Wastewater Management Alternatives for Small Colorado Communities

Cooperative Extension Service
Colorado State University
Fort Collins, Colorado 80523
Bulletin 512A

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Lowell H. Watts, Director of Extension Service, Colorado State University. By law and purpose, the CSU Cooperative Extension Service is dedicated to serve all people on an equal and nondiscriminatory basis.

750 12/82

WASTEWATER MANAGEMENT ALTERNATIVES FOR SMALL COLORADO COMMUNITIES

Robert C. Ward
J. Bart Ruiter
Ralph W. Hansen

Agricultural and Chemical Engineering Department
Colorado State University
Fort Collins, Colorado 80523

Cooperative Extension Service
Colorado State University

WASTEWATER MANAGEMENT ALTERNATIVES FOR SMALL COLORADO COMMUNITIES

INTRODUCTION

Systems that treat and dispose of domestic wastewater on-site historically have been referred to as septic (or septic tank) systems. Septic systems generally have consisted of a septic tank, where the wastes are liquified, and a leachfield, where the effluent is ultimately treated and disposed. Septic systems are designed and installed following county regulations, but once approved for operation, the system becomes the responsibility of the home owner.

Due to most home owners' rather casual attitude toward their septic systems, the systems have a poor reputation as a long-term wastewater treatment alternative. When a system does not receive proper operation and maintenance, it ultimately fails.

Sewers and central wastewater treatment plants were recommended to solve small communities' wastewater problems. With the sewers and central plant, the home owner had no responsibilities (other than paying a monthly bill) for the treatment and disposal of wastewater. Theoretically, professionally trained personnel were hired to properly operate and maintain the central plant, which increased adequate public health and environmental protection.

Replacing septic systems with gravity sewers and central treatment plants proceeded unquestioned as long as Federal money was available for initial construction and the communities being addressed were relatively large. The first indication that this practice may not be the most appropriate came during the mid-seventies when sewers and central plants began to be built in relatively small communities.

These communities could not, even with Federal grants, afford the sewers and plants. The sewer costs for each home were completely out of line, particularly in less prosperous communities. In many cases, the small-community plants were not properly operated because the community could not afford to hire a well-trained professional

operator. The smaller communities were simply trying to use a technology that was designed for larger communities. Recognition of the problem was enhanced further by reductions in Federal grant monies for wastewater treatment plant construction.

The need for wastewater treatment alternatives for small communities slowly developed during the 1970s. A number of efforts to develop and evaluate such alternatives were initiated, and today an extensive array of wastewater treatment technology is available to small communities. While the technical alternatives have been evolving, there has been an increasing recognition of the need to more carefully and thoughtfully address the problem of future operation and maintenance, regardless of the technology chosen.

OBJECTIVES

The purpose of this bulletin is to introduce small Colorado communities to some available alternative domestic wastewater management methods. Technological options for treating wastewater will be briefly reviewed, and several potential arrangements for providing ongoing operations and maintenance will be described.

Ongoing operation and maintenance must be put in the context of total system management (i.e., planning, design, installation, operation and maintenance). Therefore, a review of current septic systems management strategies to properly integrate the existing management functions into a "new" use of the technology, also is required.

To further illustrate the small community wastewater management concepts being presented, an example of how such concepts were evaluated for a Roaring Fork Valley area will be presented.

Technological concerns are emphasized rather than institutional arrangements and economics of potential wastewater management in small Colorado communities. The technology and its operation and maintenance requirements perhaps will be the most common aspect of all applications to small communities. The institutional arrangements and economics probably will vary considerably as they depend heavily on each community's existing institutions and economic conditions.

TECHNOLOGY REVIEW

Septic systems have been used up to this point to describe the technology. The term, however, currently describes only a small segment of new domestic wastewater technology for on-site treating and disposing. A more accurate and descriptive term is "on-site systems." The "on-site wastewater treatment technology" role of solving wastewater management problems for small Colorado communities, will be discussed. Where the treatment may not be on-site (individual home owner lots) and does not use gravity sewers, the term "small-flow technology" is used. These terms often are used interchangably for technology other than the standard gravity sewer and central treatment plant.

