THE HOHOKAM

The Hohokam sequence was established on the basis of excavations at the very large and complex site of Snaketown, where Pioneer period remains were found (Gladwin et al. 1938). In 1964 and 1965, Emil Haury (1976:97) returned to Snaketown in part to resolve conflicting interpretations of the chronology. The phase hallmarks of the Hohokam sequence are the ceramic types first described by Haury in 1938 (Gladwin et al. 1938), modified by the deletion of Santan Red ceramics and the Santan phase. Since the previous edition of this book (Cordell 1984), many of the difficult problems of Hohokam chronology have been largely resolved. Because Hohokam residential sites consist of pithouses with ephemeral superstructures, and because desert hardwoods are not amenable to tree-ring dating, there was no developed tree-ring chronology for the low desert region. Dean and others (1996) have recently begun a tree-ring chronology for the Tucson Basin, based on conifers, that extends to pre-Columbian times. Nevertheless, resolution of most of the Hohokam chronological problems has come about principally through large-scale application of archaeomagnetic and radiocarbon dating in the context of huge, multiphase contract projects. In 1980, there were fewer than 120 dates for the Hohokam region. By 1982, there were more than 800 (Crown 1990; Dean 1990; Eighmy and McGuire 1989). While investigators caution that not all chronological problems have been solved (Crown 1990; Dean 1990), current understanding of the Hohokam area over time is now not substantially different than that of the Anasazi and Mogollon traditions. As with these traditions, there is subregional variation within the Hohokam. The Gila-Salt basin near Phoenix, Arizona, constitutes the Hohokam core area where the phase sequence developed at Snaketown is applied. Outside this area, local phase schemes, reflecting
### Table 7.3 Hohokam Phase Sequences

<table>
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<tr>
<th>Date</th>
<th>Tucson Basin</th>
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*a* Adapted from Dean (1994:91).

*b* Adapted from Downum (1993:23).

*c* Adapted from Dean and Greenleaf (1975:12).

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different cultural trajectories, are used in the Tucson, Tonto, Safford, San Pedro, and Upper Santa Cruz basins, and the Papaguería south and west of Gila Bend (Table 7.3). This brief summary focuses on the Hohokam core area, following the discussion by Crown (1991).

The Pioneer period dates from AD 200 to 775. The earliest phase is characterized by plain brown pottery and small, squarish houses, corner-notched projectile points, flexed inhumations, and clay figurines (Crown 1991; Doyel 1990). By about AD 300, red-slipped ceramics are added, and by 500, red designs are painted on a gray, later in the Pioneer on a buff, background. Pioneer period houses were built in shallow, scooped out areas (houses in pits). They had jácal walls with a clay/mud exterior. House clusters consist of two to four houses facing each other across a courtyard. The house clusters appear to have been very stable social and economic units throughout the
Hohokam tradition. They are associated with distinct burial, trash mound, and work areas. Trash mounds were shaped, and later capped with caliche, clearly representing more than a place to dispose of debris. At Snaketown, three oversize structures in a central open area may have served special community functions. Hamlets made up of several courtyard groupings may have been occupied by about 100 individuals. Craft items include abundant clay figurines, carved stone bowls, censers, and palettes. Both inhumation and cremation were practiced. Throughout the Pioneer period, crops were most likely planted on river flood plains. By the end of the Pioneer period, irrigation canals were being constructed.

The Colonial period, AD 775–975, witnessed great expansion of the area occupied by the Hohokam. This is the period that was so well-represented in the Gila Pueblo surveys. Houses in pits continue, and true pithouses were also built. The first Hohokam ballcourts date to this period, with 34 known for the entire period from throughout the Hohokam area (Wilcox 1988). Hohokam ballcourts are oval, with floors sloping toward the center from an earth or rock berm. The courts vary in size, some as much as 80 m in length. While the way they were used is debated (Ferden 1967), it is generally thought that they were derived from the Mesoamerican ballgame. Wilcox (1991) suggests that Hohokam ballcourts reflect basic elements in the Hohokam world view, that they were formally distinctive structures carrying the meaning that those using them shared a particular ideology as well as serving as an institution for social and economic interaction. Not all Hohokam sites of this period have ballcourts, suggesting social or functional differentiation among communities. Construction of irrigation canals increased greatly, and craft items such as shell jewelry, palettes, and figurines reached their most elaborate forms.

