AGGREGATE RESOURCE STUDY, WESTERN PORTION
OF THE CARSON CITY BLM DISTRICT, NEVADA
With
ADDENDUM, ECONOMIC POTENTIAL

May 5, 2000

Report to:

Carson City District
U. S. Bureau of Land Management
5665 Morgan Hill Road
Carson City, Nevada  89701

and

City of Carson City
3303 Butti Way, Building #7
Carson City, Nevada  89701

By:

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This information should be considered preliminary. It has not been edited or checked for completeness or accuracy.
AGGREGATE RESOURCE STUDY
WESTERN PORTION OF THE CARSON CITY BLM DISTRICT
NEVADA

May 5, 2000

Report To:

Carson City District
U.S. Bureau of Land Management
5665 Morgan Hill Road
Carson City, Nevada 89701

From:

Nevada Bureau of Mines and Geology
University of Nevada
Reno, Nevada 89557

and

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By:

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Stephen B. Castor, Nevada Bureau of Mines and Geology
Gary L. Johnson, Nevada Bureau of Mines and Geology
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<td>18</td>
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**MAP POCKET**

- Plate 1 Existing Aggregate Producers
- Plate 2 Aggregate Potential Map
1. PURPOSE

The purpose of the Aggregate Resource Study for the U.S. Bureau of Land Management (BLM) is twofold:

- To identify existing construction aggregate producers and to determine current production/consumption rates.
- To identify those areas in the western portion of the Carson City BLM District which are potentially favorable for future aggregate resource development.

The primary need for the study is to provide data that will enable BLM personnel to better understand the local construction aggregate industry and to assist with future planning on public lands near the more populated areas of Western Nevada.

A similar study of southern Washoe County was previously conducted for the Washoe County Department of Development Review (Bryan and others, 1992). Much of the methodology for that study is similar to that used in the present study and authorship of the two reports are nearly the same. Although the scope for this report was adapted from that of Bryan and others (1992), the study area has been expanded considerably.

2. SCOPE OF WORK

The scope of work of the project was determined in conjunction with consultation with the staff at the Carson City District office of the BLM.

2.1 STUDY AREA

The geographic extent of the study area was determined during discussions with Carson City District BLM personnel. The factors in determining the extent of the study area are described in detail in Section 4.1 of this report.

The study focuses on the area that includes the western portion of the Carson City BLM District. The area includes the southern portion of Washoe County (that portion approximately south of and west of the Pyramid Lake Indian Reservation), Storey County, Carson City, Douglas County and the north-western portion of Lyon County (Figure 1). This encompasses an area that is reasonable to assume will provide construction aggregate resources for the continuing and future development of the largest population centers of western Nevada. The area includes the metropolitan area of Reno-Sparks and urbanized areas to the south including Carson City and the Minden-Gardnerville region, and is hereafter referred to as the Reno-Carson-Gardnerville corridor. On the basis of numbers obtained from the Bureau of Business and Economics Research, this area currently contains a population of approximately 420,000 and is steadily growing. This growth will dictate continuing demand for construction aggregates. As existing aggregate sources are exhausted or preempted by surrounding urbanization, a need to identify

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and develop new aggregate resources will arise. Construction aggregate is a high volume - low cost industrial mineral commodity, which means transportation costs greatly influence the ability of a particular aggregate source to compete in the principal market area. For the foreseeable future the majority of aggregate resources used in the Reno-Carson-Gardnerville corridor will likely come from within the study area. However, significant amounts of aggregate may be sold into the Reno-Sparks area from sources that are east of the study area along Interstate 80.

2.2 EXISTING RESOURCES AND CONSUMPTION RATES

This portion of the study included the following tasks:

1. Identification of all major and minor construction aggregate producers in the study area.

2. Personal contact with aggregate producers to obtain information concerning products, production volume and potential reserves.

3. Contact with federal and state agencies to obtain information on consumption, availability of public aggregate resources, government use of aggregates, and future trends.

4. Site visits to some aggregate producers to collect information on location, activity, products, and type of material.

5. Preparation of a map showing the locations of all construction aggregate resources in the study area.

2.3 AGGREGATE POTENTIAL

The scope of work for this phase of the study included delineation of the areas aggregate potential in the study area by the development of a 1:250,000-scale map of aggregate potential (Plate 2) based on a digital compilation of geologic maps by the Nevada Bureau of Mines and Geology (NBMG).

Criteria for identification of potential were adopted from Bryan and others, 1992 and are based on physical qualities and quantity of lithologic units in the study area. Sources of information used to identify potential resources included published and unpublished geologic maps, aerial photography, private and government reports pertaining to the availability of aggregate resources, and the authors’ knowledge of and experience with local aggregates. In addition, limited field investigations were conducted in the study area. A detailed approach to the methodology of how potential resources were classified is described in Section 4.2 of this report.

The aggregate potential map (Plate 2) subdivides the study area into subareas characterized by potential for furnishing future aggregate resources. On this map such potential is divided into six separate classifications as follows:
SAND & GRAVEL

- High Potential
- Moderate Potential
- Low Potential

BEDROCK

- High Potential
- Moderate Potential
- Low Potential

The only areas not classified for aggregate potential were urbanized areas and significant water bodies. Urbanized areas were compiled from information in Bryan and others (1992) and zoning maps obtained from the Washoe County, Douglas County and Carson City government offices.

2.4 PRINCIPAL INVESTIGATORS

Dennis P. Bryan - A geological engineer with AGRA Earth & Environmental, Inc. He served as project manager and principal investigator. Mr. Bryan specializes in industrial minerals and construction materials and has over 25 years experience in local aggregate evaluation and testing.

Stephen B. Castor - Research Geologist with the Nevada Bureau of Mines and Geology. Mr. Castor’s speciality is mineral resources, including construction aggregates, in Nevada.

Gary L. Johnson - Geographic Information System (GIS) Processor. Mr. Johnson specializes in utilizing computer data to compile maps.

2.5 ACKNOWLEDGEMENTS

This report is the result of a cooperative effort between three organizations. NBMG was the prime contractor to the BLM on the project. NBMG personnel prepared all maps using GIS technology, assisted in planning the scope of the study, participated in field investigation, and helped to write this final report. AGRA Earth & Environmental, Inc. was a subcontractor to NBMG on the project. The AGRA investigator undertook the majority of the field work conducted during the course of the study, did the majority of the aggregate potential classification on Plate 2 and prepared the aggregate producer map, Plate 1. This report was prepared jointly by NBMG and AGRA personnel.

The BLM assisted with developing the scope of work, identifying old and current resources on public lands, and with the field work. We would especially like to thank Carla James who assisted with the scope of work and contract details, and Ron Tauchen who assisted with the field reconnaissance and review of the report.
In addition we would like to thank all those individuals and companies we contacted who answered our questions concerning the local aggregate industry. Without the cooperation of local industry, portions of this study would have been lacking in substance.

