The Search for Water: Self-Supply Strategies in a Rural Appalachian Neighborhood

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ABSTRACT OF THESIS

The Search For Water: Self-Supply Strategies in A Rural Appalachian Neighborhood

An investigation of a 31.5 square-mile area of Rockcastle County, Kentucky, evaluated water-supply strategies of a rural population where a public water system was lacking. The study area is located along the western edge of the Eastern Kentucky mountains.

The research was conducted using qualitative methodologies including participant observation, interviews, and key informants. Representatives from 51 percent of households in the study area participated in the investigation. Water-supply sources included rain water collection systems, wells, natural springs, purchase of water from vendors, purchase of bottled water and transport of water from local springs.

Water supply practices were complex and many households used multiple sources. Source choice was dictated by individual perceptions of relative accessibility, quality and reliability. Spring water was perceived by most respondents as best and public system water as poorest. Sources considered best were favored for drinking water. Households having on-site sources perceived as inferior or inadequate transported supplementary water from elsewhere. Households with sources perceived as reliable and good quality were resistant to obtaining public water service, whereas households having poor supplies were very willing to connect, even at high cost. Understanding existing patterns of supply and beliefs concerning water can assist in regional water-supply planning.

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Introduction

Scope

This investigation focuses upon the strategies through which individual inhabitants of a dispersed rural Appalachian neighborhood in southeastern Kentucky, lacking a community-based water utility, provide themselves with water. The study examines the strategies used in the context of types of local water resources available to households, and examines perceptions held by the population concerning various sources of water supply. Behavior and perceptions related to the water-supply of residents of the study area were investigated using qualitative methodologies.

Water supply is one of the critical determinants in development and maintenance of human society. Water directly supports human life through consumption and use in food preparation, and in addition, it is basic to nearly all of the functions of civilization, from agriculture to manufacturing.

Access to an adequate and safe supply of water for domestic and industrial use is often taken for granted in much of the developed world. This attitude overlooks both historical and cultural perspectives. Processed and treated water piped into homes and businesses is, first, a relatively recent innovation, and second, is not currently available to a significant portion of the global population. According to estimates by the World Health Organization, 26 percent of the global urban population and 67 percent of the rural population does not have access to a public water system (WHO 1984). Inhabitants of regions where water infrastructure is lacking must secure water from sources on their own place of residence or transport it from somewhere else.

Much of the research concerning self-supplied water users has focused on developing nations, where the self-supplied population may consist of both urban and rural residents. Self-supplied households in developed nations, however, are primarily rural. There are, today, rural regions within the United States that resemble Third World countries in the lack of water-supply infrastructure. While infrastructure improvements such as electricity and improved roads have long been present in rural America, public water system development has lagged. This issue is being increasingly addressed by planners, yet 16 percent of the United States population remains self-supplied (U.S. Census, 1990). Urban or rural, in Kenya or Kentucky, self-supplied households must make independent decisions and choices regarding water supply alternatives.

The absence of a piped public water system forces rural inhabitants to develop household water supplies from local sources, despite any deficiencies in volume or quality. Some domestic supplies may serve single households, whereas others may support a group of dwellings or even a small informal community. Water sources may be free-flowing or impounded surface streams, natural lakes and ponds, rainfall catchment systems, or ground water from wells and springs. Where exploitable sources are not available locally or are not potable, residents may travel long distances to secure water or may purchase water from others. When available, residents choose among alternatives to provide themselves with a source that is considered to be most suitable.

For much of the world, ground water resources are used to supply both public and individual water systems. In the United States, ground water is the single most important source, comprising 56 percent of the drinking water supply for the entire population, whether supplied by public systems or self-supplied. Similarly, ground water is an important water resource in Kentucky; approximately 34 percent (1.1 million) of the inhabitants of Kentucky rely upon ground water sources (Solley et al, 1988). Ground water resources are of particular significance for the Appalachian counties of eastern Kentucky. According to statistics collected for this region by the Kentucky Division of Water and the U.S. Geological Survey (Sholar and Lee, 1988), ground water obtained from wells and springs is used by numerous public water suppliers and industrial users, and is the source for more than 90 percent of rural self-supplied domestic water users.

The characteristics of any given water supply that are of most significance to both individuals and communities are accessibility, quality and reliability. These characteristics are not absolutes, but vary in their application according to preconceived perceptions held by individuals. These perceptions derive in part from the values and traditions of the culture or subculture in which the individual is embedded and are further influenced by personal experience.

Water supply planning, in regions that have not previously had access to public supply systems, has generally been conducted using rather simplistic assumptions concerning household water demand. How residents have traditionally obtained water, how choices are made among differing sources, how water is used and in what quantities, and what determines affordability of public water system connections are questions that are usually mysteries to planners.

This investigation, in using qualitative methodologies, does not purport to derive theory nor to develop predictive models concerning individual water supply based upon the findings in the study area. The specific details of water-supply sources available and strategies used by self-supplied persons are dependent upon a complex interaction of physical, social and psychological factors that vary widely from one local to another. Accordingly, the value of a study such as this may abide more in what it suggests than what it actually discovers: that individual water-supply practices are far more complex than can be accounted for in models and theories. Site-specific investigations of particular areas where expansion of public water systems is intended are far more likely to address the needs of the population than are textbook engineering solutions.

An improved understanding of the perceptions and behavior of self-supplied water users can aid in more effective planning of local water systems. Site-specific studies may help public agencies and water utilities to pinpoint areas where water supplies are marginal and extension of public supplies would be most needed. Investigations of this nature can provide insight into strategies people in remote areas adopt to secure water. Discovery of water- use strategies and an increased understanding of why certain sources are chosen among various alternatives can help assess water resources of greatest potential utility. Furthermore, such studies can provide information useful in land use planning to avoid contamination of existing or potential water supplies. Finally, increased understanding of the individual and group perceptions and motivations pertaining to water acquisition can aid planners in overcoming resistance to public system expansion.

The Study Area

The 31.5 square-mile area comprising the study area for this research is located in northeastern Rockcastle County, Kentucky, and includes a small strip of bordering Jackson County. This region in the Appalachian foothills of Eastern Kentucky, situated along the Cumberland Escarpment, is characterized by extensive karst development in a thick limestone strata capped by sandstone and underlain by shale and shaley limestone. The karstic nature of the landscape is most readily observable in the presence of numerous natural springs and cave openings. The primary land use classification in this rural area is forest, with limited agricultural practice.

During the initial period of investigation, inhabitants of the study area did not have access to a public water supply and were wholly self-supplied. The study area was chosen for two reasons: (1) the researcher is intimately familiar with the area; and (2) a preliminary investigation conducted in 1991 (O'Dell 1992) suggested that water supply was a problem for many residents and a wide variety of strategies were used to obtain water.

The investigation used a wide variety of qualitative methods to ascertain user perceptions and behavior, including interviews, participant observation, key informants, photodocumentation, public records and local newspapers. The group of local residents interviewed for the study consisted of adult representatives of 107 households in the study area, or 51 percent of the total occupied households. Other persons, knowledgeable of water usage practices in the region, were also interviewed. Water line construction began in the study area during the investigation, but no households were connected until after the initial set of interviews had been completed. The field investigation period lasted 20 months, from March 1994 until October 1995.

The completion of community water lines into the study area, a construction project that began shortly after initiation of the research, should provide fertile ground for future researchers to investigate changes in user perceptions and behavior resulting from the transition.

Primary Research Questions

The initial research questions to be investigated were suggested by preliminary work reported in O'Dell (1992) and by the additional review of literature discussed in the following chapter:

1. What are the water-supply sources and strategies used by the population studied?

2. What influence do factors of actual or perceived accessibility, quality, and reliability have upon choice of water supply source used? What other factors are relevant to the decision-making process?

3. Does the relative abundance or scarcity of water in an area affect the water-supply behavior of residents?

4. What factors operate to promote acceptance of or resistance to connection to public water systems?

Additional areas of investigation concerning water supply were indicated by discoveries made during the months of field work. Some of these areas could be integrated into the ongoing research and are discussed at appropriate points in the text. Other lines of inquiry could not be addressed during this study and remain for future researchers to pursue. Several of these suggestions for future investigation are discussed in the concluding chapter.

Definitions of Key Terms

In order to facilitate an understanding of the research presented here, it is necessary to provide a glossary of some of the key terms used throughout the text. Additional terms, not listed here, are defined in the text where first used.

"City" water is a colloquial expression, often used by residents of the study area, to refer to processed water supplied by a public water system. In the text, this term is often used interchangeably with "public water supply" (see below).

Domestic water use, according to the U.S. Geological Survey (USGS) (Sholar and Lee 1988,vii) is that "used for normal household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens." In this investigation, domestic water-use activities are grouped into two classes, "drinking water" and "bulk supply." Drinking water constitutes the smallest quantity used for most households and includes that used in food preparation. Bulk water supports activities requiring relatively large quantities, such as bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens. Non-domestic water uses, such as in manufacturing, power generation, and agriculture, are not relevant to the present study.

Multiple-source household is one that uses two or more sources for domestic water needs. The sources may be used for an additive effect without differentiation, or may be segregated for specific uses. For example, one source may be used exclusively for drinking water and another for bulk purposes.

Off-site water sources are those located separate from the user's property and must be transported by some means to the point of usage.

On-site water sources refers to those water sources, actual or potential, which exist on property controlled, through ownership or lease, by the resident of that same property.

Public water supply is defined by Sholar and Lee (1988,viii) as a system where "water is withdrawn by public and private water suppliers and delivered to users who do not supply their own water. Public water suppliers provide for domestic, commercial, industrial and public water use." "Delivery" here means conveyance through a system of pipes. As used in this investigation, the term is given a narrower scope than that of the USGS definition. The modified definition limits public-supply systems to those that deliver water through pipes directly to the household of the water user.

Public water systems are defined by federal and state regulations to be only those systems exceeding a specified minimum number of connections and users (see discussion under "Regulatory Framework," below).

Self-supplied household is "a household that withdraws water from a surface or ground water source by a user and not obtained from a public supply. (Sholar and Lee, viii). In this study, self-supply includes not only use of water from sources on-site but also that conveyed from off-site (either by a resident of the household or by some other person). Water transported by the user, or by a water vendor, from a public supply located away from the residential premises is also considered to be self-supply.

In the United States, most self-supply systems serve single rather than multiple households. Frequently, however, self-supply may include loosely knit and geographically separate neighborhood groups that are directly supplied through a system of pipes from a common source. These are not, however, considered public systems because fees for usage are not charged by persons controlling the source. A key differentiation between public supply and self-supply, when considering multiple users of the same system, is that the public system implies a formal structure operated or regulated by government, whereas self-supply is an informal arrangement among the users themselves. In the United States, when these informal systems reach a certain size, they fall under regulatory authority and become public systems.

A *sole-source household* is one that uses only a single source of water for all household needs, regardless whether or not there are other potential sources available to the household.

Regulatory Framework

Public water supply systems in the United States are strictly regulated under the provisions of the National Primary Drinking Water Regulations (NPDWR), first authorized under the Safe Drinking Water Act (SDWA) of 1974, and administered by the U.S. Environmental Protection Agency (EPA). Individual self-supplied water systems are not regulated. The SDWA regulations apply, hierarchically, only to systems that serve populations greater than specified limits. Definitions used by federal and state law to define public and non-public systems are not used as a basis for the present investigation, but are discussed to present an assessment of the scope and gradations of public water supply regulation.

The NPDWR define a public water supply as one that has at least 15 service connections and provides water for at least 25 individuals during at least 60 days of the year (NPDWR 1992). A public water system may be either a community system or a non-community system.

Community systems provide water to the same population year-round (NPDWR 1992). Although this class includes large municipal water supplies, both publicly and privately operated, most community water supply systems in the United States are small systems; nearly 90 percent of the 57,000 community systems each serve less than 3,300 people. One-third of all systems serve less than 100 persons (EPA 1995). Twenty percent, or more than 10,000 such systems serve unincorporated clusters of homes, including mobile home parks and homeowner associations. According to the EPA (1995) report:

> Current safety standards and water system practices are often difficult to tailor to these various types of small systems....many of these systems may lack the financial, managerial, and technical capability necessary to ensure safe, affordable, and high quality service (p. 15).

Collectively these small systems serve about ten percent of the U.S. population.

Non-community systems are classed as to whether the population is transient or non-transient. A transient non-community system serves a transitory population in non-residential areas such as campgrounds, motels, and restaurants. Non-transient non-community systems are those that have 25 of the same people for at least 60 days of the year (NPDWR 1992).

At present, nearly 200,000 public water supply systems are subject to regulation under NPDWR (EPA 1995). Individual states have been given primacy to implement and enforce these regulations under the auspices of the EPA. States must enforce the minimum provisions of the NPDWA, but may, at their discretion create more stringent rules. In at least one respect, Kentucky regulations are stricter than federal regulations. Kentucky regulations recognize smaller systems as public supplies, by defining "semi-public water systems" as those that serve as few as 15 persons or have at least three service connections. These systems have less demanding regulatory requirements than public systems, but still must meet certain standards.

In summary, both Federal and Kentucky law exclude the individual, one- or two-household water system from regulation. For governmental authority, there is a defined lower limit, below which a system does not qualify as public. Kentucky addresses much smaller units than does the national SDWA, so that many informal, group water systems in rural areas of the state potentially could be obliged to meet treatment and monitoring regulatory requirements.

Federal law provides a loophole by which these informal water systems escape regulation, in that those which do not sell water are specifically excluded from coverage under law. For example, if a group of rural householders are sharing a supply in common and the owner of the water source is not charging a fee, then it is not considered a public system. In most cases, laws and regulations generally do not apply when the issue concerns only the health of an individual. A citizen is free under law to do much as he/she wishes on their own property, with one major qualifier: when the actions of that individual threaten the health or rights of others then civil authority must interfere. In other words, a person has the right to utilize any water source on his/her own property, even to knowingly drinking contaminated water. Civil authority may strongly urge the citizen to behave in a certain way, but may not exercise that authority provided there is no hazard to others. Should the person supply, knowingly or not, contaminated water to other persons, then it becomes a matter for regulatory authority.

By regulatory definitions, therefore, the water supplies of many Americans are excluded from consideration under the law. Many rural water systems serve single households and are not regulated. There are also rural systems that provide water to a sufficient number of people that ordinarily they would be regulated, but, being informal creations of local residents, have not come to the attention of officials. In effect, they have "fallen through the cracks" in enforcement.

By regulation, Kentucky includes such systems if they otherwise meet the magnitude requirements of population served or service connections. State officials generally do not interfere with such systems unless there is a specific reason to do so. Purportedly, the rationale behind this selective enforcement is threefold: (1) small private systems are very difficult to identify in the general population; (2) there are insufficient agency personnel to cope with the addition of many thousands of tiny water systems to the work-load; and (3) for most households served by such systems, there simply are no feasible alternatives at present (anonymous Kentucky Division of Water official, interview 1995).

Chapter 2

Pertinent Literature

The literature concerning water resources consists in large part of technical publications dealing with regional or local water resources, hydrogeology or water chemistry. To a lesser extent research focuses upon behavioral aspects of water usage, most dealing with urban populations. Subject populations are generally either urban poor in developing countries, where cities often lack adequate water infrastructure, or urban residents in developed nations where water supplies are under increasing stress from population and industrial growth. Studies that focus exclusively upon the behavior of rural self-supplied households are relatively rare in the literature, and are usually concern villagers in developing countries. The water supply behavior of rural dwellers in the United States, with few exceptions, has been largely ignored.

The existing relevant literature reviewed by the investigator is discussed below using an outline that approximates the structural divisions of the present work. The divisions of the review are:

1. The extent of self-supply in the region of the study area
2. Potential water sources available to self-supplied peoples
3. The spring water mystique
4. Factors affecting choice among alternatives
5. Water usage practices
6. Willingness to connect to public water systems

The extent of self-supply in the region of the study area

According to the 1990 U.S. Census of Population and Housing, 84.2 percent of American households were connected to a public system; accordingly, nearly 16 percent of the population was self-supplied. Nearly 20 percent of Kentucky households were self-supplied at the time of the census.

In Rockcastle County, Kentucky, where the study area is primarily located, 22 percent of the population was self-supplied; in adjacent Jackson County, which includes a narrow strip of the study area, 34 percent was self-supplied. Within Rockcastle County, the boundaries of the study area are the same as those of the northern half of U.S. 1990 Census tract 9504. The reported extent of self-supplied households for this census tract was 48 percent. For the study area alone, self-supply at the time of the investigation was undertaken by 100 percent of the population, as no public water supply lines extended into the study area.

These figures reflect, in focusing from the general population to the specific area of interest, an increasing rurality and lack of water-supply infrastructure

Water sources available to self-supplied people

In reporting the sources of water used by American households, the most recent U.S. census (1990) provided only four categories: public system (public or private ownership), drilled well, dug well, and "other." This "other" represents many additional source types and often complex behaviors by persons in households lacking connection to a public water supply system. In order to anticipate some of the forms of water self-supply that might be found in the Rockcastle County study area, it was necessary to turn to literature resources other than the census.

Several significant investigations concerning water self-supply have been conducted in the developing world, where many households, even in urban areas, do not have connections to public supply systems. These investigations are relevant to the current study in providing an assessment of the many possible sources and strategies by which people obtain water for domestic needs. A seminal work in this genre is that by White, Bradley and White (1972), who conducted a study of water use in sections of the East African nations of Kenya, Tanzania, and Uganda. Nearly nine out of ten households in this investigation were self-supplied, relying on wells, natural springs, open ponds, streams, rooftop rainwater collection, public fountains or standpipes for domestic water needs.

Reporting on water-supply behavior in a village in Kenya, Whittington, Mu and Roche (1990) found that villagers in the sample population used kiosks (62%), vendors (25%) and open wells (13%). The kiosks in this study, run by licensed operators, were connected to a piped public water system that served only the local beach hotels; water was sold to area residents who provided their own containers. Vendors also purchased water from the kiosks and resold it to the inhabitants, transporting it by large cart or bicycle in 20-liter jerrycans. Other water supply sources mentioned by the authors, used elsewhere in the region, were yard taps and public fountains. In another study, Whittington, Lauria and Mu (1991) noted that purchase from vendors was the most frequent form of water supply for residents of Onitsha, Nigeria.

These reports from the developing world indicate some of the many possible ways by which self-supplied households may obtain water. In turning to investigations of self-supplied households in Kentucky, it is apparent that water-supply strategies elsewhere in the world have analogues here.

Money (1966) conducted a study of rural water supply in Kentucky, by mailing questionnaires to residents of 20 water districts across the state and to residents of similar adjacent areas not served by public water supplies. He found that wells were the most frequently used supply source, but that springs and rain water collection systems were also used.

Rosenstiel (1970) conducted a study in an unidentified rural northern Kentucky county, examining the characteristics of a sample of 39 purchasers of hauled water from a local water vendor. All respondents in the sample collected rainwater in cisterns and supplemented this source when necessary by water purchase. Alternative sources such as springs or wells were not used by households in the sample, reportedly due to unreliability and to an undesirably high mineral content in well water.

In 1991 and 1992 the Kentucky Geological Survey produced a series of water supply studies for sections of three southeastern Kentucky counties: Whitley, Pike and Harlan. These studies reported both primary water supply source and alternate water sources for the households in the groups studied. Domestic water supplies in these areas were entirely self-supplied, from wells, springs, and mine adits (present or former openings of deep coal mines) (Conrad, Keagy and Kipp 1991; Conrad et al 1991, 1992).

O'Dell (1992) conducted a preliminary study of water supply and use in portions of the Crooked Creek drainage basin of Rockcastle County during summer 1991. The area investigated included a portion of the study area with which the present paper is concerned. Seventy-five water sources, wells and natural springs, were identified, of which 33 were used as household supplies and four were classified as "public access". Public access springs were defined as those situated conveniently near roadways and used by a varied number of local persons in transit, either for temporary refreshment or for drinking water hauled away in containers. The type of water supply used as a domestic source depended primarily upon the household's geologic setting. Springs were frequently used in limestone valleys but generally only wells were available as on-site water sources for the more densely populated sandstone ridges. The study was concerned only with ground water sources and did not consider alternative means of supply.

From these sources in the literature, it was apparent that there are a great many possible ways by which a self-supplied household can obtain water. The outline below summarizes the sources and the forms in which they may be used:

Primary Sources
(may be present on property controlled by user or transported from elsewhere)

1. Free-flowing surface streams
2. Impoundments of surface water (lakes, ponds)
3. Rain water collection
4. Wells, drilled or dug
5. Natural springs/mine adits

Secondary Sources
(may be derived from any of above, and may include water
from a public supply system)

1. Purchase, conveyed through pipes from seller to buyer
2. Purchase, delivered by vendor in containers
3. Purchase, transported by user

a. user provides container
b. seller provides container (bottled water)

Forms of Supply

1. Unmodified natural source (surface stream, pond, lake, spring)
2. User-modified source (rain water collection, well, stream impoundment, spring)
3. Supplier-modified source (public well or fountain, standpipe, yard tap, kiosk, bottled water, piped individual public system connection)

Any or all of the sources and forms of supply listed above might, in theory, be found in the Rockcastle County study area. One of the objectives of the investigation was to discover which of these sources and forms were used, and hence to illuminate the hidden nature of the "other" reported by the U.S. 1990 Census.

Water resources that may be available to a particular region are largely controlled by two factors: (1) the extent of local infrastructure development, and (2) local geology, topography and climate. Local infrastructure development determines whether or not public supply systems are present or not and in what form access to such systems is available. Secondly, physical features of the natural landscape such as the types and thickness of underlying rock strata, surface landforms and fluvial development, and the general climatic conditions of the region strongly influence the types and amount of water resources available and how they may be exploited. For example, the local or regional water table may be at such great depth as to preclude access to ground water resources except through great effort and expense. In a study of folk practices in the karst region of which the study area is a part, White (unpublished) noted that topographic and geologic factors produced a zonal effect in the distribution of springs and wet caves from which local residents obtained water.

The United States Geological Survey (USGS) has, as an agency, conducted or sponsored many water supply investigations through the many decades of its existence. Numerous reports characterize water resources for regions throughout the United States. Such reports are generally written by geologists and are concerned with water availability and quality. These evaluations are often made in the context of the potential vulnerability of water resources. Water resource reports provide a useful overview of potential water supply sources in a region.

Only water resource reports that included the region of the study area in Rockcastle County were examined in this review of the literature. Of particular value were the reports by Leist, et al (1982), Rima and Mull (1980) and Price, Mull and Kilburn (1962). The relevant portions of these works are discussed in some detail in Chapter Four.

Various agencies and organizations in the United States have published manuals, intended for use by rural residents, concerning development and maintenance of water supply sources such as wells, springs, and cisterns. Such publications, often no more than a dozen or so pages, represent conventional wisdom and practical application for providing a water supply to farm or rural home. Many such manuals give considerable detail on installation of water system components including pumps, pipes, filtration and power supply.

Among public agencies providing information to the self-supplied rural water user are the Agricultural Stabilization and Conservation Service (ASCS), the Natural Resources and Soil Conservation Service (NRSCS, formerly the Soil Conservation Service, SCS), USDA Cooperative Extension Service (in conjunction with land-grant universities), and state environmental and health agencies. An example of a non-government organization (NGO) in Kentucky that provides somewhat similar services is Appalachia - Science in the Public Interest (ASPI). This activist organization, headquartered in Rockcastle County, distributes numerous alternative technology publications aimed at the rural resident. Several of these agency and NGO publications are referred to elsewhere in this paper and are listed in the bibliography. Lengthier works dealing with individual water supplies include the *Manual of Individual and Non-Public Water Supply Systems* (EPA 1991) and *Planning for an Individual Water System* (American Association for Vocational Instructional Materials 1982).

The spring water mystique

According to the partial survey of water supplies made by O'Dell (1992), natural limestone springs constitute a widely used water supply source in the study area where they occur. Historical references extolling the virtues of springs and spring water are multitudinous. In antiquity, Aristotle wrote of the necessity of good springs in city planning (*Politics* VII, x. 2-3). In a later era, spas and health resorts were established and thrived at certain mineral springs in Europe and America, catering to a numerous clientele who wished to take advantage of the supposedly healthful and curative effects (Back, Landa, and Meeks 1995; Baird, N.D. 1974; Coleman, J.W. 1947). Back, Landa and Meeks (1995) attribute the development of the science of chemistry largely to efforts by such pioneering researchers as Priestley and Lavoisier to synthesize the characteristics of waters from famous mineral springs.

Springs played an important role in the settlement of North America, for wherever a fine spring watered the land, a settler promptly laid claim to it. This was particularly true in Kentucky (O'Dell 1993a; O'Malley 1989; Wooley 1975). Many of these stations and settlements, founded at springs, grew into modern towns and cities (O'Dell 1993b).

From these antecedents developed a widespread perception of "spring water" as being somehow more pure and healthful than water from other sources, a notion that persists today despite evidence that groundwater is as susceptible to contamination as surface water. According to the Roper survey (1993), 45 percent of Americans believed that underground water was always cleaner than surface water (p. 25,30, and appendix); similarly, 4 of 10 respondents to the Hurd survey (1993) believed that bottled water is "safer and healthier for you" than tap water (p. 118). Although these are not majority opinions, they certainly represent a large number of persons. Robertson and Edberg (1992) observed that many bottled water products are labeled with terms such as "pure springwater," "mountain spring water," and "natural spring water," suggesting that spring waters have connotations of consistent high quality, taste and healthfulness.

Between 1976 and 1986 there was a fourfold increase in the per capita consumption of bottled water (van der Leeden, Troise and Todd 1991, 339). Studlick and Bain (1980) noted that the present boom in bottled spring water sales in the United States began in the 1970s with increased imports from Europe, where such waters had long been popular. Certain American alcoholic beverage companies, such as the makers of Jack Daniels whiskey and Coors beer, today extol the virtues of spring water used in the manufacture of their products.

According to the Hurd consumer attitude survey (1993), nearly half of all American adults surveyed (43%) reported drinking bottled water at least some of the time, although less than one in ten (8%) said they drank only bottled water. One-third of respondents drank bottled water because they were concerned about the health and safety of their tap water, and another third used bottled water as a substitute for soft drinks, coffee and other beverages. Bottled water use was highest in central cities, the Northeast and the West. The Hurd survey found that the use of bottled water was substantially less in rural regions. When comparing urban and rural regions, rural residents were less concerned about health and safety and more likely to cite substitution for other beverages.

These surveys primarily reflected the viewpoints of consumers of public water supplies. Whereas national surveys tend to generalize wells and springs together as "ground water" or "underground water," in rural areas where residents may have used such sources for generations distinct differences might be perceived.

The typical American consumer does not have ready access to spring water except in its commercial, bottled form; in the study area, springs are abundant. Residents of the study area thereby potentially have access to spring water in two forms, issuing from the native rocks and available in local stores in commercial packaging. One of the objects of the investigation was to determine whether perceptions of study area residents concerning the "spring water mystique" reflect those of consumers in the general American population, or whether alternative sources might be preferred for drinking water.

Factors affecting choice among options

One of the primary purposes of the White, Bradley and White (1972) study was to discover the conditions in which choices are made among theoretically possible water sources, "discerning those factors in culture, social organization, and natural conditions which affect the choice individual households make of the amount of water they use and of the sources to which they go" (p. 15). To evaluate the process by which choice of source was made, the authors evaluated several decision-making models and employed one that:

> views the water user as a person who perceives the choices open to her with varying degrees of accuracy and who judges according to her own perception of the quality of the source, the technical means available to her in drawing on the source, the expected returns and costs, and the interaction with other people which such use involves. The emphasis is upon the user's individual perception of the situation, as distinct from its definition by scientists or government officials....Each valuation is seen as representing a personal preference which is conditioned by the customary behavior of the culture and encouraged or discouraged by whatever formal social action is taken by the society (p 227).

The user is more influenced by what he or she perceives as the healthful qualities and accessibility of a source than by cost or convenience. Perceptions were highly individual: "What one user would consider acceptable, another might reject" (p. 238). In addition, the study found that users consistently underestimated the number of alternative water supply sources that were available to them.

Whittington and Mu, and Roche's (1990) analysis of water use in the village of Ukunda, Kenya, indicated that households that purchased water from vendors placed a higher value on their time. For those not purchasing from vendors, collection time per liter was less for open wells than for kiosks and thus wells were preferred sources.

Reliability was noted as a major determinant factor in source choice by Altaf, Jamal, and Whittington (1992) in their study of water use in the Punjab, Pakistan. Individuals in the study were quite willing to pay significantly more for a reliable system, demonstrated by household investment in multiple water systems, hand pumps, piped connections, and electric motors. Similarly, McPhail (1994) concluded that, to residents of Tunis, Tunisia, perceptions of the reliability of the potential water supply source was a significant factor in choosing among alternatives.

O'Dell (1992) inventoried all potential ground water supply sources, springs and wells, in a part of the present Rockcastle County study area. The inventory was conducted in a section where springs were plentiful and residents often had multiple choices of water supply source. He concluded that those springs not used as domestic supplies had specific characteristics that discouraged exploitation. Among the negative features he identified for these unused springs were seasonality of flow (unreliability); water quality problems; difficulty of access due to terrain; or location in areas where there were no residents.

In summary, the major factors related to choice of water supply source described in the literature include:

1) Accessibility
    - Physical accessibility
    - Economic accessibility
    - Convenience/time expenditures
2) Quality
3) Reliability

Other factors, attributed less significance but still relevant, included technological considerations and the potential for social interaction at particular sources.

Accessibility in this context is an indication not only of the ability to obtain water from a particular source, but the ability to obtain water efficiently. Accessibility may be influenced by physical, economic and social incentives or restraints. A potential source may be physically very difficult to reach due to intervening rugged terrain, or may be situated at such a great distance from the intended point of use as to preclude exploitation save at great expense in labor and resources. This applies whether water is to be hauled or piped from the source under consideration.

The concept of water rights is important in regard to accessibility. Ownership of land conveys the right to use water resources originating on or flowing across the property, but does not convey ownership of the water itself. Under riparian doctrine, only persons owning land on natural watercourses possess riparian rights, or the right to divert water to their own use. Riparian rights do not apply to ground water, diffuse surface water, or artificial water bodies. Riparian doctrine is in effect in all states east of the Mississippi River except Mississippi, and to the west in Arkansas, Iowa and Missouri. The "reasonable use" rule is applied; reasonable use is defined as use that does not interfere with the rights of other riparians on the watercourse (Goldfarb 1988,10-11,21-31).

Surface water use in Kentucky is governed by riparian rights, but riparianism does not apply to ground water from springs and wells. Part of the difficulty in establishing water law for ground water users has been that ground water flow characteristics have not been well-known. Different states allocate ground water rights under differing legal conceptualizations. In Kentucky, the theory of reasonable use applies to ground water use. Landowners may withdraw ground water for any purpose to the extent that they exercise their rights reasonably with regard to the similar rights of others (van der Leeden, Troise, and Todd 1991,725). Kentucky law requires that users of more than 10,000 gallons per day (gpd) obtain a water withdrawal permit. Since this quantity is far in excess of domestic usage, rural households need not obtain such a permit.

Thus, in essence, property ownership conveys the right to use ground water thereon. The rights of non-owners may be conveyed by deed to a particular water source, if those involved feel the necessity of formalizing the relationships, or otherwise may be maintained in an informal understanding. Conversely, rights of access to water sources can be denied to others by the property owner.

Cost can be a significant barrier to water supply access. McPhail (1994), in a study of an urban population in Tunis, Tunisia, concluded that the primary barrier preventing many households from obtaining service from the public water system was the relatively high one-time connection fee. Cost may also be a factor in determining choice of self-supply sources. Certain sources may be eliminated from consideration because the household lacks the financial means to exploit them. For example, installation of a drilled well in the United States may cost several thousand dollars, a sum frequently beyond the ability of poor households to pay. The lack of capital may force residents to choose options that are less desirable.

Perception of water quality was identified by several investigators as one of the significant factors affecting choice of water source, when alternatives exist. Altaf, Jamal, and Whittington (1992) noted a distinction between the use of water as an end-product, a commodity required for direct uses such as drinking and cooking, and water-based amenities such as indoor plumbing, showers and flush toilets. Self-supplied users do not always have alternate options. The cost of changing to another water supply source may be beyond the means of the user, or the only alternative sources may not be of good quality. According to Money's (1966) study comparing selected areas in Kentucky supplied by public systems to areas where residents obtain water through self-supply, 35 percent of self-supplied respondents reported water quality problems.

Studies of water use and water quality were conducted by the Kentucky Geological Survey in 1991 and 1992 for three counties in southeastern Kentucky: Whitley, Pike, and Harlan. Domestic water supplies in these areas were entirely self-supplied, from wells, springs, and mine adits. Private water supplies in each area were surveyed and residents were interviewed concerning perceived water quantity, quality and changes in each that may have occurred during the period of residence. Objectionable water taste, odor, or color were reported by 50 to 70 percent of the households (Conrad, Keagy and Kipp 1991; Conrad et al 1991, 1992).

Money (1966) noted that in areas served by water districts, local supply sources such as springs, wells and rainwater collection systems formerly used for household purposes before piped water became available were shifted to secondary, non-household usage such as livestock watering.

The objectives of Money's study of rural water supply in Kentucky included an inventory and analysis of differences in rural water sources, uses, reliability and amounts used in typically selected rural communities in Kentucky. He concluded that individual self-supplied systems varied considerably in the ability to provide an adequate supply of water throughout the year. Wells were the most frequently used supply source. Wells and cisterns were considered to be the most reliable individual supply sources and springs were the least reliable.

Water usage practices

Although, as indicated earlier in this chapter, there are only a certain number of water supply source types, the combinations of ways and means by which these sources are used can be varied and complex. Whittington, Mu and Roche (1990) noted that individuals may obtain drinking and cooking water from different sources than those they use for bathing or laundry. Seasonal variations in water abundance may force change of source. For example, villagers in a small Somalian village obtain water from nearby ponds during the rainy season, but must travel to distant wells in the dry season when the ponds dry up (Roark 1984,52-53). Water scarcity may promote use of two or more sources simultaneously even when the intended end use is the same. Rosenstiel's (1970) study concerned a group of Kentucky households where rain water collection was supplemented by purchasing water from vendors when rainfall was inadequate. Some researchers reported that the subjects of their investigations tended to use only one source (Whittington, Mu and Roche 1990; Money 1966). White, Bradley and White (1972) and Altaf, Jamal, and Whittington (1992) noted instances of both sole-source and multiple source usage.

A single source may be shared in common by users: a river, spring, well or other source may have the status of community property or be favored by a particular group of persons. White (unpublished) recorded his observations of group sharing of the water from springs and spring caves in the region that includes the study area. White, Bradley and White (1972) observed that usually group use of a water resource engendered a sense of group responsibility toward its care and maintenance.

In many cases, self-supplied households do not have an adequate water source at the residence and must either transport water from elsewhere or purchase from vendors. The Whittington, Lauria and Mu (1991) study of water vending in the large city of Onitsha, Nigeria, provides one of the most detailed analyses of this form of water supply. The public water supply in this city was unable to supply the majority of citizens and most of the demand was filled by private enterprise. Most households obtained their water from unionized water vendors, who operated a fleet of at least 275 tanker trucks supplied from wells in the city. These trucks did not have routes or regular customers, but drove around the city looking for customers. Many households possessing water storage facilities subsequently resold water, purchased from these trucks, in smaller amounts to other residents. A large number of residents also purchased water in buckets from local wells.

Rosenstiel (1970) studied water vending in one rural Kentucky county and found that more than half of the population studied, who collected rain water, depended heavily upon hauled water for domestic use, purchasing more than six loads per year from the water vendor.

When water must be transported by the household, it has an economic cost in terms of the labor that is required to collect it even if there is no charge for the water (Whittington, Mu and Roche 1990; Curtis 1986; Whiting 1983; White, Bradley and White 1972). Curtis refers to this as an "opportunity cost," meaning that time spent in hauling water might be better occupied in other activities.

Water hauling takes many forms, and can utilize many different types of containers. As described by Curtis (1986), the basic forms are foot transport, animal transport, wheeled non-motorized (as with a wheelbarrow or handcart) and wheeled motorized (truck or auto). Containers used can range from small vessels to jerrycans to large tanks. Many of the water self-supplied peoples of the developing world engage in foot transport, sometimes spending much of their day trudging back and forth many miles between source and home. In the developed world, water transport by truck or auto is more common, but water is still hand-carried by many families.

White, Bradley and White (1972) found that the size of the container used to transport water was a good indicator of the amount of water used, as the number of trips per day that could be made was limited. For self-supplied households, per-capita and total water use decreased with increasing distance of the source from the household. Most residents in the areas they studied were required to travel to obtain water, as few had a water source on their own premises. Most households could not store water in bulk, so that one or more trips to the source were necessary each day. For both piped and nonpiped (self-supplied) households, per-capita water use was a function of the number of persons in the household, in that a larger household size leads to smaller per capita use.

This relationship between household size and per-capita consumption was reflected by a more recent study concerning use of water from public systems for households in 677 Texas communities from 1974-

1983. The investigators, Murdock, et al (1991) concluded that persons living in small households use nearly as much water as those in large households. They attributed this finding to the greater efficiency of water-using appliances in larger households, and that activities such as lawn sprinkling use the same amount of water regardless of the number of household occupants.

According to Rosenstiel's (1970) study of water vending, for households that collected rain water, storage capacity had little apparent effect upon the amount of water purchased by a household. Total monthly precipitation was found to have only a minor effect on water purchase. Purchases were slightly higher during drier months and slightly less during wet months. In addition, there was a carryover effect, in that precipitation rates for a particular month affected purchase levels for the following month.

Using linear regression, Rosenstiel analyzed various factors to account for variation in amounts of water purchased, using quantity as the dependent variable. Independent variables were classed as related to the status of the household, such as household income or number of water-using appliances, and non-status, such as the price of water. The analysis concluded that there was a correlation between increasing socio-economic status and increasing water purchase. This accords with Batchelor (1975), who found that an increasing level of household technology increases water demand.

Sholar and Lee (1988) calculated mean per-capita self-supplied domestic water usage for Kentucky at 49.62 gallons per day. The format of the Sholar and Lee report allows a comparison to be made between per-capita water usage by self-supplied populations and those served by public systems, and to make a distinction between surface and ground water sources.

According to White, Bradley and White (1972), when water was manually transported, per-capita use seldom exceeded 10.5 gallons per person per day despite proximity or abundance of the source. The average figure was estimated at 3.2 gallons per day. Money's (1966) study of rural water supply in Kentucky determined that in cases where water was carried into the residence, mean daily water use was about 10 gallons per capita.

Connection to public water systems

The U.S. 1990 Census of Population and Housing reported that nearly 20 percent of Kentuckians did not have access to a piped public water supply system. The Kentucky Geological Survey reports by Conrad, Keagy and Kipp (1991) and Conrad et al (1991, 1992) recommended extension of public water systems to alleviate the water supply problems noted for southeastern Kentucky. According to earlier studies by the Mountain Association for Community Economic Development (MACED, a non-government organization headquartered in Berea, Kentucky), such extensions were not feasible under existing political and economic circumstances.

In 1985 MACED produced two reports addressing water supply issues for the residents of 21 counties in southeastern Kentucky, including Rockcastle County. *Gaining Access to Drinkable Water in Rural Kentucky* (MACED 1985a), emphasized the importance of ground-water as the leading source for most residents of the region and the inability of public water systems to supply most rural residents. Many public water supply facilities were found to suffer from poor initial design, aging lines and equipment, and poor financial performance. Despite these problems, the most economical systems in southeastern Kentucky have already been built, serving areas of relatively dense populations in or near county seats or along the main roadways. Ground-water, the authors emphasized, will remain the only feasible source of drinking water in some areas. The authors of *Drinking Water and Health Issues in Southeastern Kentucky* (MACED 1985b) similarly concluded that, for many rural areas, public water systems were not then economically feasible. The authors believed that the most reasonable solution was to protect existing water resources while developing a more useful approach to financing and constructing new systems and upgrading the old ones.