During the Sedentary period, AD 975–1150, the Hohokam tradition reached its maximum spatial extent and sites such as Snaketown their greatest size (Crown 1991). Most of the 206 ballcourts at 165 sites were in use around 750 to 1000 (Wilcox 1991). While craft items continued to be produced, they became less elaborate, suggesting to some that they were being produced by specialists (Crown 1983; Haury 1976). A few platform mounds were constructed at the end of the Sedentary, but the form became important in the following Classic period. By the end of the period, the size of the area settled by Hohokam began to shrink.

The Classic period, AD 1150–1400/1450, is generally divided into two phases, the Soho phase (ca. AD 1150 to 1300) and the Civano phase (ca. AD 1300 to 1400/1450). During the Classic, there was the first change in Hohokam domestic architecture and site layout. Houses in pits and post-reinforced caliche walled surface structures were built, as were adobe-walled houses. Adobe-walled rectangular compounds enclosed settlements of contiguous rooms of adobe houses and a plaza. At Casa Grande, Arizona, an adobe multistory great house was constructed. Ballcourts were not built after AD 1300; however, rectangular platform mounds were constructed at more than 40 sites in the core area (Crown 1991; Wilcox 1987). From the mid-1200s, houses were constructed on platform mounds and access to these houses was impeded by walls (Gregory 1991). Petrographic and chemical characterizations of pottery (Abbott 1996) suggest that when household clusters were walled off from one another by compound
walls, the clusters interacted (exchanged less utilitarian pottery) somewhat less with each other than with other communities. Polychrome pottery replaces red-on-buff, and the elaborate palettes and projectile points were no longer made, but there may have been specialized production of utilitarian objects such as textiles, tabular knives, and ground stone axes (Neitzel 1991). Irrigation canals reached their maximum extent, and it was at this time that communities along a single canal would have had to cooperate in order to allocate water and maintain canals. There are at least 17 documented irrigation communities of this sort (Masse 1991; Wilcox 1991). Ceramic analyses (Abbott 1996) indicate that plain ware was exchanged within irrigation communities but red ware—perhaps used for more formal functions—was exchanged outside the irrigation community. Finally, sometime between AD 1350 and 1450, most sites in the Hohokam core area were abandoned, although end dates of the Hohokam tradition are not well established.

A great deal of field research continues to be done in the Hohokam area, much of it stimulated by modern housing and other development of the Arizona deserts. Among those topics being pursued are documenting and explaining variability in subsistence strategies over time in the various kinds of settings used by the Hohokam; understanding and explaining the ways core area Hohokam articulated with peoples throughout the expanded Hohokam territory; examining changes in production technology and exchange; and learning the ultimate fate of the Hohokam archaeological entity after 1450 (Adams 1996; Doyel 1989; McGuire and Villalpando 1989; Wilcox 1991).
cultural communities but these were finally abandoned. In some areas agricultural production was increased substantially through the use of various technological innovations such as water-control features. In these situations quite large communities developed with elaborate mechanisms of social integration. Not all of these were ultimately successful and despite considerable efforts to ensure a successful crop and distribution of food to consumers, relocation, abandonment, and reorganization were all necessary at various times.

THE LOW DESERTS: COLONIAL
AND SEDENTARY HOHOKAM ORGANIZATION

As described in Chapter 6, before the first excavations at Snaketown, there was no information about Hohokam origins because all visible sites seemed to represent a similar widespread and well-developed pattern. That pattern was established and spread between about AD 800 and 1150 during the Colonial and Sedentary periods. On the broadest level, the pattern is characterized by the development of irrigation systems, large villages, elaborate arts and crafts, public architecture such as ballcorts, formal mortuary ritual, and geographic expansion (Doyel 1987). Specifically, with community subsistence tied to irrigation agriculture, residential mobility was greatly reduced. Houses became larger, reflecting a need for additional, differentiated storage space. Irrigation opened new lands for farming on terraces above the river flood plains. Cremation became the most common burial treatment, with elaborate stone palettes, stone censers, and clay figurines as components of mortuary ritual (Doyel 1991). Trade with Mesoamerica is reflected by the presence of iron-pyrite mosaic mirrors. Intrusive ceramics indicate exchange with the Anasazi and Mogollon (Crown 1991). Hohokam sites of the Colonial and Sedentary periods were not stamped out cookie-cutter fashion; there were certainly differences among sites in various subregions, such as the Phoenix and Tucson basins and the New River areas. Also, within each subregion, there were sites reflecting population aggregates (usually termed villages) and scattered dwellings (referred to as rancherías). Nevertheless, the basic components of Hohokam village sites and patterns of integration are broadly similar.

