FRONT RANGE INFRASTRUCTURE RESOURCES PROJECT
Aggregate Resources Activities

Infrastructure, such as roads, buildings, airports, and dams, is built and maintained by use of large quantities of aggregate—sand, gravel, and stone. As urban areas expand, local sources of these resources become inaccessible. Other competitive land uses have a higher value than aggregate resources. For example, gravel cannot be mined from under a subdivision. The failure to plan for the protection and extraction of infrastructure resources often results in increased consumer cost, environmental damage, and an adversarial relationship between the industry and the community.

Government land-use decisions and environmental mandates can further preclude development of natural resources. If infrastructure resources are to remain economically available, current resource information must be available for use in well-reasoned decisions about future land use.

Natural aggregate is an infrastructure resource in the Front Range that is produced as sand and gravel or crushed stone. About 80 percent of Colorado's aggregate is sand and gravel, which comes from floodplains and terraces along stream and river valleys, or as high dissected terraces and alluvial fans along the mountain front (fig. 1). About 20 percent of Colorado's aggregate is crushed stone, which is produced from rock quarries commonly located in the mountains.

During 1973, the Colorado legislature passed House Bill 1529. That act declared that the State's natural aggregate resources are essential to the State's economy; the populous counties of the State face a critical shortage of such resources; and such resources should be extracted according to a rational plan calculated to avoid waste and cause the least practical disruption to the ecology and to quality of life of the citizens.

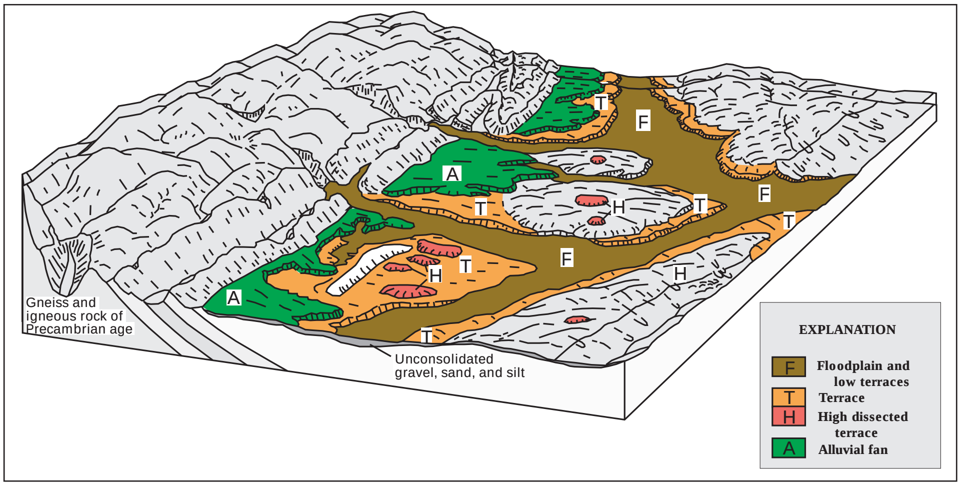


Figure 1. *Block diagram showing general types of sand and gravel resources in the FRIRP area. Modified from E.J. Crosby, Landforms in the Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado (USGS Misc. Inv. Series Map 855-H, 1978).*