The process of extending water infrastructure into the more remote areas of Kentucky's mountain counties appears likely to remain incomplete for many decades yet to come. The difficulties of financing new public water supply systems or extension of existing lines may not be the only obstacles that must be overcome by water supply planners. Several studies have indicated that self-supplied persons are not uniformly eager nor even willing to obtain connections to public supply lines. Barriers to connection are economic, social, and psychological.

A number of water-supply papers have incorporated investigations of willingness-to-pay (WTP) for connections to public water supplies as a primary or significant concern in the research design. Appraisal of willingness-to-pay can aid in assessing the push/pull factors for public supplies versus self-supplied alternatives. Such studies generally provide information on self-supply behavior and on the perceptions of residents in regard to water supply and quality. Whittington, Lauria and Mu (1991), referred to previously in this context, is one example of several papers arising from a World Bank research project titled "Willingness to pay for water in rural areas" involving field studies in six countries: Brazil, Nigeria, Tanzania, Zimbabwe, India, and Pakistan. Among the conclusions reported in the Whittington, Lauria and Mu investigation was that, in regard to connection to a public water supply, residents were not willing to pay more than the price of water charged by vendors because water provided by vendors was perceived as good quality and readily available.

A World Bank WTP paper of particular interest is that by Altaf, Jamal, and Whittington (1992) concerning the Punjab, Pakistan. This investigation of village households in a developing nation, in its consideration of WTP factors, was particularly concerned with physical characteristics of the alternative sources. The sources were classed in regional zones according to perceptions of water quality and quality as sweet, brackish, or arid (limited availability).

In the sweet water zone, every household had a private well hand pump inside the house to avoid the inconvenience of having to carry water from outside sources. Ground water in this area is of good quality and available at easily accessible depths. Public water supplies were not provided to villages in this zone, as official reasoning was that such regions are already adequately self-supplied. The study indicated that households in this zone were able and willing to pay for a higher level of service. In the brackish water and arid zones, official policy was to provide access to public water supplies. Although satisfactory self-supply could be obtained by some residents in the brackish zone by installation of deeper wells that tap aquifers of higher quality, not all could afford this option. If a household in the brackish zone wished to obtain a higher level of service and could afford to, it could either connect to the public supply or upgrade the self-supply system from a hand pump to an electric pump. In the sweet water zones, the only option was to upgrade to electric, as public supplies were less accessible.

In the arid zones, according to Altaf, Jamal and Whittington, the demand was for water itself and not for water-based amenities, due to the scarcity of water. Connection rates to public systems, when such became available, were nearly 100 percent as opposed to much lower rates in the sweet and brackish water zones. While official policy has been not to provide public supplies to villages of less than 5,000 persons, this policy was not followed in the arid zones.

The authors believe that upgrading of water supplies does not necessarily mean connection to a state-run public water system. Instead,

> Privately built and managed water systems should not only increase community participation but should also prove to be less expensive to build, thus enhancing the prospects of a full cost recovery (p 83).

McPhail (1994) provides an equally valuable study, based on a sample population in Tunis, Tunisia, concerning the reasons why individual households may not connect to public water systems when such are available. McPhail noted that there were several economic barriers, including required cash deposits, existing investment in individual systems and non-ownership of the residence. An important barrier was that most residents of Tunis considered the public water system to be unreliable, not in quality, but in maintaining a consistent supply. McPhail concluded that "the more the water company can guarantee good quality and reliable service, then the less the monthly tariff will be a deterrent" to connecting to a public system.

In summary, the following (unranked) factors appear to influence an individual's choice whether or not to connect to a public supply system, when connection is possible:

1. Availability of water from local sources
2. Perceived reliability of public system service compared to alternatives

3. Perceived water quality of public system compared to alternatives
4. Investment in existing domestic supply system
5. Ownership/rental of residence
6. Initial connection fee
7. Recurrent service fee

Although not explicitly discussed in the papers cited, the present investigator believes that "tradition" should be added to this list. The inertial resistance inherent in a person (or culture) having always done something in a particular manner should not be discounted.

Chapter 3

Methodology

The investigation of water self-supply strategies in the study area was intended to discover practices, patterns, perceptions and beliefs for a particular group of people. The study is intended to be illustrative of the potential complexity of behavior in this regard, and to indicate future areas of research. This investigation of water self-supply was designed to recognize that there may well be "pull" factors encouraging use of certain sources in addition to "push" factors of dissatisfaction with certain other modes of supply. One objective was to evaluate these factors in regard to strategies of self-supply as opposed to the desire to obtain connection to "city" water. Understanding that forms of water supply are many and complex and vary substantially according to localized physical factors of geology, topography, and climate, as well as social and economic factors, qualitative methodologies were chosen to conduct the investigation.

Among the methods chosen for this investigation were the use of participant observation, key informants, interviews, photodocumentation, and public records and local newspaper accounts concerning water issues. The forms in which each of these methodologies were used is discussed below.

Participant Observation

The role of participant observer in the study area was a relatively easy position to assume, as the investigator has been well-acquainted with the region for more than 25 years. An initial preoccupation with exploring the numerous caves in the vicinity, that eventually led to a more academic interest in the local landscape and culture, allowed the development of many friendships among the residents. During 1972, the researcher lived in an ancient frame house in a remote valley of the current study area and was employed in the local workforce. While in residence, all water for domestic needs was hand-carried in buckets from a nearby spring in the hillside.

The ties of friendship were strengthened into bonds of kinship by the investigator's marriage in 1991. His wife, Carol, is a native of the region and related, although often through tenuous connections, to a large percentage of the population in the study area. Her family owns a large tract of ridgetop and forest immediately south of the study area. In consequence, the researcher became accepted as "family" to many of the residents and no longer an outsider.

Carol participated in the study of water-supply as a co-investigator, and was present on all of the initial interviews and during many other subsequent occasions. Many persons interviewed recognized her as either a close or distant relative, or related to someone they knew well. This greatly aided in alleviating any reluctance to be interviewed and often served to transform what might have been a stiffly formal occasion into a friendly visit among relatives. During the course of the investigation, the interviewing team was invited to participate in several social functions, such as family reunions and church services, and was privileged to do so on occasion.

Among other reasons, reflecting the inclinations of the researcher, a qualitative methodology was chosen because the circumstances of the investigation precluded a strictly objective approach. The impersonal term "respondent" is used throughout the text and signifies accepted academic practice. To the investigating team, however, these were people with humanity and dignity and not merely objects to be studied or numbers to be analyzed. Participation in local social functions was not undertaken to study the behavior of the persons present, but rather arose from a wish to spend time with persons genuinely liked and respected. The process of learning more about the culture and practices of the people was a secondary benefit and not a primary motivation.

During the course of the study, the investigating team frequently practiced water-hauling. Empty one-gallon plastic milk jugs were carried at all times in the trunk of the car. At some convenient point during the day, these jugs were filled at one of the roadside springs in the study area and later used to water flowers. On occasion, water from a spring that had been found free of harmful bacteria was also transported home to use as drinking water. By so using the local public-access springs, many persons were there encountered, filling containers of their own, who lived outside the study area or were not among the residents interviewed.

Engaging these persons in casual conversation, a great deal more was learned about water-supply practices in the area and concerning the spatial extent of usage of such springs.

Following the initial interview phase, described below, a number of respondents were subsequently visited on several occasions. In some cases, this arose from new or renewed friendships stimulated by the initial interview. Conversations on such occasions might or might not include water supply issues. In addition to these persons, repeat visits to certain households were made as part of a separate but related investigation; this latter research involved taking water samples for analysis from 25 domestic water-supply sources and the four roadside public-access springs. Where samples were taken from household systems, residents had agreed to allow water testing on a monthly basis for 12 months. Although the results of this study are still being interpreted, the recurrent contact allowed the water-supply situation for these households to be evaluated over the course of an entire year. Seasonal changes could thus be assessed first-hand. The residents at the households from which water samples were taken continued to impart additional information concerning water supply issues.

From persons with whom repeated contact was established, either from personal friendship or as part of the water quality analysis project (some persons were included in both groups), a number of key informants were developed.

Key Informants

As described above, certain persons residing in the study area proved to have either specialized knowledge concerning local water issues, an exceptional interest in the investigation, or both. These persons became key informants, meaning that they were willing to discuss their knowledge and perceptions of local water supply strategies at length and on several occasions. In addition, a key informant - John H. - was developed who resided outside the study area but who had been intimately involved in the local water supply situation for many decades. The general background and roles played by the major key informants are described below.

1. John H. has been drilling water wells in Rockcastle County for more than 70 years. Although elderly and less vigorous than formerly, John still manages to install about a half-dozen wells each year in the vicinity, using an ancient cable-tool rig. In a lengthy interview with the investigator in 1993, prior to the commencement of the study, John described the business of well drilling as he had been practicing it for these many years.

2. Both Elmer and June have been officers of the Rockcastle County Water Association and active in the efforts to obtain extension of water lines into the study area. Both were willing to discuss the difficulties encountered by the Association during this process.

3. Henry, at age 96, is an acknowledged "water witch," or dowser, who has an extensive practical knowledge of ground water flow. Many of the wells drilled in the study area were originally located by Henry who, although now somewhat frail, still occasionally practices his art for his neighbors.

4. John C. once hauled water for his household, but more than a decade ago excavated a seep in the valley below his house and developed a spring from this with considerable ingenuity. John provided a great deal of practical information on how this was accomplished, from the way in which certain plant species marked the appropriate location to the exact details of construction.

5. Aaron, accompanied by his wife Helen, regularly hauls water for the nearby households of his two sons as well as his own. A great deal was learned from Aaron concerning this arduous chore. In addition to these persons, there were a great many others who contributed substantially to the investigator's knowledge concerning water self-supply in the study area.

The Initial Interviews

The initial phase of field investigation consisted of structured interviews with an adult representative of participating households in the study area, using a survey form designed for the purpose (see Appendix A). The survey was intended to provide basic statistical information concerning individual water-use behavior and perceptions concerning different sources. No attempt was made to base the survey upon a representative sample of the population; instead, respondents consisted of all persons contacted who were willing to participate in the study. Adult representatives of 51 percent (107 of 208) of the occupied households in the study area cooperated in the investigation. Interviewing took place from March-October 1994.

The interview effort was concentrated upon the paved perimeter roads that border the study area, where most of the population resides, and along two major internal roads, one recently hard-surfaced for the first time (1992) and one with macadam surface. No interviews were attempted along less-populated minor roads. Interviewing was conducted on successive Saturdays, this being considered the optimal time to make contact with an adult resident. Every house along the selected routes was visited in an attempt to make contact. In cases when the residents were not at home on a particular Saturday, a second attempt at contact was made later the same day or on the following Saturday. Out of 109 households where contact was made with an adult resident, 107 consented to be interviewed.

Although interviews were conducted only on the selected roads, all of the roads in the study area were traversed in order to conduct a census of occupied housing. A dwelling was considered to be occupied if signs of residency, such as operable vehicles in the yard or curtains in the windows, were observed. From this drive-by census it was determined that 208 households were present in the study area. Consequently, the 107 interviews completed represent 51.4 percent of the housing population of the study area.

The questionnaire used in the interviews (Appendix A) was in part derived from a prior investigation in the same region (O'Dell 1992). For this 1991 study, the investigator inventoried ground water sources along the Dry Fork and Crooked Creek roads, including wells and springs used as domestic supply sources and also those not then in use. Standard inventory forms provided by the state Division of Water were used for this initial investigation. These forms were designed to collect only basic information, such as the name and address of the property owner, the number of persons in the household, description of the water source, and if quantity or quality problems were present. Although these standard forms were suitable for the 1991 project, which focused primarily upon physical manifestations of water-supply, they were not appropriate for an investigation of the relationship of values and perceptions to water-supply strategies.

The time spent in the field during 1991 later proved invaluable to the process of designing a study to investigate water-use perceptions and behavior. During the earlier study, residents contacted were very interested in water-supply issues and willing to discuss their views at length. Although many of these informal discussions were not directly relevant to the purposes of the 1991 study, they served to plant seeds of curiosity that grew into future inquiry. The research questions addressed by the present study were in large part prompted by the earlier investigation.

Four major types of data were collected through the initial interviews. General data classifications are:

1) Basic demographic information such as total number of persons in the household; number of children less than 18 years old; occupation of residents; whether indoor plumbing was present; and number and type of water-using appliances;

2) Water use, including description and location of all water sources used on or off the premises; amount, frequency and seasonality of such usage; travel related to obtaining water; and whether water was purchased from retail stores (bottled) or in bulk from vendors and amounts and frequency of such purchases;

3) Perceptions concerning water quality and reliability from various sources and willingness to obtain access to a community water supply;

4) Information pertaining to respondent's other activities, specifically those concerning travel behavior related to work, shopping, church attendance, health care, social connections, and recreation.

The researcher was accompanied by his wife on all interviewing occasions. Her presence, aside from her own interest in the research project, was intended to facilitate cooperation by local residents in the study. More significantly, it was believed that a husband-wife survey team would alleviate suspicion and overcome the possible reluctance of a single female head-of-household to admit a unknown man into her home.

Upon contacting a resident for the first time, the interviewers introduced themselves and requested permission to conduct an interview. The content and purpose of the interview was described. Interviews ranged from as little as 15 minutes to more than an hour in length, depending upon the interest of the respondent. On most occasions 6-8 interviews were conducted on each day.

A few persons expressed reservations about questions that concerned behavior not directly related to water supply, and were not pressed for this information. Conversely, many persons voluntarily spoke at length concerning aspects of water supply that were not directly addressed by the questionnaire. Respondents were encouraged to comment in detail beyond the framework of the survey instrument.

Whenever possible, the on-site water source and its modifications were examined. Many respondents, particularly those using springs, were pleased to exhibit their water supply systems. Often, they accompanied us out to the back yard, or up the "hollow," relating how the spring had been developed, or the well drilled. Much was learned, in this more informal setting, that might not have otherwise surfaced during the interview process.

The researcher was equipped in the field with a complete selection of U.S. Geological Survey 7.5-minute topographic maps of the region and with Kentucky Department of Transportation county-based highway maps. Each household, whether or not interviewed, was assigned an identification number and the location marked on the appropriate topographic map quadrangle. Where domestic water sources were not adjacent to the household, the locations of these sources were determined and also marked on the maps.

Structure of the Survey Instrument

The questions in the survey instrument included: (1) multiple choice, i.e., selecting the most applicable option from a list; (2) yes/no; (3) short answer; (4) ranking of some parameter on a scale; (5) making an ordered list; (6) making a non-ordered list; and (7) contingent valuation. Of these, the contingent valuation was the most complex, most time-consuming and required the most thought on the part of the respondent.

An example of one of the multiple choice questions is one that asked, "What do you consider to be the best drinking water, if you had your choice? (a) bottled water (b) well water (c) city water (d) spring water (e) other (specify)." In some cases, "don't know" or "not applicable" was offered as an option. If a respondent offered more than one answer, if for the example given considered both well water and spring water to be best and equal to one another, then both options were recorded.

Only a few "yes/no" and "why/why not" questions were included in the survey. These took three forms. The simplest form simply recorded either a positive or negative response, as for "Do you have hot water?" Another form requested a "why or why not" explanation for the response, as in the question, "Do any other persons, other than residents of the household, use water from your household water supply source?" The remaining format used was dependent upon a "yes" answer, subsequently requesting a time frame. An example of such questions were those regarding aspects of existing water quality, as in, "Does your water supply source ever run muddy or sandy?" If the response was "no," then the interviewer recorded this and moved to the next question. If the answer was "yes," the interviewer asked if this took place sometimes or always, in dry weather or wet weather.

Questions that required a short answer, other than a simple yes/no, usually required the participant to recall a numeric quantity. Examples of this question format are: "How many adults 18 or older reside in the household?", "How many gallons are in a load of purchased water?" and "How much do you pay for a load of purchased water?"

For ranking, or evaluation, questions, respondents were asked to give an overall rating (from 1-5 with 1 being unacceptable and 5 indicating outstanding). An example of ranking would be in regard to their perception of the quality of water used in their home. The reasons for the ranking were then elicited. Evaluation of quality was a highly subjective process for respondents. The majority of contaminants, particularly inorganic substances and living pathogens, are not detectable by unaided human senses. In consequence, only aesthetic factors such as color, taste and odor can be monitored by the individual. In the evaluation process for quantity, respondents considered temporal factors such as seasonality of flow and susceptibility to drought as well as actual volume of flow.

Similarly, respondents were asked to rank the reliability of their water supply source on a scale from 1 to 4, with a "4" indicating the greatest reliability. This question was framed in a different manner than the one for quality, in that respondents were only asked this question if they first indicated that they did not always have enough water throughout the year and, second, they affirmed that the source was seasonally variable. If so, they were asked to rank the source according to season, with "1" indicating not enough for household needs and "4" indicating more than needed.

Another question for which ranking was required was that in which respondents were asked to indicate during which months of the year they either purchased or hauled the greatest volume of water.

For certain questions, multiple ranked responses were anticipated, for which all possible choices could not be predefined by the survey instrument. The respondent was asked to list his/her responses in order of importance from most to least. Questions framed in this manner were concerned with (a) all water sources used, and (b) all the uses which each water source served, such as drinking, cooking, bathing, laundry, all domestic uses, etc. The potential list was left open-ended so as to accommodate any unusual water use practices of the household.

Non-ordered lists were used primarily to record various non-water-related activities. Lists of this sort were responses to questions such as "What towns do you do most of your shopping in?" and "What occupations are held by each household member?"

There was only one contingent valuation question on the survey, concerning willingness to pay for public water supply service. The procedure followed was based upon that described in McPhail (1994) and Whittington, Lauria and Mu (1991). A bidding "game" was played in which the object was to find the level at which the respondent would no longer be willing to pay for service from a public supply.

A number of respondents expressed at the outset their opinion that they would not care to have "city" water at any cost and were consequently excluded from this valuation. Two specifics were built into the "game." First, it was explained to the respondent that the cost of service referred specifically to the minimum base rate for water and did not reflect additional charges for quantities used above the minimum monthly quantity. This was established in order to standardize the cost framework, given that actual total costs may vary according to usage by individual households. The second embedded constraint resulted from the fact that water line construction for part of the study area was scheduled to begin in the fall and that notices of the base rate, $10/month, had appeared several times in the local paper. Since the base figure was likely well known to many of the respondents, this was used as the starting point for the bidding. The interviewer proposed a monthly rate, to which the respondent indicated either a willingness to obtain service at that rate or would not obtain service. The interviewer then counter-proposed rate increases in steps of $5 per month. Once the bidding had reached a figure beyond which the respondent would be unwilling to pay for monthly service, the figure was recorded.

Not all questions were applicable to all respondents. For example, a large section of the survey instrument dealt with the practices of persons who did not possess a water source and were required to haul water from a distant source. When the respondent, queried prior to the section dealing with water hauling, indicated that they never engaged in hauling, this section was omitted.

Deficiencies of the Survey Instrument

Any sort of survey is subject to inherent errors. One of the primary keys to collecting information of value through interviews is in knowing the right questions to ask. In some cases this may be accomplished by testing the survey instrument on a small sample population and, based upon this experience, revising the instrument prior to interviewing the intended population. Another method by which a survey instrument can be constructed of meaningful questions is by undertaking preliminary investigation in the field, so that the researcher is well enough acquainted with the subject and the local situation to know which questions will elucidate the information desired. This latter was the basis upon which the Rockcastle County study was designed; even so, as indicated above, some errors were made.

Although the investigator was very familiar with the study area from previous investigations, in subsequent analysis the instrument used proved to have a number of flaws derived both from questions asked and unasked. One particular question proved of little value, as respondents found it to be rather puzzling: "What is the maximum distance you would travel to obtain water?" Although such a question would likely generate responses of significant interest when applied to services such as medical care or commodities such as alcoholic beverages, in regard to water it was essentially meaningless. This was an error on the part of the investigator, based on examination of similar surveys, and shortly after initiation of field interviews this question was deleted from the instrument.

The investigator had overlooked the fact that, while people are able to make choices among different types of water supply sources, the ability to choose whether to have water or not have water is not a viable option. A daily supply of water for consumption is a necessity to maintain life. Consequently, the usual response to this question was a baffled look followed by, "Well, I'd go as far as I had to." There was no upper limit to the distance that they would travel; it was not a matter of whether they would be willing to do so, but an understanding that whatever would be necessary to obtain water would be done. A more useful approach, which was addressed by other questions in the survey, was to determine the actual travel distances for those persons who were required to haul water. This allowed a comparison of perceptions of the desirability of the various sources in the study area that were used as sources for hauled water.

Conversely, hindsight indicates that a number of additional questions could have been added to the survey that would have provided useful information. Certain questions were suggested by conversations with respondents. Among these, one of particular value would have been, "What, if any, water conservation measures do you practice at home?" (with checklist). Many persons volunteered this information and this is discussed in a later chapter, but a systematic evaluation would have been of greater value.

Other Research Tools

A 35-millimeter camera was carried along on every trip into the study area in order to record various aspects of water-supply sources and activities. Photodocumentation provides an excellent cross-check against field notes; phenomena are often later observed from photographs that may have escaped notice at the time. A number of the photographs taken in the study area are reproduced at appropriate locations in the text.

Public records were consulted to fill certain gaps in understanding and to supplement information gained from respondents. Of particular service in this regard were the records of the Public Service Commission concerning the application of the residents of the study area for public water line extension into the region. In addition, deeds and records filed within the Rockcastle County court house provided detailed information on the means by which understandings in regard to water rights and access had been formalized among users in common of local sources.

A subscription taken out to the local newspaper, the Mount Vernon Signal, provided some local viewpoints concerning water issues and allowed the progress of the proposed water line project to be followed from week to week.

Defining the Water Source Type

When field investigation began, it soon became apparent that it was not always an easy task to identify the exact nature of a water source in use. It might at first appear a relatively simple matter to differentiate between a well or a spring, but on several occasions during the course of the investigation the distinction between these two classes of objects became somewhat blurred. In such cases a field determination was required on the part of the investigator as to whether a particular feature was a well or a spring.

Robertson and Edberg (1992) note that there is no universally accepted definition of the term "spring" nor of “spring water.” The United States Geological Survey and the American Geological Institute (AGI) consider a spring to be "a place where, without the agency of man, water flows from a rock or soil upon the land or into a body of surface water" (Bates and Jackson 1987). According to the AGI, a “water well” is “an artificial excavation generally cylindrical in form and often walled in, sunk (drilled, dug, driven, bored, or jetted) into the ground to such a depth as to allow the water to flow or be pumped to the surface.”

According to Robertson and Edberg, for regulatory purposes many states have adopted definitions similar to those of the USGS and AGI. California, a state having large numbers of bottled water consumers, defines spring water as: "water which issues by natural forces out of the earth at a particular place." Vendors of bottled water, through their trade associations, have sought a more liberal and self-serving interpretation. Accordingly, a number of states have a provision that water may be considered spring water where it is captured prior to its natural emergence from the ground, by use of interceptor wells or interceptor trenches.

This allows bottling companies easier access to greater quantities of water, with the legal right to call it "spring water." Kentucky does not have regulatory definitions for either springs or spring water.

The key concepts inherent in the AGI and USGS definitions are those of natural (springs) and artificial (wells). A spring is a feature of the landscape that has originated "without the agency of man, whereas a well is constructed by human endeavor. Prior to the field phase of the investigation, these were the definitions intended to classify springs and wells found in the study area. Ground water sources were, however, encountered that did not fit precisely into this definition nor appeared to be wells. Therefore, a less restrictive definition had to be adopted. The definition employed in the investigation was modeled after that used in California law, where a spring is considered: "water which issues by natural forces out of the earth at a particular place." This revision allowed springs created through human agency to be included.

The difficulty in distinction arises when a water source exhibited characteristics of both a spring and a well. For example, a drilled well will occasionally intersect a confined aquifer that possesses a potentiometric surface that is greater in elevation than the land surface at the point of drilling. Under these conditions a well may discharge water out onto the land surface or even spout into the air. Is this a well or a spring? In this case it appears most satisfactory to designate this an artesian well, as the water flow was created by drilling a hole. In another example, frequently found in Eastern Kentucky, a horizontal tunnel of an underground coal mine intercepts water-bearing strata, which even after the mine has been closed continues to discharge from the hillside at the former mine entrance or "adit". This, although resulting from a human excavation, is certainly not a well. In terms of surface form and function it operates as a spring. According to reports in the files of the Kentucky Division of Water, many such mine adit "springs" serve as local water supplies for residents in Eastern Kentucky.

No mine adit springs or artesian wells were discovered in the study area, but certain private water sources were ambiguous in nature. In several cases, particularly at higher elevations where natural springs seldom occurred, springs were created by excavation of places that appeared to have groundwater near the surface. John C. described how he had created the spring that became his water supply. At the valley head located behind his residence, about 100 feet lower in elevation, he observed that a small patch of ground tended to be greener and damper in summer, and that certain plants, requiring a moist environment, thrived in this particular spot. He hired a man with a backhoe to excavate at this location and found a water seep a few feet down at the soil-bedrock interface. He thoroughly cleaned the rock ledge and laid several lengths of perforated pipe on the ledge to collect the seepage, which he then covered with a layer of gravel. Over this he laid a large sheet of tin and then covered the whole over with soil. Directly before the seep location he built a concrete block reservoir in the excavation, with a small building over this. Subsequently he had a ditch made from this new "spring" to his home and laid a water line. A shorter line diverts overflow from the storage reservoir to his cattle.

There were found to be many of these created springs in the study area, and despite their origin through human activity, when classifying water sources they were grouped with naturally-occurring springs. In another situation, though of similar circumstances, a different classification was chosen. The resident, who lived at a high elevation and was accustomed to hauling water, had not sought to find water on his own property. Instead, during an excavation for a proposed septic tank, a strong water seep was encountered in the soil. The excavation was deepened, lined with concrete blocks, and a low protective structure erected above it (the septic system was subsequently constructed on the opposite side of the residence). This was classified as a well, since the excavation, which filled with water from the bottom, was much deeper than it was wide and there was no outflow of water onto the surface.

These distinctions are admittedly somewhat arbitrary, but are based on the general form and function of the water source. In the present investigation, a fairly broad definition of "spring" and "spring water" is used to reflect water sources that, while possibly having been created at a particular site through human intervention, thereafter function as springs. Other classes of water source were not found to suffer from similar ambiguities in definition.

Chapter 4

Study Area

For communities and dispersed rural households alike, it is the nature of the water resources available that determines the use, if any, that can be made of them. Water supplies are not isolated entities but exist in a contextual framework that imposes structure on location and limitations upon accessibility. This holds true for natural sources of water, surface and subterranean, upon which both public and individual water supply systems depend. This chapter begins with a description of water resources available in the study area, as related to precipitation, topography and geologic composition and structure. Characteristics of the population and regional culture are discussed next, and the chapter concludes with an analysis of existing and potential future public water supply infrastructure for the region.

Topography and Geology

The study area lies in a rugged terrane located primarily in northeastern Rockcastle County, Kentucky, but also includes a small strip of northwestern Jackson County (Fig. 4a). These counties are located in southeastern Kentucky, at the western margin of the Appalachian foothills. The study area is roughly triangular in shape, pointing northward, and contains 31.5 square miles of land. Approximately 0.5 square miles of this area lies in northwest Jackson County, a strip 500 feet wide along the east side of the highway that divides the two counties. The study area represents almost exactly ten percent of the land area of Rockcastle County's 311 square miles.

Although Rockcastle County is a transitional area among three physiographic regions, the study area is wholly within the region known as the Eastern Kentucky Mountains. This region is also referred to as the Eastern Coalfields. The western portion of Rockcastle County lies in the Eastern Pennyroyal region, and a small part of the northern extremity falls in the "Knobs" section of the Outer Bluegrass region.

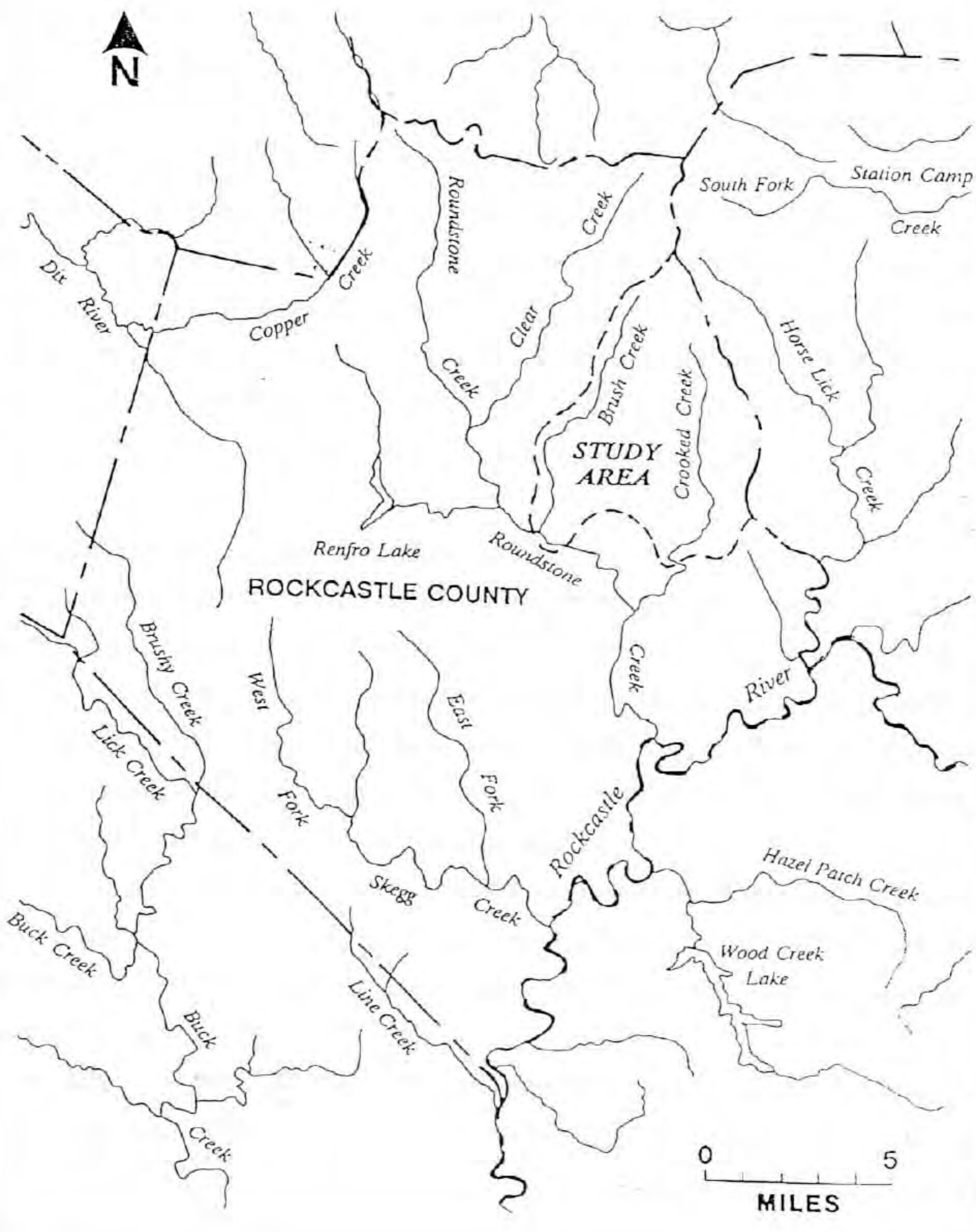
The study area is on the eastern flank of the Cincinnati Arch, a major structural feature extending across Kentucky from northern Kentucky to west-central Tennessee. As a result, the rock strata dip slightly to the east. The study area may therefore be considered to be part of an eastward-dipping monocline. Rockcastle County is roughly bisected, from northeast to southwest, by the edge of the Cumberland Escarpment. This escarpment parallels the Arch, from the Ohio River to southern Tennessee. In Kentucky, it serves as the boundary between the eastern mountain region and the Pennyroyal. The escarpment is deeply dissected by surface streams and, consequently, the edge is not a clearly defined boundary as is seen along other, "classic", escarpments.

The change in elevation from the uplands east of the escarpment traveling west and north to the Eastern Pennyroyal is 600-700 feet. Typical elevations range from 900-1,000 feet above sea level in the areas below the escarpment to as much as 1,600 feet in the uplands. The deep stream dissection characteristic of the study area not only prevails along the margin of the escarpment but also in the uplands east of the escarpment. Major surface streams draining the study area flow southward, away from the escarpment, and have entrenched to elevations of 900-1,100 feet.

The study area is drained primarily by two streams, Brush Creek at the western boundary and the more centrally-located Crooked Creek. In addition, a portion of the extreme northeastern edge of the study area is drained by the headwaters of Horse Lick Creek. Both Brush Creek and Crooked Creek are important tributaries of Roundstone Creek, which in turn drains to the Rockcastle River and hence to the Cumberland River. Horse Lick Creek drains directly to the Rockcastle River and historically was locally known as the "Middle Fork" of Rockcastle River (Fig. 4b). The study area may be characterized in general as rugged, although the limitations imposed by the landscape are not as severe as for the more mountainous counties further to the east. Narrow ridges 300-600 feet in height are separated by narrow valleys. The predominant rock strata of the area are, in descending order of elevation, sandstones of Pennsylvanian age interbedded with occasional thin coal seams, thick-bedded, relatively pure Mississippian limestones, and shaley limestones and shales below. An idealized geologic model of the study area would depict sandstones that cap

Figure 4a
Location of Study Area

Figure 4b
Regional Drainage



the ridges, valley floors composed of shales and interbedded shale/limestone, and about 200 feet of relatively pure limestone sandwiched in the centers of the ridges. In reality this picture is modified by a slight dipping of the strata from west to east. To the west the sandstone cap of the ridges is sometimes lacking, having been completely eroded away, and the shales extend further up into the ridges. To the east, sandstones are thicker and less limestone is exposed in the valley bottoms (Fig 4c). Nowhere in the study area are valley floors comprised of sandstone, although this occurs further east as the limestones continue to dip downward. The geology of the area has a profound influence upon the types and amounts of water that are available for use by the population.

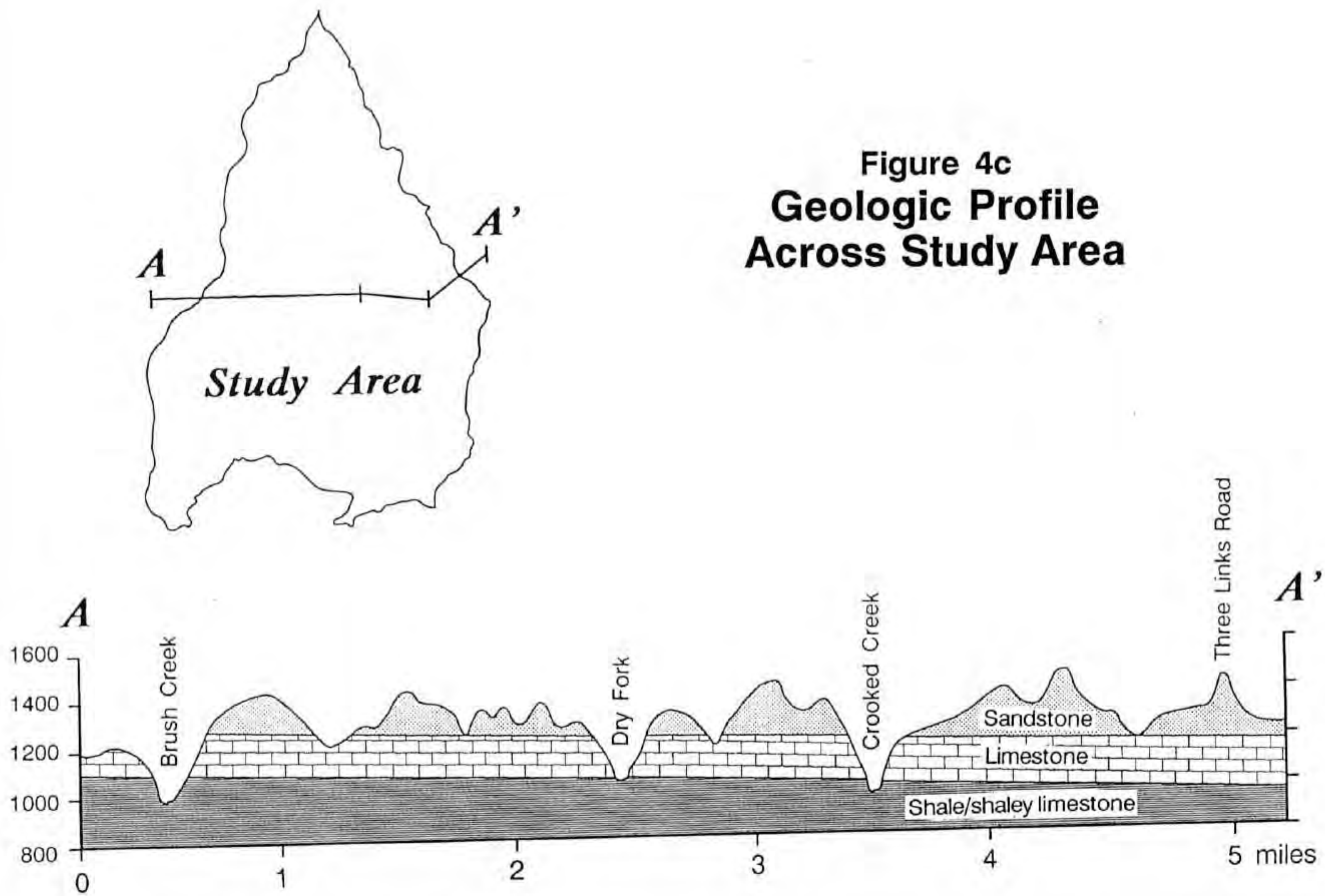
Karst Geomorphology and Ground water Flow

The presence of carbonate rocks, mainly limestones, at or near the surface throughout the study area, has led to the development of a significant karst landscape. Karst terranes are characterized by ground water flow in dissolutionally enlarged conduits and by features such as sinkholes, sinking streams, and caves. Because the land surface is rugged, the study area is not immediately recognizable as a karst landscape; the topography is very similar to non-karst regions farther east. Surface karst characteristics in Rockcastle County are less pronounced than those of such classic karst terranes as the sinkhole plain near Mammoth Cave, Kentucky, or in southern Indiana, where surface drainage is absent over large areas.

Because relatively pure and massive limestones most conducive to development of conduit flow systems are sandwiched between rocks that are not soluble, visible karst features in the study area are generally expressed on a vertical rather than a horizontal plane. These take the form of cave entrances and springs. Sinkhole development is generally limited to areas where a thick overlying sandstone caprock is absent, at the edges of the caprock where the sandstone is thinner and highly fractured, and in the valleys of small tributary streams that flow upon relatively pure limestone at higher elevations. These constitute the points of direct ground water recharge for conduit flow systems that discharge at lower elevations along the courses of major surface streams in the area. As major surface streams are situated upon shale and shaley limestones, they have not been captured by subsurface conduit systems and serve as local base level. Crooked Creek does plunge underground briefly, for a few hundred yards, midway along its course, but this is the result of a minor syncline. Many of the tributary branches, however, have been captured by subsurface systems. Drainage along second-order tributaries such as Barnett Valley and Dry Fork, although shown as continuous on the USGS topographic map of the area, in fact only occurs intermittently as a consequence of heavy rainfall. Smaller, first-order tributaries seldom have flow in their beds except during or immediately after precipitation. For many of these first-order streams, flow may occur at such times along the upper segments of their courses, that lie upon sandstone, but is diverted underground through fractures or swallow holes upon encountering limestone at lower elevations. From all these points of recharge, as well as from widespread and diffuse infiltration through the soil and hence into dissolutionally enlarged fractures, ground water flow is concentrated into increasingly larger conduits. Many of the minor conduits quickly intercept hillsides or stream beds and there discharge as intermittent springs or seeps. Others converge to form complex dendritic systems that drain substantial areas, ultimately discharging into one of the major streams. The base flow and a significant portion of flood flow for both Brush Creek and Crooked Creek is derived from ground water discharged by local springs.