We would especially like to thank Washoe County Planning Department for allowing us to use the previous study’s methodology and information (Bryan and others, 1992). The previous study encompassed an area of approximately 1,000 square miles. The current study encompasses an area of approximately 3,200 square miles and includes most of the previous study area.

2. EXISTING AGGREGATE RESOURCES AND CONSUMPTION RATES

3.1 CONSTRUCTION AGGREGATES

This study concerns itself with only those construction aggregates which were deemed to be high quality, i.e. aggregates that exhibit physical properties that indicate that they are sufficiently durable and sound to satisfy generally accepted specifications for use in Portland cement concrete, asphaltic concrete and aggregate base. These uses are considered to be the three most important high-end applications for construction aggregates.

Construction aggregates in the Reno-Carson-Gardnerville corridor can be classified as either sand and gravel or crushed bedrock. A description of these aggregate source types is as follows:

Sand and Gravel - Approximately 40 percent of the high quality construction aggregate in the study area can be considered sand and gravel. This material primarily comes from sources along the floodplain of two rivers (the Truckee and Carson Rivers) and tributary drainages. It predominantly includes river gravels, glacial outwash and glacial terraces. In addition, minor amounts of good quality sand and gravel come from beach deposits, originally formed several thousand years ago when inland lakes were common in Nevada. Other sources of sand and gravel are widespread alluvial fan deposits; while these sources provide much of the borrow materials and aggregate base, they are generally not used as a source for high-quality concrete or asphalt aggregate. Sand and gravel deposits generally occur in relatively flat and low-lying portions of the study area, land that is in most cases the most desirable for construction. For this reason, urbanization takes place most rapidly in areas with sand and gravel potential, and such areas tend to be preferentially removed from consideration as aggregate resources.

Sand and gravel generally can be easily mined but in most cases it must be washed to remove fine silt and clay for high quality applications. Oversize material is generally crushed.

Bedrock - Approximately 60 percent of the high quality construction aggregate in the Reno-Carson-Gardnerville Corridor comes from bedrock sources. The percentage of bedrock sources being used as aggregate has dramatically increased in the past 20 years because of declining availability of sand and gravel reserves due to urbanization. Bedrock sources for high quality aggregate are primarily igneous rocks which include both granitic and volcanic rocks. Currently exploited granitic rock in the study area is technically referred to as quartz diorite, a relatively uncommon local compositional variety. Volcanic rocks used for aggregate include rhyolite, basalt and andesite. One bedrock source in the Carson City area utilizes metamorphosed volcanic rock.
Bedrock materials must be ripped or blasted to enable mining and then must be crushed to smaller sizes for use in most aggregate applications. They may or may not have to be washed to remove deleterious fine material depending on the nature of the raw material. In general, the cost of mining and processing bedrock into aggregate is higher than costs for sand and gravel.

3.2 PRESENT CONSUMPTION

3.2.1 Overview of the Market

Total current aggregate consumption in the study area is estimated at 7.0 to 7.5 million tons per year based on the findings of this study. This consumption includes only that sand and gravel or crushed rock that is used in the higher quality applications for construction aggregates; such as for use in Portland cement concrete, asphalt concrete and aggregate base. More common types of construction material which are not necessarily processed and which are used as common borrow or fill material would boost this total production substantially.

Table 1 is a compilation of aggregate production in the study area based on data from the U.S. Geological Survey, the now-defunct U.S. Bureau of Mines, and from information gathered during the course of this study. The table compares production figures in the study area to that in Nevada as a whole and also to total production in the United States. Production figures for the study area were arrived at by compiling information from local producers and by estimating production for producers from which information was incomplete. Individual company production is not reported for proprietary reasons.

<table>
<thead>
<tr>
<th>Year</th>
<th>Study Area</th>
<th>Nevada</th>
<th>U.S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>7,000,000 - 7,500,000</td>
<td>30,800,000</td>
<td>2,520,000,000</td>
</tr>
<tr>
<td>1990</td>
<td>------</td>
<td>19,977,000</td>
<td>2,140,000,000</td>
</tr>
<tr>
<td>1985</td>
<td>13,530,000</td>
<td>1,800,900,000</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>7,000,000</td>
<td>1,746,642,000</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Estimate this study
2. Production estimates from 1998 for Nevada and the U.S.A. are from the U.S. Geological Survey (USGS) and are based on canvassing of sand and gravel and crushed stone producers.
3. Production figures from 1990 and before for Nevada and U.S.A. are from the U.S. Bureau of Mines (USBM) and are based on canvassing of sand and gravel and crushed stone producers.

3.2.2 Producers

Table 2 lists the principal construction aggregate producers in the study area. Locations of the principal producers are also shown on Plate 1. For the purpose of this report, a principal
producer is an individual deposit that currently produces in excess of 100,000 tons of total aggregate product per year (not including borrow or ordinary fill material). There are twelve principal producers in the study area and one (Paiute Aggregates) that is just outside the study area.

Plate 1 shows only those producers that have been currently active. There are numerous abandoned or inactive pits that are not shown. There are five aggregate sources shown on the map which are outside the study area. These were included because they sometimes furnish aggregate into the study area. For example, Paiute Aggregates, a major producer at Wadsworth, furnishes the majority of its production into the Reno area.

Minor aggregate producers are listed in Table 3 and are also shown on the accompanying map, Plate 1. These sources either produce less than 100,000 tons of high quality aggregate per year or produce only fill or borrow. Some minor borrow pits that have intermittent production may not be shown.

### Table 2

**Major Construction Aggregate Producers in the Reno-Carson-Gardnerville Corridor**

(Active pit or quarry that produces over 100,000 tons of product per year excluding borrow)

<table>
<thead>
<tr>
<th>Sand &amp; Gravel</th>
<th>Crushed Stone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>A &amp; K Earthmovers</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Bing Materials</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Granite Construction</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Hughes Sand &amp; Gravel</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Paiute Aggregates</td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>All Lite Aggregate</td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>Basalite</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>Bertagnolli Aggregates</td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>Frehner Construction</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Granite Construction</td>
</tr>
<tr>
<td><strong>11</strong></td>
<td>Granite Construction</td>
</tr>
<tr>
<td><strong>12</strong></td>
<td>Rilite Aggregate</td>
</tr>
<tr>
<td><strong>13</strong></td>
<td>Rocky Ridge (BLM sale)</td>
</tr>
</tbody>
</table>

**Abbreviations**

<table>
<thead>
<tr>
<th>AB</th>
<th>PCC</th>
<th>AC</th>
<th>LW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate base</td>
<td>Portland cement concrete aggregate</td>
<td>Asphalt concrete aggregate</td>
<td>Lightweight aggregate</td>
</tr>
</tbody>
</table>

**3.2.3 Products**

Tables 2 and 3 also list the primary products manufactured by the principal aggregate producers. The products include only the high quality aggregate materials that are screened and/or washed through a processing plant. These products include three primary materials (concrete aggregate, asphalt aggregate, and base aggregate) and other materials produced in smaller volumes (bedding sand, drain rock, rip-rap, de-icing sand, landscaping material, etc.).
Ordinary bank-run borrow or fill material are not included in production totals for aggregate products.