Aggregate occurs where nature put it, not necessarily where people need it

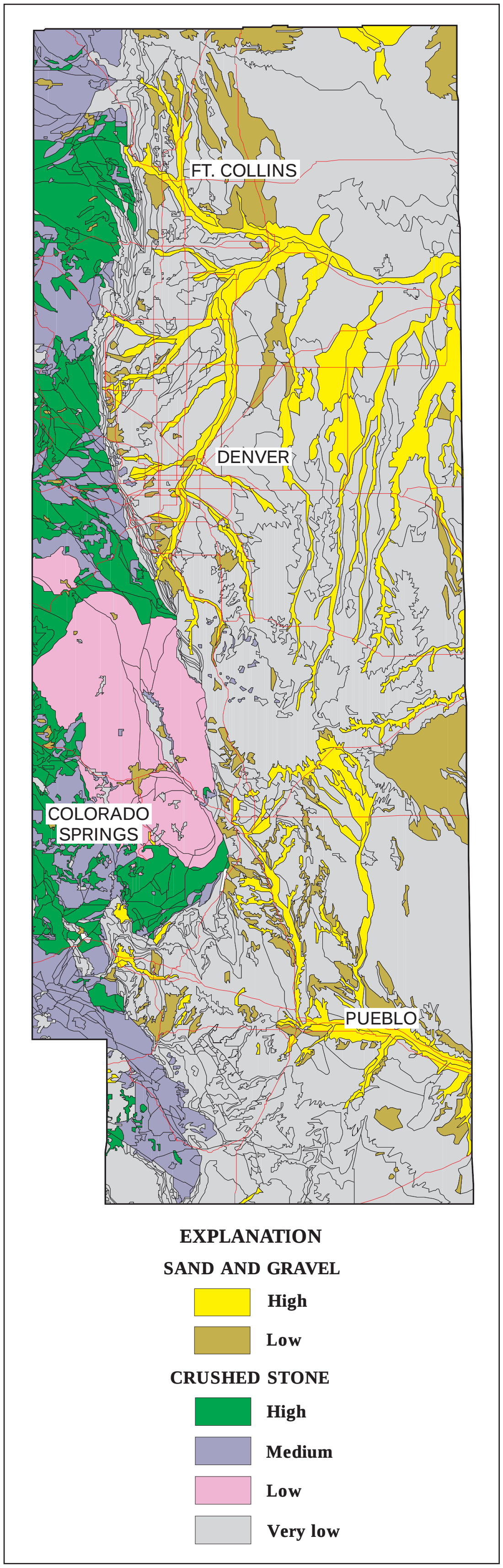


Figure 2. *Map showing probability of finding high-quality aggregate in FRIRP area.*

Geology controls the location and quality of aggregate resources. Local aggregate resources may not have the quality requirements for some uses. For example, to be used in a highway, aggregate must be hard enough to withstand abrasion from tires, strong enough to support the load of vehicles, and sound enough to withstand freezing and thawing or wetting and drying (fig. 2).

Even if adequate supplies of suitable quality aggregate resources are available, they may be difficult to obtain because of urban encroachment or other incompatible land uses.

Aggregate is a high-bulk, low-unit-value commodity. Transportation is a significant part of the put-in-place cost of aggregate, and therefore most aggregate operations are located near populated areas. This can put aggregate producers in direct conflict with communities that have their own priorities for use of the land surface, water supply, air, and roads. In some areas the options for places to develop aggregate resources are extremely limited.

Frequently urban growth occurs with neither consideration of the resource nor an analysis of the impact of its loss. The old idea that aggregate resources can be found anywhere is false. New aggregate operations may have to be located long distances from the markets. The additional expense of the longer transport of resources must be passed on to consumers in the community. In addition, longer transport results in higher fuel consumption, higher emissions, and higher exposure to accidents.

As available resources are consumed or preempted, the cost of maintaining or expanding the infrastructure increases, and the costs are passed on to the public as higher taxes or in reduced services. To provide for a continuous supply of reasonably priced, high-quality aggregate resources, the remaining resources may need to be identified and protected.