At the lowest level, within village sites, individual house structures are grouped around an open courtyard or plaza that had continuity over time as houses were added or abandoned (Howard 1985; Wilcox et al. 1981). The entryways of individual houses open to the courtyard/plaza. If houses have interior features, these are aligned with the entry (Doelle et al. 1987). Most houses were used for both storage and domestic activities, although in some large courtyard groups, the smallest house may have been used only for storage.

Some courtyard groups had communal cooking ovens (hornos), trash mounds, and burial areas. It is thought that between about 16 and 20 individuals may have occupied each courtyard group. At a more inclusive level, clusters of courtyard groups arranged around outside activity areas sometimes also with hornos, trash mounds, and cemeteries are referred to as village segments. They are distinguished by being spatially
FIGURE 9.2 Hohokam ballcourt. The excavated west half of ballcourt number 1, Snaketown, 1935. View is to the east (photograph by Emil W. Haury, courtesy of the Arizona State Museum).

separated from other such units (Doyel 1991; Howard 1982). At large villages, the village segments are loosely arranged around a great central plaza, with trash mounds and later one or more ballcourts. In the succeeding Classic period, platform mounds are the public architectural features. In the Hohokam area, the term ballcourt is applied to oval, bowl-shaped features flanked by earthen embankments because they are thought to be analogous to ballcourts in Mesoamerica and to have been used in the ritual ball game played throughout Mesoamerica, Central America, and parts of the Caribbean (Scarborough and Wilcox 1991) (Figure 9.2). This interpretation is discussed below. Hohokam ballcourts fall within distinct size classes. With crest to crest dimensions of as much as 20 m in length and 10 m in width to more than 70 m in length and 30 m in width and depths of about 1 m (Wilcox 1991) these were clearly public architectural features requiring a substantial labor force to build. Several hundred people may have occupied a Hohokam village simultaneously. Very large villages, such as Snaketown, may have had as many as 2000 inhabitants, although a number closer to 1000 is probably a better estimate (Doyel 1991; Fish and Fish 1991).

Most Hohokam villages are not as large as Snaketown. Most would have had populations numbering in the hundreds rather than thousands. Fish and Fish (1991) point out that organization that functioned at the supravillage level would have been
required for mating, risk management, labor procurement, craft production, and so forth. Also, wherever comprehensive surveys have been carried out remains of populations living dispersed in between villages have been found. Hohokam communities integrated these dispersed populations into “bounded units centered on pivotal sites” (Fish and Fish 1991:162). Pivotal sites are defined on the basis of the presence of ballcourts and population size for this time period. Later, during the Classic period, platform mounds are defining characteristics.

Plotting the distributions and examining the spacing between public architecture components allows estimating the size of the areas integrated in each supravillage unit. In the Phoenix basin the average linear distance between ballcourt sites is 5.5 km (Wilcox and Sternberg 1983). Interestingly, this linear distance is maintained during the Classic period between platform mound sites, although there is little overlap in the two sets of sites. The regularity in spacing, and continuity in this regularity, along canals and canal segments, “may define an optimal distance over which agricultural travel and day-to-day communications concerning canal function could be carried out within a single community or between adjacent communities” (Fish and Fish 1991: 163). While there are far less data available for site distributions in nonriverine settings, Fish and Fish (1991) have documented settlement clusters around separate ballcourt communities in the Tucson and Picacho basins. The locations of settlements correspond to sources of water for agriculture and domestic use that would have been available year-round.

The hierarchical levels of Hohokam organization just described, courtyard group, village segment, village, and community, have been interpreted in terms of social organization. While the interpretations are reasonable and are discussed here, it is worth recalling that they depend on assumptions that may not be entirely justified. At the most basic level, the courtyard group (Figure 9.3) is most often viewed as the residential locus of single extended families, with separate house structures for each nuclear family. The courtyard group is then seen as being held together by kinship, and probably a single form of post-marital residence (such as matrilocality). The size and long-term continuity of courtyard groups is interpreted as indicating the ability of a prominent household head to maintain cohesion among families. These interpretations, as Fish and Fish (1991) indicate, depend upon a clearly established functional equivalence of houses, suggesting that all were used for domestic activities and storage by a nuclear family, and their simultaneous occupation. Neither of these is easy to demonstrate given less than intact assemblages in house abandonment contexts and imprecision in available dating techniques.