No attempt was made to determine the quantities of each commodity produced.

**Table 3**

**Minor Construction Aggregate Producers in the Reno-Carson-Gardnerville Corridor**

(Active Pit or Quarry that produces less than 100,000 tons per year excluding borrow)

<table>
<thead>
<tr>
<th></th>
<th>Company</th>
<th>Location</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Frehner Construction</td>
<td>Miraloma Pit</td>
<td>AB</td>
</tr>
<tr>
<td>15</td>
<td>Granite Construction</td>
<td>Wadsworth Sand Pit</td>
<td>Sand only</td>
</tr>
<tr>
<td>16</td>
<td>Granite Construction</td>
<td>Tri-Partners Pit</td>
<td>AB</td>
</tr>
<tr>
<td>17</td>
<td>Hunewill</td>
<td>Smith Valley Pit</td>
<td>PCC, AC, AB - PCC batch plant</td>
</tr>
<tr>
<td>18</td>
<td>Sha Neva</td>
<td>Hungry Valley Sand Pit</td>
<td>PCC, deicing sand</td>
</tr>
<tr>
<td>19</td>
<td>Tedford</td>
<td>Hazen Pit</td>
<td>PCC</td>
</tr>
<tr>
<td>20</td>
<td>Tedford</td>
<td>Lahonton Pit</td>
<td>AC, PCC</td>
</tr>
<tr>
<td>21</td>
<td>Brown Brothers</td>
<td>Mound House Pit</td>
<td>AB</td>
</tr>
<tr>
<td>22</td>
<td>Canyon Creek</td>
<td>Mound House Pit</td>
<td>AB, drain rock, gabion</td>
</tr>
<tr>
<td>23</td>
<td>Cinderlite</td>
<td>Goni Road Pit</td>
<td>AB</td>
</tr>
<tr>
<td>24</td>
<td>Cinderlite</td>
<td>Red Mt. Cinder Pit</td>
<td>LW, decorative, masonry, deicing</td>
</tr>
<tr>
<td>25</td>
<td>NDOT</td>
<td>Miraloma Pit</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Red Rock Homeowners</td>
<td></td>
<td>AB</td>
</tr>
<tr>
<td>27</td>
<td>Rocky Ridge (BLM sale)</td>
<td>Plant 7 - Mustang</td>
<td>Basalt, rip rap</td>
</tr>
<tr>
<td>28</td>
<td>Washoe County (BLM)</td>
<td>Silver Knolls Pit</td>
<td>AB</td>
</tr>
</tbody>
</table>

**Abbreviations**

AB = Aggregate base  
PCC = Portland cement concrete aggregate  
AC = Asphalt concrete aggregate  
LW = Lightweight aggregate

**3.2.4 Prices**

The cost of producing aggregate in the study area is influenced by a multitude of factors, a few of which are itemized below.

**Land Ownership** - Acquisition cost, royalty rates, etc.

**Mining Costs** - Drilling, blasting, dewatering, rippability, sand and gravel vs bedrock, contamination by deleterious material, overburden removal, etc.

**Production Costs** - Crushing needs, washing requirements, screening, dust containment, handling, durability of the rock, amount of reject material or fines, etc.
Volume - The higher the volume of material mined and sold, the lower the mining and processing costs become

Location - Transportation costs to the market, availability of good roads, access to the deposit, etc.

Regulation - Federal, State and Local Government regulations, permits, and taxes. Includes zoning and environmental concerns.

Political - The cost of mitigating perceived public impacts of mining on the community.

The selling price of aggregate in the Reno area is also influenced by the marketplace. An aggregate must be competitive with others in the same market in order to sell. It is also important to realize that prices fluctuate with the market as a whole and with general economic conditions.

3.2.5 Transportation Costs

In general, the further from the point of use an aggregate source is, the lower the F.O.B. price of the material will be at the mine site. This lower selling price reflects the higher cost of transportation to deliver the aggregate to the market and ensures that it will be competitively priced with other sources of aggregate that may be located closer to the market. This is a very important factor in supply and demand in the aggregate industry. No matter how cheaply the material can be mined or how good the quality, beyond a certain distance from the urban market area it cannot compete with other sources because transportation costs are too high.

Transportation costs in an urban environment, however, are not entirely based on mileage. Instead, they are partly based on the time it takes to transport aggregate to the jobsite or batch plant. Freeway transportation is more economical per mile than urban streets because it is faster. In urban areas delivery time, combined with an established hourly rate for a certain capacity truck, gives a transportation cost per ton of aggregate.

3.2.6 Present Production/Consumption Summary

On the basis of the results of this study, 1998/1999 consumption of high quality aggregates in the Reno-Carson-Gardnerville metropolitan area is estimated at 7.0 to 7.5 million tons per year. Using a 1998 population of approximately 420,000 people which includes Washoe County, Storey County, Douglas County, Carson City, and a portion of Lyon County consumption in the study area is approximately 17 tons per person per year. This figure does not include ordinary borrow material used mainly for fill applications. It does include all aggregates which have to be processed in some way, mainly concrete, asphalt, and base aggregates.

Table 4 is a summary of the production-consumption rates for the study area in comparison to the State of Nevada and the United States as a whole. The consumption rate in Nevada over the past decade has greatly exceeded the national average, reflecting the rapid population growth in the state and the resulting need for new infrastructure and housing. This contrasts with those areas of the country where growth is considerably slower and construction aggregate demand is therefore lower.
Table 4
Consumption Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Study Area</th>
<th>Nevada</th>
<th>U.S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>17.0</td>
<td>17.6</td>
<td>9.5</td>
</tr>
<tr>
<td>1990</td>
<td>--</td>
<td>16.1</td>
<td>8.6</td>
</tr>
<tr>
<td>1980</td>
<td>--</td>
<td>8.7</td>
<td>7.7</td>
</tr>
</tbody>
</table>

Nevada and Study Area population estimates modified from Bureau of Business and Economic Research, College of Business Administration University of Nevada, Reno, October 1998
Study Area Population 1998 ~ 420,000
Nevada Population 1998 ~ 1,750,000
USA population estimates from: U.S. Census Bureau, www.census.gov
U.S. Population 1998 ~ 266,000,000
Nevada and USA Aggregate Production: See Table 1

3.3 PROJECTED FUTURE CONSUMPTION RATES

3.3.1 Overview

According to population estimate changes between 1990 and 1998 published by the University of Nevada’s Bureau of Business and Economic Research, the growth rate in the study area is approximately 3 percent per year. The construction aggregate market in the study area 20 years from now could be as much as 80 percent larger than it currently is, if current population trends and consumption rates continue. Recycling of construction materials will probably be more prevalent as costs and environmental concerns increase. Locations of new pits and quarries are likely to be further from population centers if land-use conflicts intensify and local environmental concerns are emphasized.