Certain conduits in the larger ground water flow systems have, over millennia, developed to sufficient size that they are recognized as caves, meaning that the conduits are large enough to be explored by humans. Although many of these cave systems do not have external openings large enough to be entered, many do. Hundreds of caves, large and small, that can be entered by human beings, are located in the study area. Several of these caves are many miles in length. The morphology of passages in these caves indicates two major periods of development. Large conduits, or cave passages, at higher elevations seldom carry water, except briefly as a consequence of being intersected by shafts or conduits of more recent development. These passages are former ground water flow routes, abandoned as surface stream valleys were cut deeper and the local base level dropped. Conduits lower in elevation, near the valley floors, represent recent or contemporary flow routes which usually transport ground water. These discharge as larger springs situated near local base level.

Figure 4c
Geologic Profile Across Study Area



When maps of surveyed cave passages are overlain upon topographic maps, a distinct pattern emerges. Cave passages, and consequently ground water flow routes, tend to parallel contour lines and thus trace the approximate outlines of the ridges that contain them (O'Dell 1992,9-13). Sasowski (1992) has proposed a model to account for ground water conduit flow and cavern development in this and similar terranes, based upon his research along the Cumberland Escarpment in Tennessee. According to his hypothesis, the bedrock in valley walls fractures because of unloading during surface stream entrenchment. It is along these stress-relief fractures that ground water flow occurs, and hence dissolutional enlargement of conduits.

Regional Water Resources

Southeastern Kentucky averages more than 40 inches of precipitation annually. This is distributed fairly evenly throughout the year, about three to four inches per month. The volumes of available surface and ground water flow do not, however, demonstrate the same degree of regularity but instead vary considerably with the seasons. Stream flow and ground water flow is generally lowest during the summer months, a condition called summer base flow. This is primarily a result of the increased level of evapotranspiration that exists during the warmer months. Precipitation at this time is often so thoroughly absorbed by soils and plant life that little reaches streams and bedrock aquifers.

This effect can be seen by comparing a chart of precipitation for the local area, recorded at a station in Mount Vernon a few miles from the study area, with a hydrograph of the flow of the Rockcastle River, recorded at a USGS gauging station at Billows about ten miles south of the study area (Fig. 4d). During the winter and early spring, when the soil is saturated with moisture, even minor precipitation events cause a sharp increase in the volume of the river flow. As the season progresses into summer, river flow becomes less and less responsive to precipitation. By mid- to late summer, even a fairly significant rainfall fails to produce much effect on the Rockcastle River.

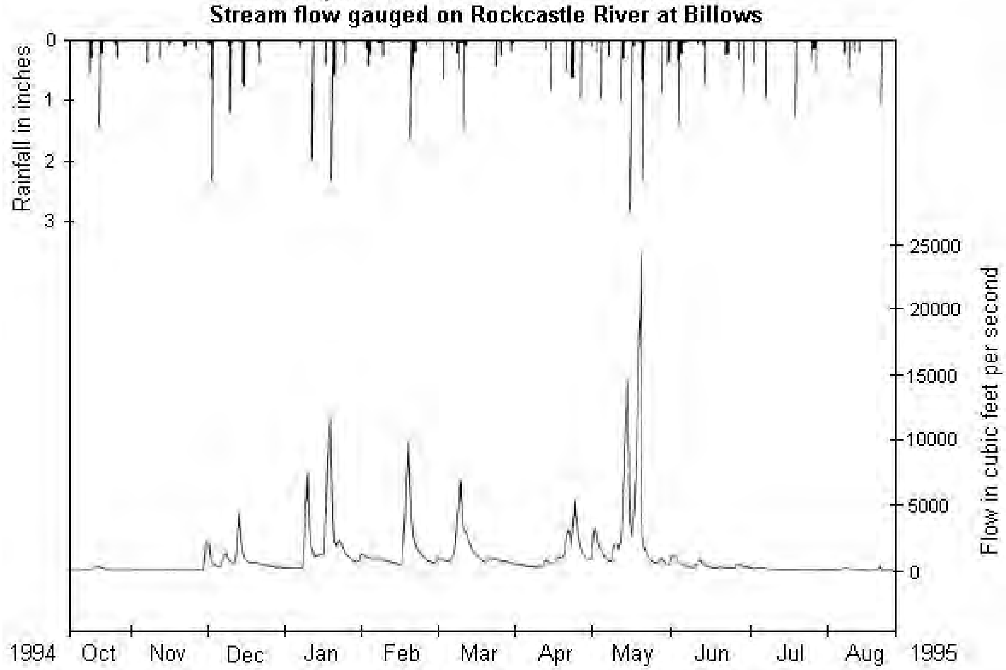
Flow levels are also reduced, although not as much as during summer and early autumn, during the coldest months, when precipitation is often bound to the surface as snow and ice. The gradual melt and release of such bound water causes the winter base flow level to be greater than that of summer. The soil at this time is usually near saturation, so that rainfall during the milder weather that often occurs even during mid-winter in Kentucky is not intercepted but can almost immediately enter streams and aquifers. Accordingly, flow rates are extremely responsive during the winter and through the spring season.

Figure 4d

Regional Precipitation and Stream Flow

Precipitation measured at Mount Vernon

Stream flow gauged on Rockcastle River at Billows



As a consequence of this seasonal variability in flow, water resources available for use by the local population often vary in the same sequence. During the summer and autumn, water levels in many wells drop and spring flow diminishes; some water supplies may dry up entirely if summer weather is slightly warmer or precipitation slightly less than usual. During winter and spring, water sources usually have abundant flow.

Other than the flow of surface streams, the hundreds of perennial karst springs present in the study area comprise the most readily available water resource for use by residents. These springs are not ubiquitous, however, discharging only at lower elevations at or near the base of the limestone formations. This generally limits their use to households sited in the valleys. At higher elevations, where sandstones overlie the limestones, ground water flows through the cracks and fractures in the sandstone. These fractures have been created largely through stress relief and orogenic processes. As sandstone, unlike limestone, is not generally subject to dissolution by water, fractures are not enlarged and consequently ground water travels at a much slower rate through sandstone. Springs and seeps discharging from sandstone fractures are present in the study area, but generally are of very limited volume. Water resources present in sandstone aquifers must usually be obtained by drilling of wells to intercept fractures. The thickness of the sandstone caprock in the study area generally precludes tapping underlying limestone conduits except by relatively deep wells. Figure 4e presents a model of the occurrence and exploitation of natural water resources in the study area.

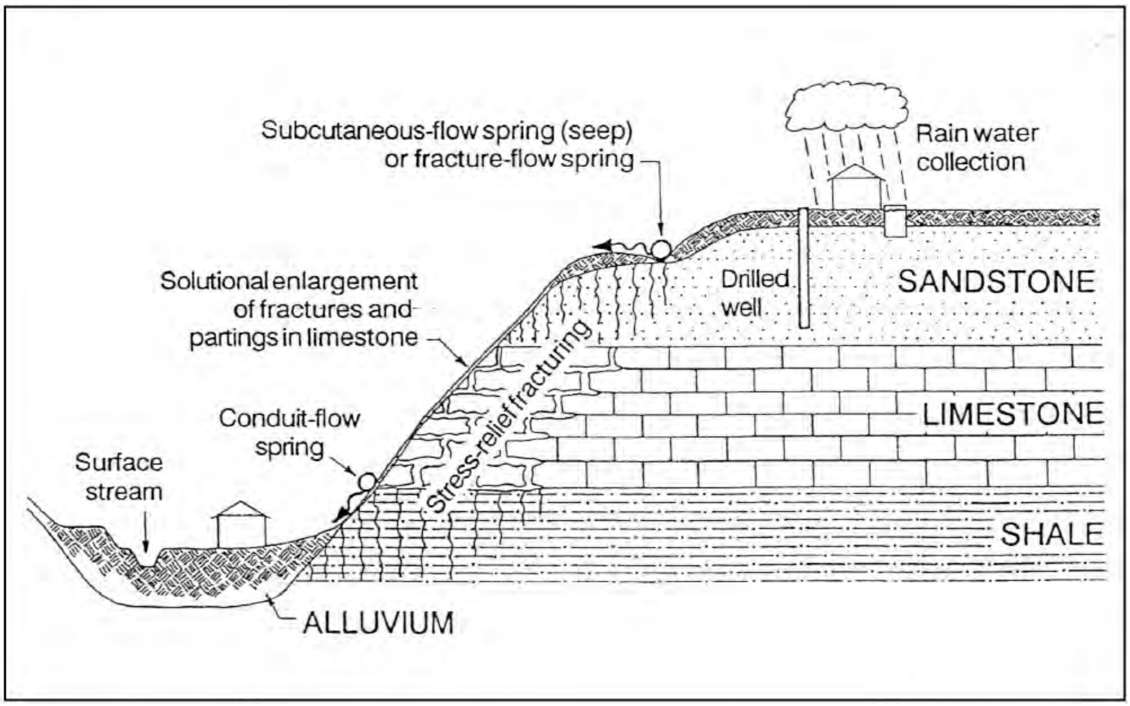


Figure 4e. Model of the occurrence and exploitation of natural water resources in the study area. Households located in valley bottoms are easily able to exploit hillside springs using gravity flow systems. Households located upon the upper elevations, on sandstone bedrock, must either pump springs uphill with difficulty, collect rainwater, drill wells, or transport water from elsewhere.

In addition to ground water carried in limestone conduits and sandstone fractures, another potential source for ground water extraction exists in the subcutaneous flow that is carried at or near the soil/bedrock interface. Where limestone underlies the soil mantle, the rock surface has been extensively channeled by infiltration of chemically aggressive (acidic) water through the soil. This is known as the epikarst zone and comprises the major source of storage for ground water that eventually becomes part of the flow of deeper conduit systems (Williams 1983). Epikarstic flow frequently discharges as small springs. The sandstone caprock, steep slopes and confinement of the limestone between non-dissoluble units and above the valley floor are factors that limit the horizontal extent of epikarst in the study area, compared to karst terranes where the topography consists of gentler slopes. Regardless, subcutaneous flow is a water resource in the study area on both sandstone and limestone bedrock.

As ground water is the most important water resource for the region, several writers have attempted to assess its availability. Price, Mull and Kilburn (1962) provided the first systematic assessment of ground-water for eastern Kentucky through an inventory of approximately 45 wells and springs in each county along with the physical characteristics of these supplies and determination of the source aquifers. This report indicated that aquifers in the Mississippian rocks along the western margin of the Cumberland Escarpment generally yielded sufficient water for a modern domestic supply (defined by the authors as >500 gallons per day) when limestones were tapped. In contrast, Mississippian shales and overlying Pennsylvanian sandstones and shales of the Lee formation were generally found to yield inadequate or minimal domestic supplies. The report further stated that, since a large segment of the population resides on hilltops, their wells have been drilled in locations unfavorable for obtaining ground-water.

Rima and Mull (1980) pointed out that the traditional approach to appraising ground-water resources in a region by using the yields of existing wells is misleading, as the drilling of a particular well is usually discontinued as soon as sufficient water is obtained. They argued that the highest yielding wells are a better indicator of the potential ground-water supply. According to the authors' regional projections, the Rockcastle County area has the potential for substantial ground-water resources ("substantial" defined here as >100 gallons per minute). The authors qualified this by noting that, in the Mississippian limestones, ground-water is carried in discrete conduits and therefore wells that do not intersect such conduits yield less.

Leist and others (1982) produced a report on the hydrology of Area 15 in the Eastern Coal Province. Area 15 consists of the drainage basins of the Rockcastle and Laurel rivers and a portion of the drainage of the upper Cumberland River. The Rockcastle River basin was described as a "partially mined" area as opposed to adjacent "mined" areas and thus suffered less from potential detrimental effects of coal mining such as ground-water level reduction and water-quality degradation from acid mine drainage and increased sediment load. This paper noted that, for this region, ground-water availability in pre-Pennsylvanian [Mississippian] rocks is related to well depth, topography, rock type, and the character of the overlying rocks. Major aquifers are in limestone strata, in which interconnected solution openings may yield more than 50 gallons per minute (gpm) when intersected by wells and more than 20 gpm when such conduits discharge as springs. Yields generally are less than 1 gpm where limestone above stream level is overlain by shale or siltstone of Pennsylvanian age.

In summary, when based on flow type and related to the geologic situation, available ground water resources in the study area fall into three categories: conduit flow, fracture flow, and subcutaneous flow (which may involve small conduits when on limestone bedrock). Perennial surface water flow is generally found only in the major base-level streams, as many second-order and most first-order streams are quickly captured or flow only after rainfall. Although regional water resources are numerous and appear in total to be adequate for the needs of the existing population, these resources are not evenly distributed because of variations in local geology and topography. Certain areas have adequate water for domestic needs and other areas do not.

Regional Spatial Organization

The primary land use in Eastern Kentucky is forest, private and public. More than 80 percent of the land area in the study area is in forest. The eastern half of Rockcastle County and nearly all of Jackson County fall within the designated borders of the Daniel Boone National Forest. This national forest, along with most of the other eastern national forests, was created during the Depression era. The U.S. Forest Service (USFS) is authorized to purchase lands within the official borders, or to trade existing holdings for land; by law, the USFS cannot sell land once acquired. Since the establishment of the Daniel Boone National Forest boundaries, this program of land acquisition has been carried out. In many parts of the Boone Forest, nearly all of the authorized land area has been acquired. In Rockcastle County and the study area, acquisition has not been as successful as elsewhere; tracts belonging to the national forest are widely scattered among private woodlands.

The study area does not contain any incorporated communities. The nearest communities are Mount Vernon, the county seat of Rockcastle County with a 1990 population of 2,654 and located 8 miles from the midpoint of the study area; Livingston, also in Rockcastle County with a population of 241 persons and located 8 miles from the midpoint; Sand Gap in Jackson County, having about 200 persons and located 9 miles from the midpoint; and Berea, population 9,126, 12 miles distant in Madison County. The second tier, consisting of larger towns located some distance away, that provide the greater part of employment opportunities, commerce, and services for the study area, include Richmond, 25 miles distant; London, 21 miles; and Somerset, 30 miles. The major regional hub is Lexington, 47 miles to the north, which serves as an important commercial center for all of Eastern Kentucky (Fig. 4f).

There are numerous small unincorporated settlements in the study area, such as Orlando, Johnetta, Climax and Three Links. Although in a former, more prosperous era these communities possessed post offices and a few other services, they were little more than slightly denser concentrations of the dispersed housing along the roads. Community-based services have largely been eliminated from these settlements, but the linear communities remain known by their former designations.

The study area was served by only unimproved dirt and macadam roads until the middle of the 20th century, when some of the major roads were paved with asphalt. No federal or state highways extend into the study area, although US 25, US 421, and Interstate 75 serve adjacent parts of Rockcastle County. Until 1992, only the roads outlining the perimeter of the study area were paved. In that year, the Dry Fork road was paved with asphalt as far as Crooked Creek. All other roads in the study area are dirt or gravel, having but sporadic maintenance by the county.

Electrical power, provided by the local rural cooperative, is available throughout most of the study area except in a few of the most remote hollows. Accordingly, most private systems could be supplied with water under pressure by electric pumps, although other considerations, physical, economic, or social, may operate to determine which systems will be so provided by the users. This aspect is discussed in more detail in subsequent chapters.

Socioeconomic Characteristics

In many of the rural counties of Kentucky, infrastructure development has lagged far behind the few urban centers. The counties of Kentucky, on average, are among the smallest in the nation. As a result, many counties have not had the tax base necessary to provide more than the absolute minimum of improvements and services.

The lack of infrastructure development has been particularly true for eastern Kentucky, where conditions for agriculture are unfavorable and economies have historically been tied to extraction of natural resources such as coal and timber. Most of the wealth that has been generated by such industries has been taken out of Eastern Kentucky rather than employed in the local economies. Since the Great Depression, as extraction operations became increasingly automated and less dependent upon local labor, populations have generally declined in most of the Appalachian counties. The effects can be seen on the rural landscape in the form of numerous abandoned homesteads that have been gracefully decaying for decades. Frequently, land titles are encumbered in a tangle of absentee inheritors, the descendants of former residents who fled from the area to perceived opportunities elsewhere.

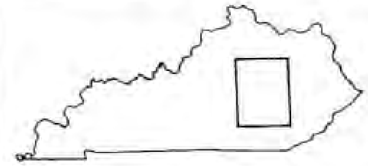
Eastern Rockcastle County and Jackson County are contained within the Southern Appalachian culture region. The northern part of the 1990 U.S. Census tract 9504 corresponds exactly to the boundaries of the study area, excluding the narrow strip in Jackson County (Fig. 4g). The remainder of the tract is characterized by a topography and settlement pattern very similar to that of the study area. Accordingly, statistics for this census tract are used to provide a general description of the population and housing characteristics of the study area. Where possible, actual statistics specific to the study area, derived from the author's field work, are presented in lieu of extrapolations from the census.

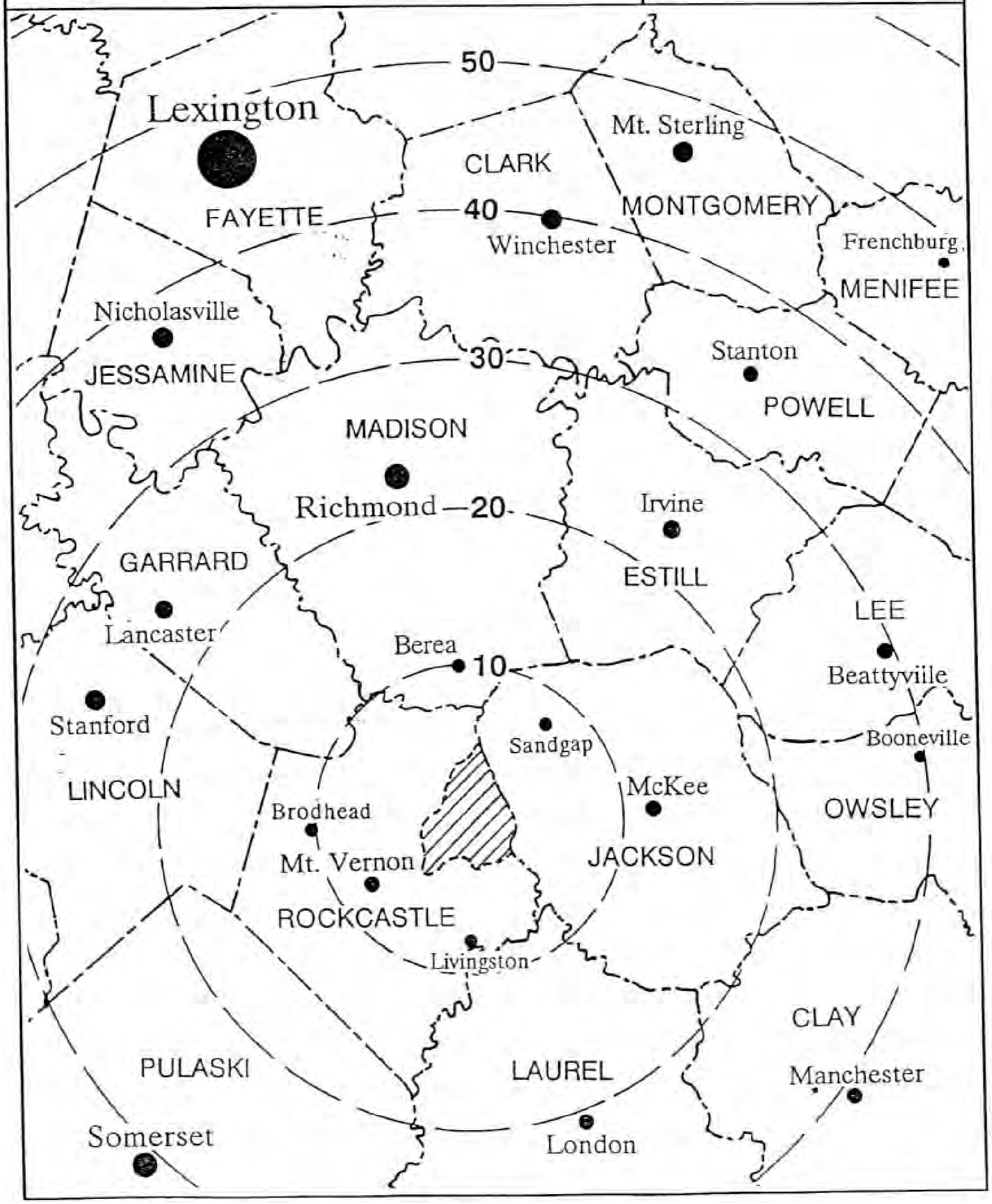
According to the U.S. Census of Population and Housing, in 1990 Rockcastle County had a total population of 14,803 persons. Census tract 9504 had a population of 2,772 persons who occupied 1,003 housing units. This is an average of 2.76 persons per household in the tract. The entire population of the tract was defined as rural.

Figure 4f

Regional Community Hierarchy

Concentric rings indicate distance in miles from study area.
Only county seats are shown outside the 10-mile radius.





The 107 households interviewed in the study area were determined to contain a total reported population of 304 persons, or 2.84 persons per household. Based on these figures, by extrapolation the total study area population for 208 dwellings is estimated at 591 persons. Thus, in the study area three percent of the county's population lives on ten percent of the land. Figure 4h shows the occupied housing in the study area, and indicates which households were interviewed during the investigation. An additional gauge of the rural nature of the study area can be achieved by comparing average number of persons per square mile. There is a average of 19 persons per square mile in the study area. In the remainder of rural Rockcastle County, excluding the three towns of Mount Vernon, Brodhead, and Livingston (combined 1990 population of 4,045), the population density is 36.3 persons per square mile.

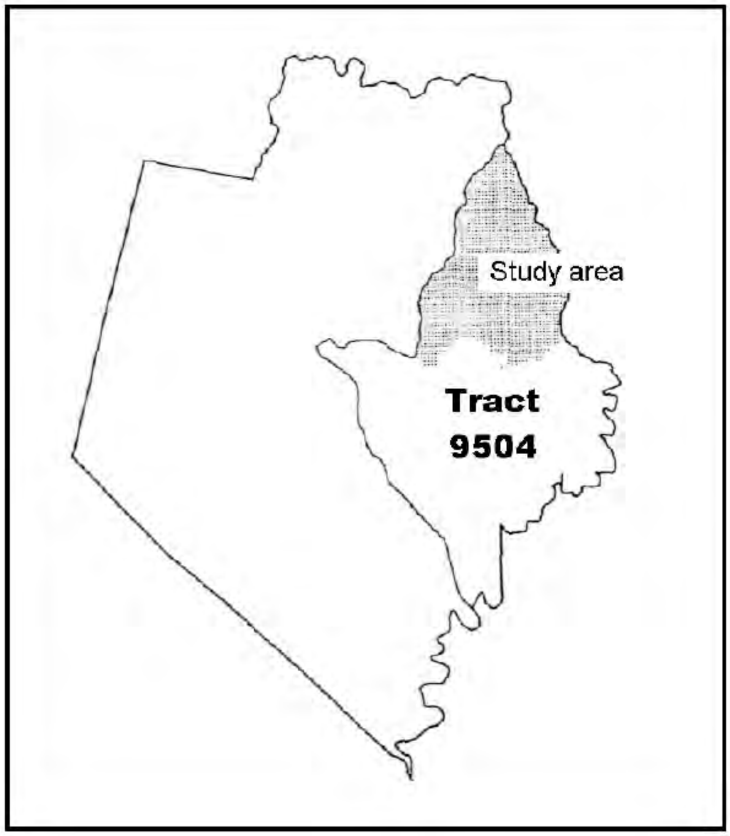


Figure 4g. Boundary of study area compared to that of U.S. 1990 Census Tract 9504.

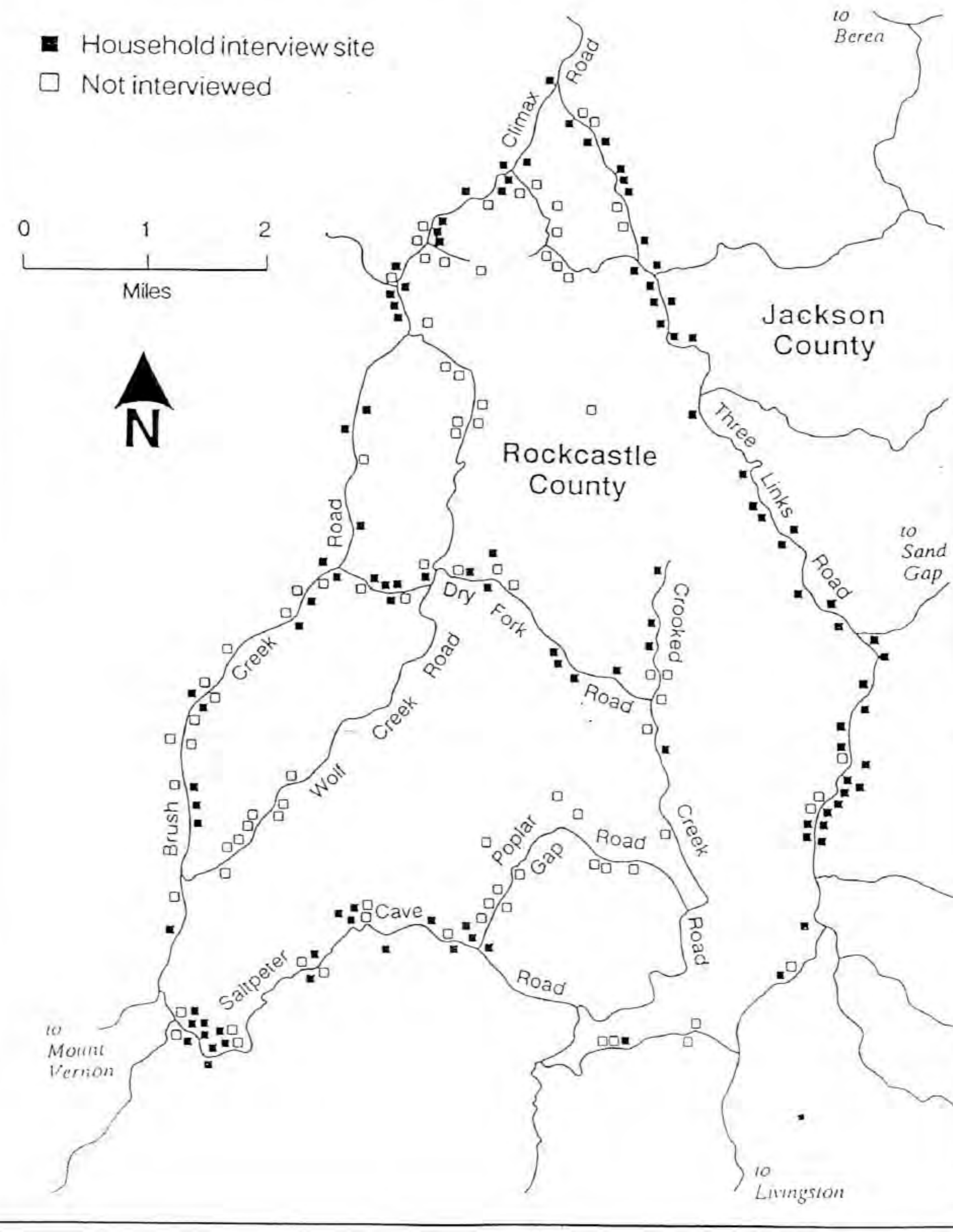
Occupied housing in the study area is concentrated along the paved perimeter roads, and is more sparse on the roads of the interior. In the interior, only the Dry Fork road is paved and approaches the housing density found along northern perimeter roads such as those near Climax and Three Links. Elsewhere, occupied housing is most numerous along interior roads near their junction with the perimeter roads. There are many miles of unpaved and often nearly impassable roads in the interior of the study area along which there are no occupied houses. Long-abandoned relics, overgrown and crumbling, are sometimes observed. Figure 4h depicts only the major roads of the area, both paved and unimproved, and does not show all of the presently unpopulated roads and trails.

Table 1 compares a few selected characteristics of population and housing in census tract 9504 with those for the state as a whole. These statistics serve as an indicator of the relatively economically depressed condition of the study area, although this is typical for most of the counties in the Eastern Kentucky mountain region.

Characteristic	Tract 9504	Kentucky
High school graduates (%)	34.8	64.6
% males > age 16 in labor force	55.8	70.8
% females > age 16 in labor force	35.8	51.2
% unemployed	15.8	7.4
Median household income $	13,088	22,534
% persons below poverty level	36.6	19.0
Median value of housing $	20,800	50,100

Table 1. Selected characteristics of population and housing in Census Tract 9504 and in Kentucky. Source: U.S. 1990 Census of Population and Housing

Figure 4h
Study Area Road Network and Distribution of Occupied Housing



More localized statistics based on interviews in the study area indicated that, of the 304 persons residing in households where interviews were conducted, 90 (29.6 percent) were under the age of 18 years. Fifty-seven households (53.3 percent) had no resident children under 18 years. Twelve of these households had only a single occupant. The remaining 50 households, where children were present, therefore averaged 1.8 children. All housing consisted of single-family residences, although in some instances extended family resided with the primary householders.

In this group of households, slightly less than half (49.5 percent) of the 214 persons over 18 years old were employed in income-producing occupations. The remaining 50.5 percent reported themselves to the author as homemakers, retired, disabled, college students or unemployed. Of the 106 employed persons, 27 percent were engaged in part-time or seasonal occupations, primarily logging, sawmill operation, or part-time farming. Slightly more than three-quarters of the employed population (76.4 percent) worked in full-time occupations away from their own property; of these occupations, factory work, construction, nursing/medical technology, and clerical were the major classes.

Most of the workers were employed in nearby communities. Mount Vernon (22 percent) and Berea (20 percent) accounted for more of the jobs held by study area residents than any of the other regional cities or towns. Ten percent of the workers drove more than 50 miles to the Lexington metropolitan area. Excluding the study area as a work place, 36 percent of the workers were employed elsewhere in Rockcastle County communities.

The study area itself offered few opportunities for employment. There were only four small business establishments within the study area: two tiny grocery stores which offered little more than soft drinks, candy and cigarettes; a sawmill and a used-car lot. Each of these was a family business and generally did not employ persons from outside the family. There was only one significant full-time farm operation in the study area, a dairy farm that supported two related families.

Four general classes of housing in the study area were determined by the field investigation: mobile homes, wood exterior houses, concrete block or asbestos siding, and others with brick or stone veneer. A few of the wood exterior homes were nearly a century old. Some of these consisted of wood siding over the original hewn logs. Many of the wood exterior homes constructed since World War II have tarpaper or asphalt siding on the exterior. A few homes defied classification, being highly individualized combinations of styles and materials. One person in the study area was living in a converted tool shed on his parent's property.

During the time that the author was in the field, from spring 1994 through autumn 1995, some minor changes occurred in the housing characteristics of the study area. Two new residences were established in previously unoccupied locations; one, a mobile home, the other, a new wood exterior house. Conversely, four structures were destroyed by arsonists. Only one of the burned structures was vacant; fortunately there was no loss of life. During the author's stay in the field, several respondents commented upon the local prevalence of arson as a means to settle grudges. They stated that, because of this unfortunate tendency, local fire insurance rates were extremely high.

Regional Water-Supply Infrastructure

The spatial extent of public water supplies is dictated by economic and political considerations. The physical expression of a public water system is a hierarchical network of supply lines or pipes. Typically, these systems exist in a dendritic, radial pattern extending outward in several directions from a central point. The central point is comprised of the treatment and pumping facilities and, usually, the source from which water is acquired. Sometimes water is piped from a distant source to the processing location. Supply lines parallel the existing network of streets and roads.

Because of its physical nature, provision of water by a public system is generally continuous along the length of a supply line, except where individual households or businesses may choose not to connect. Boundaries are very distinct between areas served by public supplies and areas not served.

Public water supply utilities face many of the same physical constraints as the self-supplied user, and must make the same sort of choices. Their freedom of action is, however, limited by state and federal regulations that require certain standards be met. One of the primary differences is simply that of scale. A public supply must be able to obtain water of relative purity (or be able to treat it successfully at low cost) and in immense quantities. Where an individual self-supplied user may withdraw from a pond or stream, a city needs a lake or river; where a rural household usually has but a single well, a city requires a well field that may include dozens or even hundreds of wells. The needs of both public supply and individual supply are similar in kind if not amount.

Public water systems are far more likely to use surface than subterranean sources (Sholar and Lee 1988; Solley *et. al.* 1988) because surface waters are usually available in larger immediate quantities and can be withdrawn more rapidly. The rate of ground water withdrawal is limited by the rate at which water can travel through the subsurface media to recharge the withdrawal point. It is possible to pump water out of the ground faster than it can be replenished and produce a cone of depression in the local water table, causing wells to temporarily run out of water. This is the reason that numerous wells are often needed by communities that use ground water.

Public water supplies generally serve populations in and adjacent to population centers. Throughout much of Eastern Kentucky, spatial coverage of rural regions by community systems is unevenly distributed. Systems that are not based upon towns or cities serve areas of relatively high population density. North and west of the study area, community systems include a higher proportion of the total rural areas of individual counties than to the south or east. This situation reflects the greater population density and affluence and gentler terrain of the Bluegrass region compared to the scattered population, relative poverty, and rugged terrain of Eastern Kentucky.

In Kentucky, public water supply systems that usually serve rural regions, in contrast to community-based systems, are divided into two classes, water districts and water associations. A water district is a special governmental district established by the county judge-executive and comprises an arm of the county government. The district is usually administered by commissioners appointed by the judge-executive. In contrast, water associations are non-profit corporations, similar in function to districts but with looser ties to local government. Establishment of a water association requires the approval of the county judge-executive but the association board is not under his/her control. Both water districts and water associations are regulated by the state public service commission, the agency authorized to oversee non-governmental utilities.

Figure 4i shows the distribution of public water supply systems, circa 1993, for an eight-county area including Rockcastle and Jackson counties. This map was compiled and cross-checked and digitized from information in the files of both the Kentucky Public Service Commission and the Division of Water, Drinking Water Branch. The boundaries shown are approximate and represent information of varying accuracy provided by the individual suppliers. No composite maps of this sort have been compiled previously.

Calculation of the areas of the various polygons, using a Geographic Information System (GIS), indicates that 67 percent of the land area of the region is served by public systems, not including such tiny systems as those serving isolated schools, trailer parks and the like. For Rockcastle and Jackson counties, the level of public water supply service was much less than that of the region represented as a whole. These two counties had an areal coverage by public systems of about 55 percent and 40 percent, respectively.

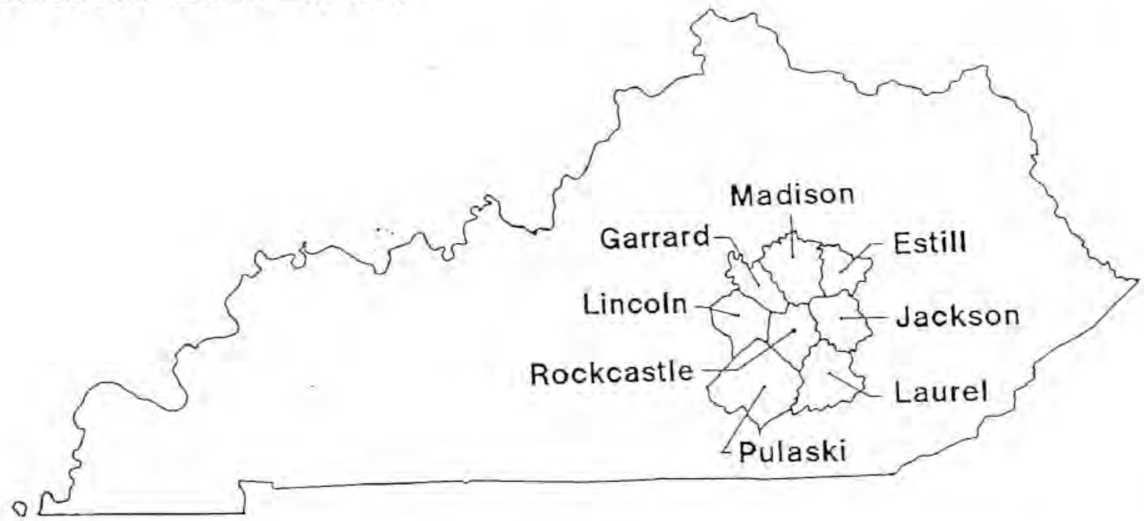
Statistics from the 1990 U.S. Census of Population and Housing provide another means to assess the regional water supply situation. The census data indicates that areas not served by public systems are much less densely populated. For the eight-county area, 88 percent of the occupied housing is served by public water systems. Accordingly, the one-third of the total land area for these counties that is self-supplied contains only 12 percent of the housing. In census tract 9504, 52 percent of the households were connected to public water systems. In the study area, which constitutes the northern section of this tract, there were no public system connections during the time of investigation.

General characterization of self-supplied water systems in the study area, using the 1990 U.S. Census type classifications, and data provided by the field interviews, indicates that 12 percent of respondent households in 1994 were supplied by drilled wells, 2 percent by dug wells, and 86 percent by "other." Given the magnitude of the "other" component, the U.S. Census classification system is over simplistic and unsatisfactory for describing rural water practices.