When on-site or small flow technology "management" is discussed, the term refers to five major functions. All must be performed properly for adequate public health and environmental protection. The five functions that make up a total management system are: planning; design; installation; operation and maintenance.

The septic tank and leachfield are the oldest and most common on-site or small-flow technology. The septic tank provides for settling and digestion of the solids resulting in a liquid effluent. This partially treated effluent still contains a large amount of dissolved and suspended pollutants. It is filtered and purified by the soil in the leachfield. Water leaving the leachfield reenters the hydrologic cycle without causing health or environmental problems. When the septic tank/leachfield system is properly planned, designed, installed, operated, and maintained, septic systems can perform as adequately as a central sewer system (General Accounting Office, 1978). The problem is that in many cases, the management functions are not performed properly, and the systems ultimately fail. The key to success in this old technology is management.

Proper management of the classic septic system includes restricting its use in hydrologic, geologic or land-use situations where it is not able to properly function (e.g., high water tables, shallow soils, steep slopes and small lots). The new on-site small-flow technology, in many cases, has been developed to overcome restrictions that have

caused septic system failures. Many small communities have trouble with septic systems due to one of the above problems. It appeared the only recourse was the gravity sewer/central plant. The new on-site and small-flow technology is designed to overcome the septic system limitations. The newer technology and its proper management permits small communities to obtain proper wastewater treatment at a cost much less than a central sewer system.

Several examples of this new technology will be reviewed briefly.

Situation I

Consider the situation where a community has a high water table problem. The standard septic tank/leachfield system cannot function properly. The wastewater is not properly filtered before it reaches the groundwater. In this case, the septic tank effluent pollution enters the groundwater. It could move considerable distances and cause potential health and environmental problems. A similar situation exists where the soil is too shallow to provide proper filtration. In both cases, the "mound system" is an alternative that provides needed filtration. It is an artificial or built-up filtration media generally placed above the original ground surface. Effluent from the septic tank is pumped to a pipe distribution network on top of the mound. The effluent then filters through the mound and is purified before it reaches the water table or passes through the shallow soil. A pumping chamber is added to the septic tank.

Another alternative for these situations is the intermittent sand filter. Effluent from the septic tank is applied to a bed of fine granular material that is underdrained to collect and discharge the final effluent. The effluent may be disinfected and disposed on land or to surface waters. Soil filtration is replaced by the sand filter. The 1980 U.S. Environmental Protection Agency's (EPA) on-site system design manual describes the systems and several modificiations in detail. These systems often use a common treatment system for commercial or cluster home applications.

Another alternative to the leaching field for septic tank effluent is an evapotranspiration bed. The bottom of the bed may or may not be sealed depending on whether confinement is necessary. The bed consists of a sand medium from which the wastewater either evaporates or transpires through the plants. Climatic conditions and size requirements often limit the use of these systems.

Situation II

A common situation involves a small community that due to small lot sizes, is unable to use on-site systems. In addition, there may be a slow rate of projected build-out of the undeveloped lots. The standard gravity sewer/central treatment plant would appear to be the only solution. However, there are several possibilities. Gravity sewers could be installed, and the wastewater treated and disposed by a large common septic tank/leachfield system servicing a number of homes. The leachfield could be installed in an open area. Large leachfield systems may be limited to smaller communities.

Another alternative would continue to use the septic tank at each home or business in the community. But rather than discharge the effluent to individual leachfields, it would be pumped through a collector system of small diameter pressure sewer pipes to a treatment site. A pressure sewer system is often referred to as a septic tank effluent pump (STEP) system. Wastewater from the house flows into the septic tank where solids, grease and oil settle and digest. Effluent from the septic tank flows into a storage tank, and then is pumped into a small diameter pipe that carries the effluent to a treatment site (Bowne and Ball, 1980).