During this study, reserves were collected or estimated for all of the principal and minor producers that are shown on Tables 2 and 3. In some cases, these reserves were obtained from producers themselves; in other cases, reserves were estimated on the basis of geologic or other parameters. Reserve estimates for individual producers are confidential and are not reported here.

Using the current consumption and growth rates, over the next two decades approximately 200 million tons of aggregate will be consumed within the study area. If one combines all of the inferred reserves from the existing aggregate suppliers that provide aggregate in the study area there are probably sufficient reserves to satisfy this demand over the next 20 years. In looking at the study area in more detail, however, the future availability of reserves from existing producers is not so certain. Some of the Reno area producers have extensive reserves but the southern portion of the study area lacks producers with long-term reserves. To furnish aggregates that are close to the market, the Carson City - Gardnerville areas will require the development of new deposits within the next 20 years.

The above described reserves are not always guaranteed because in most cases the quality of all of the material in existing deposits has not been proven by extensive drilling, geologic
The above described reserves are not always guaranteed because in most cases the quality of all of the material in existing deposits has not been proven by extensive drilling, geologic mapping and testing. In certain cases there may be specialty products that become depleted. In addition, reserve projections are based on the premise that there will be no changes in specifications or accessibility. Also, if specifications change or are “tightened,” some of the present sources may no longer be viable. If residential growth impinges on the location of existing aggregate sources, citizen or regulatory pressure could force closures of some operations. A currently permitted aggregate source does not assure that the source and its inferred reserves of millions of tons of aggregate are available for use in the future because Special Use Permits must be reviewed periodically and renewed. In summation, unforeseen circumstances may terminate production by some operators, and therefore existing reserves (whether proven or inferred) cannot be relied upon with certainty far into the future.

3.3.2 Plans of Present Suppliers

All of the present major suppliers of aggregate in the study area plan to stay in the business of furnishing material for the construction industry. Those with limited reserves have plans to expand operations or open new sources elsewhere to assure themselves of adequate supplies of aggregate. In recent years, study area aggregate producers have merged operations, and national and international companies have entered the local market. For instance, RMC, a United Kingdom Company and reportedly the largest concrete supplier in the world, recently acquired the Paiute Aggregate and All Light Aggregate operations. In such a competitive arena, long-term planning is likely to be increasingly important. The future political climate and changes in regulations will be important factors for all producers, determining their ability to expand current operations or start new ones.

3.3.3 Borrow Material

Borrow is defined as “earth material taken from one location to be used for fill at another location.” For the purposes of this study, borrow includes all earth materials that are not included in the aggregate production figures that were discussed previously. They primarily include those materials that are used as common fill for highways, building sites, dams or dikes, etc. For instance, a common use for borrow in the currently developing southern Truckee Meadows (Double Diamond Ranch, South Meadows Industrial Park) is as fill used to bring ground elevation up to or above the 100-year flood level at building sites. Construction then takes place on this fill “pad”. Perhaps the largest use of borrow is in new road construction such as the recent extensions of the U.S. Highway 395 South Freeway. Future extensions of this freeway and other major roads in the south Truckee Meadows over the next few years will take millions of tons of fill material.

In most cases, borrow does not need to be high quality material, hence there are abundant sources of borrow locally available. Usually a specification for fill material has an upper particle size limit (i.e. there can be no rocks larger than 1 ft.), a size distribution limit (there must be a balance between fine and coarse material), and it can not be too plastic (it can not contain too much clay).

In the study area, borrow sources are typically located in easily mineable material such as sand and gravel from nearby alluvial fans, or in similarly easily mineable bedrock units such as the
locally abundant volcanic or igneous intrusive rocks. DG (decomposed granite) pits are common in the area and are often sources of ordinary borrow material. Borrow pits are typically located as close as possible to sites where fill material will be used because even though the cost of such material may be low, the cost of transporting large amounts of it is high, similar to that for other aggregate materials previously mentioned.

Some of the principal and minor high-quality aggregate producers in the study area produce fill material as well. This fill material comes from overburden or reject material during the ordinary course of mining the more valuable higher-quality aggregate products. Locations of sources for the bulk of the fill used in the study area are shown on Plate 1; however, some small local producers may have been missed.

Production rates for ordinary borrow was not determined for this study. In our previous study (Bryan and others 1992) we estimated demand in the Reno area to be approximately 5 to 7 tons per person per year. If these estimates are still correct then current demand for ordinary borrow should be approximately 2 to 3 million tons per year based on the current population of the study area. Twenty years from now, if consumption rates for fill materials remain similar, then demand could be over 4 million tons per year.

4. AGGREGATE POTENTIAL IN THE WASHOE, STOREY, DOUGLAS COUNTY AND CARSON CITY AREAS

4.1 AREAS INCLUDED IN THE STUDY

Limitations on the area encompassed by this study of potential aggregate resources are listed below. These were developed in conjunction with the BLM.

1. Identification of potential aggregate sources was to be confined to the study area as shown on Figure 1 and Plates 1 and 2. No field time or research was to be conducted on potential resources outside this area. However, it should be noted that there are minor sources of aggregate outside the study area that currently furnish material for consumption within the study area.

2. The limits of the study area were determined by the BLM and are shown on the accompanying maps. These limits extend from the northern end of Pyramid Lake to Topaz Lake, approximately 110 miles to the south. The western boundary is the Nevada state line. The eastern boundary runs along the western boundary of the Pyramid Lake Indian Reservation, south along Alternate U.S. Route 95 and then south-southwest to along the western edge of Smith Valley. Areas outside this boundary were not included as it was agreed that aggregate sources outside this boundary would likely not be able to compete economically in the near future in the study area because of haulage distances involved. However, based on the results of this study, it is now known that aggregate sources located east of the study area along Interstate 80 will have some impact.

3. Potential aggregate sources on both private and public land would be included.

4. Certain incompatible use areas are not included in the study area if their presence would preclude aggregate development, such as areas that are urbanized or under larger
bodies of water. Therefore, the resulting map (Plate 2) classifies the entire study area except that portion which is presently developed or is existing lakes.

5. It is recognized that some parts of the study area have conflicting land uses that are incompatible with aggregate mining (such as parks and Wilderness Areas). In addition, other possible incompatible features such as scenic corridors, cultural resources, wetlands, wildlife habitat, environmentally sensitive areas, urban buffer zones, proximity of rural residents, current and/or planned zoning, etc. were not taken into consideration. Identifying and ranking the impact of such possible incompatible uses on aggregate mining is beyond the scope of this study.

4.2 METHODOLOGY USED TO IDENTIFY POTENTIAL RESOURCES

The classification of materials as potential aggregate resources and compilation of a potential map was based on existing information, the investigators’ own experience, and field investigations. Budgeting and time constraints for the project were such that only a minimal amount of field time was allotted for confirmation and/or raw exploration. Detailed field examination of the entire study area was beyond the scope of this study.

