GROUND WATER FOR HOUSEHOLD WATER SUPPLY IN RURAL AMERICA: PRIVATE WELLS OR PUBLIC SYSTEMS?

Andrew W. Stone, American Ground Water Trust, Concord, NH 03301, USA

Paper presented at the Joint Conference of the International Association of Hydrogeologists and the American Institute of Hydrology, Las Vegas, September 1998 and published in the Proceedings:

"Gambling with Groundwater – Physical, Chemical and Biological Aspects of Aquifer-Stream Relations"
American Institute of Hydrology, St Paul, Minnesota 1998

ABSTRACT

Ground water supplies over 50% of America's drinking water needs. Rural household supply is provided by a mixture of independent home wells, small local rural water systems, and regional water utilities. There are 15 million independent household wells, with thirty nine states having more than 10% of their household water supplied from private wells. Some water supply policies in the US are having the effect of encouraging centralized water supply systems and discouraging independent household wells. The availability of subsidies for water systems, and state departments predisposed towards pipelines, can skew local supply decisions. Individual home owners do not have the financial ability to retain "experts" to make the case for retaining independent wells. Ground water specialists have a critical role to play as objective scientific watchdogs, so that decisions affecting ground water use and protection are made without undue influence of political agendas and vested interests.

GROUND WATER USE IN THE U.S.A.

Ground water is that part of the hydrologic system that occurs in a geologic environment. It plays an important role in water supply, ecology and maintaining river flow. In addition to directly providing water to wetlands and to vegetation with roots at or near the water table, it is estimated that 54% of all the US annual stream flow results from natural ground water discharge, Table 1. From a water supply perspective, ground water sources provide on average over 30.3 million m^3 of water a day, about 20% of all daily water use in the US, (EPA, 1995a). By far the largest user of ground water is irrigation, with over 60% of withdrawals. The next largest ground water use is for public drinking water supply, Table 2. Virtually all agricultural irrigation use of ground water is in rural areas. Most rural communities have ground water based supplies for their public systems in addition to the millions of homes and farms served by water wells. Ground water has been very significant in the development of rural America. Continued demands for food production, and expanding rural settlement by non-agricultural residents continue to increase demands on the renewable, but finite ground water resources.

Flow and Use Category	%
Stream Baseflow	54.0
Agricultural Irrigation	29.0
Public Drinking Supply	8.7
Industrial	2.3
Domestic	1.9
Mining	1.9
Livestock Watering	1.4
Commercial	0.5
Thermoelectric	0.3

Table 1. PUMPING AND DISCHARGE
US EPA (1995) (Based on USGS Data)

Use Category	%
Agricultural Irrigation	63
Public Drinking Supply	19
Industrial	5
Mining	4
Domestic	4
Livestock Watering	3
Commercial	1
Thermoelectric	0.7

Table 2. ANNUAL GROUND WATER USE
USGS Open-File Report 92-63

Ground water provides approximately 53% the household water needs in America, supplying water to the homes of 150 million people. Of these, an estimated 40 million are supplied from private domestic wells. Approximately 15 million US homes have their own wells, most are drilled wells, but over a million are still the old-style dug wells. In Europe, private household ownership of water wells is a rarity whereas in the US 15% of the population is "self-supplied" by wells for drinking water. Such wells are usually referred to as "private wells", "on-lot wells"or "independent wells". The well and the water system infrastructure form part of the home's equity value and as such are the property of the homeowner or landlord.

In addition to private wells, much of rural America is supplied with domestic water by small water systems, Table 3. There are approximately 176,000 public water supply systems in the US. Many of the small systems, principally in rural areas, are based on ground water sources.

	Community Water Systems	Nontransient, Noncommunity	Transient Noncommunity
Number of Systems[1]	56,747	23,639	106,436
% Systems Based on Ground Water	81%	97%	98%
Population Served by Ground Water Sources	90,588,000	5,645,00	12,709,000

([1]Includes 50 states and US territories) Source, US EPA (1995b)

Table 3. GROUND WATER SOURCES AND PUBLIC SUPPLY

The basis for dividing the systems is somewhat arbitrary, but the EPA definitions provide a consistent nationwide basis for categorization. Community Systems provide water to the same population year round. Nontransient, Noncommunity Systems serve at least 25 of the same people at least six months of the year; for example, schools, factories, and hospitals. Transient, Noncommunity Systems provide water for transitory customers in non residential areas, for example, motels, campgrounds and gas stations. (US EPA 1995b)

STATE VARIATIONS IN WATER SUPPLY

Questions in the 1990 US census provide important benchmark information about the sources of water used by US households. The data set presented in Table 5, details state by state the proportion of household water supply obtained from public water systems and private supply. The table includes every state but excludes US territories. The table has six columns of information for each state. Table 4 provides an explanation of the information presented in Table 5.