There are several ways to treat effluent from a STEP system. Treatment processes include package treatment plants, lagoons, oxidation ditches, absorption fields, and central treatment plants. The major difference is how wastewater is moved from home to plant.

Since a small diameter pressure sewer can follow any surface terrain and doesn't depend on gravity flow, it is less expensive than gravity systems. Primary treatment occurs in the septic tanks, so the central treatment facility does not have to be as large or complex.

Situation III

A small community that utilizes septic systems, but has problems with them failing, due to poor management, presents a different situation. The geology, hydrology and lot sizes permit continued use of septic systems. The failure is due to home owners not providing the needed management. There are alternatives to the sewers and treatment plant central system that is often considered to be the only solution.

In this case, the disposal system technology being used is appropriate, but the management is inadequate. A solution is available if the community will recognize that maintenance neglect is creating the problem. Central management to provide individual on-site systems maintenance may be all that is needed. Repairs, maintenance and management will be less expensive than replacing existing technology with an entirely new central sewer system.

The community, including property owners, must recognize the problem and develop 100 percent cooperation and participation if the central management system is to be successful.

MANAGEMENT STRATEGIES

On-site and small-flow technology's ultimate success in solving a community's wastewater problems depends on the management strategy chosen. The community's strategy must be compatible with current on-site wastewater management approaches and be accepted by everyone involved.

A community should evaluate an on-site wastewater management strategy for its particular situation. Each community must:

1. recognize that the management approach must include all necessary on-site technology functions;
2. understand the current approach under Colorado regulations (at the state and county levels) to manage on-site wastewater treatment technology; and
3. be familiar with the various possible management approaches available to small Colorado communities for wastewater management.

Management Functions

Five management functions must be provided if a management strategy is to succeed. These functions are: planning, design, installation, operation and maintenance.

Planners need to consider carefully the technological requirements at a particular site and to evaluate the geology, hydrology, land use patterns and any other related factors. The relationship of these factors to the array of technology that may best fit the total setting, means that land use planning must have a very strong wastewater management component in communities where on-site technology is being used.

Design refers to application of technology that best matches the community's and home owner's physical, economic and institutional setting. In the case of a standard septic tank/leachfield system, design provides sizing of the tank, leachfield and system layout.

Installation converts design to an operating system. Systems that depend on the soil for final treatment and disposal require installation procedures that protect the soil structure and its ability to filter wastewater. Installers must excavate, assemble the equipment and piping, place the proper media (rocks, sand, etc.) on the site, replace soil cover and finally, make the system operational. They also must insure that parts are not damaged and are properly installed. This may require working only when proper soil moisture conditions exist.

Operation deals with the day-to-day use of a wastewater treatment system. The system has a hydraulic load design that should not be exceeded. Some chemicals and non-biodegradable materials should not be deposited in the system. Soil compacting traffic should not be permitted on the leachfield. An informed home owner can insure that the system is operated and maintained properly. The management organization should provide the educational efforts and provisions to remedy problems that will develop.

Maintenance refers to routine inspection of the system; service of components where needed; and repair of any malfunctioning components. Most home owners overlook the maintenance function. This is where an organized management program potentially may have the greatest impact.

Current Management Approaches

The State of Colorado (the Colorado Department of Health) and Colorado counties currently share on-site wastewater treatment technology management. The state establishes minimum guidelines that the counties must follow, in developing county regulations, and assists counties in reviewing designs that deal with unusual situations.

Figure 1 lists the five management functions and the entities currently responsible for their successful implementation. In general, planning is a county responsibility. Design and installation approval are jointly the responsibility of the county and state, under the Colorado Department of Health Individual Sewage Disposal Systems Guidelines that are the basis for most county regulations. Operation and maintenance are theoretically required by county regulation, but for all practical purposes, are the home owners' responsibility. The complete on-site wastewater treatment system is managed by three different groups:

1. county planning regulations (under state guidelines);
2. county and state health regulations and
3. home owners.

