1938 to 1970, received from the U.S. National Personnel Records Center, Office of Personnel Management, St. Louis, MO, January 28, 1991, in particular personnel records dated September 1943 through July 1947, Geiger (1955); and NAP for this period.

3 Freeman traveling scholarships were funded through a program to enable young U.S. engineers to study in Europe, especially at German universities, and experience the advanced engineering of research organizations in Europe. The program was named for John Freeman, a highly influential engineer who donated $25,000 to the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the Boston Society of Civil Engineers to provide the scholarships. The first of the Freeman scholars were chosen in 1927, and three were sent overseas each following year.

4 The Hydrodynamics Laboratory, the Cooperative Hydraulics Laboratory, and the Pump Laboratory at the California Institute of Technology are described by Knapp (1944), Knapp et al. (1948), and Daily (1985).

5 See Vanoni (1946) and Rouse (1964).

6 Information on family life and travels in the 1940s was from in-text citations and these additional sources: Evelyn Einstein (interview by C. Mutel, July 16, 1991); Bernhard Einstein (interview by C. Mutel, June 20, 1990); AEA, letter from AE to Bernhard, 75–898, mid-1940s; letters from AE to HAE, 75–800, April 21, 1945; 75–849, March 8, 1946; and 75–808, June 24, 1947; letter from H. Dukas to HAE and Frieda, 75–842, September 9, 1946; and HAE Papers, letter from HAE to AE, February 4, 1946. *Also see* endnote 6 in Chapter 5 for additional citations regarding Mileva's life and ongoing health problems in the 1940s.

8

Move toward Prominence

Following the Second World War, Hans Albert's professional prospects brightened because expectations for his Soil Conservation Service (SCS) job shifted squarely back toward sediment transport research. During the war, formal programs addressing sediment problems associated with rivers, reservoirs, and soil erosion had shrunk. But now, national attention returned to sediment's effects on river basin development and the conservation of water and land resources, and Hans Albert's expertise was in great demand. In 1947, Hans Albert gained national prominence when he investigated sediment problems of the Rio Grande River and presented his work at a major conference convened by several U.S. federal agencies (USBR 1948).

Conspicuous among the nation's sediment problems were those associated with development of the Rio Grande River along its reach through the Middle Rio Grande Valley, which extended about 160 miles in the vicinity of Albuquerque, New Mexico. The Rio Grande's bed was rising, or aggrading, in response to extensive use of the river's watershed and water. An extensive levee system, the Middle Rio Grande Valley floodway, built in 1936 along the river's floodplain, offered modest but inadequate protection. Water diversion for irrigated farming, along with logging and mining activities, had diminished the river's flow and increased the amount of sediment entering it. Furthermore, the sediment-transport capacity of the river had been diminished in 1915, when a large dam was built at Elephant Butte downstream from Albuquerque. Flood levels were rising along the Middle Rio Grande River. So too was the level of frustration of Middle Rio Grande Valley residents. The public was clamoring for the government to impose law and order on the troubled river. Complaints were so vociferous that the federal government asked the U.S. Army Corps of Engineers (the Corps), the U.S. Bureau of Reclamation (the Bureau), and the Soil Conservation Service to cooperate on efforts to ensure that the river stay in its channel.

The agencies were urged to conduct studies on both minimizing erosion in the Middle Rio Grande River's watershed and reversing channel aggradation, but they were unsure about what actions would effectively restore the river. The Corps began comprehensive studies on flood control along the Middle Rio Grande River. The Bureau, which saw the river primarily as a source of irrigation water, commenced studies to improve irrigation and drainage works by channelizing the river. The SCS, interested in mitigating soil erosion, stepped up its activities to measure the watershed's erosion and sediment conditions. A fourth agency, the U.S. Geological Survey (USGS), took over sediment-monitoring activities previously conducted by the International Boundary and Water Commission, which provided joint management and jurisdiction of rivers and lakes between the United States and neighboring countries. By early 1947, all four agencies were measuring sediment in the Middle Rio Grande River, making it one of the most intensely monitored alluvial channels in the United States[1] (Figure 8-1).