Table 4	EXPLANATION
Households (1990 census)	Lists the number of households for each state; this figure multiplied by 2.6 (average household size) provides a close approximation for the 1990 census estimate.
Households, Independent Water Source	Lists the % of households with an independent water supply. In addition to water wells, this figure includes all households with an unspecified water source which could include creeks, rivers, lakes, springs and cisterns.
Households with Public Water Supply	Lists the % of households served by a public water supply. This includes virtually all homes connected to a “piped water supply” with the service provided for payment, either fixed charge, metered sales or a combination.
Households with Own Supply from Water Well	Lists the number of households with an “independent well” supply source. The percentage figure includes drilled wells and dug wells. The census data indicated about 7% of wells as “dug wells”. In the US, well drilling is still referred to in many areas as well digging, an anachronistic use of the principal pre-drilling machine method of well construction . Many people refer to their wells as “dug”even when they were drilled!
Ranking by State, % with Independent Wells	This column ranks each of the 50 states in terms of the proportion of the state’s household water supply needs provided by independent wells. Maine, New Hampshire, Vermont and Wisconsin head the list with Arizona, California, Utah, and Hawaii the least dependent on private wells for household water.

Ranking by State, Number of Independent Wells	This column ranks each of the states in terms of absolute numbers of private wells. Michigan, Pennsylvania, North Carolina and New York have the most independent wells with Wyoming, Nevada, Utah, and Hawaii having the lowest numbers of independent wells.

Table 4 – EXPLANATIONS OF TABLE 5 HEADINGS

State	Number of Households	% Households Independent Water	% Households Public Water	% Households Own Well Supply	Rank % Own Wells	Rank Total Wells
Alaska	232,607	34.41	65.58	24.12	11	43
Alabama	1,670,371	12.94	87.06	12.04	36	26
Arkansas	1,000,655	18.54	81.46	17.46	22	32
Arizona	1,659,430	5.47	94.53	4.65	47	41
California	11,184,259	4.60	95.40	4.16	48	13
Colorado	1,477,347	9.01	90.99	8.12	42	34
Connecticut	1,320,848	22.25	77.75	21.95	15	19
Delaware	289,920	23.79	76.21	23.61	12	42
Florida	6,100,272	13.15	86.85	13.02	31	5
Georgia	2,638,410	18.74	81.26	18.07	21	12
Hawaii	389,809	2.42	97.58	0.22	50	50
Iowa	1,143,672	18.88	81.12	18.36	20	23
Idaho	413,323	29.96	70.04	27.18	8	35
Illinois	4,506,215	10.24	89.76	9.77	42	14
Indiana	2,246,047	25.90	74.10	25.12	10	9
Kansas	1,044,103	10.50	89.50	9.97	41	38
Kentucky	1,506,942	19.39	80.61	13.70	30	24
Louisiana	1,716,234	10.98	89.02	10.66	39	30
Massachusetts	2,472,713	8.39	91.61	8.10	44	27
Maryland	1,885,364	17.04	82.97	16.46	26	18
Maine	587,042	46.80	53.20	41.88	1	21
Michigan	3,847,933	29.54	70.46	29.13	7	1
Minnesota	1,848,439	27.04	72.96	26.19	9	11
Missouri	2,199,185	16.35	83.65	15.31	29	15
Montana	361,159	34.50	65.49	30.25	6	37
Mississippi	1,010,421	12.65	87.34	12.12	34	33
N Carolina	2,816,516	34.55	65.45	32.38	5	3
N Dakota	276,337	21.02	78.98	19.16	19	44
Nebraska	660,618	17.00	83.00	16.77	24	36
New Hampshire	503,907	39.69	60.31	37.47	2	28
New Jersey	3,075,314	10.38	89.62	10.24	39	17
New Mexico	632,058	16.90	83.10	15.35	28	40
Nevada	518,856	7.54	92.46	7.09	46	48
New York	7,226,903	12.42	87.58	11.41	37	4
Ohio	4,368,718	17.53	82.47	16.14	27	6
Oklahoma	1,406,495	13.04	86.96	12.59	33	31
Oregon	1,193,563	19.31	80.69	17.13	23	25
Pennsylvania	4,938,137	21.93	78.06	19.81	18	2
Rhode Island	414,572	11.24	88.76	11.06	38	46
S Carolina	1,424,151	22.78	77.22	22.38	14	16
S Dakota	292,435	18.60	81.40	16.72	25	45
Tennessee	2,025,977	14.31	85.69	12.09	35	22
Texas	7,008,983	8.44	91.56	8.09	45	8
Utah	598,384	4.21	95.80	3.10	49	49
Virginia	2,496,332	23.87	76.13	21.60	16	10
Vermont	271,216	49.14	50.87	36.80	3	39
Washington	2,032,376	14.28	85.72	12.97	32	20
Wisconsin	2,055,774	33.46	66.54	32.81	4	7
W Virginia	781,314	27.91	72.08	23.56	13	29
Wyoming	203,413	22.36	77.64	19.96	17	47