The management system's fragmented nature does not provide the perspective needed to successfully utilize on-site technology as a viable alternative to gravity sewers and central treatment plants for small communities. To utilize on-site technology, the small Colorado community must provide for all management functions not adequately addressed by the current management strategy.

The weakest links in the management system are operation and maintenance. There are formal, although not necessarily closely coordinated, management procedures providing for planning, design and installation, but none for operation and maintenance. Most small communities need to focus their attention on operation and maintenance to have all functions included.

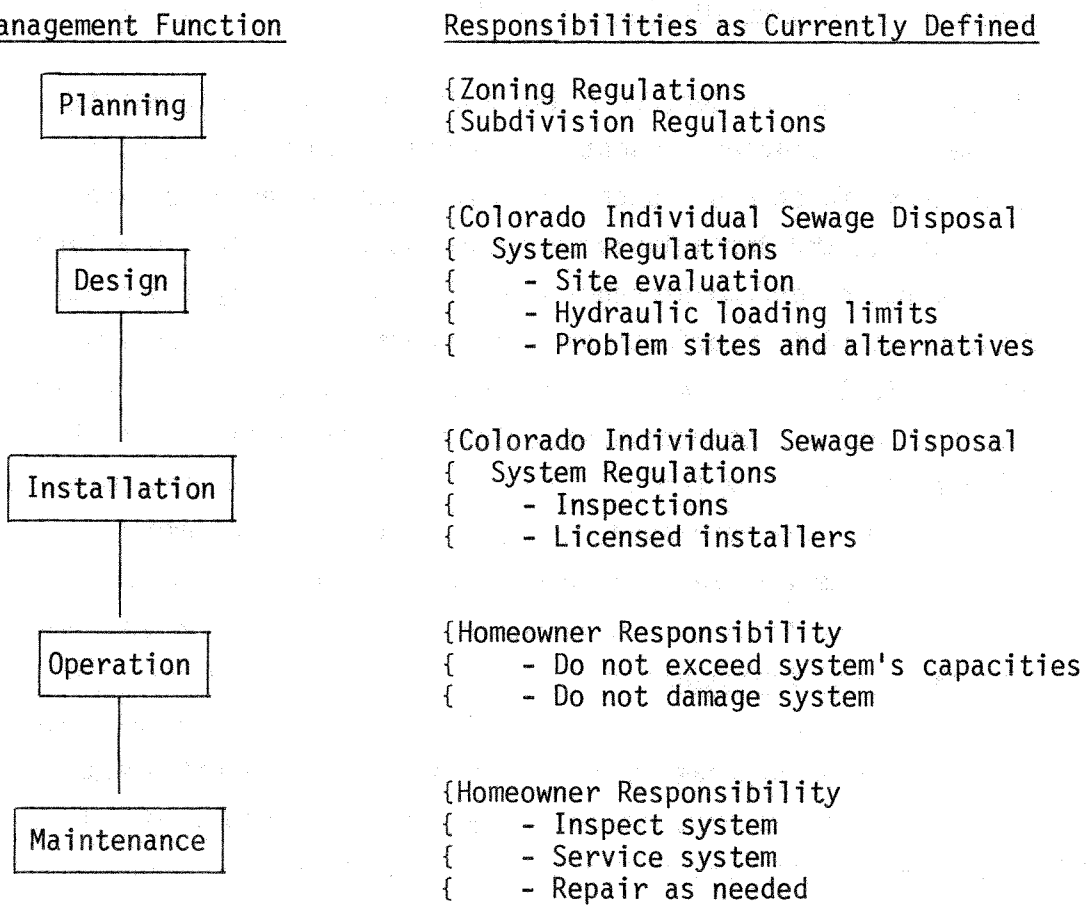

Figure 1. Entities currently responsible for the five on-site management functions in Colorado.