Goal of Aggregate Resource Activities

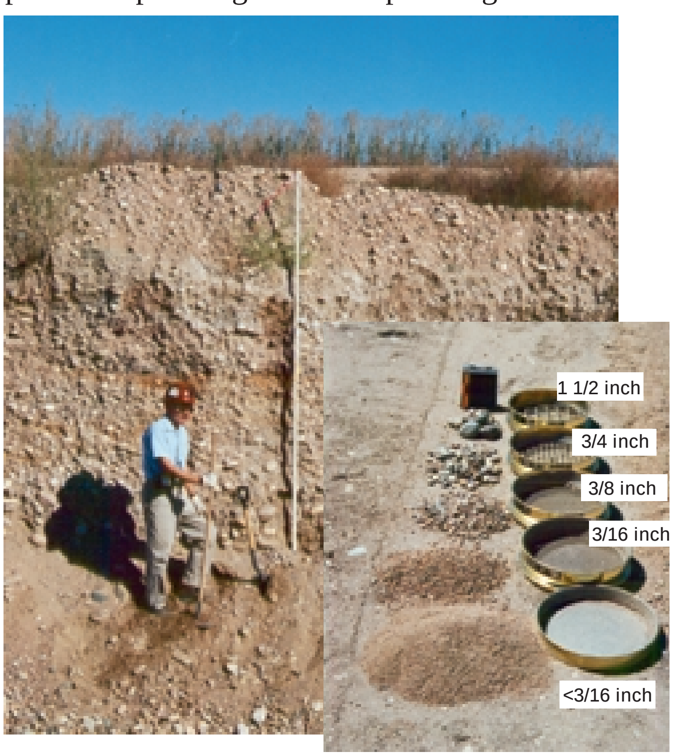
The goal of the aggregate resource activity is to provide industry, decision-makers, and the public with aggregate resource information necessary for making informed decisions on future resource availability. This includes information regarding the location, thickness, and quality of aggregate.

The Front Range Infrastructure Resources Project studies of natural aggregate are focussing on using existing techniques, as well as finding new approaches to identify and characterize aggregate resources

Digital Maps Available

A reconnaissance map (scale 1:500,000) of natural aggregate quality in the Front Range Urban Corridor has been completed (Langer and others, 1997). The Colorado Geological Survey (CGS) undertook mapping of the area's sand and gravel resources during the 1970's. Those maps are summarized in "Colorado Geological Survey Atlas of sand, gravel and quarry aggregate resources, Colorado Front Range Counties." Those aggregate resource maps (1:24,000 scale) have been converted to digital format in a cooperative effort between the USGS and CGS.

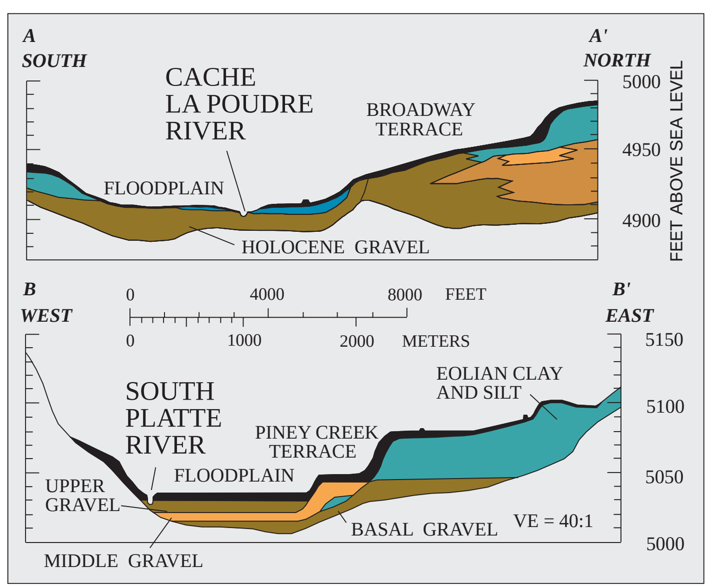
Planners and other decision-makers responsible for resource management should find both digital files just described useful in regional planning and land-use management. Because statutory regulations, technological capabilities, available funding, and land-use priorities vary from place to place and can be expected to change with time, the maps are designed to provide a resource data base that will be useful over the years. Being in digitial format, these maps can be used with other digital data sets, according to the specific needs of a particular planning issue. As planning criteria change, the selection of pertinent resource characteristics can be adjusted to meet the changing needs.