Table 5. GROUND WATER FOR HOUSEHOLD WATER SUPPLY IN THE USA

The State household water supply data listed in Table 5. show considerable spatial variation. The state and regional patterns in ground water use, and the differences in the proportion of water supplied from private wells are a function of both hydrogeologic conditions and population demographics. The combined influences of rock type, topography and climate are the principal determinants of ground water availability. Agricultural activity, other economic development, settlement density and planning policy influence the extent to which ground water resources are used, and/or have been taken out of use because of urbanization or quality degradation.

The American household water well industry has some $3 billion in annual sales, and contractors install about 6,000 new water wells each week. (NGWA, 1998). However the drilling of new wells is not rapidly expanding national inventory of active private wells. Some wells are replacements and other wells are taken out of production because of urbanization or competition from pipeline supplied services. Overall, the American water supply industry is a $50 billion a year business, (Hyman, 1998). Increasing privatization, international investment in American utilities and the merging of small water companies into more viable regional utilities are increasing trends in the water supply business. This trend towards consolidation is largely in response to the more stringent application of drinking water quality standards that may be difficult for small systems to achieve without outside capital. Many rural supply systems were established at times of no regulations or guidelines and their source, treatment and distribution infrastructure are now inadequate.

RURAL WATER SUPPLY INFRASTRUCTURE

Drinking water supply systems in rural areas have evolved because of growing population, increasing consumption demands and changes in technology. In the early days of American settlement people went to the water. The evolution of drilling technology in the late 1870s was important for opening up much of the Midwest and High Plains, especially in those areas where few rivers were perennial. Without drilled wells, and wind pump technology to raise water for locomotive boiler feed, some of the early transcontinental railroads would have been seasonal. Once drilling machines, and wind powered pumps became economically available, settlement patterns were changed by the almost ubiquitous availability of ground water for domestic water use. The wind pump (often mistakenly called a wind mill) became a landscape feature throughout much of rural America. As communities grew, it often became economically feasible to create a centralized water system. The availability of water provided incentive for further development of small urban areas. Many such small water systems were based on ground water sources, and as towns grew, new wells were added to meet the demand for water.

Household water supply in rural America now involves a complex pattern of private wells, small water systems (often organized as Rural Water Districts), larger regional systems, and suburban pipeline extensions from urban utilities. See Tables 3. and 5. Most of the larger water systems are organized as a service of local government, but there is an increasing trend towards privatization. This mix of supply provision infrastructure would seem to be an appropriate solution to the rural population's need for safe economical drinking water supplies. If the decisions about the most effective way to supply water in rural areas were based solely on ground water availability, the choices would often be straightforward. However, the availability of federal grants to centralized systems, but not for private wells, has introduced politics, skewed the economics, and reduced considerations of hydrologic science in the rural water supply decision making process, (Stone, 1997). Funding for rural water projects is the basis for much of the current controversy about the supply options for rural household water.

CONTROVERSIAL ASPECTS OF RURAL WATER SUPPLY

Government Influence

The role of water in ancient civilizations is well known, and governments in virtually every country have always had some degree of involvement in funding and influencing water supply decisions. Given enough investment, water engineering projects have the capability to move water to people almost anywhere. Control of water provides a power base whether at a national, regional or local level. Insightful historical perspectives on government involvement in water projects is provided by Woorster's book, *Rivers of Empire*, (Woorster, 1986), and McCool's book, *Command of the Waters*, (McCool, 1994).

In general, most government agencies (state and federal) have policies that encourage the growth and expansion of water systems. A common policy rationale is that water utilities can be regulated, and so the authorities have more effective control over issues of health, welfare and regional development. However, government involvement is not always welcome in rural areas. Of additional consumer concern are the effects of home purchase lending applications that may require a government backed loan guarantee. A home owner may be refused a home purchase loan because the well water quality does not meet all federal drinking water standards, even though the problem can easily be fixed by point-of-use conditioning equipment. The effect is to force people to move to, or to demand, centralized water provision, even although there is no health-related statistical evidence that to show that water from properly constructed and maintained private wells is better or worse than water from properly maintained municipal or rural supply systems.