Considerable speculation arose about whether the upward trend of bed aggradation was continuing, to what extent it had taken place, and how best to reverse the trend. Both the Corps and the Bureau quickly developed plans to reverse it. The Corps' plan entailed placing small dams on selected tributaries and on the main stream of the Middle Rio Grande. Their reservoirs theoretically would retain sediment, thereby reducing the Middle Rio Grande's sediment load and causing the river's bed to waste back down to an earlier profile. In addition, the dams would retain floodwaters and thereby reduce peak flood magnitudes. The Bureau's channelization plan entailed using control structures, notably wing dams, to deepen the river and increase its capacity to convey sediment. Much the same approach had been considered by Meyer-Peter in his plan to adjust the Upper Rhine River in Switzerland.

A comparative assessment of the two plans was needed, a task more easily conceived than done. The customary approach of using a small-scale

Figure 8-1. The locations of the Rio Grande and other major rivers in the United States: the Missouri, Mississippi, Arkansas, and Atchafalaya Rivers. Whereas the Rio Grande River typically conveys about 18% and 28% of the flow and total sediment load of the Alpine Rhine, respectively, the Mississippi near its mouth conveys more than 1,200% and more than 5,500% of the flow and total sediment load of the Alpine Rhine, respectively.
Source: IIHR–Hydroscience & Engineering.

laboratory model to simulate the reach would be inadequate for several reasons: The extent of the problem, the length of river reach, and the duration of sediment movement all were too large. Besides, questions always attended the accuracy of small-scale models of sediment transport. An analytical approach was needed, one enabling engineers to relate river-bed elevation to quantities of water flow and sediment load. With such a method, it would be possible to determine the channel and watershed modifications needed to keep the river in its channel.

SCS's Carl Brown thought that Hans Albert's bed-load method offered a promising approach. It had demonstrated reasonable success when applied to small streams like Mountain Creek and West Goose Creek. Moreover, Hans Albert knew more about the theoretical and practical aspects of bed-load movement than did anyone in the United States. Accordingly, Hans Albert was assigned to assist the Bureau and the Corps with their Middle Rio Grande efforts. In late 1946, SCS sent Hans Albert to Albuquerque for an interagency meeting to discuss how best to respond to the river's aggradation problem. The meeting would be pivotal for connecting Hans Albert to key sedimentation engineers.

SCS had extensively surveyed the Middle Rio Grande before its floodway had been constructed and had continued to document flood damage, drainage impairment, and loss of croplands caused by river aggradation until 1942. SCS's Albuquerque office thus could give Hans Albert a large amount of data to use in determining the upstream dams' net effect on the aggraded bed. It took Hans Albert some time to digest the data and plan his approach. His method was not yet up to the task of predicting bed-load rates in a river with such complicated bathymetry. Also, the formulation required further development to handle rivers with beds of sands or mixed gravels and sands. Yet for Hans Albert, these problems were a godsend. They gave him the needed impetus to forge ahead with the development of his bed-load theory, and he now could test it against a full-size river. Thus, throughout early 1947, much of Hans Albert's effort was focused on the sediment troubles of the Middle Rio Grande. Digesting data from the river and figuring out a workable plan took about half of his time. The remaining half was spent reworking his method to bring it into a form better suited for practical application (NAP, letter from HAE to C. Brown, March 26, 1947).

He soon recognized that the flow and sediment-load conditions in the Middle Rio Grande were considerably more complex than those of flume-size creeks like West Goose Creek and Mountain Creek. Besides, being far larger, the Middle Rio Grande was more irregular in geometry, and its flow and sediment were markedly variable. The river's bed lay in a comparatively wide basin of erodible sediments, such that the river could devour its own low banks and shift with ease. The ephemeral nature of the river's tributaries caused inflows of water and sediment to be intense and short lived. Moreover, different populations of sediment sizes moved through the river when it was in high flow. Taken together, these features made sediment transport by the river harder to describe mathematically.