4.2.1 Research

The first phase of this portion of the study was to compile technical information that would help to identify potential aggregate resources in the County. This primarily included published geologic maps of the study area, unpublished geologic mapping based on current research at the Nevada Division of Mines & Geology, aerial photography, and selected information from the files of the authors. Of special value was Washoe County’s Aggregate Resource Study (Bryan and others, 1992). Much of the published geologic mapping was available digitally from the NBM&G enabling compilation of a geologic map for the study area. The scale of this published geologic mapping is variable. In some parts of the study area the geology is known in considerable detail (e.g., 1:24,000 scale mapping can be used). In other areas, the only available geologic mapping is 1:250,000 scale geologic maps from NBMG County bulletins.

4.2.2 Field Work

Field work was undertaken during the summer and early fall of 1999. A total of 10 man-days of field work was performed throughout the study area. The field work was undertaken to determine the aggregate potential of different geologic units by direct observation. Additional field time was spent visiting some of the principal aggregate producers to become familiar with the geology and aggregate characteristics of each deposit.

The total area classified for its aggregate potential was approximately 3,200 square miles or approximately 320 square miles for every man-day in the field. Compilation of an aggregate potential map for such an area in the limited amount of field time available necessitated considerable generalization and reliance on existing geologic mapping. It was impossible to visit every square mile or evaluate every mapped geologic unit for its aggregate potential.
In general, field time was utilized for the following:

- To field check existing aggregate sources to determine their geology and if that geology could be used to help determine aggregate potential in the same or similar geologic units throughout the study area.
- To better delineate aggregate potential in those areas where available published geologic mapping is highly generalized.
- To field check geologic units that are unknown as far as their potential for aggregate resources.
- To field check geologic units similar to those whose aggregate potential was known.

The field work allowed us to help determine the general physical properties and extent of some of the rock units. Weathering characteristics and geomorphologic interpretation were used to help visualize the physical characteristics of rock units below the ground surface. Much of our interpretation was based on past experience with surface expression and outcrop patterns of known aggregate sources.

4.2.3 Criteria Used to Determine Aggregate Potential

"Potential" of a rock unit for use as an aggregate, according to our definition, refers to its potential for use as a high-quality construction material such as in Portland cement and asphalt concrete.

Rating geologic units, including both unconsolidated and bedrock units, according to their potential for use as sources of high-quality aggregate is based on determinations of pertinent physical properties. The most important features of high quality aggregate are hardness (resistance to abrasion), soundness (resistance to deterioration, particularly by the effects of weathering), and durability (resistance to deterioration with time). Aggregate quality is usually determined by detailed testing prior to use, and such testing is well beyond the scope of this project. However, quality of a material may generally be estimated on the basis of its overall competence during hand specimen examination of surface samples, in conjunction with subsurface geologic interpretation of the site. Competent rock at the surface does not always mean the deposit as a whole would provide an adequate aggregate source. During the course of this study, once a competent material was identified as either having a high, moderate or low potential for use as an aggregate, then the entire geologic unit, as mapped, was generally assumed to have a similar classification if it was known to be relatively homogeneous. The following characteristics may be used as indicators of quality:

**Lithologic Type** - The type of rock is the initial indicator for its suitability for use as aggregate. For instance, shale, sandstone and other sedimentary rocks in the study area are generally soft or friable and therefore would not likely make high-quality construction aggregates. However, slate and quartzite, metamorphic derivatives of shale and sandstone, may make adequate construction aggregates because they are generally harder and more competent than the pre-existing material. Utilizing geologic maps and knowing the inherent physical characteristics of geologic units can generally assist in evaluating their potential for high-quality construction aggregates. For instance, in the study area all young (Quaternary or early Tertiary) basalts are
considered high potential for use as high-quality construction aggregate as experience tells us these rocks are generally very competent and durable. On the other hand, all Tertiary sedimentary rocks are considered low potential because experience and published descriptions of these rocks indicate they are generally relatively soft and friable.

**Weathering** - Different rock types have variable reactions to long-term surface exposure. Most Mesozoic granitic rocks in the study area are deeply weathered, resulting in weakened strength along grain boundaries. Such material, which is referred to as decomposed granite (DG) in the local construction industry, is generally not suitable for use in Portland cement and asphalt concrete. However, some metamorphic rock types that are as old as, or older than, the granitic rocks and were exposed to the same weathering environment, are not decomposed as are the granites because their mineralogy and texture is different. In addition, some types of granitic rock are highly desirable as aggregate. This quartz diorite mined at the Rocky Ridge quarry about 10 miles north of downtown Sparks is an example; however, this granitic rock is an exception in the study area. Tertiary volcanic rock in the study area is of variable potential; basalt is generally of higher quality than the more siliceous volcanic rocks. Some siliceous rhyolites, however, have been found to make suitable concrete aggregates. In addition to rock type, the extent of weathering is also dependent upon the age of the rock and the length of time that it has been exposed, as well as upon the weathering environment. For example, granitic rocks at higher elevations in the Sierra Nevada are generally more competent than their weathered counterparts at lower elevations in the study area. This is probably due to the fact that the Sierra Nevada has been uplifted several thousands of feet over a geologically short period of time and much of the deeply weathered material has been eroded away, leaving unweathered material more suitable for high-quality aggregate exposed at the surface. In general, the extent of weathering can be determined from long-range or aerial photograph examination. Deeply weathered material underlies relatively smooth, low-angle slopes, whereas more competent rock forms craggy, steep slopes.

**Alteration** - Some rock units underlying large areas in the study area have been altered by hydrothermal processes, rendering them useless for high quality aggregate, mainly because of the transformation of more resistant silicate minerals to clay. Some metamorphic rock units on Peavine Mountain that have high aggregate potential are locally altered to relatively incompetent material. Other areas of intense hydrothermal alteration include rocks in the Virginia City and Wedekind areas. Because of the favorability of such altered areas for metallic mineral deposits, their extent is well known and is shown on some detailed geologic maps in the Reno area.

**Age of Sand and Gravel Units** - The age of sand and gravel deposits can be used as a rule-of-thumb gauge of aggregate potential. Most sand and gravel units in the study area are composed of a mixture of rock types. If some of the gravel clasts are composed of rock that is relatively susceptible to decomposition, this may preclude the entire unit from being economically useful as a source of high quality aggregate. In general, material in older alluvial fans and other alluvial deposits includes more decomposed rock because of longer exposure to weathering processes, and the highest quality gravels are the youngest alluvial deposits associated with the Truckee, Carson and Walker Rivers. For example, sand and gravel in Eldorado Wash southeast of Dayton are suitable for use as high-quality aggregate and are currently being mined (Locality 3, Plate 1) but the adjacent alluvial fan gravels are not suitable as desirable and are considered to have only moderate potential.
Volume of Mineable Material - In general, a major aggregate deposit must contain millions of tons of mineable material (reserves) in order to support long-term return and defray capital start-up costs. However, smaller deposits of unique material, such as clean beach sand may also be economical. Areas containing deposits smaller than a few million tons generally were not considered to have high potential.