Legal Authority

At the present time, citizen concerns about power and authority also create local controversy about rural water policy. There are real concerns about the "right" to use ground water, and the concept that forced hook-up amounts to a "taking" of property. The essence of the problem is that once a centralized water project is established there are usually laws and statutes that can

force people to connect to the pipeline system and give up their independent wells. For example, in New Jersey a homeowner was jailed for refusing to connect his home to the municipal system (New York Times, 1997), and in Wisconsin homeowners are faced with $500 per day fines for delaying connection beyond the proscribed date, (Statute 281.45).

The authority to create a water or sewer system can also provide authority to levy local taxes. Usually it is not the water provider that passes rules or ordinances. Local health departments and zoning commissions may use the existence of a centralized system to force home owners, or new developments, to join the system. A problem arises when only some wells in an area are not satisfactory and only a few homes in a community are in need of water supply improvement. In order to make water supply projects cost effective the water system needs to obtain as many connections as possible. The only solution that will attract federal dollars, private investors, or justify raising a local bond, is to provide a water infrastructure system for the whole community. Laws can force all homes to connect to the system, even if their wells are perfectly safe and reliable. A similar forced-connection situation may arises if a pipeline, from source area to an area of need, passes through a community on independent wells, chances are that there will eventually be hook-up requirements. In some areas, home owners are not even allowed to retain wells for garden irrigation.

The reasons for so-called forced participation often relate to the authority's attempts to ensure financial viability for a water system. It is a concern to federal officials that many of the nation's smaller water systems are sub-standard because of lack of capital investment. The Safe Drinking Water Act of 1974, amended in 1986 and 1996, requires the EPA to establish drinking water standards for America's community water systems. The responsibility to enforce standards has been granted to individual states. The agencies in the state government therefore promote local water supply solutions that will ensure system viability and hence compliance with quality standards. Water quality for individual wells is the responsibility of the homeowner. Most local departments or agencies have limited authority to impose or enforce standards for wells. Local rules can be applied to private wells by way of construction code standards for new water wells and the requirement for a "safe" water sample, usually just basic nitrate and bacteria testing, at the time of property transfer.

Water Issues and Self Interest

One of the major difficulties is that citizens do not always receive objective unbiased information concerning water options. For example, pipeline advocates may play up the benefits of centralized water supply, and minimize the costs to consumers. Independent well advocates may try to minimize specific water quality concerns, and promote the absence of monthly utility bills as a reason to use private wells. Some water project funding sources, for example, those available from the US Department of Agriculture's Rural Utilities program, are intended to help poor communities where there are infrastructure needs. The application process is competitive. Applicants for funds have an interest in showing that their current supply situation is unsatisfactory. The availability of funds can have the effect of stimulating demand. Community water supply operators will seek their "share" of funding. Water will move uphill towards money, (Stone, 1997).

Federal money for water supply is a popular "pork barrel" funding item for politicians, (McCool, 1994). Providing tax revenue money for water infrastructure is rarely challenged. Rural Water Districts and municipal authorities in rural areas have received billions of dollars in grants and loans to construct water distribution and treatment systems. Rural water systems have a good reputation for providing a safe and reliable water supply, but systems have also been created or extended into areas where there is no apparent hydrologic nor economic reason. National organizations that represent the interests of rural water providers retain professional lobbyists in Washington to ensure that they continue to benefit from federal funding.

There can be other influences on local water policy, for example, no-growth or pro-growth advocates may use/ misuse water supply availability and quality information as a means to achieve their particular agenda. Piped water availability means that lot-sizes for property can be smaller. Homes can be built on ¼ hectare lots rather than the more usual ½ - 2 hectare lot size for rural homes. Developers anxious to maximize profits from land sales generally favor piped water, especially if it is provided with a government subsidy. Without a piped supply, developers have to bear the expense of providing water to new homes. To obtain authority to create a new water district there is usually a local ballot requirement. In a June, 1998, referendum vote in Newton County, Missouri, several of the main advocates for the creation of the district had interests in property adjacent to the route of the proposed pipeline. The citizen vote was against the proposal, with the principal opposition focused on the fear of losing independence and not wanting to vote for the creation of a water supply monopoly.

GROUND WATER PROTECTION

Protecting American ground water resources is essential. By the year 2050 there will probably be close to 370 million people in the US, an increase of 100 million. While urban areas will expand, there will be continued population increase in rural areas. It makes sense to encourage use and protection of all local ground water resources. There are great uncertainties about the water resource implications of possible climatic change. There is good reason to protect each and every area that has ground water supply potential, even if the potential is for low yielding but reliable household wells.