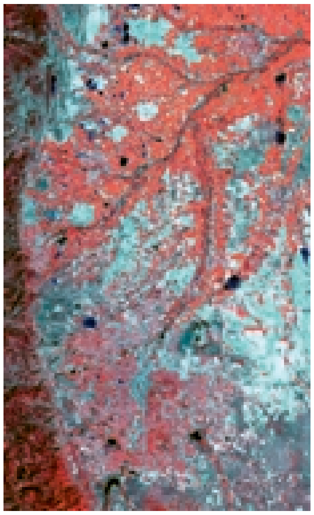
Report Describes Aggregate Quality

Descriptive models of gravel deposits for the Front Range Urban Corridor are being directed toward prediction of quality and quantity of unexplored deposits. Quantity is described in terms of areal extent, thickness, and volume. Quality is described in terms of areal and vertical distribution of physical parameters such as thickness, clast size, sorting, rock type, proportion of fines, and deleterious materials.

Field studies to determine aggregate quality have been conducted along the South Platte River and the Cache la Poudre River. Seventeen cross sections have been constructed along these two rivers (see examples below) showing details of thickness and physical properties of sand and gravel resources. Field studies have been conducted at 26 sites, and samples from two or three geologic horizons at each site have been collected and analyzed. Results of the studies along the South Platte River are available in USGS Open-File Reports 98-148-A, B, and C (Lindsey and others, 1998).



Remote Sensing Studies of Aggregate Resources



Satellite and airborne remote sensing data, in combination with field, laboratory, and theoretical studies, help characterize the geology, mineralogy, geomorphology, vegetation, and land-use patterns associated with current, reclaimed, and potential aggregate operations. Image processing techniques are used to develop effective visualization for a variety of raster data sets.

Geophysical Studies of Aggregate Resources

Shallow geophysical techniques are employed to characterize deposit thickness, stratigraphy, physical characteristics, and location of the water table. We conducted field studies in a sand and gravel pit using a variety of geophysical techniques. The most accurate thickness data were obtained using a technique known as time-domain electromagnetism. Results are described in Ellefsen and others, 1998.

Tool for Characterizing Crushed Stone Resources

We have completed a study to determine if a correlation exists between rock properties estimated by the Los Angeles degradation test and field tests of rocks using the Schmidt rebound hammer. Results show that limestone and andesite have an inverse relationship between the rebound number and the corresponding Los Angeles degradation value. The rebound number does not correlate well with granite, gneiss, quartzite, and sandstone. A description of the test methods and an analysis of the results are available in USGS Open-File Report 98-331 (Davenport and Langer, 1998).

Environmental Studies of Aggregate Resources

Based on an inventory and historical review of reclamation after aggregate extraction in the Front Range Urban Corridor, and using other information dealing with aggregate resources, the principles of landscape architecture are being applied to develop methods of assessing the visual impact of extracting and reclaiming aggregate. The objective is to identify the geologic and aesthetic factors required to evaluate existing and planned reclamation and to develop a methodology that can be used in future management and planning. A description of reclamation-related issues has been prepared (Arbogast and others, 1998).

References Cited

Arbogast, B.F., and others, 1998, The human factor in mining reclamation: USGS Open-File Report 98-523.

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Ellefsen, K.J., and others, 1998, An evaluation of several geophysical methods for characterizing sand and gravel deposits: USGS Open-File Report 98-221.

Langer, W.H., and others, 1997, Distribution and quality of potential sources of aggregate, Infrastructure Project Area, Colorado and Wyoming: USGS Open-File Report 97-477.

Lindsey, D.A., and others, 1998, Gravel deposits of the South Platte River valley north of Denver, Colorado: USGS Open-File Reports 98-148-A, 98-148-B, and 98-148-C.

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