Alternative Management Strategies

Because of the problems associated with operation and maintenance, the management strategies presented for small communities tend to emphasize these functions. Such strategies simply recognize that planning, design and installation are currently addressed in a formal manner. Operation and maintenance are not. A community's operation and maintenance (O & M) efforts can complement state and county regulatory efforts in planning, design and installation. The ultimate management strategy, not necessarily the most practical, gives the community responsibility for all functions. The alternative management strategies have been developed through a range of involvement, from educating home owners about O & M to full control.

Educational Programs

An educational program informs home owners on the different aspects of on-site systems, particularly O & M. It would include individual Sewage Disposal System (ISDS) regulations and land use controls. The program would make on-site systems owners aware of the on-site system function, the design to treat and dispose of wastewater, system failures and their identification, health and environmental problems associated with on-site system failures, information to obtain an on-site permit and information to operate and maintain on-site systems. Home owner education could be accomplished by literature distribution, seminars and short courses on on-site systems, neighborhood discussions on on-site system O & M and other methods.

Management Assistance Programs

A management assistance program provides home owners with technical assistance to correct specific problems. For example, it reminds home owners when to pump their septic tanks. It would also include regulations and land use controls.

Operation and Maintenance Programs

Currently Colorado counties issue permits for the construction of on-site systems. The O & M program could be based on the requirement for a renewal of the permit. Renewing the permit would allow a home owner to continue to use an on-site system for wastewater treatment and disposal. The renewal process would require inspection of the septic tank and pumping of solids when necessary. The renewal period would vary depending on the type of on-site system.

Fully Centralized Management Programs

A fully centralized management program provides all services required by on-site systems and, in addition, more comprehensive planning. Besides zoning and subdivision regulations, planning would involve preparation of a wastewater disposal plan for the community. It would indicate the relative suitability and opportunities for on-site alternatives, as compared to centralized wastewater collection and treatment systems. These plans should be prepared for an entire community and specific subareas, such as subdivisions. Coordination of agencies and programs also should be a part of the planning function (Roy F. Weston, Inc., 1979).

Institutional Arrangements

Colorado agencies and institutional arrangements available to carry out the on-site management programs include:

1. existing public agencies—including municipal, county and state agencies, soil and water conservation districts;
2. special service agencies—created solely to provide wastewater management, special districts, sanitation districts or public authorities and
3. private sector entities—private contractors, private utilities, rural cooperatives and property owner associations.

Singularly or together these agencies could implement wastewater management functions. The authority and administrative structure of a particular management entity varies from community to community (Roy F. Weston, Inc., 1979).

Selection of an institution, to manage on-site systems or to coordinate on-site system management, should include consideration of enforcement responsibilities, political and public acceptance, funding and professional staffing.

ALTERNATIVE WASTEWATER MANAGEMENT STRATEGIES EVALUATION EXAMPLE

Small Colorado communities evaluating a range of wastewater management strategies must consider these different factors: technology, economics, institutions, development goals and human resources. Except for operation and maintenance technology, these factors are site specific. The following alternative evaluation example focuses mainly on technological considerations. Rough cost estimates have been developed, but other factors are discussed only in generalities.

The example illustrates alternatives for initial consideration by community decision makers, but does not deal with detailed design or installation—these would come after a community's decision for a particular alternative.

The example uses an area near Carbondale in the Roaring Fork Valley. The area has experienced some growth, and housing density is increasing. Hydrological factors are limiting classic septic systems. The discussion below illustrates how technical aspects of alternative wastewater management strategies initially could be evaluated. Since the evaluation is preliminary, the area is referred to as the "planning area."

Current Situation

The planning area is a low-lying area of approximately one square mile along the Roaring Fork River east of Carbondale. The planning area is unincorporated and consists of approximately 34 homes. These homes use on-site systems to treat and dispose of their household wastewater. The water supply for each home is from an individual on-site well. There are no commercial establishments or industries in the planning area.