Hans Albert devised a three-part approach that he considered straightforward. It depended on him reconfiguring his bed-load formulation and having the requisite field data for implementing and checking his formulation's accuracy. First he would use his method to calculate rates of sediment transport in test reaches of the river under its existing water and sediment loads. Then he would repeat the calculations using the same test reaches but applying them to water and sediment conditions expected to prevail with the Corps' dams in place. The calculations would indicate the extent to which the river bed in the reaches would degrade or aggrade over time. If the results showed that the beds would degrade down to their original levels, the Corps' dam plan should be effective, and the Bureau's plan to use wing dams could be adjusted as needed.

In March, Hans Albert wrote to Carl Brown, apologizing for the longer than anticipated time he had taken to figure out how to approach the Middle Rio Grande problem (NAP, March 26, 1947). He explained his approach and requested that additional field data be gathered, claiming that if more data were available immediately, he could complete the first two parts of the investigation by May.

The complexity of the Middle Rio Grande's channel complicated his approach. Under most conditions, the river flowed along a meandering braided course, with several subchannels linked like ribbons around many shifting bars and alluvial dunes that protruded above water during lower flows. As flow cycles rose and waned, they resculpted the river; where the river flowed wide at high flow, it entrenched itself in narrower subchannels during low flows in an effort to reduce the drag between water and the river's bed. Sometimes, withered by drought and bled by irrigation, it appeared more like a wide band of sand than a river. The river really became impressive when in flood. Then, it raged as a mighty torrent several thousand feet wide, lifting swollen crests of red, sediment-laden water over sand bars formed on its shifting bed, its banks having about as much confining strength as ropes of sand. Applying Hans Albert's method demanded a major effort to account for these huge variations in flow conditions (Figure 8-2).

To simplify things, he divided the river into long subreaches of more-or-less constant geometry, hoping thereby to define a channel cross section

Figure 8-2. Flooding along the Rio Grande River in New Mexico near the San Marcial–Val Verde road bridge, May 1941. The view is to the southeast with the sediment-laden old Rio Grande channel in the foreground (showing practically no flow). The new main channel flows along the far edge of the flooded area.
Source: Elizabeth Einstein, used with permission.

and slope that averaged out the influences of the actual channel's deviations. Up to a point, he was lucky because among the great pile of data and reports sent to him were useful SCS reports documenting changes in bed levels and sediment of the Middle Rio Grande River from 1936 through 1942 (Happ 1943, 1944).[2] Estimates of the volume and particle-size composition of sediment deposited on the river's bed for that period could be used to check the accuracy of sediment-deposition estimates predicted from his method. He could reconstruct the deposition sequence for the period from a functional relationship between bed load and water flow in the river, such as his method expressed, using the typical annual distributions, or flow-duration curves, for water flow through the river (Figure 8-3).

The river's complexity was mirrored by the bureaucratic difficulties of working with four federal agencies. Hans Albert quickly became frustrated with the struggles about jurisdiction and duplication of work. The similarity of the problem to that faced by Meyer-Peter dealing with the Alpine Rhine prompted Hans Albert early in 1947 to write to Meyer-Peter,

Figure 8-3. A team extracting cores of sediment from the bed of the Rio Grande River upstream of Elephant Butte Reservoir. The cores yield information about the particle size composition of the river's bed sediment, information needed for calculating bed-load transport at the site.
Source: Elizabeth Einstein, used with permission.

whom he respectfully addressed as "Professor," for advice in formulating this approach and to learn more about resolution of the Alpine Rhine problems (HAE Papers, March 14, 1947). Hans Albert characterized the dispute between the Corps and the Bureau on the Middle Rio Grande as a "real tragic comedy." He had been asked to resolve the dispute because, as he explained, engineers with the Corps and the Bureau lacked the education to address the technical issues. According to him, SCS was the only agency with substantial successful research in the area of sediment transport. In the letter, he explained how he was approaching the dispute and mentioned somewhat wistfully that he often wished that he could discuss the troubles with Meyer-Peter and learn more about how Meyer-Peter had addressed the problems with the Upper Rhine River. Though the rivers were different in several ways—for example, the Upper Rhine had much coarser sediment—their responses to changing provenances of flow and sediment should be the same.