Figure 4i: Part One

Spatial Distribution of Regional Public Water Systems

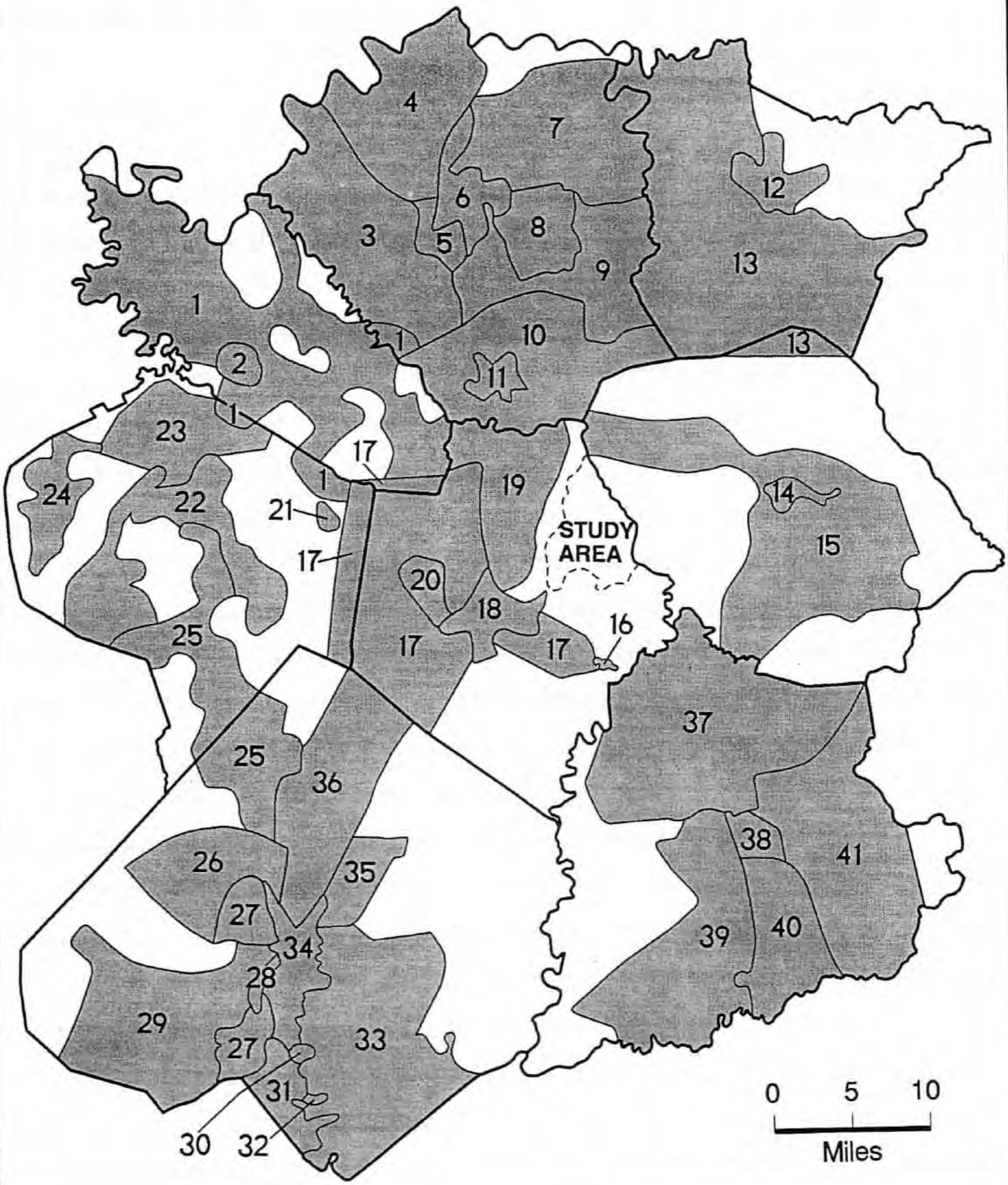
REGIONAL INDEX MAP



KEY TO PUBLIC WATER SUPPLIERS

1. Garrard County Water Assoc.
2. Lancaster Water Works
3. Kirksville Water Association
4. White Hall Water District
5. Milford Water District
6. Richmond Water Works
7. Waco Water District
8. Bluegrass Army Depot
9. Kingston-Terrill Water District
10. Southern Madison Water Dist.
11. Berea College Water Dept.
12. Estill County Water District #1
13. Irvine Municipal Utilities
14. Jackson County Water Assoc.
15. McKee Water Works
16. Livingston Water Works
17. Western Rockcastle Water Association
18. Mount Vernon Water Works
19. Northern Rockcastle Water District
20. Brodhead Water Works
21. Crab Orchard Water District
22. McKinney Water District
23. Hustonville Water Works
24. Eubank Water District
25. Science Hill Water District
26. Pleasant Hill Water District
27. Pulaski County Water Dist. #2
28. Oak Hill Water Association
29. Somerset Water Company
30. Burnside Water Company
31. Bronston Water Association
32. Southeastern Water Assoc.
33. Barnesburg Water Association
34. Nelson Valley Water Assoc.
35. Wood Creek Water District
36. London Utility Commission
37. West Laurel Water Association
38. Laurel County Water Dist. #2
39. East Laurel Water District

Figure 4i: Part Two
Spatial Distribution of Regional Public Water Systems



Five public water systems served Rockcastle County in 1994 when the study commenced. These were the Mount Vernon Water Works, Northern Rockcastle Water District, Brodhead Water Works, Western Rockcastle Water Association, and the Livingston Municipal Water Works. These systems encircle the study area from north to west to south. East and northeast from the study area, much of Jackson County is served by the Jackson County Water Association.

Prior to 1995, no portion of the study area was served by any public water supply. The relatively low population density and rugged terrain discouraged extension of water lines from existing community systems. Supply lines from the Mount Vernon system approached to within two miles of the southwestern boundary of the study area, and from the Jackson County Water Association to within two miles of the northern point of the study area.

The inhabitants of the study area had, for more than eight years, sought to obtain extension of community water service. In June 1990 a group of citizens proposed forming a new water association to serve several scattered parts of eastern Rockcastle. A portion of the study area would be served by extending lines from the Mount Vernon and Jackson County systems. Slightly over 100 households would be provided with service, along a portion of the Brush Creek, Climax and Three Links roads in the northern part of the study area and a section of state road 1004 in the southern part.

On May 14, 1991, the Kentucky Public Service Commission (KPSC) granted approval of the application by the Rockcastle Water Association, even though a feasibility study by its own staff had advised against it (Kentucky Public Service Commission 1991b). The concluding remarks of the Commission stated: "...it is clear that the formation of the proposed association represents the only means by which the residents proposed to be served by the new association will be able to obtain water service" (Kentucky Public Service Commission 1991a). The project was financed through grant money from the Appalachian Regional Commission (ARC) and loans from the Farmers Home Administration (FmHA). Construction of main lines began in autumn 1994 and was completed by Spring 1995.

Additional water lines are planned for the region in Rockcastle of which the study area is part. The cost of the expanded Rockcastle Water Association project has been estimated at $1.7 million. The 30 November 1995 edition of the Mount Vernon *Signal* reported that both Congress and President Clinton had approved $170 million in funding for the Appalachian Regional Commission (ARC). The ARC is one of the major sources of financing for construction of public water systems in the mountain region.

Chapter 5

SOURCE TYPES

Classification of Source Types

Water supplies potentially available to a particular population fall into two basic categories: (1) Internal water resources, indigenous to the region, are determined by characteristics of local climate, geology and topography. (2) External water resources are transported to the point of use either in containers or through a system of pipes. The present chapter describes in detail the various physical manifestations of water sources specific to the study area. The significance of each of these sources to the population, based on actual usage, is discussed, along with the means by which such sources are commonly exploited.

Water supply sources indigenous to the study area and potentially available for domestic purposes include: free-flowing surface streams; natural ponds and artificial impoundments; subcutaneous (soil-bedrock interface) ground water flow that may be tapped by drilled or dug wells; conduit-flow (limestone bedrock) and fracture-flow (sandstone bedrock) ground water aquifers that may be tapped by drilled wells; natural and created springs derived from subcutaneous, fracture, or conduit drainage; and rainfall, which, while providing recharge for all of the other forms, can itself be directly intercepted by collection systems.

Potential sources external to the study area include other regional springs, wells, streams, etc.; bottled water sold by various types of retail outlets in regional towns and cities; and water obtained from public supply systems. Public system water was not available in homes through piped service connections anywhere in the study area during the period of investigation. Area residents, however, were potentially able to obtain "city water" for domestic use by transport from three sources: (1) homes of friends or relatives, or places of employment, outside the study area that were connected to public systems; (2) coin-operated water vending stations in regional towns and cities; and (3) truck deliveries of public system water by water vendors who purchase and resell water.

The spatial dichotomy of internal or external water sources applies not only to the study area in general but also to individual households within the study area. Potential water resources, surface or ground water, may exist within the domain of a household or else must be obtained from off-site. The categorical division of source types available to households is equivalent to those for a region, save that choices may be far more limited for individual households. Certain sources may be more easily exploited than others, or require a lesser expenditure of financial resources to use. Households may find it more economical in the short-term to transport water from a distant source, because of the costs that may be associated with developing a personal source. In addition, individuals may prefer to transport water from a distant source because they perceive the water from the distant source as more desirable.

Water-supply strategies in the study area may be further classed as to whether supplies are derived from a sole source or multiple sources. A sole-source household obtains all of its water needs either from a single source on the property controlled by the household ("on-site source"), such as a spring or well, or from a single outside source, either piped from a source on an adjoining property or transported from elsewhere. Multiple-source households obtain water from a variety of sources. These may be multiple sources on the same property that individually are insufficient but collectively provide enough water for daily domestic needs, or may include water hauling as a supplement to an on-site source, resulting from need or preference. This aspect of use is addressed more fully in Chapter Seven.

For statistical purposes in this chapter, the sources used by the study area population have been condensed into a relatively few classes. These general classifications, and the number and percentage of households using each source type for any domestic purpose, are summarized in Table 2. The total is greater than 100 percent as numerous households obtain water from several sources. In addition, this summary does not differentiate between use of on-site and off-site sources, a distinction which is discussed more fully below. The significance of certain source types can be more fully appreciated if a more general classification is used. In virtually all discussions of water supply found in the literature, wells and springs are lumped in a single class called "ground water." Ground water, regardless of source, was used in some form by nearly 90 percent of households in the study area; coinciding exactly with Sholar and Lee's (1988,8-11) estimate.

Source Type	Number Households Using	Percent Households Using
Surface water body	1	1
Rainfall collection system	19	18
Spring on-site or adjacent property	47	44
Well on-site or adjacent property	20	19
Bottled water, commercial	9	8
Self-hauled from spring	34	32
Self-hauled from public supply	4	4
Delivered, vendor purchase	17	16

Table 2. General water supply sources used by 107 study area households

On-Site Sources

(1) Surface waters (lakes, ponds, and streams)

Surface waters, including both natural and artificial impoundments and free-flowing streams, are seldom used as private domestic water sources. This holds true not only for the study area but for the state at large. Only ten percent of Kentucky's self-supplied population uses surface water as a source for domestic supply (Sholar and Lee 1988, 8-11). In only one household of the study area was surface water brought into the residence for domestic use. The water was obtained from a small pond on the premises and used only for bulk supply purposes, such as laundry and operation of toilets. Drinking water was obtained from the well of the respondent's parents, who lived nearby.

Surface water bodies in rural regions are used almost exclusively for agricultural purposes, livestock watering and crop irrigation. More than 95 percent of water withdrawn for agricultural use in Kentucky is derived from surface sources (Sholar and Lee 1988, 28-35).

In contrast, most public water supply systems in Kentucky obtain water from surface sources, lakes, reservoirs and streams. Public systems supply water for domestic, industrial and commercial usage. Nearly 90 percent of water withdrawn by public systems in the state is taken from surface sources (Sholar and Lee 1988, 4-7). This is a consequence of the limited quantities available from most ground water sources. In addition, public systems are equipped to treat surface waters to meet quality standards, whereas few rural residents can either afford such equipment nor have training in its operation. In only a few regions of the state, such as along the Ohio River alluvium, are ground water sources (springs and wells) sufficient to supply a large and concentrated population.

In Rockcastle County, existing public water supply systems are all derived from surface sources. Mount Vernon, the county seat, obtains water from an artificial impoundment, Lake Linnville. Other public systems in the county either obtain water directly from surface sources or indirectly by purchase from other systems that use such sources. Adjacent Jackson County, in which a minor portion of the study area is included, is largely supplied by a series of impoundments. The extension of public water supply lines into the study area will expand the percentage of population whose water is derived from surface sources.

(2) Rain water collection

Rain water collection systems serve to trap and store water derived from precipitation before it comes into contact with the ground surface and potential contaminants. Rainfall is collected by gutters from the roof of a structure such as the residence or a barn, and directed into a storage tank or cistern.

A rain water collection system that is properly constructed, maintained, and operated can provide water of acceptable quality for domestic use. A well-designed system includes several filtering components and a provision for diversion of roof water away from the storage tank (Fig 5a). Screening of the gutters excludes debris of larger size such as twigs and leaves. Secondary filtration of smaller particles is achieved by directing the collected rain water through sand and gravel filters.

As a roof may become coated with a substantial amount of dirt and grit between rainfall events, diverting

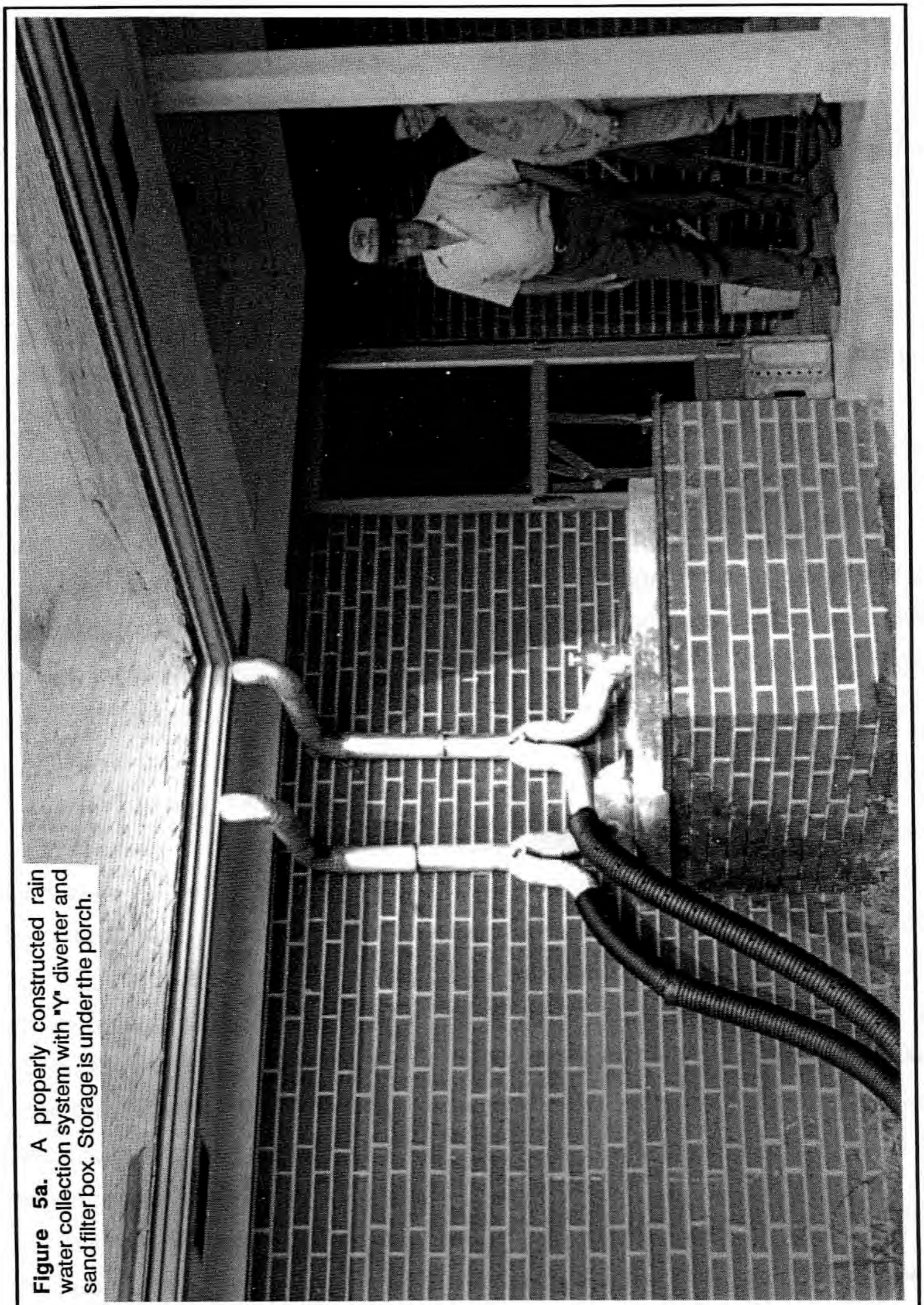


Figure 5a. A properly constructed rain water collection system with "Y" diverter and sand filter box. Storage is under the porch.

the first washing of the roof during a rain away from the storage tank by use of a manual or automatic cut-off valve allows cleaner water to be collected. According to a study made in northern Kentucky by the University of Kentucky, less than ten percent of domestic rain water collection systems used a roof prewash or diverter (Holmes and Taraba 1989, 3).

Rain water collection systems used in the study area varied from simple to elaborate. Some few were equipped with filters and diversions, others had only a direct pipe into the storage reservoir with perhaps a screen over the gutter downspout. The greatest variety was observed in the types of storage reservoirs used. While most of the storage reservoirs were mostly or partly underground to prevent freezing during cold weather, a few were free-standing and offered no such protection. One household, a mobile home, collected water from the roof into a rain barrel, using this source for washing. Other systems observed were constructed of concrete block or concrete cast in place. A practice common to several households was the installation of a previously unused cast concrete septic tank as a domestic water storage receptacle.

Most water storage systems in the study area were built as an integral part of the house so that the top of the tank served an additional function in providing a usable hard-surface. The most frequent such use was as a front, side, or rear porch to the residence, where the reservoir top extended one or several feet above the ground surface. These systems were generally custom-designed and owner-built, with one or more steps from the yard up to the top of the tank/porch and an access hatch in the upper surface. In one case, a very large double tank system, where the tops were set level with the ground, provided a hard surface for a carport and an enclosed room. The wisdom of such use, however, may be questioned because the water supply is thereby exposed to potential contaminants such as gasoline, oil and grease.

It should be noted that the use of cisterns or tanks for water storage was not limited to households collecting rain water but was a common practice for many households using other water sources. Accordingly, the term "cistern," as used in this paper, does not specifically indicate only storage of water derived from rain, because residents using other sources also store water in cistern-like structures. All households that hauled water or purchased hauled water were so equipped, simply because water must be stored for usage between loads. Many households depending upon spring flow also used reservoirs of some sort, although most well owners did not. A more detailed discussion of water storage may be found in Chapter Eight.

(3) Drilled and dug wells

There are two classes of well construction, dug and drilled. Examples of each kind were found in the study area. Dug wells are usually excavated by hand labor and most often are confined in extent to the soil profile, although some may be blasted a short distance into bedrock. As might be expected, most dug wells are of much greater diameter than drilled wells. Borehole diameters of dug wells in Kentucky, as reported in the well inventory of the state Division of Water, typically range from 36 to 72 inches and occasionally more. Reported depths for such wells seldom exceeded 30 feet. Dug wells usually have a liner of stone, brick or concrete to prevent soil caving.

The water source exploited by these shallow wells is in the soil and in the subcutaneous zone (soil/bedrock interface). Precipitation falls upon the land surface and infiltrates through the soil. Upon reaching the bedrock, this water follows the rock surface downgradient until a fracture or fissure is encountered that allows penetration to deeper aquifers. Because of the shallow depth of ground water tapped by dug wells, they are far more susceptible to potential contamination from surface sources.

Many wells constructed by hand labor exist in the rural landscape today, but the majority have been abandoned in favor of deeper, drilled wells. According to the 1990 U.S. Census of Population and Housing, of the 15.1 million American households depending upon wells for domestic water supplies, only 10.8 percent used dug wells. The proportions given for the general population are reflected almost precisely in the study area statistics. For the population studied, of the 19 households using wells for all or part of their water supply, only two wells, or about 10 percent, possessed dug rather than drilled wells. One of these dug wells was of recent construction; the other had been excavated by the grandfather of the current resident more than 50 years prior. Neither of these two wells extended more than twenty feet below the surface.

Bored water wells are constructed by several means, of which the two most common are impact and rotary percussion drills. The impact drilling rig, usually known as the cable-tool rig, has been in use in the United States since early in the 19th century and continues as a favored outfit for small operators. The cable-tool rig is operated by continuously raising a heavy steel bit and allowing it to fall in the same spot, gradually chipping away at the rock until a borehole of substantial depth is created. Depending upon depth, a well drilled in this manner may take from a few days to several weeks to complete. Rotary percussion rigs are capable of drilling a well in rock in a day or less, but are extremely expensive equipment and often beyond the means of the small operator. A large percentage of the wells in the study area have been constructed by one man, using a cable-tool rig, who has been in the drilling business for nearly 70 years.[1]

Since 1985, construction of water wells has been regulated by the Kentucky Division of Water. In many states, a permit is required to construct a well. This is not the case in Kentucky. Well contractors must be certified by the state, and are required to submit a well log and report to the Division of Water for each well constructed. The Division maintains a data base containing this information in addition to archives of the original well logs.

Construction of a water well is an expensive proposition for the rural householder, many of whom live below or near the poverty level. Charges for water wells installed by Kentucky drillers average $10-15 per foot of borehole depth. Additional costs for well construction include casing of the borehole, developing the well, and installation of the pump and associated plumbing to connect to the residence. A typical domestic well may cost $2,000 or more.[2]

Wells are sited on the property with regard to several considerations. The size and extent of the property on which the well is to be located comprise the initial limiting factors in well site choice. The purpose of the well is to obtain water, but the act of drilling a hole does not guarantee access to a usable amount of water. Accordingly, in theory, the well is sited within the existing boundaries to maximize the opportunities of obtaining water. In practice, there are additional considerations that influence actual well location.

Two important factors that relate the choice of well site to maximizing chances of obtaining water are the knowledge and experience of the driller, and local tradition or folklore concerning locating water. Factors not related to maximizing chances are the physical boundaries of the property on which the well is to be constructed, laws and regulations concerning well construction, and economic constraints of the householder/customer. The knowledge and expertise of the driller is an important factor in placement of a water well. This is not to say that all well drillers are highly educated geologists or hydrogeologists; in fact, most are not. The lack of formal training is in most cases more than compensated for by years of practical experience. The well driller in most cases has been employed in this profession for many years in a particular region and has gained an intuitive grasp of the characteristics of the local aquifers and consequently borehole placement most likely to yield water. Having assessed the physical characteristics of the customer's property, the driller will make recommendation as to where the well should be placed to most likely assure obtaining water. When the driller is constrained on a horizontal plane by other considerations, it is the experience of the driller that largely determines how deep a given well will be drilled - whether water is to be found at shallow depths or deep in the bedrock strata.

Choice of well location may also be influenced by local traditions or folklore about ground water, particularly in the form of water dowsing. It is not within the scope of this paper to evaluate the validity of water dowsing; there are learned papers both pro and con. Of recent papers on the subject, one of interest is a summary by Raloff (1995). The significance of dowsing is that there are a great many people, including some well contractors, that perceive dowsing as an important tool to use in locating water.

Within the study area is a man, 95 years in age and a resident of Dry Fork Road, who is highly regarded by many of his neighbors as a dowser, or, in local parlance, a "water witch" (Fig. 5b). Many of the wells in the region were sited upon the recommendations of this man, who now, nearly a century in age, is less active than formerly. In spite of his years, however, he still occasionally practices his art.

The "water witch" indicated that he favored dogwood for his divining tool. Of greater interest was his claim to "know where the water is coming from, and where it is going." He related several examples of his

[1] Interview with John U. Hamm, Mount Vernon, Kentucky, 1993.
[2] Cost information obtained by the writer through phone conversations with several drillers, 1995.

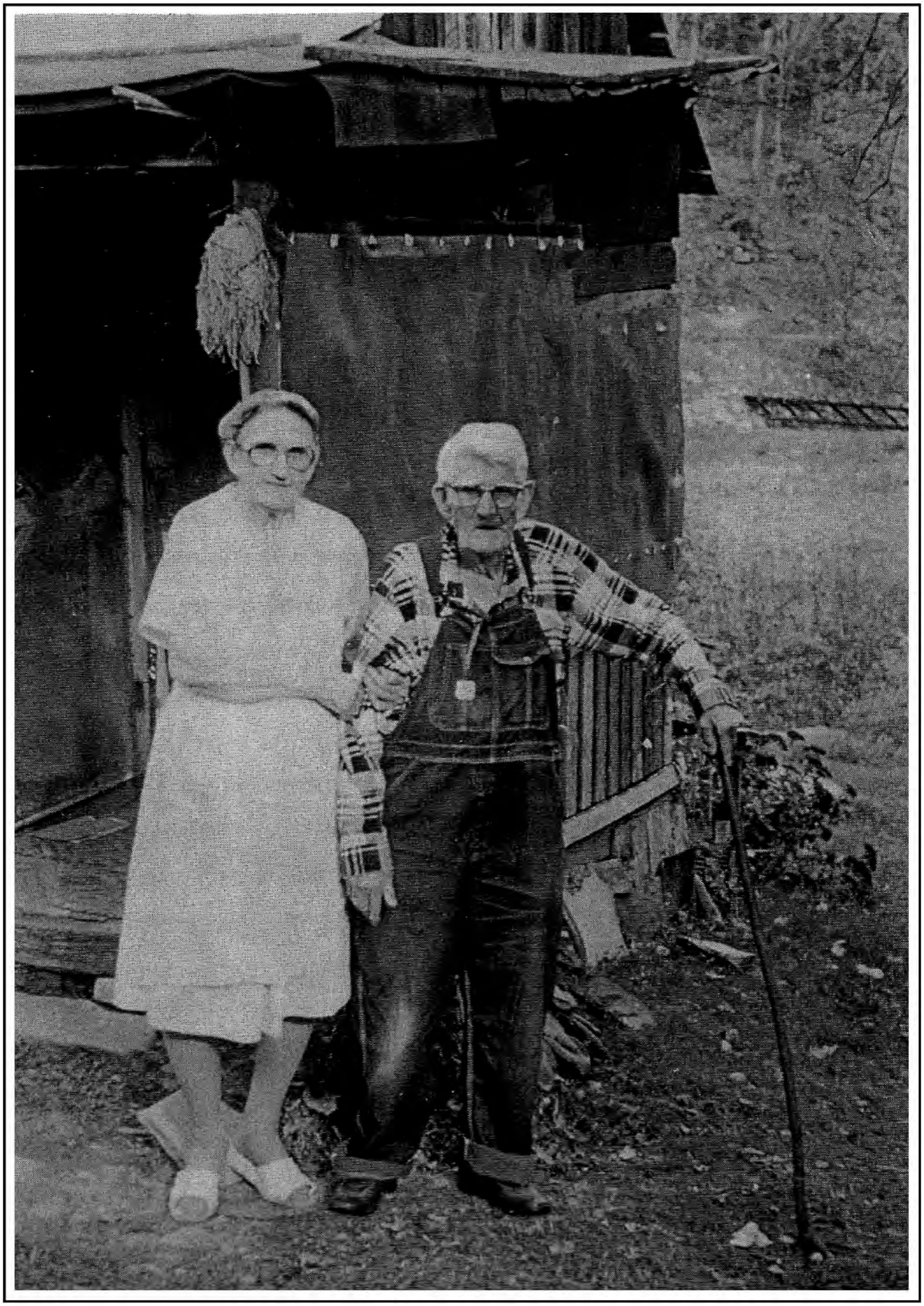


Figure 5b. Henry, a "water witch" or dowser well-known in the study area.

beliefs concerning local water flow. It is of interest that his untrained observations of local ground water hydrology were generally consistent with general principles of karst hydrology, although stated in informal terms. It appears likely that, from 50 or more years of experience as a dowser, this man, like the well drillers, had developed an intuitive understanding of local conditions.[3]

The boundaries of the property controlled by the resident for whom the well is built provide the primary spatial limits in which well site choice can be made. If the controlled area is large, such as farm acreage, boundary limits are less significant than other factors. If the property is small, less than an acre in extent as is common among many non-farm rural residents, then boundary limits may severely restrict choice of location.

Regulatory issues may also influence placement of wells. These issues, concerned with health and safety, do not recommend where a well should be placed but rather exclude certain areas of a property from consideration. Regulations of the Kentucky Division of Water require that wells be sited at prescribed distances from potential contamination sources such as pit privies, septic fields, sewer lines or fuel storage tanks. In some cases, where the size or other restrictions of the property will not permit these distance requirements to be fulfilled, variances may be granted. Regulations of this nature have only come recently into existence, and so apply only to new construction. As previously noted, Kentucky Division of Water regulations applicable to water wells have only been in existence since 1985. Most water wells in the study area predate these regulations, and so frequently have not been sited with regard to potential contamination sources.

Financial resources and the desires of the resident appear to comprise the most significant factors for determining the well location, capable of overriding all other considerations except those required by law. The driller's experience or the dowser's divination often matter less than the resident's desire to have the well located in a particular spot. The driller will of course ultimately bow to the wishes of the customer, although with likely a disclaimer of responsibility should water be found lacking or inadequate. The resident naturally desires the well to be placed as close to the point of use as possible so as to minimize the cost of connection. All wells in the study area had been built as close to the residence as possible, ranging from about six feet to fifty feet distant.

In summary, wells are not placed in random locations upon the property controlled by the household but rather are sited according to a variety of factors. These factors are a balance between the desire to obtain water, the beliefs of involved parties concerning how water may be found, legal constraints, and the financial resources available to construct the well.

Kentucky regulations require that the driller leave casing extending at least four inches above the ground surface, to reduce the possibility of contaminant entry from the surface. Well owners often subsequently cut off the casing so that the wellhead is buried underground. Possible reasons for this practice include aesthetics, so that an unsightly well casing is not visible; convenience, so that the well casing does not interfere with various activities such as mowing grass; or security, so that the well cannot be interfered with by other persons. A buried wellhead also prevents or hinders access to the well for cleaning or other maintenance. O'Dell (1992) notes that modification of wellheads after installation is a common practice in the study area. Figure 5c shows a properly constructed well house in the study area that aids in protecting this household's well from surface contamination.

The flow from some few wells was directed into a storage tank between the well and residence, to increase the amount of available water. Most wells were not equipped with storage capability other than that present in the borehole itself, and were connected directly to household plumbing. A few wells did not have a pump or plumbing system, so that water must be raised by bucket or bailer and carried into the home. Table 3 summarizes this information.

There were several households among the sample population that possessed a drilled or dug well which was no longer used but had been superseded by use of some other water source. One elderly man reported that he had discontinued use of his well about four years before as he was no longer able to haul the heavy bucket out of the well. As a consequence, this household purchased water delivered by a vendor.

[3] Interview with Henry McCracken, Orlando, Kentucky, 1995.

Characteristic	Well Type	
	Dug	Drilled
Number of reported users	2	17
Direct connection to house	2	16
Hand carried to house	0	1
Water directed to storage tank	0	2

Table 3. Characteristics of wells in the study area

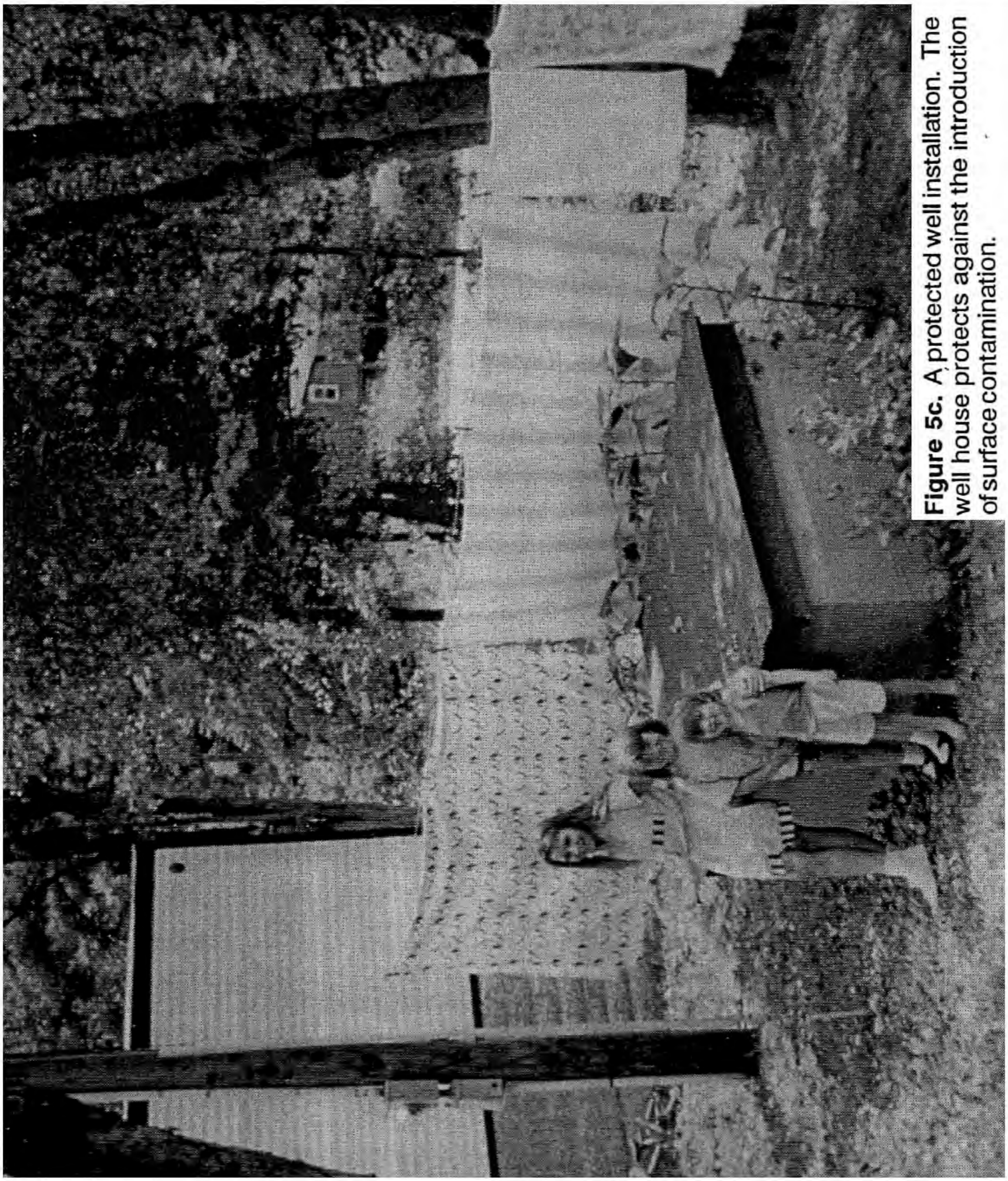


Figure 5c. A protected well installation. The well house protects against the introduction of surface contamination.

(4) Natural and created springs

As previously noted, the concepts of "spring" and "spring water" are somewhat difficult to define with precision. Although the United States Geological Survey and the American Geological Institute (AGI) define a spring as "a place where, without the agency of man, water flows from rock or soil upon the land or into a body of surface water" (Robertson and Edberg 1992), the present investigation uses a definition based more upon function rather than form. Accordingly, a spring is an outflowing of ground water onto the land surface that may be naturally occurring or may have resulted from an interception of the water table through human agency; well boreholes with artesian flow are excluded from this working definition.

By far the majority of springs in the study area are natural springs, of a nature that would qualify as springs under the USGS or AGI definitions. These natural springs are of three types, defined by the flow regime of the ground water that feeds them, which in turn derives from the media in which flow occurs: (1) Conduit-flow springs are characteristic of limestone bedrock and therefore occur at lower elevations within the study area (generally from 900-1,000 feet above sea level) where limestone is present. Thus conduit-flow springs are generally available only to valley residents in the study area. (2) Fracture-flow springs receive drainage from the network of fractures found in sandstone bedrock, and accordingly are characteristic of higher elevations, above 1100 feet. These fracture-flow springs tend to drain smaller areas and to be of lesser mean discharge than conduit-flow springs. (3) Subcutaneous-flow springs arise from the shallow flow carried in the subsoil and at the soil-rock interface. Where limestone bedrock is present at the surface, a network of dissolutionally enlarged channels has developed at the interface that carries the flow in an anastomosing pattern. Subcutaneous flow is present upon all bedrock types wherever there is a soil mantle, which is to say, almost ubiquitous throughout the study area.

The suitability of a particular spring for development as a domestic water source is dependent upon numerous variable characteristics of the spring and its physical setting. O'Dell (1992, 20-22) inventoried 55 springs of all types in what is a portion of the present study area. Only 15 of these springs were used as domestic sources; the remaining 40 springs had deficiencies of some type that had rendered them less desirable than those being used. Among the undesirable characteristics exhibited by the springs not used were: location in inaccessible terrain, limited flow, seasonal or wet-weather flow, remoteness of site, and obvious quality problems.

Such characteristics determine the potential use of a particular spring. Accordingly they are among the most important factors upon which choice is made by a water seeker whether or not to use that spring. These characteristics, discussed in general terms in the literature review, can be grouped into classes as accessibility, quality, and reliability.

Persons in the study area for whom it becomes necessary to choose a particular spring do so for certain reasons: (1) the spring they are currently using for the household is unsatisfactory and other springs exist on or adjacent to the property; (2) they are moving to a property where several springs exist and must decide which one to use; (3) they intend to move and will make choice of location according to the available water supply; (4) they do not have a water source on the property and engage in hauling water from a distant spring. This latter category is discussed later in this chapter in the section on public access springs.

It is probable that most persons in the study area do not have to make such choices often, perhaps never in their lifetime. Usually the water source decision has been made long in the past and the household continues to use the same source from tradition and because of the expense and difficulty of switching sources. When choice must be made, as under the conditions outlined above, usually the number of available choices is not great. Although there are hundreds of springs within the study area, few households (where geologic conditions favor spring occurrence) have access to more than one. This is especially true for the non-farm population, where individual property size is small. Some households are thereby required to use springs that may have some undesirable characteristics. For example, the only spring on the property available for use may be relatively distant from the residence, or subject to greatly reduced flow during the summer.

The relative elevation between a given spring and an existing or proposed home site appears to be an important factor in determining choice. The most desirable relative position for a spring is above the level of the house, so that water may be piped to the residence by gravity flow. This saves a considerable investment in pumping equipment and the recurring expense of electricity to operate the system. Increasing elevation of the spring above the residence increases the "head' or available water pressure. One respondent had two separate water lines run from his spring, which was located nearby at only a slight height above the house. One line operated under gravity flow and was used for most domestic purposes. The other line was attached to a pump specifically to provide sufficient pressure to operate a shower.

Springs that are located below home sites would be less desirable for use. The greater the distance that the spring is located below the residence, the greater horsepower capacity, and hence expense, required for the pumping system. In consequence, springs at lesser elevations than the residence were seldom used unless other alternatives were not available or not practical. In some cases, springs so located were among the most copious in the region, yet were unused because of their situations (O'Dell 1992, 34).

The relative elevations of springs to home sites in the study area is dependent upon factors of geology and topography. In the first instance, the slight tilt of the rock strata dictates that limestone formations are at higher elevations west and lower in the east. Accordingly, springs in the west and central sections of the study area are generally higher above the valley floor than those further east. Thus springs west and central are easier to exploit than eastern springs. The relationship of elevation, hence bedrock type, to water source used is strongly suggested by the fact that 87 percent of the 38 households below 1200 feet elevation (average point of contact between the sandstones above and limestones below) used on-site or adjacent springs as primary water sources, whereas only 20 percent of the 69 households above 1200 feet used springs (Fig. 5d). Those few households located at higher elevations that used springs were required either to pump water uphill several hundred feet or to use closer, but less desirable soil seeps they had developed as springs.

In the second instance, narrow valley confines somewhat limit the sites that are suitable for houses, in order to avoid building in a flood prone area. Along most of Crooked Creek in the central area, for example, the road that parallels the stream has been built 10-40 feet above the floodplain and many of the homes have been built at the same level. As a result, most of the springs along Crooked Creek are at a lesser elevation than the road.

In many parts of the study area where springs occur, there are fewer suitable springs than there are households wishing to use them. Because of this inequity, several households may share a single spring. While such arrangements are often informal understandings among neighbors, occasionally the rights of access have been specifically described and entered into the deed books at the county courthouse.