Currently, the wastewater treatment and development efforts are not organized. Garfield County's ISDS regulations provide design and on-site systems installation controls, but the home owner is responsible for the system's operation and maintenance (O & M).

Since the planning area is unincorporated, the population data was not available. A rough estimate was calculated using 3.5 persons per unit (Wright-McLaughlin Engineers, 1980) giving the approximate current population as 119 persons.

The planning area is designated agriculture/residential/rural/density. The area zoned for residential development near the planning area is:

1. Te-Ke-Ki Planned Development, presently undeveloped;
2. Aspen Crystal River Estates, residential/limited/urban density, presently undeveloped and
3. Ranch of Roaring Fork Planned Unit Development, partially developed.

The Colorado West Area 208 plan, that includes this planning area, stated:

> "Potential conflicts between septic systems (on-site systems) and domestic groundwater supplies are of particular concern to Garfield County near Carbondale (planning area), however, historical data did not indicate any existing problem."

Potential problems exist between the on-site systems and the high groundwater levels in the planning area. At certain times of the year, the high groundwater levels may cause insufficient filtration soil depth below the soil absorption fields. This could result in pollution of groundwater, surface waters and the well water supplies in the general area.

The planning area currently is served by on-site systems. The 34 homes use approximately 19 standard septic systems and the rest are evapotranspiration systems. The sludge pumped from the septic tanks is disposed of in Garfield County landfills.

Other existing wastewater treatment systems near the planning area are the Carbondale Sanitation District's centralized wastewater treatment system and a package wastewater treatment system at the Ranch of Roaring Fork.

In the planning area, 12 of the 34 homes were surveyed to determine the existing systems performance:

1. any problems with their on-site systems and
2. the last time the system was pumped.

The evapotranspiration systems performance seems to be satisfactory. Most of these systems have been installed within the past three or four years.

The standard septic systems performance appears to be less satisfactory than the evapotranspiration systems. Some of these septic tanks have not been pumped in seven years. Also, a few other home owners stated that during the spring, if they use a lot of water, their system will fail. One home owner stated that there is a high turnover rate in the planning area, and most new home owners do not ask questions about the on-site system—such as when the septic tank was last pumped and where the septic tank is located. She also said that some people probably will say their system is working satisfactorily when it isn't, because they do not want to invest their money in fixing the system.

System performance—groundwater monitoring or after installation inspection—is not monitored by the county. As noted earlier, the O & M services needed by on-site systems are the home owner's responsibility.

Future Situation

Currently the county planning department is not allowing the subdivision of any land in the planning area until the wastewater treatment problem is solved (Baldwin, 1980). Before the county

planning department made this decision, the planning area was developed by individual property owners subdividing a piece of their property and selling it to someone who would build a house on it. The population increased from approximately 88 persons in 1977 to 119 persons in 1980.

The type of wastewater system that the county or the home owners select will, to a large extent, determine the planning area's future population. For example, if the planning area decides to use sewers, the population would tend to increase because this type of system allows a higher housing density and needs hookups to offset the sewer's cost. If the planning area decided to improve wastewater treatment by better on-site system management, the planning area development probably would proceed as before. Property owners would subdivide their land, and population growth probably would be slower than in the first example.

In developing comparisons between wastewater management alternatives, it is necessary to calculate the planning area's wastewater flow. The following assumptions will be necessary:

1. the planning area will not be rezoned,
2. the "saturation" number of houses in the planning area will be 68 and
3. all houses will connect to the sewer line (if it is selected to be installed).

A rough population estimate, using 3.5 persons per house (Wright-McLaughlin Engineers, 1980), is 238 persons. A wastewater flow estimate using 75 gallons per day per person is roughly 17,850 gallons per day total. If conventional sewers are used, the estimate does not include seepage into the sewer lines by groundwater. This infiltration could be significant due to the planning area's high water table.