4.2.4 Criteria Differentiating Low - Medium - High Potential

The classification used to differentiate between high, moderate, and low aggregate potential (Plate 2) is as follows.

High Potential - Areas where favorability for high quality aggregate deposits (that can be used in Portland cement and asphalt concrete) is high. At least 70 percent of this area is likely to contain high quality aggregate material.

Moderate Potential - Areas where favorability for high quality aggregate deposits (that can be used in Portland cement and asphalt concrete) is fair. Between 30 and 70 percent of this area is likely to contain high quality aggregate material.

Low Potential - Areas where favorability for high quality aggregate deposits (that can be used in Portland cement and asphalt concrete) is low. Less than 30 percent of this area is likely to contain high quality aggregate material.

It should be understood that, because of the limited scope of the field work and the generalizations that are necessary to compile a map at 1:250,000 scale, the boundaries for potential areas are approximate or sometimes speculative. Therefore, there may be portions of high potential areas shown on plate 2 that do not contain high-quality material, and there may be some areas within low potential areas that contain high-quality material.

4.2.5 Map Compilation - GIS System

The Nevada Bureau of Mines and Geology (NBMG) Geographic Information Lab uses workstation based ARC/INFO on a SUN ULTRA II, and NT workstation ARC/INFO running on 2 PC based workstations. The SUN workstation operates under SUN SOLARIS, has 18 gigabytes of dedicated disk space, 9-gigabyte tape drive, and a CDROM reader. The NT workstation operates under Windows NT 4.0, has 512 megabytes RAM, 18 gigabytes of dedicated hard drive. Digitizing is accomplished via two CalComp 9500 series digitizing tablets. Hard copy map plots are produced using a HP DesignJet 2500CP 36-inch plotter.

Available published geologic mapping that had been previously digitized for use by NBMG staff was used as the geologic base for this study. The aggregate potential areas are generally based on the mapping geologic boundaries but in some areas potential boundaries and mapped geologic boundaries differ substantially.

All data layers that were digitized in-house or modified from existing files were checked for accuracy by staff members that were not involved in the original digitizing process, then edited by project investigators. Project maps can be supplied as hard copy plots or as a digital file. Digital output files can be exported in an ARC/INFO format or ARCVIEW shape file.
4.3 SAND AND GRAVEL POTENTIAL

4.3.1 High Potential Areas

The vast majority of high potential sand and gravel resources in the study area are located along, and associated with, the Truckee River, Carson River and West Walker River drainages as shown on Plate 2. They consist of a minor amount of very recent stream gravels such as that mined at sites 4 and 5 (Plate 1) and much more abundant and somewhat older glacial outwash deposits, site 2 (Plate 1). The glacial outwash was deposited during the most recent glacial advances in the Sierras (10,000 to 100,000 years ago) when abundant melt water was pouring out of the mountains and carrying great volumes of sand and gravel. For instance, the Truckee Meadows is mostly underlain by the glacial outwash deposits in which numerous high-quality aggregate deposits were mined in the past. If it weren't for the presence of urbanized areas the high potential area that contains this material would include most of the valley (Plate 2).

Other high potential sand and gravel resources are old beach deposits associated with extinct Pleistocene lakes. Sand and gravel deposition in these lakes coincided with the relatively wet climates of past glacial periods. Wave action along some shorelines washed and concentrated sands along beaches or in sand bars. There are several examples of this type of high potential sand and gravel deposit in the study area including Sha-Neva’s sand pit in Hungry Valley (Site 18, Plate 1), similar sand bars near Cold Springs and on the north end of Washoe Lake.

4.3.2 Moderate Potential Areas

Areas of moderate potential for sand and gravel include some of the older glacial outwash along the Truckee River drainage, young alluvial fans that emanated from moderate to low potential granitic and volcanic bedrock sources, and beach deposits associated with prehistoric Lake Lahontan. The Bella Vista Pit (site 1, Plate 1) produces aggregate from a young alluvial fan deposit on the east side of the Truckee Meadows. Other young alluvial fans, especially along the steep eastern escarpment of the Carson Range and in other steep granitic mountainous terrain in the study area, are classified as moderate aggregate potential because they are composed of weakly weathered granitic debris from high elevations that was naturally washed and abraded during flow down the mountain. The moderate potential sand and gravel designation for the Lake Lahontan beach deposits include areas in Honey Lake Valley at the very northern end of the study area, and near Silver Springs along the middle of the eastern edge of the study area.

4.3.3 Low Potential Areas

Low potential areas for sand and gravel include most of the alluvium in the study area that mainly occurs in the form of older alluvial fans or general valley fill. Low potential alluvial fans, for the most part, contain clasts of rock that are not themselves high quality material or they may be deeply weathered and may contain abundant clays which are detrimental to aggregate production or coat more competent particles.

Playa deposits, old lake deposits, and some Tertiary sediments are also included in low potential sand and gravel. These are primarily fine grained, consisting of fine sands, silts, and clays which are not suitable for use as aggregate. The fine grained lake sediments of old Lake
Lahonton along the lower Truckee and Carson Rivers and between Wadsworth and Pyramid Lake are included in this classification. Exposures of Tertiary sediments, which are scattered throughout the County, are lithologically variable and include diatomite, dirty sandstones, and mudstones, but do not contain appreciable amounts of high quality aggregate.

4.4  BEDROCK POTENTIAL

4.4.1 High Potential Areas

High potential bedrock covers less than five percent of the study area. The rock types are mostly volcanic rocks, consisting primarily of basaltic types, or are metamorphic rocks. There are minor amounts of high quality granitic rocks.

The basaltic rocks are relatively young, dense, fine-grained, dark colored flow rocks that are true basalts or basaltic andesites. In the Reno-Sparks area, large areas that are underlain by such rocks are in the Pah Rah Range just to the northeast of Sparks, near the top of the Carson Range north of Mount Rose, and in the north part of the Virginia Range south of the Truckee River. Frehner construction is now mining high-quality aggregate from such a source (Site 9, Plate 1). In the Carson city area, large areas of basaltic flows occur in the south part of the Virginia Range northeast of the Carson Airport and in the Bismark Peak area in the Pine Nut Range.

Rilite Aggregate’s semi-lightweight rhyolite deposit to the east of Steamboat (Site 12, Plate 1) is shown as high potential because it is used extensively in Portland cement concrete. Similar rhyolites to the east of Sparks also have a high potential designation, including the Washington Hill Rhyolite mined by All Lite Aggregate (Site 6, Plate 1). In the Carson City area, the Naturalite Quarry (Site 7, Plate 1) also exploits rhyolite that is used extensively in concrete and masonry products.

Metamorphic rocks with high aggregate potential are found primarily on Peavine Peak, immediately northwest of Reno, and in the Cold Springs area near the California state line. The high potential rocks here consist of both metavolcanic and metasedimentary units. In the Carson City area, Bertagnolli Aggregates (site 8, Plate 1) produces high-quality aggregate from a small area of good-quality metamorphic rock.