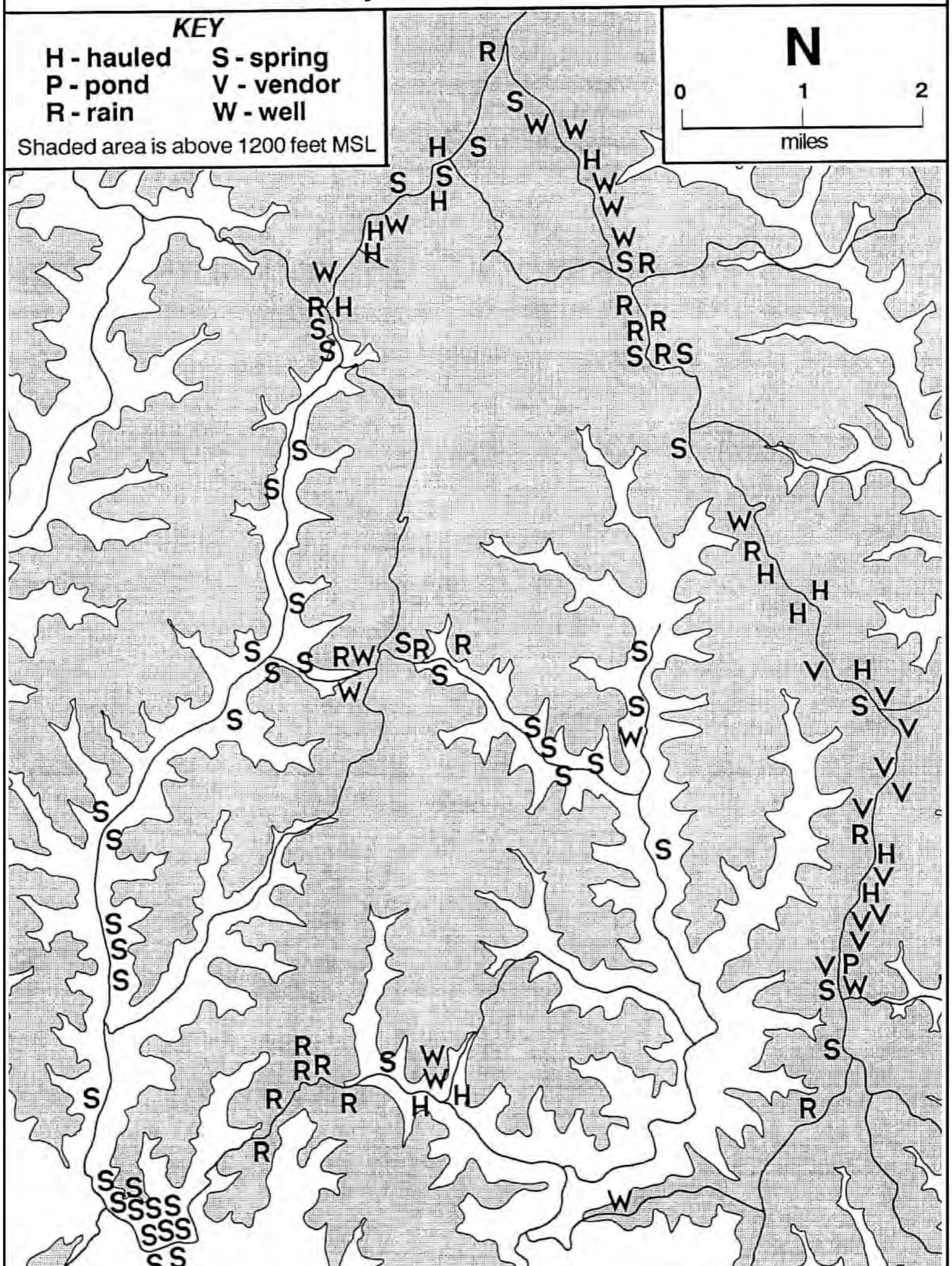
A water seeker will not, of course, deliberately choose to use water from a source that has overtly unpleasant aesthetic characteristics of appearance, taste or odor. In much of the eastern Kentucky mountain region, detectably high concentrations of iron and/or sulfur in ground water from wells and springs is frequently reported. Resource extraction activities, primarily mining and logging, also frequently have adverse effects on water chemistry and overall quality. Operations that disturb the soil, including agriculture, tend to increase the dissolved and suspended sediment loads of ground water.

Tangibly undesirable water quality characteristics tend to discourage selection of the particular spring in favor of one that has no detectable characteristics. These, then, are "push" factors, that push the water seeker elsewhere. There are also "pull" factors, that do not lend themselves to laboratory analysis. These are subjective factors that relate to the perceptions of the user, often concerning issues of taste or believed origin of the waters, and are variable from one user to another according to the worldview in which the user is embedded. The discussion of the aspects of individual perception in regard to water quality is considered of sufficient interest to warrant a separate chapter later in this report (Chapter Six).

The concept of reliability constitutes the last of the principal factors for water seekers choosing a spring as source. If a given spring is accessible, if the quality is agreeable, then is it dependable? Dependability to the spring water user means that there is some constant flow, no matter how little, throughout all seasons of the year. Even the most minute seep, as little as one gallon per minute, can provide sufficient quantity for a single household when the flow is captured and stored. A spring that discharges great volumes immediately following precipitation but ceases flow soon after (a "wet-weather" spring) is not suitable for domestic use. Similarly, springs that perform adequately during the "wetter" seasons of winter and spring but fail during the "dry" months of summer and early autumn ("intermittent" springs) are not suitable for household use.[4] Only

[4] See Chapter 4 for a discussion of the relationship among precipitation, stream flow, and seasons of the year.

Figure 5d. Elevation of Residence Compared to Primary Bulk Source Used



perennial springs are adequate for a domestic supply.

Modifications or improvements made to domestic-use springs in the study area ranged from minimal to elaborate. Even the most extensive improvements, with few exceptions, were of a strictly practical nature, intended to protect the water source or to render it more accessible. With only one exception, flow from all domestic springs used by the study population was conducted through pipes into the residence. Residents of a single household hand-carried water from their private spring. In this case, the spring was located at about the same elevation as the house so that gravity flow into the house was not possible and the occupants had chosen not to purchase a pump.

The simplest form of use observed was that in which the end of a run of plastic pipe leading directly to the residence was immersed at the spring discharge point, with no other improvements made. The most frequent modification, observed for 9 of 10 domestic springs in the study area, was to create or deepen a pool at the discharge by damming the flow or building a "spring box" around it. A variation, or often a supplement, to this was to direct flow into a holding tank just below the spring. In many cases, a protective structure was built over the spring to prevent the introduction of debris or to shield it from livestock or pets. Often this was as simple as a sheet of plywood or galvanized roofing placed over the spring box or holding tank and weighted with rocks.

The culminating protective structure is the spring house, which can be made of almost any material: wood, brick, dry-laid or mortared stone, concrete, concrete block, or galvanized roofing. Although spring houses are common in the central Bluegrass, only two households in the study area had a formal spring house (Fig. 5e). Among the most elaborate works of spring reengineering were those where subcutaneous flow was utilized; the efforts of one gentlemen to capture a limited flow through installing a system of buried collector pipes was described in the chapter on methodology, as part of the discussion on distinguishing between a well and a spring. Spring house construction is limited only by the budget, ability and imagination of the builder. The frequency and types of spring improvements in the study area are summarized in Table 4.

Category	Number	Percent
Total number domestic-use springs	47	100
Pipe line only, placed in spring	4	9
Small dam or spring box	41	87
Spring house structure	2	4
Gravity-flow system	24	51
Electric pump system	23	49

Table 4. Improvements to domestic-use springs. Total of percentages is greater than 100 due to multiple improvements for some springs. Water from one spring was hand-carried to residence but had been piped by gravity flow to a point nearby.

It appears that settlement patterns in the valley sections of the study area may be strongly influenced by the presence or absence of suitable springs. Houses are built where reliable springs exist; where springs are unreliable or absent, settlements have either not been made in these locations or have been abandoned. Many abandoned houses or house foundations were observed in the study area. When examined closely, it was found that in many cases the attendant water supply was very poor. In the valleys where this was observed, the springs were of marginal suitability, or possibly the flow of formerly adequate springs experienced a decline for one reason or another (see also O'Dell 1992, 31). Certainly this is only circumstantial evidence, but indicates an interesting area for future research.

A specific example of spring influence upon residence siting was related to the researcher by one of the respondents, who lives in the Dry Fork Valley. The man had long been dissatisfied with the reliability of the small spring that served his household, so that when the opportunity arose to purchase a few acres of land on the same road that included a very reliable spring, he moved his household to the new tract. In this case, relative characteristics of water supply motivated a change of residence.

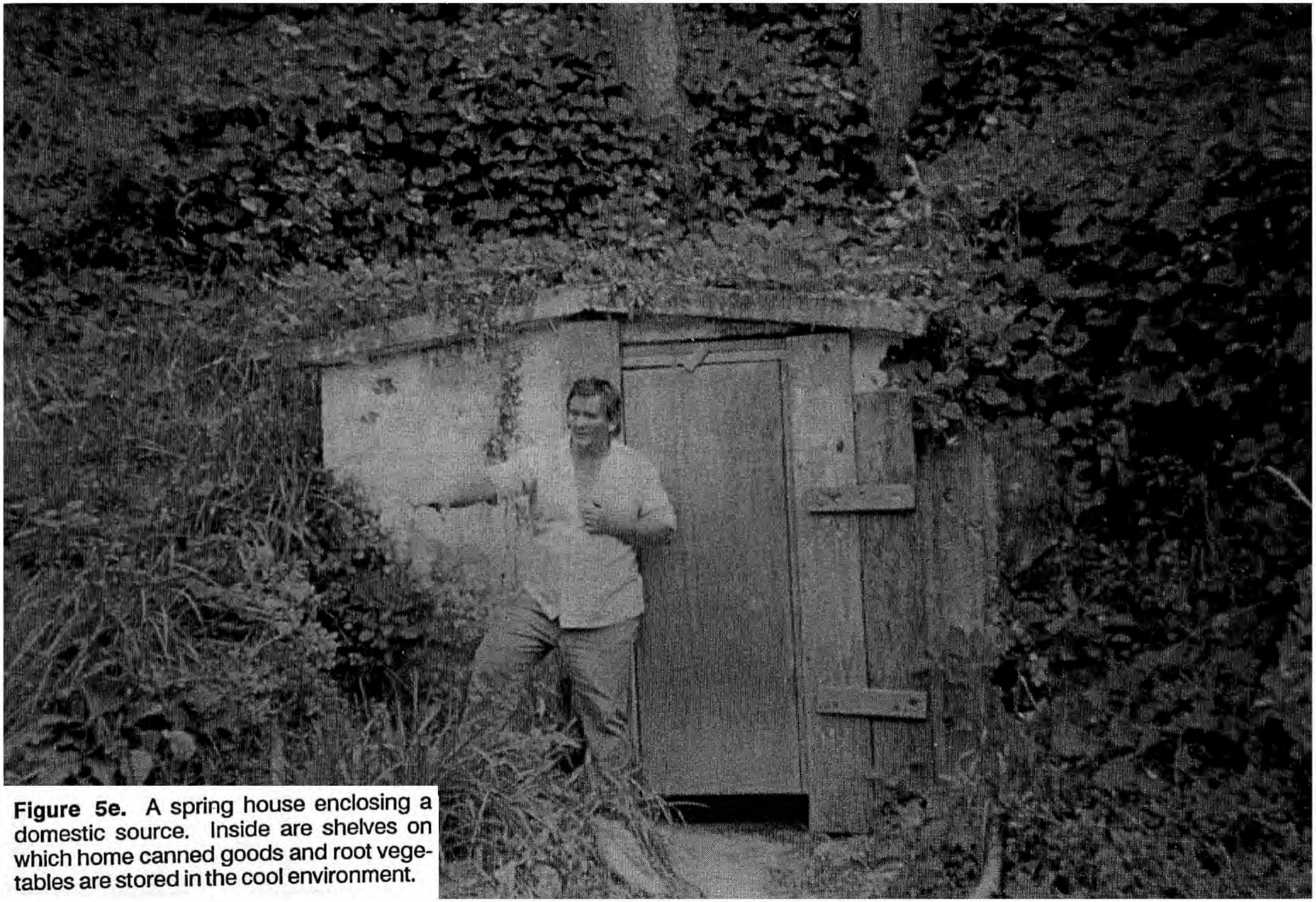


Figure 5e. A spring house enclosing a domestic source. Inside are shelves on which home canned goods and root vegetables are stored in the cool environment.

Off-Site Sources

(1) Bottled Water

The use of bottled water has both advantages and disadvantages. On the plus side, bottled water is often assumed to have purity equal to or better than "tap" water from public systems (Hurd 1993, 69), it is easily transportable, and it is available in a wide variety of locations. On the minus side, it is not feasible to use bottled water for any purposes other than drinking or cooking, as bulk use would be very expensive and require handling and transporting large numbers of individual small containers.

According to Allen and Darby (1994, 19) there are more than 600 brands of bottled water produced in the United States, in addition to a smaller number imported from outside the country. These various brands fall into two general classes that appeal to different market segments of the American population. One class consists of mineral and carbonated waters. The use of bottled waters of this class is favored by persons seeking health benefits, soft drink substitutes, or to conform with popular fashion. Such waters are not generally used in food preparation or domestic functions other than direct consumption. They are usually sold in small, single-serving containers. In recent years marketing of specialty waters has greatly expanded the number of styles, sizes and even flavors such as black cherry or lemon-lime.

These specialty waters are relatively expensive, often costing as much as a dollar per single-serving container. Accordingly, they were not favored as a standard, daily drinking water source by study area residents, many of whom reside in low-income households.

The second class of bottled water is intended to be a daily drinking water alternative and is promoted as such in advertising by bottlers. Most, but not all, of these products feature the words, "spring water," or a variant thereof, on the label. Bottling is almost invariably in standard one-gallon plastic "milk jugs" which are priced considerably less than the single-serving containers. A phone survey was made of eight retail stores in the immediate shopping region for residents of the study area. The shopping region was defined based on responses to survey questions that requested information concerning where the primary shopping needs of the household were met. The stores were located in Brodhead (1 store); London (3); Mount Vernon (1); and Richmond (3). Four of the stores were large discount operations; two Wal-Marts and two K-Marts. The remaining four stores were retail groceries; two were chain stores of the same outlet (Kroger) and two were independent, locally-owned establishments.

The discount stores, as expected, had the lowest mean price for bottled water, at $0.54 per gallon. The prices varied between Wal-Mart and K-Mart, but were identical for stores of the same company, indicating that price-setting was made on a regional rather than local basis. The two large chain groceries, or rather supermarkets, had prices that were slightly higher than the discount stores. The prices were different for each store, with a mean of $0.67 per gallon and a range of $0.04. This appears to indicate that pricing is more under the control of local store managers. Pricing at the independent groceries was substantially higher than that of either the discount stores or chain supermarkets. For these, the mean price per gallon was $0.87, with a range of $0.04. Admittedly, this is a small sample but does provide an indication of the range of pricing for bottled drinking water. None of the stores, when queried, indicated that they would give a quantity discount to purchases in case-lots.

(2) Public Supplies

The three local communities nearest to the study area are Sand Gap in Jackson County, nine miles east from the study area center; Livingston, eight miles south in Rockcastle County; and Mount Vernon, eight miles west in Rockcastle County. In each of these towns, provision has been made so that citizens can purchase water in bulk from public access outlets. These water outlets are located at the fire stations in the respective communities. The charges for bulk water are $0.50 per 100 gallons ($5.00/1000) at Sand Gap, $0.50 per 150 gallons ($3.33/1000) at Livingston, and $0.75 per 275 gallons ($2.72/1000) at Mount Vernon.

These public water supply "filling stations" are seldom used by the residents of the study area, for several reasons. The primary reason is that points of access to "city" water are more distant from the majority of residents than are the few well-known local roadside, or "public access," springs (see below and also Chapter Seven). A second important consideration is that of the terrain. There are very steep hills between the towns and the study area that are difficult to drive in a truck weighed down by a heavy load of water. Residents that haul water in bulk generally use light-duty trucks that are often strained to their load limit by a full water tank. A final consideration is that there is a charge for water obtained at the towns, however minimal, whereas water from the roadside springs is free to all.

Only four respondents hauled water from these filling stations on a regular basis. For three of these households, the water was used for bulk purposes only and was not consumed. Only one household was identified that hauled water from a public supply system for drinking and cooking. The family concerned consisted of two adults, two natural children, and six foster children. The agreement under which the foster children were supported required that they be provided with a safe drinking water supply; in consequence, water was hauled from the public water supply filling station at Sand Gap.

(3) Private Springs

A number of persons obtained water from springs on private property belonging to their neighbors, friends or relatives. In most cases, this was from a spring on an adjacent property where the water was directly piped to the household rather than hauled. In only one case was water regularly hauled from a spring on private property that was the domestic water source of another household. The spring in question belonged to the mother of the respondent.

(4) Public Access Springs

During the interview process, four springs (A, B, C, and D) were identified that served the population as public access water sources (Figure 5f). For the purposes of this paper, a "public access spring" is defined to be a perennial spring, generally not used as a private domestic supply, located next to a public road and easily accessible to persons desiring to obtain water. Such a spring is used by one or more households, other than that of the property owner, for part or all of their water needs.

As noted previously in regard to on-site household springs, the amount of flow appears to be a much less significant factor in usage than convenient access and year-round reliability. For example, spring C has the greatest discharge (>150 gpm, summer low flow) of any of the four public access springs, yet is used by the fewest number of people. Springs B and D have summer low flow of less than 2 gpm, but are used by a large proportion of those households that haul drinking water.

User numbers appear to be strongly influenced by the physical setting of the spring. Although spring C has a very convenient location, it has only a single user among the respondents. The spring emerges from the base of a limestone bluff adjacent to a good gravel road with sufficient parking for two or three vehicles. This location is only a few hundred feet from a well-traveled paved road. Despite the ample spring volume and convenient access, other factors operate to cause this spring to be less favored than others. Because this spring emerges at a low relative altitude, at the same level as the road, there is no easy way to fill containers or water tanks. Dipping containers into the flow risks gathering mud, sand or gravel along with the water, and is a very slow way to

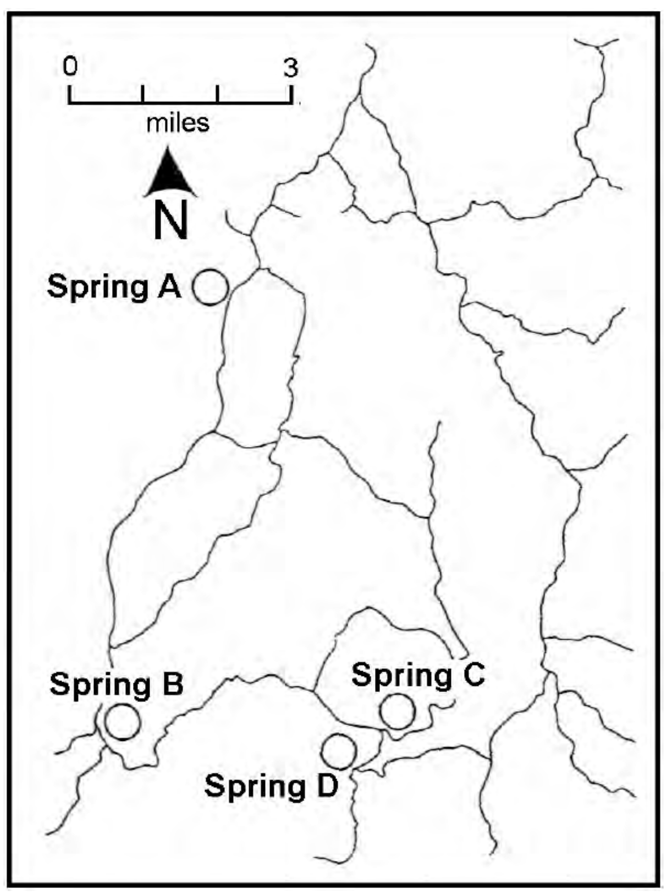


Figure 5f. Location of public-access springs.

fill a large tank. Unlike the other three public access springs, spring C does not have a discharge pipe. Small jugs or buckets might be dipped into the spring, but at the risk of also collecting mud or sand as the stream is only a few inches deep. In order to fill a large tank, the user must bring a pump.

Springs B and D are located next to the public road, but the spring originates higher on the hillside and has allowed a discharge pipe to be installed using gravity flow. The presence of a discharge pipe makes it easy for users to fill containers, and is perhaps a major factor in attracting users. The discharge pipes for these springs B and D are 0.75 inch ID polyethylene pipe. As the flow from spring D is very limited, a concrete holding tank was constructed many years ago into which the discharge pipe feeds. Persons using spring D generally dip water out of this receptacle rather than filling from the very slow trickle of the overflow pipe (Figure 5g). As a consequence of the limited flow from springs B and D, only small containers are hauled from these two springs as large water tanks would be difficult and time-consuming to fill. Eleven respondents (30 percent of the 36 households for which spring water is hauled) use Spring B, and four (11 percent) use Spring D.

Spring A is the most frequently used of the public access springs; 22 respondents (61 percent of total spring water haulers) reported use of this spring. There are a number of factors that operate in the favor of this spring. The spring emerges from the hillside near the Brush Creek Road, one of the two major transit arteries in the study area. This location is at the mouth of a small tributary valley, in the floodplain of Brush Creek, and the terrain is reasonably level. There is room for several vehicles to pull off the main road next to the spring. The ground surface in the parking area is hard packed rock and stream gravels, so that there is little chance of becoming mired. Spring A is also closer, in terms of travel time and distance, to a larger proportion of the population than springs B, C, or D. This spring therefore rates very high in accessibility.

The actual discharge point for spring A is located about thirty feet up the hill, and cascades down a series of rock ledges to form a small stream that flows a few hundred feet to Brush Creek on the opposite side of the paved road. Part of the spring's flow, as it drops over the ledges, is diverted by a short section of tin, shaped into a trough, to a 40 gallon plastic trash can. The top of the can is covered by a fine wire screen that prevents leaves and dirt from washing into the container. At the bottom of the can, a 2-inch diameter galvanized pipe fitting was installed. Attached to this is about 200 feet of 2-inch polyethylene water line that carries water down to the bottom of the hill. An elevation difference of about 20 feet from the receptacle to the pipe's discharge provides for a substantial pressure on the line. The end of this pipe is only about 50 feet from the paved road.

Because of the relatively large flow volume available from this spring, it is suitable for filling large truck-mounted tanks of 250-gallon and greater capacity.

(5) Water Vendors

Respondents for 17 households reported obtaining all or part of their domestic water supply by purchase from one of three regional water vendors. None of the vendors was resident within the study area. Two vendors operated from Rockcastle County; one vendor operated from adjacent Jackson County. These vendors purchased water from public outlets in the local communities of Mount Vernon, Livingston and Sand Gap and resold to households in the region, delivering in tanker trucks with capacities from 1,000 to 1,500 gallons. Public system water was the only source used by vendors; none transported water from springs or other local sources.

Characteristics and practices of these households with respect to water purchase are discussed in Chapter Seven.

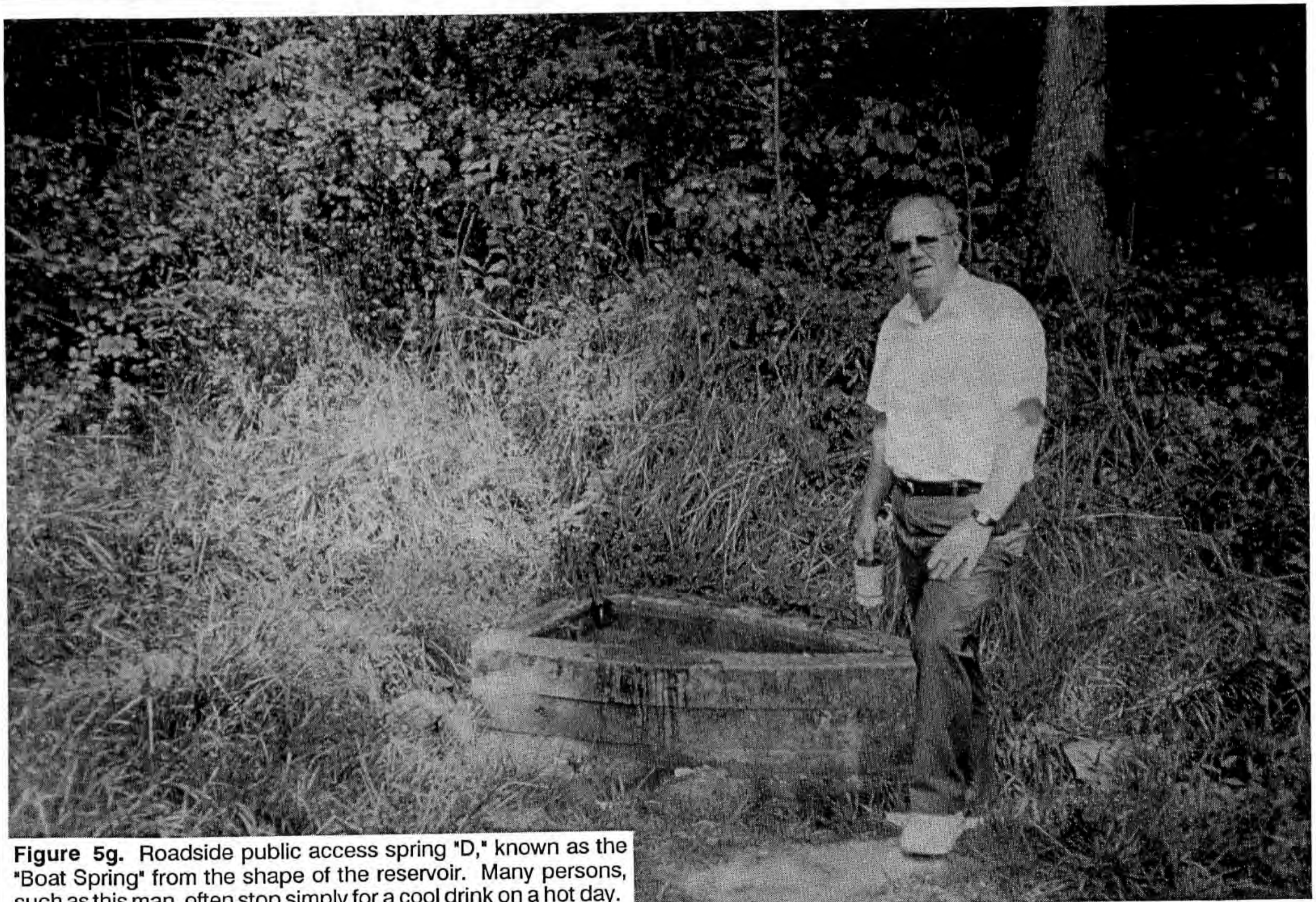


Figure 5g. Roadside public access spring "D," known as the "Boat Spring" from the shape of the reservoir. Many persons, such as this man, often stop simply for a cool drink on a hot day.

Chapter 6

PERCEPTIONS OF WATER QUALITY

Water Quality Factors

The quality of water available from a particular source is important to the uses that can be and are made of that water. "Quality" is not an absolute, but rather a relative concept that can vary according to the intended use, the context of such usage, and the individual user's culturally derived perceptions.

Pure water is colorless, tasteless, and odorless. One of the most significant properties of water is an ability to react with many substances, to the extent that it has sometimes been called the "universal solvent." For this reason, absolutely pure water is never found in nature but contains dissolved minerals and other substances, as well as suspended particles. Even water distilled under laboratory conditions is not absolutely pure.

The concept of water contamination is contextual and subject to differing interpretations. Certain substances dissolved in water are sometimes considered desirable and sometimes not. In the latter case, they become water "contaminants." In addition, substances may be considered desirable in low concentrations but undesirable at higher rates. Fluoride, for example, when present below a certain concentration, has been demonstrated to have a beneficial role in preventing dental caries but causes tooth mottling at higher concentrations (USEPA 1991,13). Similarly, calcium is an element necessary for human growth and development, but at relatively high concentrations causes water to be "hard" (low sudsing ability) and results in encrustation of the interiors of water pipes.

There are numerous substances, often occurring as solutes in natural waters, that are considered undesirable or that may even be harmful to human health. Substances such as arsenic, mercury and lead, which may derive from sources in nature or as a result of human activity, and many complex organic compounds, such as pesticides and industrial solvents, are considered to be very undesirable water contaminants. In addition, water may contain pathogenic microorganisms, such as those responsible for hepatitis, typhoid, or polio, that constitute serious threats to human health.

Drinking water standards, as set forth in the 1974 Safe Drinking Water Act, the 1975 National Primary Drinking Water Regulations, and subsequent revisions, attempted to set guidelines for allowable concentrations of non-biological contaminants and for indicators of microbial contamination. The fact that such guidelines are constantly being revised indicates that expert opinion diverges as to the concentrations at which such substances represent a real threat to human health.

Water quality assessment for the self-supplied individual usually consists only of evaluation of factors that are apparent to the unaided senses. These factors include aesthetic qualities such as appearance, color, odor, and taste. Some aesthetic factors can be measured analytically, such as color, or else the root cause can be so measured, for example the concentrations of chloride compounds that give a detectable salty taste. In practical terms, evaluation of aesthetic factors is strictly a subjective and highly individualistic process. Water from a particular source that is acceptable or even highly desirable to one individual may be unacceptable or even despised by another.

An example of differing perceptions of desirable qualities for drinking water is found in the Rockcastle study area, in the case of a woman who had a preference for sulfur-flavored water. Water that contains a high proportion of hydrogen sulfide has a strong smell best described as a "rotten egg" odor, and an equally strong flavor. Most persons would find water with a high concentration of hydrogen sulfide to be highly unpalatable; water with this characteristic was one of the water quality problems cited in eastern Kentucky by Conrad, *et al* 1991 and 1992. The woman in the study area, in contrast, expressed her preference for sulfur water, the stronger the better, claiming that it "settled her stomach." She described three separate kinds of sulfur-flavored ground water: (1) clear with a sulfur odor, losing its scent and flavor a few hours after exposure to atmosphere; (2) brown, strongly flavored and scented, gradually declining in strength over a period of several weeks; and (3) black, capable of holding its sulfury character indefinitely. Her husband did not share her taste for sulfur.

Assessment of water quality, whether conducted objectively through laboratory analysis or subjectively through individual perception of detectable factors, strongly influences the end use for water from a particular source. Water that is assessed, by whatever means, to have the greatest purity, is assigned to the highest categories of usage. The highest categories of water use are those in which water is taken directly into the human body and hence has the greatest potential for good or harm. Lower categories of use are successively removed from direct contact with the human body.

This concept is reflected in federal and state statutes and regulations that attempt to classify actual and potential water use according to quality. The Environmental Protection Agency's Water Quality Standards Regulation (40 CFR 131) describes various uses of surface waters that are considered desirable and should be protected. Among these uses that involve human contact are: (1) drinking water; (2) primary contact recreation; and (3) secondary contact recreation. The relevant points are that drinking water use involves ingestion; primary contact (swimming, water-skiing, skin-diving, surfing) involves immersion and potential ingestion; and secondary contact (wading, boating, fishing) involves only partial immersion and no ingestion. This constitutes a hierarchy for the extent of human water contact and, accordingly, the guidelines for purity of each of these classes are succeedingly less strict (USEPA 1994). Kentucky regulations (401 KAR 5:026 through 031) concerning classification of surface waters are virtually identical to those of the EPA.

The EPA also addresses classification of uses of ground water according to quality, "based on drinking water as the highest beneficial use of the resource" (USEPA 1986,15). The EPA classification essentially divides ground water supplies into those that are currently and potentially sources for drinking water, and those that, because of poor quality, are not suitable for drinking water supplies.

Batchelor (1975, 209) distinguishes three classes of water use: sanitary (bathing, clothes washing, dishwashing, toilet flushing); cleaning (car washing); and culinary/horticultural (cooking, gardening). Batchelor's classification is based solely on the function for which water is used. Inherent in his classification is the assumption that water quality is constant for all uses.

Respondents in the study area used a different scheme for classing water, basing function upon perceived quality, reserving the highest quality waters for human consumption or direct contact.

Accordingly, the writer proposes a hierarchy of domestic water use categories based upon the amount of contact (Table 5).

Extent of Contact	Form of Domestic Water Use	Necessary Water Quality
INGESTION	Drinking	HIGH
	Cooking	
	Dishwashing	
	Personal bathing	
IMMERSION	Filling swimming pools	
	Laundering	
SUPERFICIAL	General cleaning	
	Water gardens & lawns	
NEGLIGIBLE	Wash cars	
	Flush toilets	LOW

Table 5. Relative water quality / domestic water use hierarchy

The water use/water quality hierarchy proposed above evolved from the observed and reported practices of the households in the group studied. The survey questionnaire differentiated only between two classes of water use: (1) water used for drinking and or cooking, and (2) all other uses; also termed "bulk" usage. The ranking of uses within these two categories (such as the relative importance of water quality for drinking versus bathing) was not investigated in detail but was estimated from comments and anecdotes related by respondents. This classification assumes that there are perceived differences in water quality, and that water of the highest quality is used for the highest purposes. When water users have a choice among sources, water from sources perceived as superior would serve for purposes involving the most intimate contact (drinking, cooking, bathing), whereas water from sources perceived as inferior would be reserved for indirect or non-contact purposes. The above classification is intended only as a generalization, with the caveat that there are variations in the ordering of significance among individuals and cultures. Accordingly, perception of the relative ranks of various domestic water uses remains a field for further investigation.

Perceptions of Water Quality from Differing Sources

The respondents' perceptions of water quality from various supply sources was evaluated in several ways. Among the means to evaluate these perceptions were questions included in the survey instrument that asked them to: (1) rate the quality of their primary water supply source on a scale; (2) describe specific water quality problems of their source, if any, that were continuous, seasonal or occasional; (3) indicate the uses made for each water supply source; and (4) express their opinion as to the best source type for drinking water. In addition, anecdotal information was collected from the respondents on this subject.

Respondents were asked to rate the quality of their primary water supply source on a scale from 1-5, with 1 being very poor and 5 being very good. Those who responded to this question were classified into two groups, households using only a single water source and those using multiple sources. For the first group, the sole source provided drinking water as well as all other needs. For the second group, in all but one case, the source rated was not used for drinking water but provided for bulk water uses only. There was a substantial difference between the responses of these two groups (Table 6).

	Sole Source Households		Multiple Source Households	
Source Type	N	Mean Rating	N	Mean Rating
Well	12	5.0	5	3.2
Rain water collection	1	5.0	15	2.9
Spring, transported from	7	4.9	4	3.7
Spring	42	4.8	2	3.5
Vendor, purchase from	2	4.5	2	4.5

Table 6. Comparison of respondents' ratings for source used by sole-source households and by households using multiple sources. For the multiple-source households, the source rated was not used for drinking water.

The results shown in Table 6 indicate a high level of satisfaction among the sole-source households with the source used; this is presumably why they continue to use only a single source. In contrast, where multiple sources were used by a household, the source used for bulk water needs, such as laundering, was rated much lower. All but one of these households obtained drinking water from a source off the property, most often by transporting water from another spring or purchasing commercial bottled water. The on-site water, which rated so poorly, was usually described as having one or more objectionable characteristics, such as a musty taste, sulfur odor, or red color.

Although many persons used rain water collection as a supplemental source, only one person considered it to be suitable for drinking. Water purchased from vendors was rated high in quality by both groups; it may be that those who purchase from vendors but obtain drinking water elsewhere may do so more out of personal preference for the taste of an alternate source rather than from a perception of "city water" as poor quality.

One question that proved very revealing in this regard asked respondents to indicate their personal preference for a drinking water source, regardless of whether or not that source was currently used by the household. The results from this question are shown in Table 7.

The expression of a widespread distaste for drinking water supplied from public systems was quite striking. Of 107 respondents, only three indicated a preference for so-called "city" water as a drinking water source. Only rain water, chosen by a single respondent, was viewed with less favor. Water from local springs was overwhelmingly the preferred drinking water choice for more than three quarters of the group studied. Well water and bottled water ran a distant second and third place. Several respondents indicated that they saw little difference between spring water or well water and that either would be acceptable. If the tabulation is modified to distinguish combined groundwater sources (wells and springs) from other source types, then groundwater is favored by 93 households or 87 percent of the group studied.

Source of Drinking Water	Respondents' Preference: Number of persons choosing this option	Respondents' Preference: Percent of total respondents (N=107)
Spring water	83	76
Well water	15	14
Bottled water	11	10
"City" water	3	3
Rain water	1	1

Table 7. Expressed drinking water preference. Numbers in parentheses express percentages. Sum is greater than 107 (100%) because some respondents expressed more than one preferred type.

It would seem very likely that the expressed preference for a particular drinking water source is influenced by the type of source that has been historically used by the household, in that preference may be dictated by traditional custom. Indeed, many respondents stated that "I was raised on spring water" (or well water), giving this as a reason for their preference. Table 8 compares the expressed preference with the drinking water source type currently in use by the household.

Existing Drinking Water Source	N	Respondents' Preference (in percent of users of source indicated)				
		Spring water	Well water	Bottled water	Rain water	"City" water
Spring water	78	88	5	5	0	3
Well water	16	50	50	0	0	0
Bottled water	9	33	11	44	0	11
Rain water	1	0	0	0	100	0
"City" water	9	44	11	33	0	11

Table 8. Expressed drinking water preference compared to actual source being used. Total number of existing drinking water sources exceeds total number of respondents (107) because some households use more than one source for drinking water. Percentages do not add to 100% because of rounding errors.

It appears from the data represented in Table 8 that there is a strong relationship between the drinking water source currently used by the household and the expressed preference for drinking water source. This is as might be expected, given that tradition has a considerable impact upon preference. Even so, it is of interest to note that for three of the existing source types, springs, wells, and public water system, respondents indicated that spring water was either preferred or shared equally in preference. Only for those who drank commercially bottled spring water did local spring water take a greatly diminished importance; this is not necessarily a difference in kind as bottled water is usually portrayed as spring water on the label. It may be that this preference represents a greater concern over health issues held by users of bottled water. Note that the pattern of preferences expressed by drinkers of bottled water and "city" water is very similar. In both cases, preference for bottled water and public system water is greater than expressed by users of other sources.

Another way to assess the perception of water quality from various sources by respondents is to compare usage of different sources for drinking water and bulk supply for those persons using multiple sources. Thirty-four (32 percent) of the 107 households interviewed in the study area used different sources for drinking and for bulk purposes (Table 9). Two additional households used two separate sources interchangeably for all household needs but are not listed in this compilation.

		Drinking Water Source, Percent Using				
Bulk Source	**N**	**Spring water**	**Well water**	**Bottled water**	**Rain water**	**"City" water**
Spring water	7	43	29	29	0	0
Well water	3	100	0	0	0	0
Rain water	16	69	13	13	0	0
"City" water	8	50	0	50	0	0

Table 9. Drinking water source compared to bulk water source for 34 households using multiple sources

Perhaps the most striking feature of Table 9 is again that rain water, while easy to collect, is held in such low esteem. First, not one household chose rain water as a drinking water source. Second, it was primarily those households collecting rain water that obtained drinking water from another source.

Although rain water collection systems are particularly susceptible to shortages because of meteorological vacillations, water used for drinking and cooking constitutes only a minor fraction of household water demand. Thus, the need or desire to obtain drinking water elsewhere cannot be dictated by a scarcity of water from the supply commonly used for bulk purposes, unless that supply fails completely. The disfavor in which rain water is regarded is apparently attributable to considerations of perceived water quality. Among reasons given by respondents for not drinking collected rain water were a "concrete taste" from the storage reservoir (although many residents drink water from other sources stored in this way); lack of filtering; fear of contaminants derived from air pollution; and a seasonal souring of the water each spring from washed-in pine pollen. One respondent stated, "it's pretty nasty, there's always bugs and frogs and snakes and stuff in there."

The next significant feature of the data in this table is that spring water by far is the preferred source for drinking water among those who choose to obtain drinking water separately from their main source. It is of interest that the three well users all sought spring water, thus making a distinction between well and spring water even though both are derived from ground water. Similarly, of the six users of spring water in bulk, three obtained drinking water from an entirely different spring, indicating that there are perceived differences even among springs. Given these figures, and taking into consideration that 54 of the 71 other, single-source, households in the study area (76 percent) use only local spring water for all their needs, spring water is evidently considered as superior to all other sources.

Viewpoints concerning water quality were expressed by many respondents. This was particularly true concerning spring water and water from the local public supply systems. Although not specifically addressed by the survey, most respondents indicated a familiarity with water from various sources, having sampled them at one time or another in their lives. Because public water supply lines were projected to be extended into sections of the study area in the very near future, this was a frequent topic of discussion among residents and hence water and water supply in general had occupied much of their thought.

Water from public supply systems: "city" water

In an article examining the causes of a waterborne outbreak of hepatitis A in Meade County, Kentucky, during 1982, Bergeisen, Hinds and Skaggs (1985) stated:

> Many people in rural Kentucky drink untreated water from springs and wells. Anecdotal reports suggest the chlorine taste and expense of city water as possible explanations. Perhaps for the same reasons, some people who have access to city water also drink well or spring water (p. 163).

Although this statement minimizes the important consideration that many rural residents simply do not have access to city water, it does provide some insight into reasons why city water was rated as less desirable than most other water sources in the study area.