Not all sites have supra-household village segments. Rather, they tend to be associated with the larger sites. They have been interpreted as representing corporate groups or lineages that would have pooled labor and shared or provided access to well-watered or irrigated agricultural land. Among the criteria defining these units, the one that would fit the lineage model is the shared cemetery area. However, this feature is not consistently associated with village segments. In some villages, cemetery areas are further localized within the courtyard group. Nevertheless, viewing village segments as corporate groups is widely accepted (Fish and Fish 1991).
FIGURE 9.3 Before AD 1150 at many Hohokam sites, houses faced central courtyards. The stability of the courtyard group suggests that these were occupied by extended families over time (adapted from Sires and Doyel [1987] by Marjorie Leggitt, Leggitt Design).

At the larger village sites, the arrangement of village segments around an open plaza area with ballcourts at the edges of the plazas indicates that the settlement as a whole operated as a unit at times. It is likely that where ranchería settlements occur outside such villages, their inhabitants may also have participated in ritual activity within the large village. Key issues here are understanding the relationships that might have pertained among the various segments making up the village as a whole and the function(s) of the ballcourts themselves. With respect to relationships among village segments in Colonial and Sedentary sites, there is no evidence of differentiation among those within the same village with respect to either their placement or contents (Fish and Fish 1991). Differences in the abundance of exotic items and quality of craft items have been noted among cemeteries within the same village (Nelson 1981). These observations suggest that there may have been higher-status individuals within each village but they were likely recruited from any or all of the village segments. The village segments themselves do not appear to have been of unequal status or importance.

There is no conclusive evidence that Hohokam ballcourts were either derived from central Mexico or used for the performance of a ritual ball game. In fact, Ferdon
argued that they may have been used as dance grounds for a ceremony similar
to one performed by the Akimel O’ODham. Two rubber balls have been found at
Hohokam sites, but neither was in association with a ballcourt (Haury 1937). Further,
variations of the ritual ball game were played throughout Nuclear America, frequently
without a court. Nevertheless, as Wilcox (1991) points out, a version of the ball game
could have been played in the Hohokam ballcourts. In Wilcox’s view, a very old idea
of a ceremonial ball game could have been part of the most ancient Hohokam
traditions of knowledge, perhaps having been derived from Mesoamerica, along with
corn, during the Archaic. In the Colonial period, the Hohokam “independently in-
vented” the ballcourt/ball game in a context that served a necessary integrative role.
With irrigation that developed at the end of the Pioneer period, the Hohokam found
themselves with population increasing differentially—the greater rate of increase
associated with irrigated lands. Older exchange networks among settlements would
have been disrupted, and “formalization of the ballgame, then may have been a social
mechanism to adjust to the new realities of exchange flows in southern Arizona, follow-
ning the success of irrigation” (Wilcox 1991:123).

Wilcox goes on to point out that ceremonial exchange systems are a way of mobil-
izing a great many people to transport goods (presumably primarily food) to be ex-
changed at a specific place and time. In this view, the ballcourt network “marks the
presence of a ceremonial exchange system that choreographed and regulated regional
exchange flows among a set of contiguous local populations” that shared in the Ho-
hokam cultural identity that included, among other things, cremation, pyrite mirrors,
copper bells, and of course ballcourts (Wilcox 1991:124–125). In this view, some of
the expansion of the Hohokam system is seen as the result of local populations partici-
patig in this Hohokam cultural identity, and likely benefiting from the success of
macroregional exchange mediated through ballcourt ritual. In my view, the thrust of
Wilcox’s argument that shifts discussion away from viewing the Hohokam as an ethnic
group and elaborating the functional aspects of ritual provides valuable insight into the
probable kinds of social constructs archaeologists may be able to define in their data.
Wilcox (1991) sees his model as plausible yet untested. This in turn suggests that
developing the means of testing his model is a worthwhile effort to make.