The only granitic rock that has a high potential designation is quartz diorite that is found north of the Reno-Sparks area. The Rocky Ridge quarry in Spanish Springs Valley (Site 13, Plate 1) is in this material. The Hidden Canyon Quarry of Granite Construction to the south (Site 10, Plate 1), which is in similar rock, has been producing aggregate base for about a year, and started producing concrete aggregate as this report was being finalized.

A&K Earthmovers recently expanded their operations on the Bella Vista Ranch (Site 1, Plate 1) and have identified andesitic rock that can be used as a high-quality construction material.

4.4.2 Moderate Potential

Moderate potential bedrock units consist mostly of volcanic and metamorphic rocks. The moderate potential volcanic rocks are generally andesitic, and are found primarily in the
mountains that surround the Truckee Meadows. The Lockwood quarry (site 11, Plate 1) is in porphyritic andesite, a rock type that is not generally considered to have potential for high-quality aggregate but in this case areas of high-quality andesite are present.

Metamorphic rocks with moderate potential are common in the mountain ranges around the Carson Valley. A small area of similar metamorphic rocks was previously mined for aggregate near Steamboat springs, but has not been used extensively for more than ten years.

4.4.3 Low Potential Areas

The low potential bedrock units in southern Washoe County consist of weathered granites, hydrothermally altered bedrock, and volcanic sequences that consist mainly of either tuffs, lahar’s or breccias. These rock types dominate the bedrock units to the north of the Reno-Sparks area and in the Pyramid Lake area. They are also common in the Carson Range west of Carson City. There are vast areas of the study area where weathered granitic rocks could furnish considerable amounts of DG that would make acceptable fill but not high-quality construction aggregate.

5. CONCLUSIONS

The Aggregate Resources Study for the BLM consisted of identifying the present aggregate suppliers to the study area, determining present consumption rates and mapping the study area’s aggregate potential. Conclusions that can be derived from the study are as follows:

SUPPLIERS AND CONSUMPTION RATES

1. There are currently 13 principal aggregate suppliers for the study area. In addition there are numerous smaller suppliers.

2. In 1998, the study area consumed between 7 and 7.5 million tons of high-quality aggregate for a consumption rate of approximately 17 tons per person.

3. Principal aggregate products are Portland cement concrete aggregate, asphalt concrete aggregate and aggregate base.

POTENTIAL FOR AGGREGATE RESOURCES

1. There are sufficient reserves of high quality, undeveloped aggregate resources in the study area to satisfy future demand well into the 21st century.

2. The unpredictable factor affecting the use of these aggregate resources in the future is accessibility. Economic, environmental and political pressures on the aggregate mining industry could preclude much or even possibly all of the identified high quality aggregate from being used in the future.

3. To assure that the communities in the study area have ample supplies of high quality, reasonably priced aggregate for the future, it is prudent to plan ahead, recognizing the need for an economic supply of construction aggregates.
ADDENDUM

ECONOMIC POTENTIAL

TO THE REPORT:

AGGREGATE RESOURCE STUDY
WESTERN PORTION OF THE CARSON CITY BLM DISTRICT
NEVADA

May 5, 2000

Report To:
City of Carson City
3303 Butti Way, Building 7
Carson City, Nevada

And:
Carson City District
U.S. Bureau of Land Management
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## MAP POCKET

| PLATE 3 - ECONOMIC POTENTIAL MAP |
1. PURPOSE

This addendum to the Aggregate Resource Study, Western Portion of the Carson City BLM District, Nevada, was prepared at the request of the Carson City Public Works Department. It is an expansion of the original BLM study and provides an economic analysis of aggregate potential determinations made during that study. Criteria and methods used to determine the economic potential are outlined below. Note that figures for this addendum start at Figure 2 (Figure 1 is the location map in the original report) and that Plates 1 and 2 are also part of the original report. In addition, table numbers are also continued from the original report, starting at Table 5 in this addendum report.

2. ECONOMIC POTENTIAL

2.1 CRITERIA

The criteria or factors used to prepare the economic potential map (Plate 3) include the potential of geologic units as shown on Plate 2 (and shown at a smaller scale on Figure 3) along with economic factors that influence the cost of mining and delivering aggregate to the market place. The five criteria, as described below, were chosen as those having the highest influence on economic potential and each is represented by a GIS-generated map (Figures 2 through 6). The various map units were assigned numerical values, as described below, and the economic potential map was generated using the formula described in Section 2.2. The criteria do not include, nor are they influenced by, incompatible use areas other than urbanized areas and large bodies of water.

1. Aggregate Potential (P)

The aggregate potential map from the original BLM report (Plate 2) was the basis for input on this criterion (see Figure 2). Obviously, areas of high potential bedrock and sand and gravel are considered to be the most important areas in terms of economic potential because those areas are thought to have the highest favorability for aggregate production. For this reason, P is used as a multiplier in the formula for calculation of economic potential. It does not matter, for instance, how close a low potential area is to the market, it will have a relatively low value. In other words, economic factors can not make low quality aggregate into high quality aggregate.

For economic potential, bedrock and sand and gravel potential as shown on Plate 2 are equally ranked. This contrasts with an earlier study for Washoe County (Bryan and others, 1992) that ranked sand and gravel deposits higher than bedrock deposits because of the difference in mining costs. The change to equal rank reflects a recent change in the perception of the economics of aggregate production in the region. The extra cost of mining bedrock deposits is offset by greater control on quality, and new aggregate sources in the region are increasingly sought in bedrock.
Table 5
Rank of aggregate potential categories

<table>
<thead>
<tr>
<th>Classification</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>High potential, bedrock and sand and gravel</td>
<td>3</td>
</tr>
<tr>
<td>Moderate potential, bedrock and sand and gravel</td>
<td>2</td>
</tr>
<tr>
<td>Low potential, bedrock and sand and gravel</td>
<td>1</td>
</tr>
</tbody>
</table>

2. Distance from market Areas (D)

The intersection of highways Interstate 80 and U.S. 395 was chosen as the center of the Reno-Sparks market area. The intersection of U.S. 395 and U.S. 50 was chosen as the center of the Carson City market area. And the town of Minden was chosen as the center of the Minden-Gardnerville market area. From these central points, circles with radii that varied in 10-mile increments were used to define four zones representing transportation costs for aggregate products delivered into the market centers (see Figure 3). The outermost zone extends to the furthest point in the study area from the central point chosen. It should be noted that aggregate consumed in the Reno-Sparks area, for instance, currently comes from sources that are spread through the four zones (see Plate 1). For the purpose of determining economic potential, the distance zones were ranked as follows:

Table 6
Rank of distance from market areas

<table>
<thead>
<tr>
<th>Zone</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10 miles</td>
<td>3</td>
</tr>
<tr>
<td>10 - 20 miles</td>
<td>2</td>
</tr>
<tr>
<td>20 - 30 miles</td>
<td>1</td>
</tr>
<tr>
<td>30 - 40 miles</td>
<td>0</td>
</tr>
</tbody>
</table>