Perceived objectionable qualities of taste and odor were most often cited by respondents as reasons why "city water" was undesirable. These allegedly unpleasant characteristics were primarily attributed to the chemicals added during the treatment of public system water, and to the chlorine in particular. Among comments by respondents concerning chemicals in city water were such as:

> "You can taste the chemicals in city water."
> "I couldn't drink city water with all that chlorine in it."
> "City water will kill a fish in a minute. That chlorine makes some people's hands break out."

Other comments in this regard were less specific and simply reported a general distaste for public system water:

> "I hate city water, it tastes nasty."
> "It smells bad, doesn't taste right."
> "I can't stand the taste of city water.
> "Can't stand the taste of it, can't stand the smell of it."

A few persons indicated that public system water degraded the taste or quality of foods or beverages made with it. Two persons stated specifically that city water ruins the taste of coffee.

One especially interesting aspect of the issue of public water system quality that became apparent through the interview process was that while most respondents did not care for city water, water from certain public suppliers was regarded as still more objectionable than that from others. In this particular situation, water from the Mount Vernon system was universally deplored whereas that from Sand Gap was seen as the lesser of the two evils.

The Mount Vernon water supply is withdrawn from a large lake that is adjacent to both the city and to Interstate 75; the highway in fact comprises the dam for the impoundment. The lake is highly visible to the population of the county as they travel about the region on their daily business. According to comments by several respondents, the lake is seen as an inferior water supply source and any treatment given to the lake water by the city system regarded as ineffective. The lake was viewed somewhat as a mysterious body of water in which virtually any harmful thing could be present, hidden in the depths, and passed along to the unsuspecting consumer. As one respondent confided, "...it's bad water, it comes out of the lake. They've found dead horses, pigs, even people in there." Another alluded cryptically to this situation, saying about the Mount Vernon water, "It tastes bad...we know where it comes from." Another man stated, "My mom lives in Mount Vernon. You get a glass of that water and hold it up to the light, it's cloudy." A more scientific and plausible theory for the alleged poor quality of Mount Vernon water was offered by one resident, who noted that the lake "turns over" at certain times of the year, resulting in poorer water quality.

This latter notion has a basis in reality. The "turning over" of a lake is a seasonal phenomenon that results from the stratification of layers of differing temperature within water bodies, the subsequent development of convection currents and mixing of the layers. An overturn and mixing of the layers of water occurs both in the spring and in the autumn, with an attendant mixing of oxygen and nutrients. The water treatment processes that are used by public systems should be able to easily cope with any quality problems caused by either stratification or overturn, but a local resident with just sufficient knowledge to be aware of the phenomenon may not be aware of this.

In any case, the water from the city of Mount Vernon has acquired an evil reputation among many of the residents of the area. This reputation may in part derive from actual differences in taste between treated, piped water and untreated water from local springs that are perceptible to persons accustomed to the latter. Another possible cause for the poor reputation of Mount Vernon water may have been the occasional unfavorable reports in the local newspaper concerning public health issues. For example, the Mount Vernon water system was prohibited from line expansion for several years because of low pressure; expansion would have reduced line pressure still more and increased the likelihood of bacterial contamination. This may be something of a case of the self-fulfilling prophecy: the population, reading that the public water system is having problems and may become contaminated, soon imagines that they can actually taste contamination.

Numerous respondents in the study area reported that friends or relatives, who resided in local towns, did not care for the taste of public system water and carried drinking water home whenever they had occasion to visit the rural areas. Often this water was obtained from the domestic spring of the friend or relative being visited. In one example, the grown daughter of one household spent a portion of each year as a student in residence at Eastern Kentucky University, and transported drinking water from her parent's spring to her dorm room because she preferred the taste of water upon which she had been raised. Similarly, another household reported that a married daughter residing in a nearby town hauled about 30 gallons per month from the household spring to use as drinking water. In yet another household, the respondent reported that her mother, a Mount Vernon resident, and her sister-in-law, living in Brodhead, both obtained their drinking water from the respondent's spring. Many other similar cases were cited by respondents.

Perhaps the most telling example of this sort was related by a woman respondent who worked as a counselor in a social services office in Mount Vernon. As she did not care for the taste of the local public system water, she became accustomed to bringing a gallon jug of spring water, for her own use, from her own home spring to work at the beginning of each week. This coming to the attention of her co-workers, they requested that she also bring additional jugs of spring water for their use. At the time of the interview, this respondent stated that she habitually took as many as ten one-gallon jugs of spring water to her place of employment each week for her co-workers.

Not only was water transported by town-dwellers from the springs of their friends and relatives in the study area, many residents of local communities also transported drinking water from the roadside public-access springs. Random spot-checks of the origins of water-transporters at these springs confirmed that many of them were town residents. Some had come from locations as distant as Lexington or even Cincinnati. In these cases of more distant locations, hauling of spring water was not necessarily a routine activity, but rather one that was undertaken when a visit was made to the study area for some reason. Many such persons were former residents who had moved away in the past in search of economic opportunity elsewhere but still retained strong ties to the region.

Not everyone in the study area maligned city water. One elderly man was accustomed to drinking well water until he became too frail to raise the bucket and began to purchase public system water hauled by a vendor. This man stated that he found the "city" water to be every bit as good as his well water had been. In another case, a young woman with a new baby had recently forced a change in her household to the use of public system water for drinking, because "there could be stuff in spring water." One man, who preferred the taste of local spring water, stated: "You don't know what is leaching into the ground. Even though city water tastes crappy, I know it's safe."

Ground water from springs and wells

The content and quality of ground water is highly variable from one spring or well to another and even for the same source from season to season. The ambient or background characteristics of ground water are first dependent upon the local geologic structure and the rock strata with which ground water flow comes into contact. Just as rock types differ in their chemical composition, the waters contained within those rocks reflect the nature of the host rock in the types and amounts of minerals that are dissolved or suspended. It is not within the scope of this research to attempt a detailed chemical characterization of ground water in the study area, except to note that there can be significant differences among sources. Ground water, spring or well, cannot be considered as a uniform substance.

As previously noted, there are three broad classes of springs found in the study area, categorized according to the bedrock from which they issue and the flow regime therein. These classes are conduit-flow, characteristic of limestone rocks; fracture-flow, characteristic of sandstone; and subcutaneous-flow, derived from the soil or the soil-rock interface. For simplicity, these spring types can be referred to as limestone springs, sandstone springs, and seeps. Drilled wells are generally found on the uplands and intersect fracture flow; shallow dug wells intercept seepage from the soil or soil/rock interface. The following discussion of attitudes concerning ground water quality focuses upon springs. Except where this discussion concerns installation and maintenance costs, similar attitudes were often expressed about water from wells.

The reasons given by respondents as to why they favored the use of spring water over other potential source types generally fell into three categories. Springs were valued either because they were more economical to develop and maintain than other sources, from a sense of tradition and continuity, or for a perceived superior taste and quality. In many cases, these rationales operate simultaneously to promote the use of springs.

A strong motivation for the use of spring water is the low cost of developing a spring source. In many cases, particularly where the relative elevations between spring and residence allow gravity flow, all that is required is to lay a length of inexpensive polyethylene pipe and possibly to create a small pool by a crude dam a few inches high. "Spring water is plentiful and free," as one respondent put it; a gift from the earth. With a gravity-flow system, there is no need for expensive pumping equipment and no electric bills eternally to pay.

Tradition and continuity are important motivations for behavior. One of the most common opinions voiced in support of the superiority of spring water was that the respondent had been "born and raised" on this water type, implying that if there was something wrong with spring water, they would not be here now in good health. One woman stated that "spring water is the best kind. I raised eight kids up on it." Several respondents indicated that the use of spring water was a "way of life" in the region. One man stated, "God put spring water here for drinking. It's the best water."

Superior taste and quality of spring water was cited by numerous respondents as the primary motivation for use of spring water. One man said, "Spring water tastes better, I can taste the difference." He then admitted, "But I guess it's what you get used to." This sentiment was echoed by another respondent, in regard to her preference for well water. This is a significant point, and suggests that there is an acclimatization process involved in long-term usage of food or beverage. Change in itself, from a taste to which one is accustomed to an unfamiliar taste may constitute an unpleasant or disturbing experience. As one respondent stated, "spring water doesn't have a taste...that's the way water is supposed to be."

It may be that users of spring water have become so acclimated to water that lacks a distinctive taste that they are overly sensitive to the chemicals used in treating public system water. Conversely, it seems likely that persons who are long accustomed to drinking "city" water have become inured to the "chemical" taste. The sense of taste is strongly connected to the sense of smell, and it is known that the olfactory nerves become desensitized to a particular odor after continuing exposure. Long-term use of public system water apparently does not impart loyalty. Several residents reported that they had moved away from the region to towns or cities, for periods of up to 30 years, and upon their return "home" had immediately reverted to spring water usage.

Some respondents in the study area do not view all springs to be equal in quality. This was demonstrated earlier in this chapter by the simple fact that two households chose to transport water for drinking from springs that were different than those from which they obtained water for other domestic needs. Although most persons transporting water from roadside public-access springs used the spring that was located nearest to their residence, some few persons preferred to go farther afield to a spring they favored more highly (see Chapter Seven). Several persons indicated a preference among the differing classes of springs (limestone, sandstone, seep). Sandstone spring water was viewed as "softer," easier to lather. One man stated that he preferred limestone spring water to "bubbling" spring water; presumably by the latter he meant the carbonated, commercially bottled product. One man attributed the bad taste of his well water to variations in local geology: "Water in the rocks here is different from water up the road - different rocks."

Making a distinction among springs appears to be a minority viewpoint, as respondents expressed opinions about springs in the abstract more frequently than they were specific. It appears likely that respondents voiced opinions based upon their experience with one or a few springs but saw no difficulty in embracing springs in general.

Some respondents cited specific reasons for their use of spring water. One woman indicated that they transported water from a local spring for the sole reason that she considered spring water to be the best for making iced tea. Another woman, where the household supply was a drilled well that provided a highly mineralized, briney water, routinely walked over to a neighbor's house to obtain spring water to wash her hair.

Numerous persons reported their intent to continue using spring or well water for drinking even after piped public system water becomes available to them. In such cases, those persons who had been accustomed to transporting their drinking water planned to continue; those that were provided with water by a domestic spring or well adjacent to the residence indicated that they would maintain a separate line. In the latter case, some stated they would like to have a spring water tap on their kitchen sink next to the public system tap. Other persons stated their intention to have a spring water hydrant in the yard. To prevent backflow, for reasons of public health, state law prohibits cross-connection between a private system and a public system. Having knowledge of this, one man in the study area who recently built a new house, constructed two separate plumbing systems.

Few of the springs used as domestic water supplies consistently exhibit any overtly poor aesthetic qualities. Two springs in the study area, both on Dry Fork, were reported by O'Dell (1992) to have strongly reddish water, indicating a high iron concentration. Neither was then used as a water source, although they had been domestic supplies in the past. According to the residents, the springs began to show red water shortly after mining operations in the vicinity, and use of the springs was discontinued for that reason. Three of the respondents in the current investigation reported iron in the spring currently used that was controlled by use of filtering or treatment devices. The 1992 study also reported an unused spring on Crooked Creek that displayed a puzzling milky white flow. This was later determined to be the result of reclamation operations on an old abandoned strip mine above the spring; the milky flow resulted from heavy lime (calcium carbonate) applications made to reduce acidity. During the current study, another resident of Dry Fork reported having a milky flow from his drinking water spring that had lasted for two years before returning to normal. This was probably also attributable to strip mine reclamation occurring on the ridge above the residence.

Three of the above springs that had shown visibly poor water quality were domestic use springs; of these, two were abandoned as sources for that reason. The households in question were able to convert to other springs on their property. In the last example, the resident continued using the spring for domestic purposes, having no alternative.

Many springs in the study area that normally run clear under normal conditions will often have a brief cloudy or muddy flow following heavy rains. This "flashy" flow characteristic is indicative of a direct connection to the surface and that water flow in karst conduits does not undergo any filtering. Of the 44 households in the group studied that drank and cooked with water from a spring on their own property or adjacent, 15 (34 percent) reported that the spring usually ran muddy after a moderate to heavy rain. Most such households ordinarily discontinue drinking or cooking with the water for 24 to 48 hours after substantial rains. A few households reported keeping a supply of water stored in plastic milk jugs, to be used during the short periods after rains when their springs ran muddy.

It is of interest that the presence of chemical contaminants, such as iron or sulfur, that produce a strong detectable color or odor, were considered sufficiently objectionable to cause abandonment of the water source. In contrast, cloudiness resulting from suspended calcium carbonate or heavy turbidity - muddiness - did not. This is particularly significant in that iron and sulfur, while perhaps objectionable, do not constitute a significant health risk whereas suspended sediment does. The presence of suspended sediment indicates a direct pathway from the surface for bacterial contamination of the water. In addition, suspended sediments offer a surface to which microorganisms can attach. Spring water users are evidently far more tolerant of silt and sediment in the water supply than of visible mineral contaminants.

Only a few persons expressed any concern about possible contamination of ground water drinking supplies. The woman, accustomed to spring water throughout her life, who had switched to bottled water after having a new baby, was an exception to the general belief in about spring water purity. More typical was an attitude expressed by one respondent: "I know a lot of [spring] water is contaminated with chemicals and such but I still think spring water is best."

For some people, so strongly held are beliefs about the purity of spring water that they are unwilling to accept evidence to the contrary. As part of a separate project, the investigator conducted monthly water testing for a year of 30 domestic-supply ground water sources (both springs and wells) in the study area. These samples were analyzed for fecal coliform bacteria, an indicator of potential contamination by sewage. Copies of the test results were hand delivered to each home during the following month. The residents of two households where the water supply demonstrated an alarmingly high level of bacterial contamination refused to believe the test results. One man stated, "I don't care what that paper says...my well has got good water." The other person stated simply, "Our spring has good water. We never pay any attention to [the test results] any way."

This sort of skepticism may also result from other causes in addition to a trust in spring (or well) water purity. For many households, the existing source is the only one to which they may have access. To abandon using this source, or to install expensive water-treatment equipment, would likely be viewed by the household as an extreme hardship. Hence it is easier to disbelieve, particularly when the purveyor of bad news is a representative of a bureaucracy. The spring owner refused to allow her spring to be tested further; the well owner was willing to continue but had no interest in the results. The simple, undeniable truth was that, in their viewpoint, although the water sources tested as contaminated, no one had dropped dead as a result. Many water-borne diseases, however, are difficult to distinguish from gastrointestinal disorders arising from other causes, so that a person made sick by contaminated water may simply attribute the illness to the "flu."

For some persons, unwillingness to believe may result from overexposure. One household would not allow water testing because, they reported, three different agencies had already been by to test their water in the last year and they were tired of being bothered about it. The lack of credibility placed in water-testing is perhaps best shown by the statement of one respondent:

> The EPA comes down here and checks [Spring B], they set at the spring until people come by, they told them it was pure water...then you read in the paper that they said it was bad water. This has been going on a long time, every couple of years they come in and stir up a stink about it. We've heard it all before. The water company stirs up trouble because people from Mount Vernon come here to get water from the springs and don't have to pay for it.

To this man, the reports of bacterial contamination in local spring water were simply scare tactics instigated by the local water company to keep people from using any water but their own product.

Perceptions of Groundwater Flow

Only in recent decades has the general nature of karst ground water flow, hidden as it is in the depths of rock beneath our feet, come to be partially understood. Even today, hydrogeologists who are unfamiliar with karst terranes often mistakenly assume that ground water flow in limestone can be modeled using the same Darcian equations that apply to flow in granular aquifers. If ground water professionals can hold mistaken assumptions, we should not criticize rural dwellers who lack formal training in geology for beliefs that may not be consistent with reality.

In 1872, George W. Ranck, eminent historian and resident of Lexington, Kentucky, wrote:

> The irregular disintegration of the limestone layers has caused the formation throughout the whole of this region of extensive caverns, and underground lakes and streams of water, as well as numerous sink-holes. Such lakes and streams doubtless exist under the valley of the town fork of Elkhorn quite extensively (Ranck 1872,417-418).

Only a few years later, when Lexington was gripped by a severe drought in 1879, a town resident suggested that a giant well be bored into the rock "until they pierce the cavernous reservoir that everyone believes underlies Lexington" (Dugan 1953,12-13).

The belief that springs are outlets from vast subterranean lakes and rivers has persisted to the present day and is often expressed by both the educated and unlettered alike. Although there are, rarely, pools of water underground that might be considered small lakes, ground water flow in limestone occurs in a dendritic network of conduits very similar in morphology to that of surface streams. Ground water in karst flows from an area of recharge to a point or points of discharge and does not repose in vast subterranean bodies.

Certainly every resident of the study area, and most likely of the region, is aware that there are numerous and extensive caves in the hills and mountains along the Cumberland Escarpment. As one long-time resident observed, "the hills are all hollow." While this is not literally true, virtually every ridge contains a cave and every valley a spring. Understandably, this situation leads to beliefs of the sort expressed by one respondent: "The mountain is a honeycomb of caves and streams. There is probably a big lake under there, it comes out in about four different places."

The important point to be made here is not that some local residents do not well understand karst hydrogeology, but that they have a sufficient practical grasp of cause and effect to be aware of how their water supplies might become contaminated. Reports from respondents demonstrate that many of them understand that hazardous substances that come into contact with the ground surface can ultimately contaminate ground water, even at some considerable distance. For example, one resident suffered the onerous chore of water hauling rather than having a well drilled, because there was a cemetery on the adjacent property. In another instance, the respondent stated that he applied no pesticides anywhere on his farm because he did not want to risk contaminating his spring.

Time after time, the investigator was told, as the respondent pointed up the hillside behind his or her home, "there's nothing up there to hurt my water. Nothing but trees. Nobody lives up there." This, and the previous examples, indicate that most persons seem to recognize that land use activities above the water source can have a harmful effect.

This recognition apparently only holds, for the most part, concerning chemical contaminants or those derived from point sources. Non-point source pollution is not so well recognized, yet this is most likely the most prevalent form of water contamination in the region. As the area is rural, remote, and mostly forested, there are not likely to be many point sources of contamination, such as discharge of industrial wastewater. Non-point source pollution in the region results from agriculture, logging, coal mining, and on-site sewage disposal. Of these, mining is probably the least significant, as mineral extraction is practiced only a very minute scale in the immediate region.

On-site sewage disposal is likely the most significant, resulting in bacterial contamination of water supplies. Until very recently, pit privies and burial of sewage lines was commonly practiced. Today, most residences are equipped with septic tanks and fields. Recent investigations, however, indicate that septic fields are not very effective in karst regions because soils are thin and waste is able to infiltrate directly and rapidly into conduit aquifers (Crawford 1992).

Row crop agriculture, because of the narrow valleys and equally narrow ridgetops, is only practiced on a small scale. Where crops are grown on valley bottom lands, water supplies are not affected because the limestone aquifers flow at higher elevations. Chemicals applied to tobacco acreage and kitchen gardens on ridgetops stand a greater probability of entering ground water systems. Livestock production presents a significant hazard, in part because many people do not recognize the potential for water contamination from cattle manure. Of particular note was one domestic-use spring observed by the investigator, deriving its flow from soil seepage, that was situated at the lower end of a cow pasture so that all the drainage from the pasture obviously came to the spring.

Logging is an important contributor to degradation of water supplies in the region, as it is extensively conducted throughout the study area. While some loggers take care not to disturb the soil more than absolutely necessary and leave many trees to hold the soil, others are less concerned. Because timber commands a higher price today than formerly, the rate of logging is increasing. As a consequence, soil erosion occurs in the logged-over areas and results in increased levels of sediment in ground water. Thus, although respondents may feel safe because "there is nothing up there but trees," the removal of those trees constitutes a significant health hazard by carrying microbial contamination into the ground water through soil erosion. It has previously been noted that residents seem little concerned over the presence of muddy water;

only to the extent of temporarily discontinuing use when turbidity is visibly evident.

As a result, residents of valley areas remain at risk from the activities and practices that are conducted on the slopes above them. In the study area, most valley residents depend solely upon springs for their drinking water supplies. In addition, numerous residents of higher elevations, where karst springs do not occur, either use springs derived from soil seepage (and hence highly vulnerable to contamination) or haul drinking water from certain springs.

One respondent summed up the attitude of many of the residents of the study area: "I like the taste of that cold water coming out of the mountains." This statement and attitude conveys the image of pristine waters springing from deep within the rocky bones of an ancient mountain. Not only is this the image that the purveyors of commercially bottled spring water wish to convey to the public, it is largely the image that the rural self-supplied users of untreated spring water also cherish.

Chapter 7

WATER USAGE PRACTICES AND PATTERNS

In previous chapters, the regional and local context of water supply and the various forms manifested by potential water supply sources in the study area were described. "Push" and "pull" factors that influence choice among different sources or among sources of the same type, when choice must be made, were discussed, as were ways in which certain source types were modified to increase the accessibility and availability of water. The present and following chapters are concerned more with the everyday behavior of the population in regard to obtaining and using water. Practices and patterns of water usage are examined in terms of both individual and group behavior.

Source - user relationships

Figure 7a presents a simple conceptual model of possible relationships among sources and users. "A" is the most elementary form, a user solely dependent upon a single source used only by that household, a basic one-to-one association; "B" shows multiple users of a single source; and "C" shows multiple sources with one user. Each of these relationships was found to be present in the study area. Although a classification scheme such as this appears simple and straightforward, the investigation of the study area revealed that the spatial relationships among users and sources were incredibly complex.

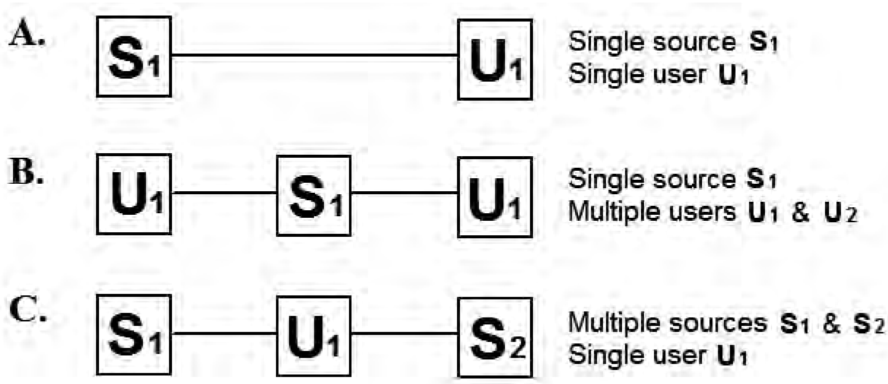


Figure 7a. Conceptual model of water source - water user linkages

Water supply in the study area should be considered an open system, in that not only are there connections among users and sources internal to the study area, but there are also external connections. These external connections take the form of users, living outside of the study area boundaries, that use water sources within the study area for all or part of their domestic water needs. In addition, residents of the study area may obtain water from sources external to the study area.

Furthermore, relationships are not static but dynamic. The major factors influencing temporary source changes are climatic; change is often forced on a seasonal basis when usual sources may be stressed, and water yield is reduced. Long-term or permanent changes may also be induced by physical factors that affect the water source, or by a change in personal circumstances. Some possible changes in circumstances for a household that may prompt a decision to change sources include: (1) change of domicile to an existing structure where supply source is perceived as inadequate or undesirable; (2) change of domicile to a location lacking a pre-existing water supply system, as in new construction or placement of a mobile home; (3) increased household affluence allows upgrading; (4) increased number of persons in household renders source inadequate; (5) a detrimental change occurs in the quantity or quality of the existing water source; (6) water delivery system breaks down; (7) cost of obtaining water by traditional means increases; or, (8) public water lines are extended into the area.

To facilitate analysis of these associations, it was necessary to examine them at several different levels, and to examine them from the separate perspectives of both user and of source. The basic level of analysis examines customary relationships between households and sources used for bulk supply and drinking water, considering only patterns involving residents of the study area and under benign weather conditions when sources are not stressed. The analysis becomes more complex when considering the effects of the use of water sources in the study area by non-residents, and changes that occur on a seasonal basis, or during extraordinary times of stress such as regional drought. Tables 10 and 11 provide summaries of the basic source-user relationships in the study area.

Nearly two-thirds, or 66 percent, of the households studied depended upon a single source for all water needs, either from a source on the property or transported from elsewhere (Table 10). Of this group of 71 sole-source households, 62 percent used springs located on their property, 14 percent transported water from a distant spring, 15 percent used wells, 7 percent purchased water from a vendor, and 1 percent used rain water only. Only 8 percent of sole-source households relied upon sources that were not derived from ground water: rainfall and "city" water purchased from vendors.

Source Type	N	Percent
Spring	44	62
Well	11	15
Spring, transported from	10	14
Vendor, purchase from	5	7
Rain water collection	1	1

Table 10. Sole-source households classed by source type. Total N = 71 households.

Table 10 contains information corresponding to that reported previously in Table 6, but includes all of the respondents using a sole source and not just those who answered the quality rating question summarized in Table 6. Similarly, Table 11 contains some of the same information found in Table 9, but uses more categories in order to present a clearer picture of the actual complexity of water source choices.

	Drinking Water Source							Total cases
Bulk Source	Spring	Well	Rain	Bottled	Vendor	Haul Spring	Haul City	
Spring						2		2
Well				1		3		4
Rain water collection	1	2		1		12		16
Vendor				4		2		6
Spring, haul from		2		1			1	4
"City" water, haul						1		1
Pond				1				1
Total Cases	1	4	0	8	0	20	1	34

Table 11. Bulk water source compared to drinking water source for those households using multiple supply sources. Two cases, where multiple sources are used for all water needs interchangeably, are not represented in this table.

Two or more sources were used by 36 households to meet their water requirements. All but two of these households used separate sources for bulk needs and for drinking water. These two households, which used two separate sources for all water needs without differentiation in usage, are not included in the data for Table 11. Of the 34 households represented in the table, only three used different sources on their own property; each of the three possessed a rain water collection system for bulk needs supplemented by either well or spring water for drinking. All other multi-source households used transported water in some form, either from local springs, commercial bottled water, or purchased from vendors. Neither rain water nor purchased water was used by any multiple-source household as a drinking water source. In the former case, the previous chapter described the low regard for rain water quality as perceived by many residents. In the case of vended water, since drinking water is required by households only in relatively small quantities, it is not necessary to purchase in bulk.

Seasonal, and exceptional, climatic conditions that affect the volume of flow of surface and ground water can disrupt the usual patterns of water supply. For the total 81 households that customarily used an on-site supply for all of their bulk needs, 16 (20 percent) reported that they frequently or occasionally were required to supplement their supply during the summer or fall months by transporting water. For some households, this is an annual task that occurs in summer or autumn; for others, only in unusually dry years.

Other meteorological conditions that can result in water shortage include the effects of extreme cold and of storms that cause power outages. Many of the water lines that supply individual water systems from springs are not buried, since bedrock is usually close to the surface, but are simply laid atop the ground. Households where water lines are exposed generally allow water to run continuously from an indoor tap during cold weather to prevent freezing of the line. During the winter of 1994-95, the investigator noted a sign taped above the kitchen sink in one household, where the water was left to run in this fashion, that stated in bold letters, DO NOT TURN OFF!! This was intended to serve as a reminder to the members of the household. In extremely cold weather, this tactic does not always work. Affected households must obtain water by other means until the frozen line is thawed, either by deliberate effort or a moderation of the outdoor temperature. If temperatures are very cold, and the parts of the water systems are not sufficiently protected, other forms of water supply such as that from wells or cisterns may also be rendered temporarily unusable by freezing. This situation is certainly not unknown to city dwellers as well.

Storms during any season, with strong winds or accumulating ice, can also be responsible for temporary cessation of supply from private systems, by interrupting the electric power that operates pumps. Households where the water is directed into the house under the impetus of gravity naturally do not have this concern. Many other systems, however, require that water be pumped. This is true for nearly all wells, for springs which lie below the residence or only slightly above, and for any system where water is stored in large receptacles, whether the original source is from rainwater, transported spring water, or purchased water. During the interview process, many respondents recalled that severe icing that occurred in the winter of 1993-94 had resulted in a power outage that had lasted for up to two weeks. During this period, many households that had seldom or never before needed to transport water were required to fill containers at the local public access springs for domestic use. Two respondents reported that they had purchased portable electric generators against the chance of sustained power outage.

As these incidents indicate, the nature of the water supply situation for self-supplied households is extremely volatile and can only be categorized by snap shots in time. The patterns of use vary from season to season and from year to year because of the influence of internal and external factors.

Sources that are used by multiple households represent complex behavior patterns, involving sharing of a resource. There are three types of water resource sharing: public sources, where users are not necessarily known to one another; private sources shared by non-adjacent households where users are known to one another; and private sources shared by adjacent households. Depending upon the class of shared arrangement, the ratio of users/source can range from only a few households per source to tens or even hundreds of thousands.

Public water supply systems, where water is piped into private homes, are an obvious source type where the majority of users are not personally known to one another. Such systems constitute the most intense level of shared use, as water utilities in the largest metropolitan areas may have customers numbering in millions. In the study area, users of water from public systems were represented only by those few households that purchased from vendors or themselves hauled from community water outlets.

The other form of shared public access to water in the study area consisted of the various roadside springs used by households that transport water. While many of the households using these springs are known to one another, many are not well acquainted. The four such springs in the study area are not public water supplies in a strict legal sense, as they are located on private property and no fees are charged for use. As a consequence of their convenient roadside locations, absentee ownership and benign non-interference by property owners who have allowed modifications to the sources, and lack of governmental regulation of usage, such springs function as informal public water supplies. For certain springs in the study area (notably springs A and B), estimated households obtaining water number in the hundreds. The intensity of use is certainly greater for these springs than is that of many community-based public water systems in Kentucky.

The first of the two forms of shared water use where users are known to one another but do not reside adjacent to the water source is that in which transport of water from springs on private land is limited to selected persons known to the property owner. In the usual practice, users are relatives or close friends. From a strictly internal perspective, taking into consideration only residents of the study area, only four examples of such practice were reported. One case involved a well, and three involved springs. In the instance of the well and for one of the springs, drinking water was obtained by an adult offspring, resident in the study area, from the parent's source. Reasons for this practice, involving tradition and perception, were discussed in the chapter on water quality. In another case, the adult son hauled all household domestic water used from the spring of his parents. For the final case, where water from the existing well was briny, the woman of the household obtained spring water from a neighbor to wash her hair.

When the boundaries are extended to include users who reside outside the study area, a greater magnitude is observed. Including the previous four examples, 11 households reported that non-residents obtained water from their domestic supply. In all but three cases, the persons obtaining water were relatives, usually adult progeny. One of the most extreme examples was the case in which water was obtained from one study area household by four adult offspring, each resident in separate households in Mount Vernon, Scaffold Cane, and Burr. In another example, previously reported, water was taken to the users, rather than the converse, by a woman who gave a gallon jug of her home spring water to ten of her office co-workers each week. While only these 11 actual cases were reported in response to the survey, the writer suspects that the practice is more widespread and so ordinary that respondents often may not have considered their non-resident children or other relatives as users when in fact they were.

The investigation discovered 7 cases in which single water resources were shared in common by adjacent households, piped into the residence of each. These 7 instances were comprised of groups of from 2 to 10 households, and represented 24 percent of the total households in the population studied. Six of the 7 user groups were supplied by springs, and one group of two households shared a drilled well.

In some cases, the rights of access to the water source were embedded in an informal understanding among the users. In other cases, these rights were set down in formal legal language in deed books of the Mount Vernon courthouse. Following is an example of one such agreement concerning a shared spring:

> WITNESSETH: Whereas grantees have constructed water lines from a spring located on the hereinafter described property, and
> Whereas, grantors desire that grantees have an easement for said water lines;
> NOW THEREFORE in consideration of the foregoing, grantors hereby grant and convey unto grantees water rights and the hereinafter described easement to an improved spring located...
> (Deed Book 127:294, 13 March 1986).

One of the seven user groups was a compact assemblage of households that constituted an informal functional community. Most housing in the study area is strung out along the roadways, so that the settlements of Climax and Three Links assume the form of linear villages. In contrast, this community was established on a single tract of land on one side of the road in a tight cluster form. This community owed its origin and maintenance to close ties of kinship. It was organized around the household of the parents, the largest and most favorably located structure, with satellite homes of the adult offspring situated about it. Also present was a business establishment, a sawmill, that was the common property of the family group. This community shared a common bulk water source, a spring (although drinking water sources varied).

Frequently, in the study area, adult offspring chose to buy or build a home very near to that of their parents, often next door. There are numerous examples of groups of two or three households in the study area that consist of parents and children, although the water supply was not always shared in common. Three of the 7 user groups, previously mentioned, consisted of close family relations. In addition to the water user group described in the previous paragraph, there was in the study area another small community, similar in form, that also consisted of households of adult offspring surrounding the residence of the parents. In this community, however, the members did not have access to a common water supply and so the sources used varied considerably by household. Because of the close kinship, and in the former case, the shared water infrastructure, these housing clusters to a certain extent functioned as communities rather than isolated dwellings.

In contrast to the above situations, the largest of the 7 user groups, although using a common piped water supply derived from a spring, did not function as a community. The group consisted of persons who were distantly related or unrelated, and the households of the users were spread out linearly over more than a half-mile of the roadside. The 10 individual users did not have daily contact with one another, although they shared the resource. Another indication of the lack of unity for this user group is found in the arrangement of the water supply delivery system.

Water was piped from a fracture at the contact of sandstone and limestone bedrock to a square reservoir holding about 1,500 gallons. An overflow pipe directed water from this reservoir to a second storage tank of approximately equal capacity. The overflow from this tank filled a trough in a nearby field for the use of the property owner's cattle. The allocation of water from the first reservoir went solely to the household of the owner; the remaining 9 households shared the overflow into the second tank. Although this may not appear at first to be an equitable arrangement, all users stated that they had never run out of water.

The importance of access rights

The previous quotation from the deed books of the Mount Vernon courthouse, concerning allocation of water rights among the multiple users of a single spring, is a good example of how the rights of access to water have sometimes been formalized. Continued access by households to their traditional water supplies is so important that provisions are frequently seen in property transfers as conditions of sale that guarantee the use of the water to the seller. One such example from the county records follows:

> Grantors hereby reserve the right to use, during their lifetimes, water from the spring on the above-described property for their own non-commercial, domestic and farm use (Deed Book 154:702, 19 August 1994).

Another example does not limit the right of access to only the lifetime of the seller:

> The grantor reserves unto himself and heirs forever a right to take water from a spring located upon said land (Deed Book 80:112, 20 February 1962).

Both of the above examples concern springs used by households in the study area. Not only is access to the spring itself considered important, but it was necessary to be able to have the right to maintain the supply line:

> ...grantors retain an easement to maintain a water line which crosses the above described property (Deed Book 130:331, 12 February 1987).

In this case, the supply line extended more than 2,000 feet from cave spring to household. Over the years since the line had first been laid, the tract containing the water supply system had been broken up into smaller parcels. The owner felt the need to secure continued access to water in a formal manner.

The legal formalization of agreements concerning water rights in the region is generally the exception than the rule. Rights of access may need to be spelled out only when a group shares a water source in common, or when a portion of a property is sold and the original owners remain dependent upon a water source on the land sold. Most often, water sources are shared in an unstated agreement among the users. In at least one case, however, failure to formalize the rights involved led to dispute and eventual loss of the source. At Orlando, a small community on the western boundary of the study area, one local resident recalled: "There was a spring there that was used by the community, but the people got to feuding over water rights. Ended up everybody put in wells instead." The spring that was the subject of so much strife is now no longer used by anyone.

One final incident reported by a resident is worth mentioning as an indication of the importance that water plays in the lives of the people of this region. A spring in the study area served a group of users who were all members of the same family. A line from the spring ran for a considerable distance to keep a reservoir filled, from which separate lines distributed the water to the individual houses. When a young woman who lived in one of these houses broke up with her fiancée, the angry young man took a violent reprisal. He leveled a pistol - and shot the main water supply line full of holes.

Maintenance of Sources and Systems

Maintaining a sanitary condition for their water supplies is a concern for many study area residents. Although few households have taken the trouble to build an elaborate protective structure for their water sources such as a spring house or well house, nearly all water sources of this type have some sort of cover upon them. Most respondents who possessed springs indicated that periodically they would clean accumulated leaves and debris from the spring pool. Many owners of cisterns or other storage tanks reported that they routinely disinfected the reservoirs with chlorine bleach, usually on an annual basis but in some cases as often as 3 or 4 times each year.

A previous chapter noted that several households keep a supply of water stored in one-gallon plastic jugs against times when the water source may be muddied by rain, or in case of power outage. One woman went to much greater effort to maintain the cleanliness of her water supply. She stated that she listened to the radio weather reports, and when heavy rains were predicted she replenished her supply of stored water in jugs to use during the precipitation period. Each time, after the rainfall ended, she emptied her large outside reservoir of water and disinfected it with bleach.

One well-educated respondent modified his farming practices in order to protect the quality of his household water supply. He stated that it was his practice never to apply pesticides on the farmland so that his spring could not become contaminated by them.

Water Vending

In order to examine the practices of households where water is purchased from vendors, it is also necessary to examine the practices of the vendors. Purchase of water from a vendor is a passive activity in the same manner as water supply piped in from springs, wells, rainwater collection systems, or public supply systems, requiring little further involvement by the resident once this mode of supply has been established. Unlike these other methods of supply, however, the purchaser of vended water does not have an investment of physical assets in a particular mode and remains free to choose among alternatives. The existing investment in a reservoir to store delivered water is one that can be easily adapted to use of spring water, well water, or water transported by the household.

Seventeen households, or 16 percent of the total households in the group studied, purchase water delivered by a vendor on a regular basis (Figure 7.b). "Regular basis" is defined to include not only those households that purchase water as their sole means of supply throughout the year, but also those that purchase annually only during particular seasons (usually summer) when on-site sources are usually insufficient. Six of the 17 customers (35 percent) purchase water only during the summer or autumn months to supplement their customary water supply source. The tight clustering of water vendor customers shown in Figure 7b is indicative of the extreme scarcity of available water supply sources along the southeastern perimeter of the study area. No satisfactory explanation has been found as to why water purchase is not similarly prevalent along the northeastern perimeter, where adequate on-site water resources are equally lacking (see also Figure 5d for a depiction of bulk water resources used in this area).

Other households in the study area, not included in this assessment, may purchase water from vendors during times of drought or other special need. One respondent, where the household is served by a spring that ordinarily provides adequately for all domestic needs, reported the one-time purchase of several loads of water to fill a newly purchased above-ground swimming pool. In this case, the purchase of water was not dictated by the lack of water, but rather by the unwillingness of the household to wait for several days while the pool was filled from the small-diameter line from the spring.

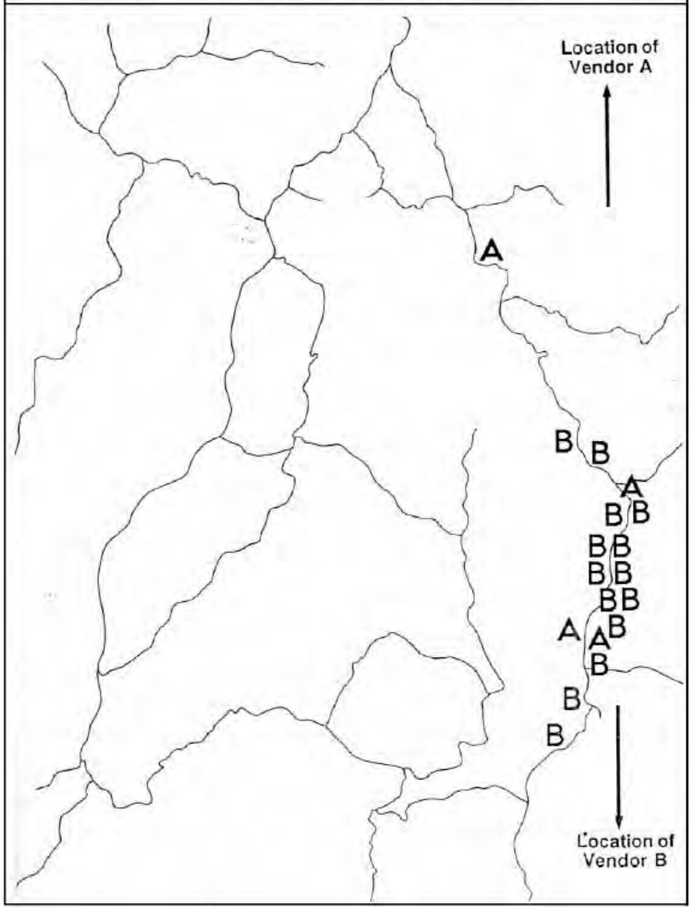


Figure 7b. Households Purchasing Water from Vendors

Three water vendors delivered water to the study area. Each business was a sole proprietorship, with the owner acting as operator; family members often assisted with deliveries or in taking orders by phone. None of the vendors resided within the study area. One was located in adjacent Jackson County (Vendor A); one resided in rural Rockcastle County a few miles from the study area (Vendor B); and the third operated from a Rockcastle County town (Vendor C). All of the vendors declined to be interviewed for this study, although Vendor A was willing to supply certain information in an informal manner. In accordance with their wishes, the vendors are not specifically located. Information concerning general aspects of these three water vending businesses was provided by their customers.