Masters of the Desert: Hohokam Canal Irrigation

The Hohokam heartland, along the lower Salt and middle Gila rivers of central
Arizona, provides an excellent example of intensive agriculture on a major scale. Early
Spanish explorers, military observers, and Anglo-American settlers were impressed by
the remains of extensive systems of irrigation canals. At one time or another at least
579 km of ancient canals have been mapped in the Phoenix area alone (Nicholas 1981).
Early archaeological tests indicated that some canals had been dug to a depth of more
than 2 m and were 3 m wide (Haury 1937; Hodge 1983; Woodbury 1961).

Most archaeologists have been pessimistic about obtaining details of Hohokam
agricultural practices and subsistence because modern agriculture and more recently
urban growth have obliterated Hohokam living sites and canals. As early as 1903,
FIGURE 9.4 Hohokam canals in the vicinity of Phoenix mapped from the ground by Turney in 1929 and from Skylab imagery in 1980 (adapted from Ebert and Lyons [1980] by Marjorie Leggitt, Leggitt Design).

H. R. Patrick lamented the loss of most Hohokam canals in the vicinity of Phoenix. Although it is true that much information is forever lost, archaeologists have learned a great deal about Hohokam irrigation and subsistence, and the application of new techniques of data recovery may permit the acquisition of additional information in the future.

One of the major goals of Haury's 1964–1965 excavations at Snaketown was to obtain a clearer understanding of the history of Hohokam irrigation agriculture. Toward that end, intensive and extensive excavations of canals at Snaketown were undertaken (Haury 1976:39). Archaeological testing and excavation in conjunction with urban development projects have also greatly augmented our knowledge of Hohokam irrigation strategies, farming, and additional subsistence techniques (e.g., Breternitz 1991; Doolittle 1991; Gasser and Kwiatkowski 1991; Graybill et al. 1984; Masse 1981; Nicholas and Neitzel 1984). Figure 9.4 shows a detailed study of aerial photographs that enabled Nicholas (1981) to map the growth of Hohokam canals in the vicinity of Phoenix, and a study of Skylab and Landsat satellite imagery suggested that some traces of Hohokam canals are still detectable within urban areas (Ebert and Lyons 1980). The research conducted at Snaketown, augmented by the work of Nicholas and Neitzel (1984), Ackerly and others (1987), with Doolittle's (1991) comments, and Gasser and Kwiatkowski's (1991) detailed discussion of botanical remains from Hohokam sites, forms the basis of the discussion below.

In the Hohokam heartland, water is the limiting factor for agricultural success. The growing-season length of about 260 days is adequate for all crops grown in the Southwest and it permitted the Akimel O'Odham to obtain two crops a year of selected
domesticates. Rainfall however is only between about 19 and 25 cm annually. About half of this falls in high-intensity summer thunderstorms, the rest in milder winter rains. Corn is the most common plant species recovered from riverine Hohokam sites. Cultivars of the Hohokam included five different species of beans, squash, bottle gourds, and cotton. Five plants found in Hohokam sites have undergone morphogenic changes that indicate domestication. These are little barley grass (*Hordeum pusillum*), Mexican cruciolo, tobacco, amaranth, and wild potato. An additional crop complex of plants cultivated or tolerated in Hohokam fields include *chenopodium*, tansy mustard, milk vetch, and maygrass (Bohrer 1991). Despite the impressive array of crops, the Hohokam depended greatly on wild plant foods. Mesquite is abundant at Hohokam sites and may have been a staple food. Macrobotanical and pollen remains indicate that saguaro seeds and fruit, carpetweed seeds, various grass seeds, hedgehog cactus seeds and fruit, wild lily roots, desert four o'clock roots, cholla buds, and cattail roots and catkins were also eaten.

Hohokam irrigation engineering is impressive by any standard. Haury (1976) suggested that the Pioneer period canal at Snaketown headed at Gila Butte, some 5 km east of the site. From there water could have been diverted to the upper terrace above the Gila River flood plain and to Snaketown, which is on that terrace. If enough water was available it could then have been used for fields on both the upper and lower terraces and on the flood plain. The remains of a Pioneer period canal were located on the edge of the upper terrace on the southwestern side of the site. This canal, in contrast to later ones at Snaketown, was relatively broad, shallow, and unlined. Later canals at Snaketown were U or V shaped in cross section and lined with mixtures of clay and loam.