Some months later, Hans Albert heard back from Meyer-Peter, who was delighted to hear from his former student and expressed empathy and encouragement regarding the difficulty facing Hans Albert. Meyer-Peter replied that he too had been frustrated by a similar tragic comedy. The work on the Upper Rhine had been interrupted by the changing bureaucracies in Austria after Hitler's invasion and subsequent defeat. Now, "the dance begins all over again and we have to respond to a decision from Vienna that made our hair stand on end," wrote Meyer-Peter (HAE Papers, August 3, 1947). Although Meyer-Peter did not elaborate, this decision related to the partitioning of Austria, like Germany, into different occupation zones administered separately by the Soviet Union, the United States, Britain, and France; the French administered the zone bordering the Alpine Rhine. The bureaucratic headaches incurred with such zoning hugely complicated projects related to rivers associated with Austria.

Frustrations aside, Hans Albert enjoyed working with many of the agency engineers. In addition to his collegial relationship with Carl Brown, he established a friendly relationship with Corps engineer Donald Bondurant, who had done much of the flow and sediment sampling work on the Middle Rio Grande River. The two were to work together on future projects and advisory boards, and at the time of Hans Albert's death they were coauthoring a book on sediment transport in flowing channels. Bondurant would become Hans Albert's closest professional associate. Hans Albert also became acquainted with the Bureau's Whitney Borland, who had considerable experience with sediment problems of reservoirs, irrigation, and hydroelectric works, and with other prominent engineers (Pemberton and Strand 2004). These connections with rising hydraulic engineers in the Corps and the Bureau created important opportunities for Hans Albert to be contracted as a consultant for the two agencies in the years ahead.

In May 1947, a few months before Hans Albert finished his Middle Rio Grande progress report, representatives of federal agencies facing sediment problems in rivers and their watersheds convened at the Bureau's Denver headquarters to hold the First Federal Interagency Sedimentation Conference, the first national meeting focused on sediment problems. All the agencies sent senior representatives. Also in attendance were sedimentation experts from state agencies, universities, and overseas organizations. The conference was fortuitous for Hans Albert. It moved him quickly toward national prominence, giving him center stage as one of the few leading authorities on sediment transport at a time when the full implications of the nation's sediment troubles were coming into clearer focus. His involvement with the Middle Rio Grande project raised his visibility. One senior federal official, when addressing conference attendees, characterized the Rio Grande as "the nation's most severely injured major river, whose valley is America's national monument to the destructive power of man-induced accelerated erosion and of its resulting sedimentation" (Munns 1947).

Carl Brown, who chaired the conference, gave its keynote talk. He estimated that sediment troubles were costing the country about $175 million annually. Conference participants concurred on the absolute necessity of curtailing the excessive erosion occurring in the Rio Grande and similar watersheds. They also agreed that if remedial activities were to be successful, the relationship between water flow and sediment transport needed to be better understood. Inadequate measurement techniques and theories had thus far made the relationship elusive. Concerns regarding the Middle Rio Grande and the plans to address these concerns were introduced in a series of papers presented by the agencies involved.

SCS sedimentation expert Vito Vanoni summarized the theories on relationships between water flow and sediment transport in rivers. He laid out the big questions in this area and lamented the lack of scientific and engineering attention given to sediment-transport problems. He ranked them in national importance alongside the more popular contemporary problems of atomic energy and rocket propulsion. Fewer than 10 professionals in the United States, he estimated, were devoting the major part of their time to the study of sediment transport, mentioning that Hans Albert was prominent among them. Hans Albert then addressed the participants on two issues of keen interest that applied to the Middle Rio Grande River—measuring and predicting the rate at which rivers move sediment along their beds. Reliable measurements were needed for determining how much sediment a river moves under natural flow conditions. Prediction is important when considering changes in sediment movement under altered flow conditions, such as when a river is channelized by wing dams and levees. He likened the Middle Rio Grande to his previous study sites, Mountain Creek and West Goose Creek. The Middle Rio Grande behaved essentially like the two smaller creeks, he stated, and should be subjected to the same laws of sediment transport. His depth of knowledge was clearly evident. His presentation on sediment transport was thorough and was delivered confidently. Moreover, he could draw on his European and U.S. experiences. The participants listened carefully and sensed that his depth of knowledge could greatly help them deal with many of the sediment