3. Distance from Major Roads (R_i)

Using amended GIS data on road locations provided by local government agencies, buffer zones were constructed around major roads to delineate proximity to available transportation routes (see Figure 4). In addition to the distance from the market, this variable is a major influence upon transportation costs for aggregate delivery.
For the purpose of determining economic potential, the distance of an area from major roads was ranked as follows:

Table 7  
Rank of distance from major roads

<table>
<thead>
<tr>
<th>Distance</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1 mile</td>
<td>4</td>
</tr>
<tr>
<td>1 - 2 miles</td>
<td>3</td>
</tr>
<tr>
<td>2 - 3 miles</td>
<td>2</td>
</tr>
<tr>
<td>3 - 4 miles</td>
<td>1</td>
</tr>
<tr>
<td>4+ miles</td>
<td>0</td>
</tr>
</tbody>
</table>

4.  Distance from Minor Roads (R₂)

Using amended minor road GIS data provided by local government agencies, buffer zones were also constructed around minor roads (see figure 5). This variable is a major influence upon development costs leading to aggregate production. For the purpose of determining economic potential, the distance of an area from minor roads was ranked identically to the ranking for major roads.

5.  Elevation (E)

Higher elevations in mountainous terrain in the study area (see Figure 6) are disadvantageous to aggregate mining. Weather conditions at high elevations may preclude mining during winter months because of excessive moisture, low temperature effects on equipment, access restrictions, and high snow removal costs. In addition, haulage from high elevations is more expensive because of steep grades, abundant curves, and generally greater travel time. For the purpose of determining economic potential, elevation of an area was ranked as follows:

Table 8  
Rank of elevation categories

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 6500 feet</td>
<td>2</td>
</tr>
<tr>
<td>6500+ feet</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure 5
Distance from Minor Roads
2.2 GENERATION OF THE ECONOMIC OVERLAY (PLATE 3)

The economic overlay (Plate 3) was constructed in the NBMG GIS laboratory using criteria (or variables) that are described in Section 2.1 and presented in Figures 2 through 6. Files containing ranked polygons for each criterion were combined (using the calculate command) following the formula \( EP = P(2D + 0.5R_1 + 0.5R_2 + E) \), where EP is the economic potential for aggregate production. The highest possible EP score for any area is 36 and the lowest is 1. The highest half of the calculated economic potential scores were subdivided into three approximately equal categories representing areas with very high, high, and moderate potential which were then color coded and shown on Plate 3. Areas that scored in the lower half of the economic potential range are shown on Plate 3 as areas with low economic potential for aggregate.

The results of the economic analysis, as shown on Plate 3, are strongly influenced by the aggregate potential (P) as shown on Plate 2 and Figure 2. Uncertainties that are inherent in delineating aggregate potential will therefore carry over into economic potential. Consequently, economic deposits of high quality aggregate may occur within areas that are shown as having low economic potential on Plate 3, and all of the material within areas of high economic potential will not necessarily be usable as high quality construction aggregate.

3. DISCUSSION OF THE ECONOMIC POTENTIAL MAP

The Economic Potential Map, Plate 3, is based on the above formula that is conceptual to a certain extent. Determination of the scores for very high, high, and moderate economic potential were done by trial and error using the controlling assumption that currently active producers of high-quality aggregate should lie within areas of very high or high economic potential. Further explanation of some of the results are warranted:

- The large "very high economic potential" (red) area near Minden-Gardnerville in the southern part of the map represents gravels associated with, and deposited by, the Carson River. Topographically this is the Carson River floodplain, a wide valley that contains Quaternary and older alluvium with high aggregate potential. It also contains or is very near the market center placed at Minden, is served by major and minor roads, and is at relatively low elevation. For these reasons application of the formula yields very high potential for sand and gravel resources. Much of this area may have fine-grained flood deposits near surface, but generally is underlain by sands and gravels. Old pits are found throughout the valley and the one current major producer, Bing Materials, is located in Quaternary Terrace gravels near Gardnerville. However, it is unlikely that any significant new aggregate pits will be developed for political (environmental) reasons. Similarly, smaller areas of high potential sand and gravel along the Truckee River in the University Farms area near Sparks and downstream will probably not be mined for political reasons.
Economic Aggregate Potential Map
Flow Chart

**Data**

- Area Aggregate Potential: BHP, SHP = 3
- BMP, SMP = 2
- BLP, SLP = 1

**Intermediate Themes**

- **Area City Centers**
  - Buffer at 10 - 40 miles

- **Area Major Roads 1:100,000**
  - Buffer at 1 - 4 miles

- **Area Minor Roads 1:100,000**
  - Buffer at 1 - 4 miles

- **Area Elevation Digital Elevation Model (DEM)**
  - Select Elevation 6500 ft

**Rank Values**

- Rank values at 3 - 0
- Rank values at 4 - 0

**Buffered Maps**

- Buffered from city center 3 - 0 values (Figure 3)
- Buffered Area Major Roads 4 - 0 values (Figure 4)
- Buffered Area Major Roads 4 - 0 values (Figure 5)
- Elevation map showing > and < 6500 ft 2 - 1 values (Figure 6)

**Merged Theme**

Potential Map, Area City Centers, Major and Minor roads, and Elevation themes

**Calculate EP using above Formula**

**Rank EP Scores**

**Economic Aggregate Potential**

Western Portion of the Carson City BLM District Nevada

**Formulas**

\[ EP = P(2D + 0.5R + 0.5R + E) \]

- EP = Economic potential
- P = Aggregate potential
- D = Distance from City Centers
- R = Distance from Major Roads
- E = Elevation greater than (> or less than(<) 6500 feet
• There are three market centers in the area studied: Reno, Carson City, and Minden-Gardnerville. Each of these three markets was weighted equally in the model, which may not be appropriate. In general, a small market such as Minden-Gardnerville would probably not draw aggregate from as far as a larger market such as Reno-Sparks.

• The high potential rhyolitic rock that is mined by All Lite Aggregate (see Plates 1 and 2) is shown on the economic potential map as mainly of high potential although it is a major source of materials that meet specifications for high-quality aggregates in the Reno market. Because it is a major supplier of high quality aggregate the rhyolite dome should clearly be rated on Plate 3 as a small area with very high potential. However, it is mostly rated as only a high potential area because the model recognizes the deposit as being in excess of 3 miles from a major highway and over 10 miles from a market center. In fact, the deposit is on an excellent secondary paved road (that is not a designated state highway - the criteria for definition as a major road) with access to the Interstate 80 freeway. In other words, the model cannot interpret all of the factors that could influence the location of a potential deposit.

• The Fernley and Silver Springs market areas were not addressed as they were outside the boundary of the study area. Both areas are small, but rapidly growing, markets that could impact the selection of new aggregate mining sites.