Wastewater Management Alternatives

The wastewater treatment alternatives considered for the planning area are listed in Table 1. The first four alternatives deal with on-site systems management improvement and were discussed earlier.

Table 1. Cost and potential institutional arrangements of the wastewater management alternatives.

Wastewater management alternative	Potential institutional arrangement	Additional personnel	Initial physical costs	Monthly fee
1. Education program	County & Extension Serv.	No	0	No
2. Management assistance program	County & Extension Serv.	Yes	0	No
3. Operation and maintenance program	County & Extension Serv.	Yes	0	No
4.[1] Fully centralized management program	Sanitation District	Yes	190,000	Yes
5a.[1] STEP[2] System with Package Plant	Sanitation District	Yes	286,294	Yes
5b.[1] STEP[2] System with Treatment by CSD	Carbondale Sant. Dist. (CSD)	Maybe	244,110	Yes
6.[1] Conventional Collection System with Treatment by CSD	Carbondale Sant. Dist. (CSD)	No	473,110	Yes

[1]Alternatives may be eligible for grants from state and federal agencies.

[2]Septic Tank Effluent Pump.

The last two alternatives deal with different ways to sewer the planning area. Alternative 5 uses a septic tank effluent pump (STEP) system and two methods of treatment: (a) a package plant, and (b) the central wastewater treatment plant in Carbondale. Alternative 6 requires the planning area to become part of the Carbondale Sanitation District by extending a trunk sewer into the planning area. The home owners would then connect to the trunk sewer.

The table presents each alternative's potential institutional arrangements and whether that alternative needs additional personnel to help administer it. The table also presents a rough estimate of the alternative's initial physical cost. The cost estimates are for new building or repairs to existing structures and potential monthly fees to cover operation and maintenance costs. The alternatives with "no" in their monthly fee column finance their operating costs by other means. Costs presented represent 1980 dollars.

The institutional arrangement for the first three alternatives probably would be administered best by the county Extension Service cooperating. Alternatives 4 and 5a would be administered best by some form of sanitation district because the management entity would need taxing power. The last two alternatives (5b and 6) call for the planning area to become part of the Carbondale Sanitation District.

Selection of the "Best" Alternative

Selection of the best alternative is largely dependent on what is acceptable to the public and the local government. Some questions the public and local government in a community (such as the planning area) should consider are: what type of development will be encouraged, what are the environmental effects, and is it within the community's economic range? Each community should evaluate its own needs and desires and select a particular technology that best matches its: economic status, development goals and environmental characteristics.

For many small communities, the most effective wastewater treatment for the least cost will involve some form of on-site technology. A range of satisfactory alternatives for the Roaring Fork Valley have been developed, described and compared to the more traditional

and expensive central sewer alternatives. The most appropriate alternative must be selected by a well-informed public and its representatives.

SUMMARY

Alternative wastewater management strategies that will provide complete wastewater management programs for small Colorado communities are available. These programs can provide for the total management of on-site systems. They also can provide small Colorado communities with a viable alternative to centralized wastewater treatment facilities.

The management functions needed to accomplish proper on-site systems management are planning, design, installation, operation, and maintenance.

Colorado's management system was described and analyzed to determine where some of the problems with on-site technology have developed. The Colorado management system's O & M functions appear to be major weaknesses in the entire management system. This is because the main responsibility for O & M rests with the home owner, and there is a reluctance by a majority of the home owners to accept this responsibility (Dix, 1978).

Alternative wastewater management strategy studies indicate the need to emphasize O & M functions.

To illustrate on-site technology use, a technical evaluation of management alternatives was developed for a small area east of Carbondale in the Roaring Fork Valley of Colorado. The alternatives included non-structural management alternatives (e.g., an educational program and a management assistance program) and, for comparison purposes, structural management alternatives (e.g., pressure sewer system with a package plant treatment).