Of the three, Vendor A operated the largest scale of business, serving a multi-county area that includes Rockcastle, Jackson and Estill counties. During the period of investigation, this vendor, who is an elderly man, retired from active participation and turned the family business over to his son. The four customers served by Vendor A constituted 23.5 percent of the households purchasing water on a regular basis. Water was sold in 1,500 gallon units, for which a charge, including delivery, of $28 is made (equivalent to $18.67/1,000 gallons). Vendor B had the greatest share of the water-purchase customers within the study area, and served only the local area within Rockcastle County. Delivering to 13 households, Vendor B had an 76.5 percent share of the local market. This vendor charged $25 for a 1,000 gallon load. The least information is available concerning the activities of Vendor C, who was reported to deliver water in the study area but was not represented by any customers among the population studied.

As reported by the customers, delivery was usually made through specific request, the vendor being "on call." Alternatively, two respondents indicated they had requested vendors to routinely check the level of water in their household storage tanks and fill them when needed, without being called. This appears to be the exception rather than the norm. Vendors operated from their homes, rather than from a place of business in a local community. Respondents reported that deliveries were almost always made promptly; usually on the same day as requested, and often within hours. This sort of urgency was not usually necessary. Most households placed orders for water to be delivered within the next day or so. A vendor began his day with a list of deliveries to be made, and presumably called home during the course of the day to learn if any urgent orders had been placed. Apparently none had radio communication between home and truck.

Water was obtained by vendors at the public system outlets in Sand Gap, Livingston, or Mount Vernon

(Figure 7c). To minimize transportation costs and save time, vendors filled their truck-mounted tank at the water station nearest in location relative to their own homes and the first delivery site. Subsequent water loads were obtained under the same conditions favoring proximity of source and delivery site. A vendor's route typically consisted of a fill-up in a local community, then a delivery, then a fill-up followed by another delivery. Accordingly, sources used by the vendor on a particular day might be any or all of the three community water filling stations, depending upon the order and location of customers visited. Presumably a vendor would tend to arrange the delivery route so as to cover the least mileage. It was somewhat of a surprise to learn, during the investigation, that none of the water vendors filled their trucks at the public-access springs but exclusively handled water from public systems.

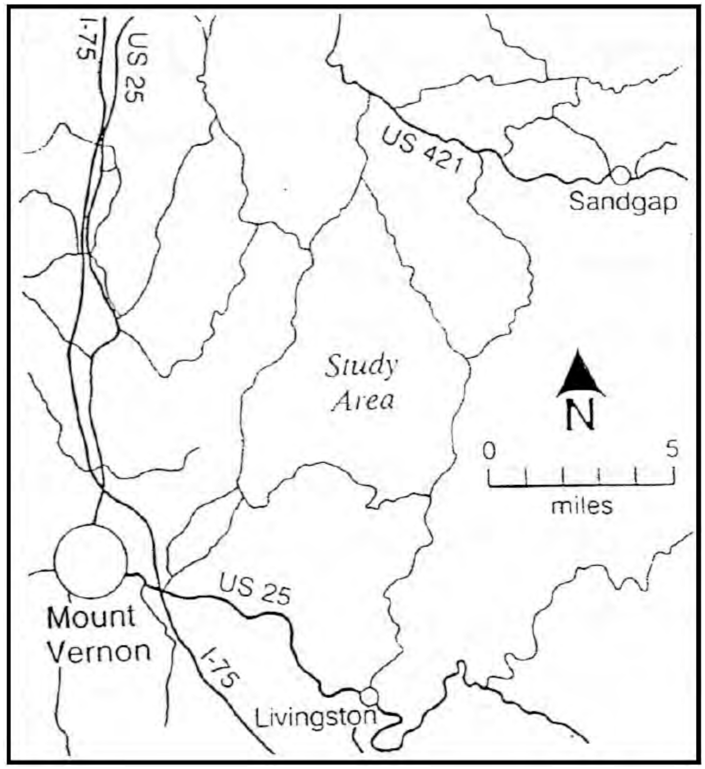


Figure 7c. Location of public water supply systems from which vendors serving the study area obtain water. It is also from these towns that residents who transport "city" water obtain their supply. Only paved roads are shown.

The trucks used by vendors in their deliveries, as observed by the writer, had flat beds on 2 1/2-ton chassis with heavy-duty suspensions and dual wheels. A full 1,000 gallon load of water can easily weigh more than four tons. Between the study area and each of the communities where water was obtained are some very long and steep hills, and there are numerous lesser but equally steep roads within the study area. Each vendor operated only a single truck. Profits in this occupation are not large. Although the vendor pays very little for the water hauled, obtaining it at the same rates as the general public at the water stations (less than $3.50/1,000 gallons), the purchase and operation of the truck constitutes a considerable overhead. The extremely heavy loads hauled serve to increase wear, maintenance and "down-time" for repairs. The income earned from water hauling does appear capable of supporting the owners in comfortable if modest fashion. For Vendor A, water-selling was a full-time occupation; Vendor B was retired and operated part-time for supplemental income.

Respondents for households purchasing water from vendors were able to provide fairly accurate estimates of the monthly amount of water used, based on the number of deliveries received per month, and thereby to provide an assessment of the cost of using purchased water. Since the capacity of the delivery trucks varied, comparisons were made based on gallons per month delivered rather than on the number of deliveries. Household demand for vended water averaged 2,235 gallons per month. The mean cost to households for water purchases was $51.40 per month, ranging from a low of $25 to a high of $100. Given the recurring costs, purchasers of vended water spend more of their income on water supply than any other group in the study area.

Water Transport

The analysis of behavioral and spatial patterns demonstrated by those households that must transport water comprises one of the most interesting and significant aspects of this study of rural water self-supply. The transport of water represents an active form of behavior that is engaged in upon some regular cycle, whether daily, weekly, monthly, or some other basis, as opposed to the passive behavior of households having access to an on-site water system. Further, the patterns and practices of water transporters are more dynamic, more likely to evolve in response to changing conditions or perceptions than are those of households having an investment in resources that are fixed in place. Water transporters are free, within certain restraints such as distance, to change supply sources at will. Having this freedom, water transporters are perhaps a more accurate barometer of perceptions regarding water.

When water must be transported from elsewhere, the important concerns are who engages in water transport for a particular household, and how is it transported. Those who transport water may be either members of the household, or outsiders. A household member may transport water if he or she is physically capable, possesses the means, and is so inclined. If all of these conditions are not present in at least one member of the household, that household must depend upon others. These others may be neighbors, friends or relatives, who most likely would not charge for their services; or may be those who engage in water hauling as a business and charge a fee for the service.

A significant proportion of the households in the study area, 41 percent or 44 cases, customarily transport water from a distant source for use in the home during all or part of each year. In many cases this is required by necessity, as the sources available on-site are insufficient to supply daily domestic needs. In other cases, water transport is motivated not by a lack of water at the household, but by a perception that water from some other source is more desirable. This stimulus particularly holds true when water is hauled strictly for drinking or cooking purposes.

Water self-haulers may be classed according to the intended end use of the hauled water, the type of source, and by the manner in which water is transported. For 48 percent (21) of the 44 households that hauled water, transported water was used only for drinking or cooking; water for indirect or bulk use was obtained from an on-site source. A similar number, 45 percent (20), hauled water for all domestic purposes and these distant sources represented their only means of water supply. Only 3 households (7 percent) transported water only for bulk use, having an on-site drinking water source considered satisfactory. These figures appear to indicate that the desire to obtain water of a perceived superior quality, for direct consumption, is the primary motivation in water transport. Table 12 shows the water resources, or lack of resources, available on-site to the 36 households in the study area that transport water from a single source, compared to the intended end use of transported water.

Households that Self-Transport (Haul) Water		Percent of Households of Each Class Having Specific Other On-Site Water Resource Available				
Intended End Use	**N**	**None**	**Spring**	**Well**	**Rain collect**	**Vendor**
Drinking water	18	0	11	17	44	33
Bulk needs	3	0	0	100	33	0
Both	15	73	7	7	20	0

Table 12. End-use of transported water compared to water resources available at the household, for 36 households transporting water from a single off-site source. (Totals for classes exceeds 100 percent because multiple on-site sources were present in some cases). For the purposes of this discussion, vendor deliveries of water are considered an on-site water supply, as this mode does not require transport to made by the household.

Some distinctive characteristics are immediately apparent from this comparison. Households transporting water only for direct consumption (cooking/drinking) all have some form of water supply available to them at the premises where they reside, even if this is simply water delivered by a vendor. For these households, the majority of at-home resources - 77 percent - were not derived from ground water. According to the reported perceptions of respondents, ground water, particularly that from springs, was generally considered to be the most desirable form of drinking water. Drinking water was therefore obtained elsewhere, either from local springs or as commercial bottled water.

Hauling for bulk, or indirect usage only, has too few cases (3) to make generalizations with any great confidence, but it is apparent that in these cases, existing on-site sources (wells and rainwater collection) are types that do not usually provide abundant or reliable quantities of water in this region. This necessitates acquisition of water elsewhere in sufficient amounts. In all three cases, a well was used for drinking water.

Where the intended end-use of hauled water is for all domestic purposes, it is clear that, for the great majority of such cases (73 percent), this was nearly the only possible means as there were no water sources existing at the household. Such households may purchase water from a vendor or install a rain water collection system, but chose not to so do for various reasons. In the first instance, the cost of obtaining the entire household supply from a vendor may be considered prohibitive. In the second, the cost of adding a rain water collection system to a structure where there was already a means to store hauled water would not be excessive, but collected rain water was viewed as one of the least desirable forms of drinking water, as well as being a generally unreliable source. In addition, persons having the means to haul their own water are not likely to pay someone else to haul it for them unless either they or their means of transport are incapacitated.

Most respondents who haul water reported using one or more of three different source types: public-supply system filling stations (Figure 7c); public-access springs (Figures 5f, 7d); or commercial bottled water from retail outlets. In no case was water hauled from rainwater collection systems. These systems are usually barely sufficient to provide for the primary household, let alone to supply others. In only one case was water transported from a private well or private spring (described below).

Water was transported from a single source only by 82 percent (36) of the 44 households that hauled water. Of these 36, 83 percent or 29 households transported from a local public access spring and 5 (14.3 percent) transported commercial bottled water from a retail outlet in one of the outlying communities. In only one case did a household haul water from a private spring that was in domestic use by another household; the respondent in question hauled drinking water from the spring belonging to his mother, who resided a few miles away. No households transported water only from public supply systems, although several hauled water from both public systems and another source.

Two different off-site sources were used by 7 (16 percent) of the 44 water-transporting households. In 5 of the 7 cases, drinking and/or cooking water was obtained from one source and bulk usage water obtained from another; these households were among the 46.5 percent that transported all water used. Four of these 5 households obtained water from two distinctly different source types (either public supply system water, local public access spring, or bottled water). The most frequent combination (2 of 4) was transport of water from a public access spring for drinking/cooking, and of water from a public supply system for bulk purposes. The other two combinations were unique: (1) commercial bottled water for drinking and public access spring for bulk use; and (2) public system water for drinking and water from a public access spring for other uses.

The remaining household of the 5 transporting water from two sources to supply all domestic needs, obtained water from two separate sources of the same type. In this case, water was obtained from local public access springs. Water for indirect or bulk use was transported from Spring A, and drinking water from Spring B. Spring B is, because of its limited flow, unsuitable for filling large tanks and hence not likely to be used for bulk water transport, and Spring A is highly suitable for bulk transport. Although many other respondents considered water from Spring A to be suitable for direct consumption as well as indirect uses, this particular respondent perceived the superiority of water from Spring B to merit a separate trip to obtain drinking water.

The last two households of the set of 7 transporting from two sources transported only water for direct consumption. In one of these latter cases, for which one source was commercial bottled water and the other was water from a local roadside spring, the respondent stated that he transported water from whichever source seemed most convenient at the time he observed the need to obtain more water. For this household, drinking water was purchased during a shopping expedition to a nearby town if the need for water happened to coincide with a need for groceries or other supplies, prompting a trip to a nearby community. When a shopping trip was not imminent but drinking water was needed, water was obtained from a public access spring. The desire to obtain water in commercial bottled form was not in itself sufficient to stimulate a trip to town.

The other case in which water for direct consumption was obtained from two separate sources involves a more complex water-supply situation and a more refined perception of differences in quality from different sources. This household obtained water for most bulk purposes, such as laundering and toilet flushing, from a pond nearby on the property. Drinking water was obtained by purchase of commercial bottled water. The respondent transported water, about 15 gallons per week, for cooking and washing dishes, from the well of her parents about one mile away on the same road.

The manner in which water is transported was largely dictated by the intended end use (Table 13). The 17 households that routinely transported large quantities of water, defined as 1,000 gallons per month or greater, generally used truck-mounted tanks of a capacity ranging from 275 to 1,000 gallons. In a few cases, a trailer-mounted tank was towed by truck or tractor. Thirteen of the 17 households (76.5 percent) possessed their own vehicle and tank. For the others, friends or relatives hauled water as needed. These 17 households reported a mean monthly water transport of 2,500 gallons, with a range from 1,000 to 4,000 gallons.

Container Size (gal)	N	Intended End-Use		
		Drinking	Bulk	Both
1 - 2	22	18		4
5-10	8	7		1
18	1	1		
275	7		3	4
300	5		4	1
500	3			3
1000	2		1	1

Table 13. Intended end-use compared to size of container used to transport water, for 44 households. Total is greater than 44 because some households transport water from more than one source and may use containers of different sizes.

For the 27 households using lesser quantities, usually those that transported drinking water only, containers ranged in size from 1 to 10 gallons. The most common container used was the standard 1-gallon milk jug with cap. Other containers used included 5-gallon plastic buckets, 10-gallon milk cans, and even plastic food coolers. Only one respondent used a truck-mounted tank (275 gallons) to transport, for bulk use, less than 1,000 gallons per month.

While it might be expected that households that obtain all of their water needs by transporting from a distant source would do so in bulk using large truck-mounted tanks, this proved not to be the case in every instance. Five of the 20 households (20 percent) that reported transporting all of their domestic water needs used containers of 1 or 5 gallon size. For these five households, the mean monthly quantity of water transported was 190 gallons, with a range from 24 gallons per month to 500 gallons. It is evident that there must be quite a significant difference in lifestyle between those households using, on average, more than 2,000 gallons per month and those that must make do with less than a tenth of that quantity.

To consumers of public water supply systems in urban areas, where water use usually averages more than 50 gallons per person per day, it must seem incredible that households with as many as four people can manage using hardly more than a gallon per day per person. Such limited water use is only made possible by strict conservation and by doing without the convenient modern appliances that use substantial amounts of water. For example, one household in the study area that reported a water usage of only 24 gallons per month for two people and a baby had no water-using appliances whatsoever, nor even indoor plumbing. Activities in the home that require considerable water are reduced (hand-washing of dishes), eliminated (use of an outdoor privy), or transferred to elsewhere (doing the laundry in a nearby town, taking a bath or shower at a relative's house). The reduction of overall water consumption to a gallon per day per person or less is made possible in households where water serves only such elemental purposes as drinking and food preparation. The issue of water conservation practices is addressed more fully in the following chapter.

The frequency of trips to obtain water varied considerably among households, ranging from several times each week to monthly. In addition, some water haulers made several trips in a single day. Only two households transported water on a monthly basis; both were bulk transporters using truck-mounted tanks. One household hauled 1,000 gallons in a single trip. The other monthly hauler dedicated one Saturday per month to the task and spent most of the day transporting a total of 2,400 gallons of water from Spring C to his home reservoir. He made 8 trips of 300 gallons over a distance of 1.8 miles. Each round trip, including filling and draining the truck tank, took about an hour.

Other bulk haulers transported water more frequently. Of the 17 large transporters, 2 (12 percent) as noted hauled on a monthly basis; 2 (12 percent) as noted hauled twice per month; 5 (29 percent) made weekly trips; and 8 (47 percent) hauled water two or more times each week. There was seldom any fixed schedule for hauling water; trips were made on an "as-needed" basis in nearly all cases. As noted, one hauler reserved one Saturday per month for water hauling. Another respondent indicated that he tried to make water trips during the week, usually on Wednesdays and Fridays, in order to have weekends free for recreational activities. For most respondents, bulk water hauling was a chore to be performed in the evenings after returning home from work. One man hauled water in the evenings for not only his own household but also for that of his mother, who lived in the house next door. One respondent reported a strategy that worked well and saved him time. This man drove to Mount Vernon each weekday morning and there joined a carpool to his job in Lexington. On days when water was needed at home, he would drive the tank truck to his carpool meet, leave the truck parked during the day, and fill it from the Mount Vernon public supply when he returned there at day's end from his Lexington job. With this exception, water transportation was, for bulk haulers, a specific task that was not associated with any other activities.

Respondents who were retired, non-working, or worked in the study area (farming, storekeeping, logging, etc.) had a broader and more flexible time frame in which to haul water. Of particular note is the case of one elderly but still active couple who spent part of nearly every weekday engaged in hauling water. Not only did they haul 2-3 weekly loads of 275 gallons each for themselves during the summer and fall months, but also hauled 3-4 loads each week year-round for the respective families of their two sons who lived along the same road. As each round-trip load occupied about an hour's time, a minimum of 6 hours each week and up to 11 hours each week in summer was spent in this pursuit. For this household, water transport was one of the most significant activities of their lifestyle.

Although many households depend upon bulk transport of water to meet daily needs, an equivalent number of households haul water in smaller containers. Thirty-one (70 percent) of the 44 households transporting water used containers of 10 gallons or less. Of these, as previously noted, two households hauled water in small containers from two separate sources. Five of the transporting households hauled drinking water in small containers from one source and bulk supplies with a large tank from another. For the remaining 24 households in this group, who transported only in small containers from a single source, 19 (79 percent) hauled drinking water only and 5 (21 percent) hauled for all household needs in this manner.

Frequency of trips for the 31 households transporting in small containers varied somewhat from that reported by bulk haulers. For the bulk haulers, nearly half made two or more trips per week. In contrast, only 16 percent of the haulers of small containers made more than a single trip per week. More than two-thirds (68 percent) of these households made one trip per week, and 16 percent made two trips per month. None reported making only monthly trips.

The amount of water hauled per trip was compared to both frequency of trips and to the intended end use. The mean quantities of water calculated for 30 of the 31 households for semimonthly, weekly, and semiweekly haulage were 18, 9.7 and 14.2 gallons respectively. While this does not appear to represent a strong correlation between frequency and amount, there does seem to be, as might be expected, a relationship between end use and amount transported. Water quantity hauled for direct consumption averaged only 8.3 gallons per trip, whereas households hauling water in small containers for all domestic purposes reported an average 29.4 gallons per trip.

Except for those households purchasing commercial bottled drinking water, trips made to transport water in small containers were usually specifically for the purpose and not associated with any other activities requiring travel. Nine of the 31 small transporters used commercial bottled water for drinking all or part of the time, and this commodity was always purchased as part of a general shopping trip rather than specifically to obtain water. For the 23 households (this figure includes a household that uses either commercial bottled or local spring water for drinking) that hauled water in small quantities from local springs, 17 (74 percent) reported that this was always a special trip for the purpose. Four households reported that the association of water hauling with other reasons for travel depended upon circumstances; sometimes trips were made specifically for water, sometimes water was picked up on the way home from some other activity. Only two households reported that trips to obtain water were usually or always combined with travel for other reasons such as returning home from work or shopping in local towns. For both bulk and small transporters, trips made to obtain water appear to be largely ad hoc and generally not associated with other lifestyle activities.

In an exception to this, one woman reported that transporting water was an important social activity to her and her elderly mother. In warm weather they enjoyed going to Spring A for water, where they could wade in the stream, hunt for pretty rocks for their gardens, and wash the car. "It's a good way to cool off in the summer," reported the younger woman. It seems likely that most persons hauling water regard it simply as a task. Whatever social function water hauling may fulfill, the survey results indicate that water-poor households would willingly forego the pleasures if water from a public system could be piped into their homes. As one respondent stated, "When you haul water, you're always out of water."

The public access springs A,B,C, and D constitute the most frequently used sources for transported water for households in the study area. Thirty-two of the 44 water-transporting households (73 percent) obtain water on a regular basis from one of these springs. Consequently it is worthwhile to investigate the usage practices for these springs in some detail. For this analysis, 4 additional, occasional users of these springs have been added to make a total of 36 users.

There are distinct patterns of preference among these four springs. With few exceptions, households that are accustomed to obtaining water from a particular spring always obtain water from that spring and no other. Only three households exhibited a variable preference. Two households alternated between two roadside springs, according to which was the most conveniently accessed during their travels at the time of water need. Similarly, another household obtained either spring water or bottled water, depending upon whether shopping trips coincided with the need for drinking water. The vectors for the user groups for springs A, B, C, and D are shown in Figure 7d.

The user group for Spring A is the most numerous and includes 22 of the 36 households (61 percent). The Spring B user group consists of 11 households, one of which also obtains water from Spring A and one which sometimes obtains water from Spring D. Spring C has only a single user. The Spring D group includes 4 households, one of which also uses Spring B. The four added households which only occasionally obtain water by hauling from these springs do so respectively to water horses, water flowers in the yard, make iced tea, and for a change of taste. Two forms of analyses were used, to compare the choice of each spring as a drinking water source and/or as a bulk supply, and to determine the effect of distance upon choice of spring.

As noted in an earlier chapter, the physical situation of each of these springs best suits it for certain purposes but not always for others. Spring A, having substantial flow available under pressure from a two-inch gravity line, is suitable for all purposes, for filling either large or small containers. Springs B and D have limited flow and small discharge lines without pressure head; either is suitable for collecting drinking water but not for bulk supply. Spring C emerges flush with ground level and has no line at all, nor any other improvements. Although Spring C has the greatest volume of flow of the four, it is difficult to fill containers of any size here. Table 14 compares the intended end-use of and containers used for transported water for each of these springs.

		Intended End-Use (percent of users)		Container Size (percent of users)	
Public Access Spring	**N**	**Drinking Water Only**	**All Purposes or Bulk Only**	**Small Container**	**Tank 100+ Gallons**
Spring A	22	45	55	52	48
Spring B	11	73	27	100	0
Spring C	1	0	100	0	100
Spring D	4	50	50	100	0

Table 14. Characteristics of usage of public access springs: Intended end-use and size of containers used to transport water. "Small" containers are less than 20 gallons in capacity.

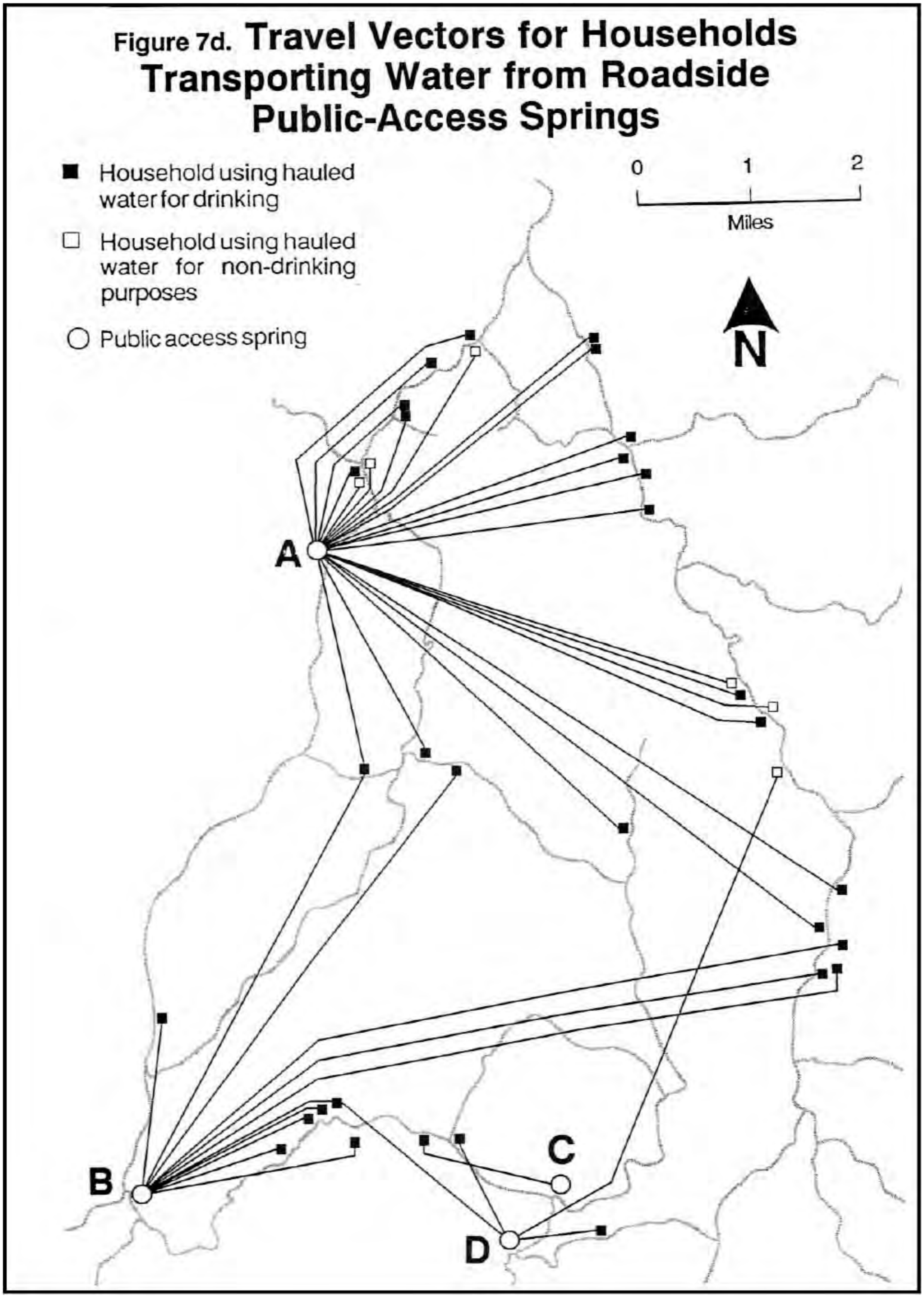


Figure 7d. Travel Vectors for Households Transporting Water from Roadside Public-Access Springs
Household using hauled water for drinking
Household using hauled water for non-drinking purposes
Public access spring
0
1
2
Miles
N
A
B
C
D

Spring A is used by more of the households that transport spring water than all the others combined. Spring B appears to be utilized to a somewhat greater extent by households wishing to obtain drinking water, but the use of springs A and B appears to be about equally divided among the two types of use. Spring A being suitable for filling containers either large or small, as one might expect, the ratios of drinking water transporters to bulk transporters and of small containers used to tanks is approximately equivalent (Figures 7e and 7f). All of the users of springs B and D transport water in containers of less than 10-gallon size. This provides confirmation of the limitations of these springs to actual practice.

The second part of this analysis investigates the effect of distance upon choice of spring used. Using a map wheel, the distance was measured from each of the 36 households transporting water to each of the 4 possible public access sources (roadside springs and to the 3 local community public water system "filling stations". The results are shown in Table 15, organized by the user groups. The effect of distance appears to be quite significant in choice of spring. This is particularly evident for Spring A, which has the largest user group. The mean distance from households using this spring is in every other case more than twice as great as the distance to Spring A.

	Mean Distance from Users to Water Source						
User Group	**Spring A**	**Spring B**	**Spring C**	**Spring D**	**Mt Vernon**	**Livingston**	**Sand Gap**
Spring A	5.5	12.1	12.2	12.0	17.2	17.6	13.4
Spring B	9.7	6.5	6.2	6.6	11.7	14.1	19.3
Spring C	12.6	4.6	1.8	2.1	10.0	10.7	20.9
Spring D	12.5	7.8	3.8	3.8	13.0	10.8	18.4

Table 15. Comparative mean distance of user groups from various water supply sources. Shaded areas indicate source used by groups in left column.

Users of Spring B are about equidistant from springs B, C, and D; it appears likely then that other factors play a part in choice of spring in this situation. The primary advantage possessed by Spring B is a highly visible and convenient location. The spring is situated in a relatively densely populated region of the study area, near the road intersection leading to Mount Vernon. In order to reach Mount Vernon, residents of the western portion of the study area pass within ten feet of Spring B, and eastern residents approach within 300 feet on their way into town. The spring has a roadside pulloff large enough to safely park a vehicle out of harm's way.

Another important factor, that encourages transporters of small quantities to use Spring B is the ease of filling containers from a spout located about three feet off the ground. The users of Spring B all transport water in small containers. Although Spring C is equally near to B users, Spring C discourages use for several reasons. As Spring C has no discharge pipe, containers must be dipped in the flowing, but shallow, stream and thereby risk also collecting mud and sand. To reach a part of Spring C sufficiently deep to submerge a gallon milk jug, the water collector would be required to wade into the stream. These are obvious factors discouraging use of this spring. The deficiencies of Spring C are not easily correctable without considerable labor and expense. As the vicinity of Spring C is among the least populated parts of the study area, no one has been inclined to make modifications to the spring.

Spring D also has certain deficiencies. The spring is located very near to Spring C (see Figure 7d), and therefore also is in the area of lowest population density. Spring D has a small discharge pipe that trickles into a concrete reservoir of about 100 gallons capacity. A steel pipe of 1/2 inch diameter directs overflow from the reservoir and is the usual filling point. During the summertime, the flow dwindles away and sometimes nearly ceases altogether. Filling containers is a very slow process at this spring, and when the overflow pipe no longer discharges water, containers must be dipped into the pool. Although this spring has its sworn adherents, they are less numerous among the group studied than those of Spring B. In addition to

Figure 7e. Filling small containers at spring "A" is a common task for many households in the area.

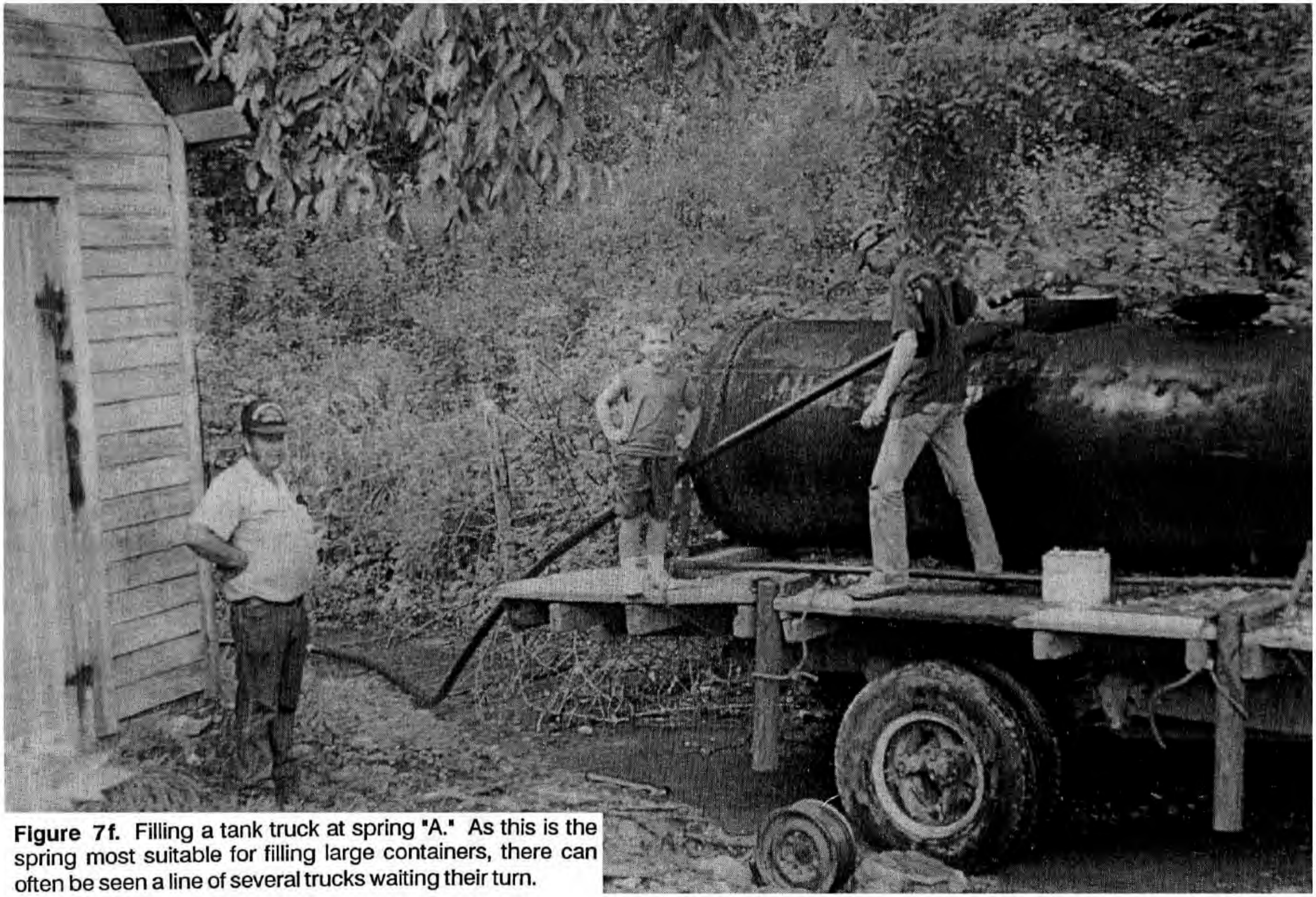


Figure 7f. Filling a tank truck at spring "A." As this is the spring most suitable for filling large containers, there can often be seen a line of several trucks waiting their turn.

the difficulties noted in filling containers, both springs C and D are located in a somewhat remote corner of the study area so that they are not convenient to persons traveling from home to elsewhere.

In comparison to the local roadside springs, the access points for public system water located in adjacent communities are quite distant. The nearest public system is nearly three times the distance from users of springs A and B than the springs used, and for the C and D user groups, the difference is still greater.

Given that spring water is seen as equally desirable regardless of source, considerations of accessibility inherent in site conditions and distance appear to be the controlling factors that determine which spring will be used by a household.

Chapter 8

DEMAND FOR WATER

This chapter describes various factors pertinent to the study area that affect the quantities of water used. Water demand and conservation practices in the study area are compared to those of urban areas where water is supplied by public water systems. The influences of household lifestyle, as reflected by the existing water-using technology and of the mode of water supply are examined in regard to water use. Periodicity of water usage, in both daily and seasonal cycles, is addressed. Both attitudes toward water conservation and actual practices are discussed. Finally, the willingness of residents to connect to public water supply lines is analyzed in relation to the existing situation.

Factors affecting quantity of water used

Numerous studies concerning water use have found a strong correlation between the size of the household and the quantity of water used (Aitken, Duncan and McMahon 1991; Hancke and de Mare 1982; Morgan 1973). These studies concerned urban residents. Other writers, particularly Batchelor (1975), have noted that lifestyle and household technology significantly influence the demand for water. Rosenstiel (1970), in an analysis of factors affecting purchase of water from vendors by residents of a rural Kentucky neighborhood, found that household size was far less significant than lifestyle ("status" factors) in explaining variations in water demand.

Results from the present investigation also suggest that lifestyle, household technology, and the mode of water self-supply are of greater import in determining the per-capita water use for a rural self-supplied household than is the number of occupants. The data used to support this conclusion were derived from the reported water consumption by households that either purchased water from vendors or who transported water themselves. Such households were able to estimate water use based on the size and frequency of water deliveries or transports each month. Water use by self-supplied households can be difficult to determine, as most persons who exploit a water source on their own property are not conscious of water quantities, having no way to measure volumes. In contrast, water supplied to households connected to a public supply is metered and customers are presented with monthly bills showing the quantity used. Consequently, fairly accurate estimates can be made on water use per capita for urban dwellers.

Two types of water use data were collected and are summarized in Figures 8a and 8b. Figure 8a represents bulk quantities reported hauled or purchased by 26 households either for (1) all household needs or (2) all needs except drinking and cooking. Based on reported practice by this group of households, mean per-capita water use was 21.7 gallons per day (gpd). The inclusion of two types of data was made necessary in that several persons who haul water in bulk obtained drinking/cooking water from an on-site source where measurement of quantities used was not possible. This introduces a possible error into both the frequency distribution and the mean per-capita use figure. Based upon reported quantities of water used for drinking and cooking by 21 households, where drinking/cooking water was hauled separately and could thus be measured, the amount of error was of low significance. Drinking water constitutes only a small fraction of total household water use.

Figure 8b summarizes data reported for 21 households in the study area that hauled drinking/cooking water as distinct from water used for other purposes. The mean per-capita drinking/cooking water usage for these households was 0.61 gpd. A comparable figure for average daily per-capita liquid consumption of 1.63 liters/day (0.43 gallons) for human needs was reported by the National Academy of Sciences (1977, 11), derived from a survey of nine different literature sources. For those households in the study group where the reported figure for average daily per-capita drinking water consumption was substantially less than this, presumably the necessary fluid intake was made up by consumption of soft drinks or other beverages. In comparing the two means, bulk uses versus drinking/cooking, water used for drinking/cooking represents only 2.7 percent of total household usage.

The figure for mean daily per-capita water use in the study area differs significantly from those generally accepted for single-family residences. The highest estimate for mean per capita daily domestic usage, 100

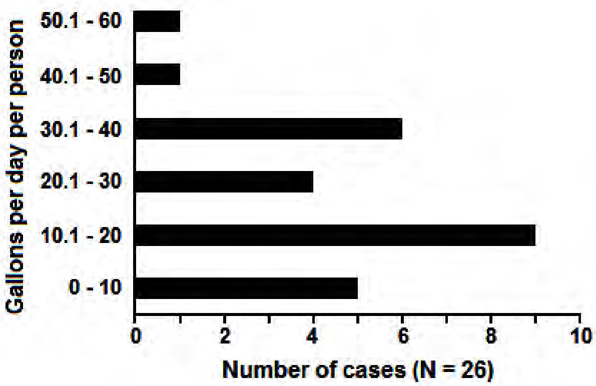


Figure 8a. Mean per-capita water use: Bulk

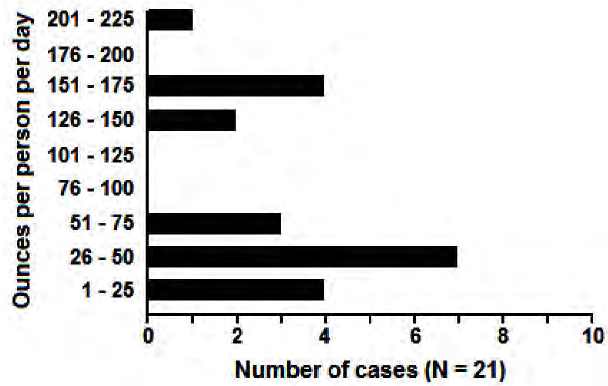


Figure 8b. Mean per-capita water use: Drinking water

gpd for farm families, was reported by Anderson (1984, 38). The U.S. Environmental Protection Agency (1991, 19) indicates a domestic use figure of 50-75 gpd per person, but does not distinguish between rural and urban single-family residences. Estimates for Kentucky domestic water use were reported by Scholar and Lee (1988, 8-11). According to their calculations, the statewide mean per capita water use by domestic users of public supplies was 65 gpd, and for domestic users of self-supplied systems was 50 gpd. For Rockcastle County, the figures reported for these categories were 62.68 gpd and 48.36 gpd, respectively.