There are strict federal guidelines and state requirements for utilities to protect ground water resources. Wellhead protection strategies have been effective in protecting important aquifers. New initiatives for source water protection encompass a watershed (catchment) based approach to safeguarding the integrity of supplies. The focus is on protecting the resources used by water utilities. There are government programs that address private well protection, but for the most part in America this is done by non-

profit education and environmental groups.

One of the major ground water quality problems in rural areas is contamination related to agriculture's use of chemicals and the disposal of animal manure wastes (Thu & Durenberger, 1998). The strongest rationale for keeping aquifers free from contamination is because of their economic importance for water supply. Importing water by pipeline can result in no use of local groundwater. If nobody is using the ground water for miles around, why would communities or individual homeowners bother to protect it?

CONCLUSION

The development of America's rural household water supply infrastructure is an ongoing process. Ground water is likely to remain as the major supply source for rural America. Ground water professionals have the training and expertise to understand the occurrence and nature of those water resources occurring in the geologic part of the hydrologic system. Ground water specialists should not shy away from lending their expertise to help decide how those resources should be used. Decisions relating to development and protection of the ground water need the heavy hand of objective science. Many local decisions, particularly those in rural areas concerning private well or public water supply issues are made in the absence of any independent hydrogeological input. Agency "experts" will tend to favor centralized solutions. Individual homeowners do not have the awareness or finances to hire their own experts. If good science is to be the basis for decisions, it will fall to the hydrological specialists who reside in rural areas to volunteer their expertise and insight at public meetings.

The principal citizen concerns about household water are safety, reliability, cost, and control. For most homes, with a properly constructed water well, and a safe aquifer, the independent well option is very satisfactory. Virtually all water utilities are monopolies and the supply of water is a for-profit business, or is organized to operate on a for-profit business basis. Local state and federal water supply policies can have the effect of removing any consumer choice and forcing patronage of the monopoly supplier. By law, virtually all utilities chlorinate drinking water supplies. Consumers are also concerned about the long-term effects of disinfection by-products. Compulsory connection to a water utility is a major concern; [If you can grow your own vegetables, why should you be forced to buy vegetables at the store? Just because your office or factory has a cafeteria, are you forced to eat there?].

There is a strong case for rigorous hydrologic assessment of the need for water projects. Are the principal beneficiaries of the proposed project the providers or the consumers? Encouraging, rather than discouraging increased use of private wells could be of great economic and environmental benefit to rural America. Every home that is self supplied with water helps reduce infrastructure demands. As we move to the next century, with an increasing (non agricultural) rural population, often stressed and finite (although renewable) water resources, and an uncertain climatic trend, we need all water supply options open. It would appear wise to keep in use, and expand the use, of small ground water based supply systems and individual household wells. Spreading the resource base gives the greatest opportunity for minimum environmental impact on aquifers, and gives a strong rationale for local and regional efforts to reduce ground water contamination risks.

There is a need to closely scrutinize the benefits of water supply programs that remove incentives for individual and community responsibility, independence and self sufficiency, and have the effect of reducing the areas of rural ground water use. Community by community, the involvement of ground water engineers and scientists is needed to ensure hydrologic and environmental objectivity in rural water supply decisions.

REFERENCES

Hyman, L.S., 1998. *The Water Business*, Public Utility Reports, Inc., Virginia.

McCool, D., 1994. *Command of the Waters*, University of Arizona Press.

NGWA, 1998. Focusing on the Household Well Market, Information Fact Sheet, National Ground Water Association, Westerville, Ohio.

New York Times, New Jersey Edition, June 7, 1997.

Stone, A.W., 1997. Are There Tax Dollars In Your Water? *Ground Water*, Vol. 35, No. 3

Thu, K.M., and Durrenberger, E.P., (Eds.). 1998, *Pigs, Profits, and Rural Communities*, State University of New York Press.

US EPA, 1995a. National Water Quality Inventory, 1994 Report to Congress, Office of Water, United States Environmental Protection Agency, Washington DC.

US EPA, 1995b. The National Public Water System Supervision Program, Compliance Report, Office of Enforcement and Compliance Assurance, Office of Ground Water and Drinking Water, United States Environmental Protection Agency, Washington DC.

US Geological Survey, Open-File Report, 92-63.

Wisconsin State Statue 281.45 (1979) Madison, Wisconsin.

Worcester, D. 1985. *Rivers of Empire* Pantheon Books, New York.