It is possible for a community to develop local wastewater management strategies that provide a total management approach, including O & M. These management strategies will help provide proper on-site systems management and may give Colorado communities a selection of very adaptable wastewater treatment technologies.

REFERENCES

Baldwin, Ray. 1980. Garfield County Planner, Glenwood Springs, Colorado. Personal Communication.

Board of County Commissioners (BOCC). 1979a. Subdivision Regulation of Garfield County. Garfield County, P.O. Box 640, Glenwood Springs, Colorado.

Board of County Commissioners (BOCC). 1979b. Garfield County Zoning Resolution. Garfield County, P.O. Box 640, Glenwood Springs, Colorado.

Bowne, W. C. and H. L. Ball. 1980. The Glide, Oregon, Pressure Sewer System, BHW Engineering, 1205 S.E. Court Avenue, Roseburg, Oregon, November.

Colorado State Board of Health (CSBH). 1979. Guidelines on Individual Sewage Disposal Systems. Colorado Department of Health, Water Quality Control Division, 4210 East 11th Avenue, Denver, Colorado.

Dix, Steve. 1978. Non-central wastewater system development through a socio-economic survey of rural communities. Unpublished thesis of Colorado State University, Fort Collins.

El Dorado Engineers. 1977. Carbondale 201 Facilities Plan. El Dorado Engineering, Glenwood Springs, Colorado.

Garfield County Health Department (GCHD). 1973. Individual Sewage Disposal System Regulations. Garfield County, P.O. Box 640, Glenwood Springs, Colorado.

General Accounting Office. 1978. Community-Managed Septic Systems—a Viable Alternative to Sewage Treatment Plants. GAO Report No. CED-78-168, Washington, D.C., November 3.

Kriessl, James and A. Cooper. 1977. Alternatives for Small Wastewater Treatment Systems, Pressure Sewers/Vacuum Sewers. Vol. 2. U.S. Environmental Protection Agency, EPA-625/4-77-011. October.

Roy F. Weston, Inc. 1979. Management of On-Site and Alternative Wastewater Systems. Draft Report prepared by the Environmental Research Information Center Technology Transfer Seminar on Wastewater Treatment Facilities for Small Communities. U.S. Environmental Protection Agency. July.

Small Scale Waste Management Project (SSWMP). 1978. Management of Small Waste Flows. U.S. Environmental Protection Agency, Report No. EPA 600/2-78/173. September.

U.S. Environmental Protection Agency. 1980. On-Site Wastewater Treatment and Disposal Systems Design Manual. U.S. EPA Report No. EPA-625/1-80/012, Washington, D.C. October.

Ward, R. C. and R. Hansen. 1979. Septic tank systems—problems and promises. Colorado State University Extension Service, No. 4.661. December.

Wright-McLaughlin Engineers. 1974. Roaring Fork River Basin. Water Quality Management Plan. Wright-McLaughlin Engineers, 2420 Alcott Street, Denver, Colorado. May.

Wright-McLaughlin Engineers. 1976. Test Hole Rf-A Phase II Groundwater Supply Evaluation for the Town of Carbondale. Wright-McLaughlin Engineers, 2420 Alcott Street, Denver, Colorado. September.

Wright-McLaughlin Engineers. 1980. El Jebel and Missouri Heights Water and Sewer Feasibility Study. Wright-McLaughlin Engineers, 2420 Alcott Street, Denver, Colorado.

A 25-minute film, "Wastewater Management...Options for Unsewered Areas," shows some options used in different parts of the country and how the systems are managed. The film is intended for local government leaders, and general audiences, high school through adult. It is available from the film library of Colorado State University Audio Visual Services, Fort Collins, Colorado 80523 (telephone 303/491-5466).

Preparation of this bulletin was supported by the Colorado State University Cooperative Extension Service, the Western Colorado Rural Communities Program (partially supported by the W. K. Kellogg Foundation), and the Water Quality Control Division of the Colorado Department of Health.