The large discrepancies between these sources and the per-capita figure of 21.7 gpd derived from data collected from self-supplied users in the study area may result from the substantial difficulty experienced in obtaining water by persons in the latter area. The usage quantity figures available from the study area were derived solely from households where water was obtained in bulk either by frequent and time-consuming trips to a distant off-site supply or by expensive purchases from vendors. Water obtained in this manner becomes a commodity and assumes a distinct value, tending to discourage wasteful practices. Under such conditions it seems likely that water conservation would be practiced in these households, as opposed to households, rural or urban, where water is both abundant and of low cost. Osborn and Harrison (1965) estimate per-capita water use at 10 gpd for households where water is carried into the home; this more nearly approaches the findings for the study area than any of the other sources. Although it was not possible to measure water usage for households that were supplied by reliable springs, per-capita use for these households may often approach levels equivalent to urban dwellings.

As indicated by the Rosenstiel study (1980), increasing water demand does not correlate to increasing number of occupants for rural households that purchase or transport water. For the study area in the present investigation, the reverse apparently holds true. Table 16 shows the mean per-capita water consumption related to household size. Households with fewer residents demonstrated a greater per-capita water use than those with more persons. The data show a steady decline from 1-4 persons per household and remains fairly stable thereafter. This implies that larger households may practice stricter water conservation. The minimum per-capita water demand appears to be about 15 gallons per day per person.

Number of Persons in Household	Number of Cases	Mean Per-Capita Water Use (gpd)
1	3	44
2	8	36
3	8	21
4	5	14
5	4	20
6	1	14
10	1	13

Table 16. Household size (number of persons) compared to mean water usage in gallons per day.

One possible way to measure the comparative effectiveness of differing water-supply sources is through the presence or absence of an automatic washing machine, an appliance that uses water in copious amounts. This is also an indication of the influence of household technology on water use. Table 17 compares four classes of source types: spring, well, rainwater collection system, and hauled or purchased; against three modes of clothes laundering: automatic washer, wringer washer, or washing at a laundromat or friend/relative's facility. For those cases where a household obtained drinking water from one source and bulk water from another, the source supplying water in bulk was used for the comparison.

	Source Used for Bulk Supply, in Percent				
Mode of Washing Clothes	**All Sources (N = 106)**	**Spring (N = 47)**	**Well (N = 20)**	**Rain (N = 20)**	**Haul or Purchase (N = 14)**
Automatic washer	73 (N = 78)	83 (N = 39)	47 (N = 7)	90 (N = 18)	58 (N = 14)
Wringer washer	7 (N = 7)	6 (N = 3)	7 (N = 1)	5 (N = 1)	8 (N = 2)
Outside home (laundromat, home of friend or relative)	20 (N = 21)	10 (N = 5)	47 (N = 7)	5 (N = 1)	33 (N = 8)

Table 17. Mode of laundering compared to bulk source used. The one household using surface water (pond) for bulk supply is excluded from this analysis.

Assessing the effect of a particular type of source in a "pure" form is somewhat difficult, because of the prevalence of multiple source usage. Based on the assumption that the presence of an automatic washer is an indicator of water source reliability and abundance, it appears from Table 17 that rainwater collection systems would rate highest. If the supplementation of on-site sources by water hauling or purchase is also taken into consideration, then rainwater collection systems would rank lowest. Exactly half, or 50 percent, of the households using rainwater collection systems also hauled or purchased water from off-site sources. This compares with 7 percent for well users and 4 percent for spring users.

Well users constituted the lowest frequency of automatic washer possession, with nearly half (47 percent) of the households using wells as a bulk source forced to take laundry to other locations. One respondent stated, "There's not a drilled well in this county that has enough water for an automatic washer." One of the well users in the group studied was forced to take washing to a laundromat, because of water quality problems, not because of water quantity restrictions. The well used by this household had a high concentration of iron in the water which caused severe discoloration of laundered clothing.

Households supplied by springs appear to have the most effective water supply sources. These households had both a high incidence of automatic washers and a low incidence of supplemental supply usage.

The possession of an automatic washer appears, in the study area, to be more closely related to the type of water supply source than to socioeconomic status. Unlike urban areas, where the laundry is just down the corner or is contained within a residential apartment complex, the nearest commercial laundromat facilities for households in the study area are located from 5-20 miles distant. Surprisingly, only two households of those that took their washing away from home made use of the more abundant water and (presumably) cost-free facilities at a relative's home (a parent in each case).

Another method to rank effectiveness of particular source types is through reported seasonal quantity variations. Respondents were asked to rate the on-site source used for each of the four seasons of the year. For the 81 on-site sources, 27 percent of respondents reported that water quantity problems existed during some seasons sufficient to require hauling, purchase, or strict conservation measures. In examining specific source type, seasonally inadequate supplies were reported for 11 percent of spring users, 33 percent of well users, and 60 percent of users of rainwater collection systems. These figures correlate well with the tendencies indicated by Table 17, above, concerning off-site laundering. Of those reporting quantity problems, 23 percent reported experiencing inadequate supply during all seasons, 27 percent during the summer only, and 50 percent during both summer and fall. One resident, a spring owner, stated that he annually hauled water from July 1 to November 1. This corresponds to the period when ground water aquifers and surface streams are at their lowest stage, or summer base flow, because of the enhanced effects of evapotranspiration.

Household demand for water is not evenly distributed through the hours of the day but rather is related to domestic activity in the home. Rates of use are generally highest in the home near mealtimes, during mid-morning laundry periods, and shortly before bedtime. During the intervening daylight hours and at night water use may be zero (USEPA 1991, 18). Thus water use is concentrated over a few hours, when actual rates of use may be far higher than reported mean rates. The peak demand for water may often exceed the delivery capability of the water source during short periods of intense usage, even though the source is capable of supplying the total quantity used by the household over a 24-hour time frame.

For example, a typical regional well may have a yield of 0.5 gallons per minute. If the well has a borehole diameter of 6 inches, the storage capacity of the well is 1.47 gallons per linear foot. For a well 100 feet deep with a static water level that is 60 feet from the surface, this provides 40 feet x 1.47 gallons or 58.8 gallons storage in the well itself. Fixtures such as a kitchen water faucet or an automatic washer may use water at a rate of 2-5 gpm (USEPA 1991, 20). In consequence, the standing water in the well would be exhausted in a very short time and the rate of replenishment insufficient to maintain the supply. Several well-users in the study area, who did not have a storage tank associated with their water supply and who laundered with automatic washers, reported that they were unable to wash successive loads of clothing but must wait for a period of time after each load to allow their well to recover.

One strategy used by most households to increase water supply system delivery, regardless of source type, is construction of a holding tank. Households that collect rainwater and those that haul or purchase water in bulk must by necessity have a cistern or storage tank of some sort, but additionally users of springs and wells also often equip their residences with such structures. In the study area, these holding tanks may range in size from a few hundred gallons to as much as 15,000 gallons in capacity. These tanks create a buffer between demand and supply so that demand can be met during peak use periods and the supply allowed to recover during off periods.

The use of a holding tank largely compensates for deficiencies in source supply capacity. To return to the above example of the well with an 0.5 gpm yield, over a 24-hour period such a well would deliver 720 gallons to a holding tank. This would be sufficient for the daily needs of a large household. The larger the tank, the larger would be the buffer supply provided. Variation in storage capacity is a significant factor in explaining why certain households that collect rainwater experience no supply problems, whereas more than half of rainwater collection systems do experience severe shortages. A large capacity tank allows long-term storage of water from sporadic precipitation to meet demands during dry weather.

Table 18 summarizes reported information concerning on-site storage capacity of households using various source types. This table has three divisions. The center section simply reports presence or absence of a storage tank. The end section reports tank size within selected ranges, where this detail is known. Unfortunately, not all residents were aware of the size of their storage tank, nor was it always possible to estimate this as some tanks were underground or at locations that were difficult to access. Sizes where reported provide an indication of the range and distribution of storage capacity.

Bulk Source		Tank Present (%)		Size of Tank if Known		
Type	N	Yes	No	Less than 1500 gallons	1500 to 5000 gallons	More than 5000 gallons
Spring	47	53	47	6	3	
Well	15	13	87		1	
Rain	20	100	0	2	6	3
Haul / Purchaser	24	79	21	2	7	1
All sources	106	62	38			

Table 18. Storage tanks compared to bulk source used.

All of the rainwater collection systems, as might be expected, were equipped with a storage tank. The storage capacity was highly variable among the systems, ranging from a simple barrel under a downspout at one residence to a home that collected rain in an underground tank of 15,000 gallons capacity. In addition to this latter system, two other residents reported rainwater collection and storage in tanks over 5,000 gallons. All three of these households had automatic washers, and indicated that they never hauled or purchased additional water. Most of the other systems, where reported, were of 2,000 gallon or less capacity. This lesser storage capacity most likely is responsible for 10 out of the 20 rainfall collection systems being required to supplement their supply during a significant portion of the year.

In contrast, only 2 of 15 wells discharged into a storage tank, despite the obvious advantage of providing an increased supply for times of high demand. As shown in Table 17, however, more than half of the households dependent upon well water for bulk use either laundered away from home or else used a manual wringer washer to save water. As only a very few well users reported transporting or purchasing water, this implies that most households using wells practice routine water conservation in order to maintain water independence.

Of those households where water was routinely hauled or purchased from off-site sources, 5 had no provision for bulk storage. In these homes, extreme water conservation was required. One resident reported hauling as much as 50 one-gallon plastic jugs of water from a local spring every week. As might be expected, none of these homes possessed an automatic or even a wringer washer but instead were required to take laundry elsewhere. None of the 5 residences had indoor plumbing, although in one case, a mobile home, the facilities were in place but could not be used because of the lack of water.

At first it might seem somewhat surprising that so many of the spring-supplied households are equipped with tanks, as springs generally provided the greatest volume of water. In most cases, where spring water was collected in tanks, the purpose was not to provide storage capacity but rather to provide a pool sufficiently deep that a supply line, whether operated by gravity or a pump, could be suspended clear of the mud and rocks of the watercourse. Most springs, except for so-called "blue hole" or artesian flow springs that upwell naturally in a deep pool, issue forth in a stream that is seldom more than an inch or two in depth. Several residents, who described their spring as having a constant flow year around, indicated the normal flow of their spring as being equivalent to a stream of a finger's width, approximately a gallon per minute. Most domestic-use springs in the study area, however, had a greater flow than this, ranging up to about 1,000 gallons per minute (about 2 cfs) for the largest during summer base flow. A number of springs in the study area had small dams built before them, sometimes consisting of only a few large rocks or a course of concrete blocks, intended to impound sufficient depth of water to submerge an intake pipe. These small impoundments were not considered as storage tanks for inclusion in Table 18 (see Table 4, Chapter Five, for a discussion on improvements to springs).

A second important reason why such a high percentage of springs were equipped with tanks was to provide a pool into which the natural velocity of the spring flow could dissipate. This allows silt and debris to settle to the bottom rather than being carried through the water line into the house. In general, spring tanks were cruder in construction than the tanks built to accompany wells, cisterns, or hauled/purchased water. Most of the spring tanks were above ground, usually made of cemented concrete blocks to a height of three or four feet with a cover of metal roofing or of plywood, tanks used in conjunction with other water supply sources were generally buried or were built as an integral part of the residence.

Water conservation practices

In the study area, nearly all water supply sources are marginal during at least part of almost every year. Even during the winter and spring seasons when the water table is usually highest and ground water flow at maximum, few of the springs and only one well provided more than one household was able to use. During the summer months, because of the greatly increased rate of evapotranspiration, ground water available from springs and wells gradually decreases. The limitations of rain water collection in this regard have already been discussed. Indeed, as noted earlier in this chapter, a number of residents are required to use every possible water supply source at their disposal in order to have the barest minimum water supply for daily needs. In consequence, water scarcity is a normal condition of existence for most households, requiring that water conservation be practiced with fidelity.

An unfortunate omission in the survey instrument was the lack of questions that specifically addressed the issue of household water conservation practices. Fortunately, during the investigation many persons volunteered a considerable amount of detail concerning measures undertaken by the household to conserve this often scarce resource. Accordingly, although it is not possible to quantify the extent of water conservation, it is possible to describe the forms in which it occurs.

According to the Roper survey (1993, 9) about 6 in 10 Americans believe that the next generation in this country will face a serious shortage of water supplies. Despite this finding, it seems unlikely that most customers of public water supply systems really expect that one day they will turn on the kitchen tap and be rewarded by nothing more than the hiss of escaping air. The Roper survey found that there was a large gap between attitudes and actual behavior in regard to water conservation. For example, there was a gap of 40 percentile points between the number of people who indicated it would be easy to shut off the water while brushing their teeth and those who actually practiced this; a 36 point gap between those who would reduce the number of toilet flushings and those who do flush less often; and a 28 point gap between those who would run only full dishwasher loads and those who actually so do (p. 56). Similarly, a study of Australian urban residents by Aitken and McMahon (1994) found that there was very little correlation between respondents' expressed attitudes regarding water conservation and their actual consumption.

Households on public water systems have the freedom to express attitudes endorsing conservation that vary from actual consumption practices simply because they can choose to conserve or not conserve; the water supply is essentially unlimited and the only factors tending to reduce water demand are price and individual sense of responsibility. This choice does not exist in water-poor regions so that an expressed attitude favoring water conservation is more likely to reflect reality.

Most public-supply customers experience water shortages only as rare and temporary inconveniences resulting from severe droughts. Because water shortages or rationing for public system users represent ephemeral phenomena for which years may pass between recurring episodes, such shortages apparently do not in themselves tend to stimulate wide-scale or long-lasting behavior modifications. In contrast to these largely urban dwellers, most self-supplied residents in the study area live under nearly perpetual water-supply conditions resembling drought. This inherent condition of daily existence has produced a pattern of behavior that recognizes the local scarcity and intrinsic value of water, and thus tends to eliminate wastage. As one man put it, "I was raised up where you always had to be conservative of water. It's part of life."

An important point here is that the attitudes demonstrated by study area residents do not represent a behavior modification from some previous water-use behavior or lifestyle, but rather represent behavior initially learned in early childhood that continues into adult responsibility. Urban residents may find it difficult or inconvenient to institute effective water-conservation measures in the home because reduced consumption often represents a significant change in lifestyle. Most households of the study area have always been operated in such fashion as to minimize water use and therefore no behavior change is necessary. When children grow into adults and leave the household to establish homes nearby in the same region, as often occurs, they are likely to continue to practice water conservation because this is the accustomed way of existence.

The two behavioral extremes, acceptance of a water-conservative lifestyle by residents of water-scarce regions and a water-extravagant lifestyle by residents of urban areas served by public systems, are each firmly implanted early in life so that change to another way can be very difficult. The difficulty of transition from water-wealthy to water-poor lifestyles is illustrated by reports of the experiences of certain residents in the study area who were immigrants from places where water conservation was unnecessary.

In one case, where drinking water was hauled because the on-site supply was of poor quality, the adult female of the household was originally a resident of Louisville. She reported that she had found it very difficult to adjust to a life where one could not obtain a drink from the faucet. In another example, where the man, a native to the region and used to the local water situation, had married a woman from an urban area, the woman stated that, at first, the circumstances of water-supply had "about drove me crazy." She recalled with particular vividness one winter when she was required to melt snow in order to wash the daily dishes. A particularly striking and tragic example of failed adaptation is that reported by a man who attributed the recent failure of his marriage to lack of sufficient water in the household. He stated that his former wife, previously an urban resident, had been a dedicated housekeeper who could not adjust to the severe water conservation regime necessary in a household where all water must be hauled from a distant source. While this story may well be apocryphal, and the failure of the marriage due more to other causes, it does serve to emphasize the problems of adaptation faced by those not born to water scarcity.

It appears that some residents may be finding it more difficult to practice traditional water conservation now than formerly, because traditional lifestyles are changing in such a manner as to require a greater consumption of water. Traditional Appalachian lifestyles did not require large volumes of water for everyday use. Rural electrification and exposure to outside values through television, outmigration/return, and expanded employment outside the area of residence have led to increasing household technology in the mountain region (Whisnant 1994). In consequence, tasks such as washing dishes or clothing that were once performed manually are now relegated to household appliances that consume considerably greater volumes of water. Batchelor (1975) noted a significant correlation between added household technology and increased water demand. One respondent put it succinctly: "Before things got modern people didn't use so much water."

The reasons for water conservation in the study area can, therefore, be divided into three overlapping categories: (1) necessity, (2) tradition, and (3) undesirable alternatives. Water conservation is necessary when existing household supplies are inadequate or too expensive for profligate use. Secondly, conservation may be practiced automatically, derived from childhood training, as a normal part of household routine regardless of whether actually required by present circumstances. Lastly, the practice of conservation may be viewed as requiring less effort and expenditure of resources than alternatives such as hauling of water or purchase from vendors.

The forms of water conservation practices include those that actually reduce overall household water consumption, and those that transfer the water-using activity to another location, so that overall consumption is not reduced but demand is lessened on a particular source. While many of the water conservation measures reported by residents of the study area are similar to those of urban residents, many are not. Conservation measures practiced in common by both rural self-supplied and urban residents with access to public water supplies include: fewer toilet flushes; less frequent dish-washing; installation of water saving fixtures in toilets, dishwashers, and shower heads; reuse of "gray water"; and letting vehicles go without washing. One of the most significant uses of water by urban residents and one that is frequently targeted by advocates of water conservation, lawn sprinkling, was not practiced at all in the study area.

Certain water-reduction practices of the study area did not have urban counterparts. One such practice was the use of disposable dinnerware, such as paper plates, to avoid the use of water necessary in dishwashing. Another practice found in the study area, perhaps unique to the self-supplied household, was deliberate seasonal variation of water usage. Many households, particularly those with marginal water supplies, were more careful of water use during seasons when water levels were reduced and less careful during wetter times of the year. Water-conservation was not a constant, steady-state behavior but rather varied directly with a cyclical perception of availability of supply.

Water conservation involving locational transfer of the water-use activity, although not truly conservative of water per se, allows conservation of the individual household supply. The most frequently reported form of location transfer was in regard to clothes washing, an activity which is a substantial water consumer. Many households routinely took the week's washing to laundromats in nearby towns, or to the homes of friends or relatives. As noted earlier in this chapter, socioeconomic status appears to be less a factor in possession of home laundry facilities than simple lack of adequate water supply. Several households, who possessed washing machines, were observed to reuse the gray water from previous washes to clean subsequent loads.

A second important form of water activity transfer was found to be transport of water for specific activities. While this may perhaps be considered hauling of bulk water, this activity has been classed as a conservation behavior because the water is hauled for a specific purpose and used immediately rather than added to a reservoir for common use. Several examples of this were found in households that hauled water to water kitchen gardens or a few head of livestock, thus sparing a drain on the domestic supply. Another example was a household, supplied from a spring, that had purchased an above-ground swimming pool and paid a local vendor to haul water to fill it rather than to burden their domestic source.

It is evident that the rationale behind water conservation is quite different for the self-supplied household than it is for the customer of a public water system. The differences in motivation can be attributed to the perceptions of water as communal property and water as private property. According to the Hurd survey (1993), 9 of 10 Americans interviewed believe that water is a natural resource that is community property and therefore there is a community responsibility to conserve this resource for the good of all. Similarly, 3 of 4 respondents to the Hurd survey believed that people should do a better job of conserving water than at present. In contrast to the concept of water as community property, a belief perhaps natural to the predominantly urbanized American public for whom water supplies are shared in common with thousands or millions of other users, water supplies in the study area are often the private property of the user.

Through the media and in education, the urban American water consumer has been frequently exposed to the notion of the "law of the commons"; when a resource exists in finite supply, individuals that consume greater than their equal share of the resource deprive others of their rightful share. This sense of the "commons," as applied to water supply, cannot operate effectively in a rural environment where every household must obtain their own water any way they can. Water conservation by self-supplied people, therefore, is apparently practiced from self-interest rather than from any sense of the public good.

Willingness to connect to public supply system ("city" water)

From preliminary field investigations conducted in 1991 (O'Dell 1992), it was evident that water supply was an important issue to most residents of the study area. Since about 1986, a number of the citizens in the study area have attempted to secure funding to extend public system water lines into the area to provide service to the many households where existing water supplies were often marginal at best. The most recent effort, begun in 1990, was ultimately successful in forming a water association and bringing water lines into the study area. This effort was led and vigorously promoted by Harold Ballinger, study area resident and official with the Agricultural Stabilization and Conservation Service, until incapacitated by illness in 1994. Approval and funding for the project were finally obtained in that same year. Although only a small portion of the study area will be initially provided with access to a public system by this project, residents anticipate that lines will be extended further in the future as additional funding becomes available.

It has frequently been the case in Kentucky that citizen groups have provided the impetus for expanding service areas into rural regions, by organizing water associations and water districts. Part of the process in obtaining funding from such agencies as the Appalachian Regional Commission and the Farmers Home Administration is determining which households are willing to pay the initial connection fees. The funding agencies require that a certain proportion of households in the proposed service area obtain connections. The process involves public notices and public meetings, so that most citizens of the proposed service area become aware of the impending project and are familiar with the issues involved.

A willingness-to-pay (WTP) study was conducted as part of the present investigation of water supply in the study area. This contingent valuation study was facilitated by the high level of awareness concerning water supply issues brought about by the publicity concerning the water line project. As described by McPhail (1994), Altaf, Jamal and Whittington (1992) and Whittington, Lauria and Mu (1991), a WTP study is a household survey in which a member of the household is asked a structured set of questions designed to determine the maximum amount of money the household is willing to pay for a good or service.

Because the amount of connection fee was well known ($300) and most persons, in the proposed area, had made a decision whether or not to connect, the connection fee was not addressed by the WTP survey. Instead, questions were based upon the willingness of the respondent to pay for monthly service. Since households vary in the amount of water consumed, the respondent was asked to consider the base rate for the first 1,000 gallons. A potential base rate of $10 had been proposed during the meetings of the water association, but at the time of the survey, no one was certain whether or not this would be the actual rate implemented. All respondents were asked to participate in the WTP section of the survey, regardless of whether their household was included in the proposed project area or not. Nearly all respondents were willing to participate, since they anticipated connection at some point in the future.

The evaluation of willingness to obtain service was conducted in two parts. The first part simply ascertained willingness-to-connect; respondents were asked whether or not the household intended to connect to a "city" (public supply) water line, should service become available in their area of residence. The question provided for three categories of response: (1) no, (2) yes, if available at low cost, and (3) yes, at any cost. This provided both a measure of the strength of the respondent's desire to connect and also took into consideration potential connection fees. The second part of the evaluation consisted of the actual WTP procedure. Using the $10 base charge as a minimum, a bidding format was used in which the respondents were prompted to answer "yes" or "no" to a proposed base charge that increased at $5 intervals. Ultimately, an amount was reached where the respondent indicated that they would not be willing to pay for service. In a few cases, respondents skipped the bidding process and flatly indicated a maximum figure that they would be willing to pay for monthly service. The respondent was then asked to indicate what they considered to be a "fair" base charge for water service.

The results of the willingness-to-connect survey are shown in Table 19. Slightly more than two-thirds of all households in the study area indicated that they would connect to a "city" water supply line if it became available; more than half indicated a strong desire. Of those who would refuse, households depending upon spring water constitute the single largest group. More than half of the respondents for spring-supplied households indicated that they would not connect to "city" water. These 24 households represent about 23 percent of all household in the group studied. Only about a quarter of respondents for spring-supplied households indicated a strong desire for service.

	Current Bulk Source Used					
Response	**All (N = 106)**	**Spring**	**Well**	**Rain**	**Haul from Spring**	**Vendor Purchase**
Would not connect	30	51	33	6	0	18
Would connect if low cost	19	21	27	6	33	0
Would connect at any cost	51	28	40	89	67	82

Table 19. Willingness to connect to "city" water supply system compared to existing bulk source used.

Users of well water for a bulk supply were more evenly divided in their opinion. Approximately equal numbers strongly desired connection and would refuse connection, with a group of similar size desiring connection only if the cost was low. For households supplied by rain water collection systems, water hauling, or water purchase, the desire to obtain connection was very pronounced. Few in these categories reported that they would not obtain a connection.

Table 20 reflects the results of the WTP bidding "game" and provides an assessment of the willingness of households to connect to public systems. Persons who had stated that they did not wish to obtain service were not asked to respond to this question. Surprisingly, even though the proposed base rate of $10 had received wide publicity in the study area, respondents indicated that they felt a "fair" rate for the utility was more than the published amount, double or even triple in some cases. There appears to be a pronounced trend of increase, with users having on-site sources opting for lower rates and those accustomed to taking a great deal of trouble or expense to obtain water, hauling or purchase, assessing a much higher rate as fair. It is of interest that the highest assessment of a fair rate came from respondents already accustomed to purchasing water.

Not all persons were willing or able to respond to the question asking them for their opinion of a fair rate. Many persons stated that they had never had a connection to city water in their lives and had not the faintest idea what it should cost. Of 70 persons who had expressed a desire to obtain connection, 15 (21 percent) did not wish to assess a "fair" rate. However, all but one of the 70 respondents was willing to indicate, through the bidding process, a maximum rate they would pay.

Contingency	Current Bulk Source Used: All (N = 106)	Spring	Well	Rain	Haul from Spring	Vendor Purchase
Fair base rate	$18.20 (55)	14.00 (19)	15.30 (6)	16.30 (13)	21.30 (12)	34.40 (5)
Maximum would pay for service	$40.50 (69)	33.90 (22)	40.00 (8)	30.70 (15)	45.00 (15)	66.10 (9)

Table 20. Willingness to connect to "city" water supply system compared to existing bulk source used. Upper figure is mean in dollars. Figure in parentheses is number of cases.

Trends are not so readily apparent concerning the maximum figure that respondents would be willing to pay for service. Oddly, it was the users of rain water collection systems who were willing to pay the least for service; a finding that contrasts with the results shown in Table 19, by which these respondents expressed a stronger and more consistent desire to obtain service than users of other source types. Again, users of sources not on their own property were the most willing to pay higher prices for water. The greatest mean figure shown in Table 20, $66.10 in the case of purchasers of water from vendors, is still less than the monthly charges paid to vendors by many of these purchasers. Such households might well consider water a bargain at $50 per month or more.

Some individual households reported a willingness to pay as much as $150 per month for "city" water service. One user of purchased water indicated a willingness to pay this much, and two respondents who hauled water were willing to pay as much as $100 per month. It is of interest that two respondents who used springs on their own property were willing to pay $100 and $150 per month respectively. In each case, the springs had undesirable characteristics. The spring that supplied the household where the respondent would be willing to pay $100 did not provide sufficient water for household needs during at least half of each year. The other spring, for which the alternative of connection to a public system might be worth as much as $150 per month to the respondent, had severe quality problems. The respondent reported that the spring had a bitter, oily taste.

This analysis of household willingness to obtain connection to a public system has concentrated on bulk source type used as providing sufficient explanation for these variations. There are certain other factors that may provide additional explanation, but are of lesser significance. Four respondents indicated that they would not connect to "city" water because they rented, rather than owned, their residence and did not wish to make the investment represented by the connection fee for someone else's property. In contrast, four other renters indicated that they would make an investment in the connection.

Chapter 9

Summary and Recommendations for Further Study

Summary

The water-supply strategies used by the households investigated in the study area proved to be vastly more complex than originally anticipated by the investigator. Only 52 percent of the households were able to rely solely for all their domestic needs upon a single water source located either on the premises or shared with other residents. Even then, some were required to supplement this from off-site sources during dry years. For remaining households, who lacked an adequate on-site source, water supply either required a constant transport of water from elsewhere by a member of the household or nearby friend or relative, or reliance upon purchase of water at relatively high cost from vendors.

Thus, water supply was in a passive state for approximately one-half of the population, in that no effort was required on their part to secure water beyond minimal maintenance of an existing system. There was no need to choose among sources, as they were generally more satisfied with what they possessed than with any of the potential alternatives. To this population segment, the act or process of obtaining water did not represent a significant lifestyle activity. Only when household circumstances changed to render the existing supply situation inadequate, as in a move to another property or increase in the family size, did it become necessary to reevaluate the water supply situation and perhaps choose a different alternative or supplement.

In contrast, the other half of the group studied, who did not have a reliable and adequate on-site water source, were engaged in an active and dynamic pursuit of water. Obtaining water supply was an important part of their everyday life in terms of the resources, time and/or money, expended to assure an adequate supply in the home. Although some of these households did have an on-site water source, the source did not provide enough water during most of the year or was considered deficient in quality for some uses. Consequently, these households were faced with the need to choose among several alternatives.

The perception of water quality played an important role in determining whether a household relied upon a single source or chose to secure water elsewhere. If water from all on-site sources, whether obtained from rainfall, spring, well, or surface body, had been considered of equal quality, only a small percentage of households would have been required to transport or purchase water. Most households had an adequate supply of water in terms of volume. Water from all sources was not regarded as equal in quality. Therefore, households having otherwise adequate supplies frequently transported, for purposes of drinking and cooking, water that they considered to be of superior quality. A few households chose "city" water or commercially bottled water as a drinking water alternative, however, by far the great majority chose water from local springs.

This preference for spring water was a perception generally embedded in the population as a whole and most likely derives from the long historic tradition of spring water use by families in this formerly isolated Appalachian neighborhood. This preference for spring water is the basic motivation that accounts for many of the patterns of water supply behavior exhibited in the study area. On-site springs supply 8 out of every 10 of those households who are content not to seek water away from the premises. Nearly 4 out of every 10 households using other sources, adequate for a bulk supply, transport local spring water as a supplement, strictly for drinking and cooking. The results of this survey contraindicate Money's (1966) conclusion that springs were the least reliable of rural water sources, although this may be attributable to flow or quality differences in the aquifers of different regions. In the current study, it was among the households supplied by on-site springs that resistance to obtaining connection to a public supply system was strongest.

Residents exhibited a willingness to travel a substantial distance to obtain spring water. In many cases this arose from necessity to obtain water, but in many other cases it was a matter of preference for spring water that stimulated travel. In nearly every case, obtaining water was considered to be of sufficient importance that trips were made specifically for the purpose rather than as part of some other activity. Those who transported water from either choice or necessity encountered two possible alternatives: water from certain local roadside springs, or "city" water from designated public-access hydrants of regional towns.

Calculation of the mean distances from users to these potential water supply sources showed that local public-access springs were closer to the user groups than were the public supply outlets. Few households transported "city water" but many transported water from these roadside springs. Households transported water from the roadside springs either in small containers for drinking/cooking or in large tanks for all domestic use. Households transporting water in bulk almost exclusively used the one spring (spring A) having characteristics most suitable for filling large containers. Households only transporting small containers typically chose the roadside spring that was geographically most convenient. There was not an apparent preference for one spring over another in this regard; there were few examples of persons traveling to a more distant spring.

A definite geographic separation of areas that may be best described as "water-wealthy" as opposed to areas that are "water-poor" was determined. Water-wealthy areas allow many alternative choices of water supply including those that are adequate for a normal domestic supply. In water-poor areas, the choices are either more limited or existing alternatives do not provide for an adequate domestic supply. In the study area, the distinction between water-wealthy and water-poor areas was a function of local geology and topography. Residents of valley areas, where natural springs were plentiful, more often had an on-site water supply that sufficed for all water needs. Residents of higher elevations where natural springs were less plentiful and of lesser flow, were frequently forced to resort to low-yielding wells, unreliable rain water collection systems, or transport or purchase of water. The boundaries between the two regions can be approximated by the 1200-foot contour, which is roughly equivalent to the local contact between sandstone and limestone and hence between types of available water resources. Persons transporting water from the roadside public access springs were most often residents of areas above 1200 elevation.

The amount of water used by households was found to vary considerably. Water-wealthy households used water at rates equivalent to that estimated for urban residents served by public systems. Households where water supplies were marginal, or where most or all water used was transported, practiced extreme conservation. Water use in such households often approached the figure given by White, Bradley and White (1972) of 12 liters (3.15 gallons) per capita daily. Similarly, the amount of water transported by households tallies closely with White, Bradley and White's observation that water use is closely related to the size of the containers used to obtain it. In a sense, the supply and demand function appears to be inverted in regard to water supply: when supply is reduced, demand does not increase but instead is adjusted downward to reflect the new supply situation. There is, of course, a minimum required demand for water for simple survival, which requires the adoption of alternate strategies to obtain water when the usual supply is inadequate for daily living.

White, Bradley and White (1972, 226-248) compared several simple decision-making models used in planning new water schemes. The first model, economic optimization, views humans as seeking to obtain the greatest returns from time and energy spent acquiring water, and assumes that water users are "well acquainted with the relevant information about water and its costs, are rational in their assessment of it, and seek to select the optimum." The second model views the consumer as acting in the future as in the past, but welcoming any technological change which offers improved supply without changing costs radically. The third model reported considers water users as captives of custom, bound by the hardened customs of their cultural group. Water users in this model are seen to conform to group patterns of habitual behavior and innovating only in special circumstances which provide incentives for those few who are disposed to innovation or disruption of the group's culture.

Behavior observed in the study area includes attributes of all the above models, but is far more complex than can be described by any one of them. The model chosen by White, Bradley and White to describe the behavior of water seekers and users in East Africa appears to approximate the situation as observed in Rockcastle County. This model is based upon the user's perception of the existing situation and of the alternatives that may be present, where such perceptions may or may not be accurate but still comprise the motivation for attitudes and behavior. As stated by the authors, "Each decision is based upon awareness of the range of alternatives and upon the value assigned to the likely outcome of choosing one rather than another" (p. 227). The valuation is derived from the sociocultural context in which the water user is embedded.

For those persons in the Rockcastle study area who were actively seeking water, the factors that most significantly appeared to influence their choice were their individual perceptions of the value of the alternatives, based in large part upon the traditions of the local Appalachian culture in which they reside. In cases where choices were made that did not conform to the historic cultural norm, these apparently often resulted from the import of differing perceptions into the region. Some of these differing perceptions may have arisen from immigration into the region of former urban residents, the return of indigenous residents, and to a certain extent, the effects of media exposure of environmental and health issues.

In some cases, as observed by White, Bradley and White, choice is "encouraged or discouraged by whatever formal social action is taken by the society" (p. 227). An example of this from the study area was the case of the family having numerous foster children, who were required by the fostering agency to obtain water from a public supply system, and consequently made this their primary supply. Societal action of more far-reaching and longer-lasting effect is the extension of public system water lines into areas that have not previously had access. The user of traditional sources, in this situation, is now confronted by the necessity to make a choice.

Planners have traditionally made the error of oversimplifying the water-supply situation in areas where extension of lines is intended, and to operate under premises that have not taken into consideration the perceptions held by populations in such regions. The demand for water service is certainly not uniform. Planners who have a better understanding of the perceptions and motives of the population for whom they are planning, gained through site-specific studies, are better able to overcome resistance to water-supply works.

As noted, resistance in the study area to connection to a public-supply system was highest among households where water was directly supplied by a spring on the premises, and lowest among the users of other types of supply. Although capital investment in a particular system of private water supply may operate as a deterrent to some extent, it appears that this is less important than the need to obtain sufficient water. Well owners, purchasers of vended water and collectors of rain water were among those most enthusiastic at the prospect of obtaining a piped water supply. Cost of service was not an important issue; many residents were willing to pay much more for water than they are likely to be charged. A number of persons indicated that they did not really need or want the service, but intended to obtain a connection for reasons unrelated to the need or desire for water itself. Among these reasons were (1) the desire to be a good citizen, to help develop the neighborhood by helping to support infrastructure acquisition; and (2) to increase the value of the property through the addition of piped water service. Planners and civic authorities may be able to more effectively overcome resistance to public water service by understanding and exploiting these two motivations, one altruistic and one selfish.

Another issue of major concern to residents was the quality of the water to be provided by the proposed service. Users expect water to be of uniformly good quality; taste was most often cited as a reason why "city" water was considered objectionable. Since taste in water appears to often be a matter of acclimatization, it may be that the reported experiences of friends and neighbors who have prior connections is the best way to surmount this perception. The existing conditions of water supply in a region strongly influence the willingness of residents to pay for public water service (Altaf, Jamal and Whittington 1992). Resistance resulting from existing capital investment may perhaps be overcome by programs in which assistance is given in converting existing water sources to other uses, such as for agriculture or livestock, or in properly plugging abandoned wells. Educational materials can be developed that inform the population of the risks of raw water use, particularly in regard to new discoveries of the hazards of *Giardia* and *Cryptosporidium*.

One elderly woman in the study area provided what is perhaps the best summary of water supply: "If it rains I'll have water...if it don't I'll be like a lot of other people - high and dry."

Recommendations

Results of the present study have suggested many further paths of inquiry both at the local and regional scales. At the local level, continued expansion of the areal coverage of public system water lines and integration of the population into this mode of supply presents opportunities to compare perceptions, behavior and demand on a before-and-after basis. For many of the households in the group studied, perceptions and attitudes concerning "city" water were often derived from impressions gained second-hand or through limited contact with public supply systems. A second survey of the 1994 respondents, made some years in the future, might provide some interesting insights into the development of new perceptions and behavior based on a new mode of supply.

Among the potential changes to be investigated by a future survey of this population would be to determine:

The percentage of households, for which public system service became available, who actually obtained connections.

The uses, if any, made of former on-site water supply sources for households who obtained connections; whether the intent to maintain a spring water connection or to haul spring water for drinking was actually carried out.

If perceptions of the relative merits of water from various sources for drinking and culinary purposes have readjusted.

If demand for water has increased, measured by metered water bills and adoption of more water-using appliances.

If water conservation is still "a way of life."

These and numerous other comparisons suggest themselves for a future investigation of great interest and utility. The survey instrument used to evaluate changes could be much shorter and simpler than that used in the original investigation.

One indication of the direction in which the results of a future comparison might lie was revealed in a 1995 visit to one of the respondents, nearly a year after the survey. The respondent had indicated during the survey that he intended to maintain his spring and to have a hydrant in the yard so that he could continue to drink spring water. At the time of the later visit, this household had been connected to the public supply system for several months. After obtaining service, he had not followed through on his plan to have a separate spring water connection, and the spring was now unused. He thoughtfully gave his opinion that the "city water" did not have such a bad taste once one became accustomed to it. It appears from this that perceptions tend to evolve to accommodate existing situations.

The question of taste suggests another line of inquiry, as to whether there are actual and significant differences among waters from various sources. Taste-comparisons, though often of dubious value, have long been used in market research and advertising to demonstrate the advantages of one product over another. A carefully structured and implemented taste test could be conducted to evaluate natural spring water, rain water, commercial bottled spring water, and water from several public supply systems. The sample populations should include one comprised solely of rural self-supplied persons and one made up of urban residents accustomed to "city water." Because of potential health hazards from untreated rain water or spring water, sources of this nature used in such a taste comparison should be tested and carefully monitored for the presence of any harmful organisms or substances.

Finally, the perception held by the great majority of the sample population in the study area, that natural spring water is unsurpassed in purity by water from other sources, should be analytically tested against reality. The ambient quality of spring water, rain water, and well water in the study area should be monitored over a period of at least one year in order to determine if there are seasonal fluctuations. The data collected could then be compared to local land use practices. Such a study, in addition to assessing the validity of local perceptions concerning ground water quality, would provide base line information to compare potential changes in water quality resulting from future changes in the intensity of land use. Water quality data can also be compared to similar data collected in other areas where land use practices differ.

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