The initial excavation of the canals was only the beginning of the labor investment for the Hohokam. Silt and apparently refuse clogged the waterways, necessitating periodic cleaning. As Haury noted, piles of silt removed from the canals may have substantially modified local topography. In addition, canal walls were breached as water sought the quickest path to the river. Haury’s excavations revealed several areas in which breaches had been repaired during the period in which the canals were in use.

As Doolittle (1991) points out, most of the excavated and studied Hohokam canals are the largest canals and canal segments in the system, and those with the greatest archaeological visibility. Along with these canals, the Hohokam irrigation systems included vast networks of smaller canals, lateral ditches, and headgates. At Snaketown, excavations of diversion areas revealed lines of post holes indicating headgate structures made of a series of posts that probably served as upright frames for horizontally laid branches and brush. Diversion dams of this type were recently constructed by the Akimel O’Odham. They do not last more than about a year, and were regularly rebuilt. In addition to headgates, water had to be slowed and kept in the fields. Doolittle notes that this requires the construction of various kinds of water spreading devices and earthen bunds within each field. These too would have had to have been maintained on a regular basis.

Archaeologists confront several interpretative problems in their discussions of Hohokam irrigation and subsistence. First, the data available are clear in showing highly
developed technological skill in the construction and maintenance of irrigation systems, but the data also indicate that a great diversity of wild plants were used for food. If the Hohokam were sophisticated hydrological engineers, then why did they rely heavily on wild foods? Second, did the construction and maintenance of the irrigation systems entail elaborate mechanisms of social control or might the canal systems have developed incrementally over time? These issues, although not entirely resolved, have received considerable attention. Recent research suggests several answers and provides directions for future inquiry. Consideration of the hydrological regimes of the Gila and Salt rivers and examination of the ways in which irrigated fields modify the landscape are important toward clarifying the first question. Research by Nicholas and Neitzel (1984), Ackerly and others (1987), and Doolittle (1991) suggests directions that might be pursued to answer the second.

The Gila and Salt rivers originate in the mountains of east-central Arizona, and both are fed by winter precipitation and summer thunderstorms. Water levels are therefore high twice during the year, in late spring and again in late summer. The biannual floods enabled the Akimel O’Odham to obtain two crops a year in recent times (Bohrer 1970; Castetter and Bell 1942). Variability however is characteristic of the precipitation pattern and in any given year, one or both periods of high water might fail to occur. In a discussion of the Akimel O’Odham ecosystem, Bohrer (1970) showed that there were no conflicts between the schedules of activities involved in agriculture and in wild plant gathering. The Gila River Akimel O’Odham could harvest their first crop in late June, but if that crop failed, they could harvest saguaro seeds in July. A second crop could be planted at the end of July and the beginning of August. If there was a lack of summer rains and the second crop failed, mesquite pods could be gathered in September. In any one year then, subsistence activities could have involved both agriculture and gathering.

Castetter and Bell (1942) note in the twentieth century, the water let out of the Gila was highly unreliable from year to year, and there were crop failures as often as 2 years out of 5. The Akimel O’Odham compensated by gathering wild plant food. Castetter and Bell estimated that perhaps 60 percent of their diet was based on wild plant gathering. The variety of wild plant remains in Hohokam sites could reflect years in which agricultural production failed completely. In addition, Hohokam fields created a well-watered habitat for plants and animals in addition to corn. Some plants, such as chenopodia, amaranth, and agave, were encouraged within garden areas and used as food. In addition, small game, such as jackrabbits, were attracted to Hohokam fields, and “garden hunting” probably supplied important protein to Hohokam settlements (Szuter 1991). Riverine Hohokam in different areas used slightly different mixes of wild and domestic plant foods. Some of these probably reflect local topography. Others may indicate a form of product specialization for trade.

Accounts of modern and historic Akimel O’Odham agriculture are probably best viewed as being suggestive rather than as direct analogs for the Hohokam, at least because indigenous populations were much reduced as a result of European contact. We do not know exactly how many Hohokam settlements were contemporary, how many canals were in use at the same time, or whether ancient population densities were
such that competition for irrigation water or for wild plant resources were additional problems requiring social solutions.

