	908
705	395	9	26	106	127	166	204	260	303	503	524	544	970
		10	27	108	128	167	205	261	304	504	525	546	
		14	28	109	131	169	206	262	305	505	526	547	
		16	31	110	141	170	211	270	307	506	527	548	
		17	41	112	142	171	215	271	308	507	528	599	
		18	92	113	153	173	221	272	310	508	530	730	
		19	96	116	155	174	223	281	397	509	531	821	
		20	99	117	160	182	224	282	401	510	532	823	

## **Appendix E**

### **Transportation of Mining/Mineral Survey Questionnaire**

## Transportation of Mining / Mineral Survey



Thank you for your participation in this study. If you have questions or concerns as you are completing this form, or if you would like more information on this project, feel free to contact Eric Jessup, at (509) 335-5558 or at [Eric\\_Jessup@wsu.edu](mailto:Eric_Jessup@wsu.edu). Once again, thank you for your assistance.

### Site information

Company	«Company_Landowner»
Site Name	«Property_Name»
Township, Range and Section	«Township» «Range» «Section»
DNR Registration Number	«DNR_Permit»

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**\*\*Please provide information specific to the site identified on the front of this questionnaire\*\***

Name of person completing the survey:

\_\_\_\_\_

Phone Number: \_\_\_\_\_

1. What is the primary commodity mined at this location?

<u>Commodity</u> (Check all that apply)	
<input type="checkbox"/> Sand & Gravel	<input type="checkbox"/> Metals
<input type="checkbox"/> Rock or Stone	<input type="checkbox"/> Ash
<input type="checkbox"/> Coal	<input type="checkbox"/> Diatomite
<input type="checkbox"/> Carbonate	<input type="checkbox"/> Silica Sand
<input type="checkbox"/> Clay	<input type="checkbox"/> Soil
<input type="checkbox"/> Peat	<input type="checkbox"/> Gold
	<input type="checkbox"/> Other: (please identify)
	_____

2. What is the average annual tons of product that is **mined** at this facility in a typical year when it is in operation?

\_\_\_\_\_ tons per year

3. In which years has this site been operated since 2000? Check appropriate line.

\_\_\_ 2000    \_\_\_ 2003    \_\_\_ All six years

\_\_\_ 2001    \_\_\_ 2004    \_\_\_ Not operational in the last

\_\_\_ 2002    \_\_\_ 2005    10 years (*END SURVEY. Please return the questionnaire to us in enclosed envelope*)

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4. What are the future plans of operation? Check if the mine may be operating in: 2006\_\_\_\_  
2007\_\_\_\_ 2008\_\_\_\_

5. Please check the days and times when this site typically is in operation.

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
a.m. 6-8							
8-10							
10-12							
p.m. 12-2							
2-4							
4-6							
6-8							
8-10							
10-12							
a.m. 12-2							
2-4							
4-6							

6. Below, check the boxes to identify 1) the months during which this site is operated, and 2) the months during which mined products are shipped from this site.

	Jan	Feb	Mar	Apr	May	Jun
1) operational months						
2) shipment months						

	Jul	Aug	Sep	Oct	Nov	Dec
1) operational months						
2) shipment months						

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7. Please identify any factors that influence the monthly shipments of mined materials. (Check all that apply)

- ☐ Variation in demand
- ☐ Seasonal road closures
- ☐ Weather
- ☐ Labor shortages
- ☐ Equipment malfunction/needs
- ☐ Other: \_\_\_\_\_

8. In percentages, indicate the amount of products shipped from this site in-state, out-of-state, and internationally.

- a) In-state \_\_\_\_\_
- b) Out-of-state \_\_\_\_\_
- c) International \_\_\_\_\_

Total 100%

please specify major country: \_\_\_\_\_

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9. What percentage of shipments are delivered to the following destinations after they leave this site?

### Destination

- ☐ Construction or road site \_\_\_\_\_ (%)
- ☐ Factory \_\_\_\_\_ (%)
- ☐ Warehouse / Distribution Center \_\_\_\_\_ (%)
- ☐ Farm \_\_\_\_\_ (%)
- ☐ Point of Sale / Consumption \_\_\_\_\_ (%)
- ☐ Truck Terminal \_\_\_\_\_ (%)
- ☐ Rail Terminal \_\_\_\_\_ (%)
- ☐ Marine Terminal \_\_\_\_\_ (%)
- ☐ Air Terminal \_\_\_\_\_ (%)
- ☐ Other: \_\_\_\_\_ (%)