The difficulty in precisely dating the construction of Hohokam canals and determining the sizes of the settlements they served also inhibits interpretations of the degree of social coordination required to construct and maintain them. In most instances quite small segments of canals have been exposed in excavations and these are dated on the basis of the ceramic assemblages recovered from them. If canals have been dug through trash deposits that predate them they will contain ceramics reflecting an age earlier than that of their use. If canals are dated simply on the basis of their proximity to sites, precise age determinations are not possible. Based on his work at Snaketown, Haury (1976) interpreted the development of Hohokam irrigation as a rather gradual process in which irrigation systems were slowly expanded and elaborated. His view was that construction of the Pioneer period canal at Snaketown did not require a large, coordinated labor force and the work could have been accomplished by the informal cooperation of as few as 50 men.

Work by Nicholas (1981) and Nicholas and Neitzel (1984) supports Haury’s interpretation of the modest scale of Pioneer period canals though not of a gradual expansion of the system. Nicholas was concerned with interpreting the extent of Hohokam irrigation systems along the Salt River south of Phoenix, and as noted, she relied on examination of a series of aerial photographs. Recognizing all the problems inherent in dating agricultural features by their proximity to dated sites, she cautiously used the method to infer the relative scale of Hohokam irrigation during the major Hohokam developmental periods. Like Haury, she found that the Pioneer period canals were relatively simple and suggests that their construction did not require highly structured coordination of a vast labor force. Her discussion indicates a persistence of this condition until the Hohokam Classic. At that time however she finds that the canal systems south of Phoenix had numerous branches. And it is important that the three canal systems in her area were interconnected in Classic times. She tentatively suggests that this major expansion in the irrigation systems depended on the prior development of complex sociopolitical institutions.

Nicholas and Neitzel (1984) applied the method of dating canal segments by their proximity to dated sites in the region south of the Salt River in order to develop a sequence of expansion of the canal system. Recognizing difficulties with the method, and attempting to control for them, they suggested that the canals had not been built all at once but had been lengthened and increased in number over time, as more land was brought under irrigation, presumably as a response to population increase. Based on excavations at the site of La Ciudad in Phoenix, Ackerly and others (1987) revealed that known large canal segments actually overlie numerous buried, earlier canals that had been in use for only short periods of time (Figure 9.5). They argued that this demonstrated that canals were modified and reworked so that it becomes necessary to rebuild a canal rather than to continue to modify the old one. Doolittle (1991) points out that these views are not entirely incompatible, but he notes an error in the Nicholas and Neitzel study. Because irrigation canals are hydraulic systems they must involve coordination of stream velocity and gradient to get water into fields. Velocity and
FIGURE 9.5 (a) Hohokam irrigation canal on Salt River near Scottsdale, Arizona. The vehicle emphasizes the size of the burm and the scale of the canal itself (photography by Helga Teiwes, courtesy of the Arizona State Museum). (b) Cross section of a Hohokam irrigation canal, with B. Bruce Masse, at the site of Pueblo Grande, Arizona (photograph by Helga Teiwes, courtesy of the Arizona State Museum).
gradient are influenced by a number of factors, including the shape of the canal, its depth, whether it is straight or sinuous, etc. If velocity and gradient are appropriate for water delivery to a set of fields, they will no longer be adequate if additional fields are to be irrigated. Hence, canals cannot be added onto when the amount of irrigated land is increased. Rather, the entire canal system must be reengineered and rebuilt. It is also true that keeping a canal functioning when the amount of land it serves does not change requires nearly constant maintenance and small modifications. “For the most part, once canal systems are in place and operating, they can be expanded only by rebuilding the entire network at one time” (Doolittle 1991:147).

Further, Doolittle (1991) argues that the amount of labor expended and organization involved in increasing the size of an irrigation system increases at some exponential rate. Whereas small systems can be rebuilt quickly, perhaps between growing seasons and with small amounts of unskilled labor, when populations become large and dense, this is impossible.

Perhaps as early as the Colonial period, the demand for food in the Salt and Gila valleys had not only reached a critical point, but it was so great that, by themselves, farmers probably could not make the necessary modifications to their field systems during the off season.... Not only could farmers not afford to make such reallocations of their time and energy, but the necessary enlargements were of such a magnitude that they could not be carried out using trial-and-error construction techniques. A staff of learned professional civil engineers and a large organized labor force was needed (Doolittle 1991:149).