**Total 100%**

#### 10. Roadway Usage Identification

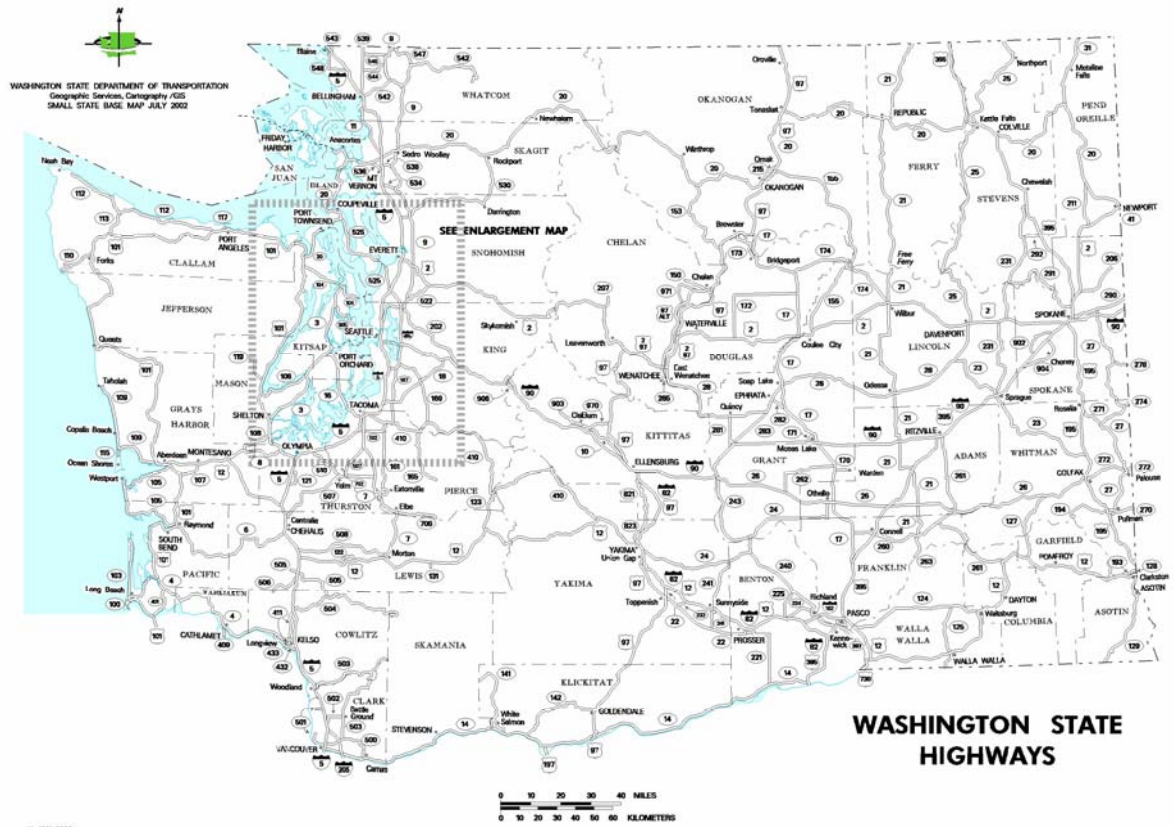
On the **following** Washington State road map, please place an “X” on the location of the mining site.

Using a pen (highlighter, marker, or colored pen, if possible), please highlight the roads this site uses most frequently when transporting materials off-site.

*If your mine is located in the Puget Sound region, you have also been provided with a more detailed enlargement map. Please highlight the mining site and roadways used on this map as well.*

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11. What proportion of inbound and outbound shipment moved by following modes at this site?

**Inbound Materials** (If any)

%\_\_ Truck

%\_\_ Barge

%\_\_ Rail

%\_\_ Other: \_\_\_\_\_

**100% Total**

**Outbound Mined Products**

%\_\_ Truck

%\_\_ Barge

%\_\_ Rail

%\_\_ Other: \_\_\_\_\_

**100% Total**

12. If any materials shipped by rail, what is the typical load configuration?

☐ 1 car

☐ 2-5 cars

☐ 5-24

☐ 25-50 units

☐ 50-100 units

☐ More than 100 units

13. Does your mining operation own its own fleet of trucks?

☐ Yes

If yes, how many trucks? \_\_\_\_\_

☐ No

If no, please identify who provides your shipping services.

☐ Private for hire

☐ Commercial Trucking Company

☐ Other: (please identify) \_\_\_\_\_

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14. What is the typical payload weight for outbound truck shipments?

\_\_\_\_\_ tons

15. Please estimate the percentage of shipments that travel from this facility within each mileage category (e.g. 20% of mined product might be hauled more than 100 miles away, and 80% might be hauled 11 – 20 miles from this site.)

a) 0 – 5 miles \_\_\_\_\_%      d) 21 – 40 miles \_\_\_\_\_%

b) 6 – 10 miles \_\_\_\_\_%      e) 41 – 100 miles \_\_\_\_\_%

c) 11 – 20 miles \_\_\_\_\_%      f) Over 100 miles \_\_\_\_\_%

**Total 100%**

16. What is the typical truck configuration for shipments leaving this facility?

☐ Straight Truck

☐ Straight Truck & Trailer

☐ Tractor & Trailer

☐ Other: \_\_\_\_\_

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17. For trucks leaving your facility, how many axles are typically on the ground?

for the truck \_\_\_\_\_

for the trailer (if used) \_\_\_\_\_

Total number of axles on  
Truck or Tractor

\_\_\_\_\_

Total number of axles on  
1<sup>st</sup> Trailer

\_\_\_\_\_

18. Through which ocean or river ports, if any, do materials from this site travel?

- ☐ None
- ☐ Seattle
- ☐ Tacoma
- ☐ Portland
- ☐ Snake River Ports (Lewiston, Pasco)
- ☐ Columbia River Ports (Umatilla, Morrow)
- ☐ Other: \_\_\_\_\_

19. Are any materials shipped into this site?

- ☐ No
  - ☐ Yes
- If yes, please list these major materials below:

\_\_\_\_\_

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Below, please include any other comments you would like to make about the transportation issues important at this site.

Would you like a copy of the results of this survey? Yes\_\_\_ No\_\_\_

**THANK YOU** for taking time to fill out this survey! Your help is much appreciated by Washington State Department of Transportation and Washington State University.

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**All information reported in this survey will be kept confidential.**



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