A Massachusetts Guide to Needs Assessment and Evaluation of Decentralized Wastewater Treatment Alternatives

Prepared for the

***ad hoc* Task Force for Decentralized Wastewater Management**

by

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***ad hoc* Task Force For Decentralized Wastewater Management**

The *ad hoc* Task Force for Decentralized Wastewater Management is a group of non-governmental organizations, municipalities, regional planning agencies, state and federal government representatives, academics and engineers working together to help municipalities achieve real cost and performance benefits from wastewater technologies through education and implementation of basic wastewater planning and management programs.

ad hoc Task Force for Decentralized Wastewater Management Steering Committee members:

- Town of Barnstable. MA
- Cape Cod Commission
- City of Gloucester, MA
- Coalition for Alternative Wastewater Treatment
- Marine Studies Consortium
- Massachusetts Bays Program
- Massachusetts Department of Environmental Protection
- University of Rhode Island On-Site Wastewater Training Program
- U.S. Environmental Protection Agency - Region 1
- Waquoit Bay National Estuarine Research Reserve

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EXECUTIVE SUMMARY

Background

In governmental literature, both state and federal, the term "facilities planning" originally referred to the mandated process by which a community could obtain a federal "construction grant" to build a centralized sewage treatment facility. There were three major steps to the process: Step 1, Planning; Step 2, Design; and Step 3, Implementation. Step 1, the planning step, was often divided into three phases: Phase I, Needs Assessment; Phase II, Development and Screening of Alternatives; and Phase III, Detailed Plan Evaluation. The plan evolving from Step 1 was to have both environmental/ technological and administrative/ institutional components. The Environmental Protection Agency's Construction Grants Program has since been phased out. However, most of the existing literature pertaining to such planning still places emphasis on central facilities, even during an era when both governmental and civic interest in *decentralized wastewater management* has increased.

"Decentralized wastewater management" is shorthand for the "centralized management of dispersed on-site or "near-site" individual, or neighborhood and community, small-scale wastewater treatment systems." The concept carries the implications that small-scale systems require varying degrees of prescribed maintenance, e.g., regularly scheduled inspection and pumping at the least; and that the planned and managed use of conventional and advanced small-scale systems might indefinitely forestall the need for a community to sewer and convey waste to a central treatment plant. In this context, "managed use" may often imply more than Title 5 management of conventional septic systems in terms of planning, permitting, and maintenance. But it may also imply less, in that the conservative, prescriptive standards for Title 5 systems may be replaced with performance-based and environmentally-based standards that are altogether more flexible.

By analogy, a process similar to central facilities planning can be established for the "alternative" of long-term, proactive, decentralized wastewater planning. In varying degrees it has even come to be required in revisions to federal and state regulations because both the cost of centralization and its adequacy have increasingly come into question. Just this year (in January, 1996) the Massachusetts Department of Environmental Protection issued a new set of guidelines to communities, entitled *Guide to Comprehensive Wastewater Planning*, which implies in its title, as in its content, that on-site systems as well as central systems may be part of a 20-year plan sanctioned by the

DEP, thus qualifying for several types of loans and grants.

Even so, it remains that much less has been published in the way of planning guidance for decentralized alternatives. The DEP guidelines themselves comprise only 30 pages of advice for a process that may result in the expenditure of millions of dollars; only a portion of that advice concerns decentralization. Furthermore, the decentralized solution can be more complex than that of centralization alone, particularly if the planning is conducted comprehensively. Technologically, it involves the examination of many more variables, including the place (and type) of central facilities that may be part of an overall wastewater management plan. Administratively, the organizational and institutional structures required for management may need to be created, if not wholly from scratch, at least by modifying the charters of local governmental agencies. This isn't the case for public utilities, such as a central treatment plants, where clear-cut instrumentalities already exist for their management. And financially state support of decentralized management is only now coming to be explored in sufficient ways.

Therefore, this document, and a companion to this one entitled *Managing Wastewater: Prospects in Massachusetts for a Decentralized Approach*, have been written to familiarize members of Wastewater Planning and Citizens Advisory committees with the issues that arise in the decentralized context, and to provide some guidance to their exploration during the planning process. It is hoped that this background will help such committees participate effectively in their dialogues with consultants, planners, and state officials.

This, the "planning document," is concerned mainly with the environmental, regulatory, geographic, demographic, and technological variables that arise. The other, the "management document," is a more elemental exploration of the kinds of administrative, regulatory, and financial structures that other states or regions have created in order to proactively manage on-site systems. The multi-state inquiry was necessary because the very concept of a decentralized management program, particularly one that could substitute for, and perform as well as or better than, central treatment, is comparatively new to Massachusetts.

The target readerships of both documents are local officials, such as Selectmen, members of Boards of Health, or others under whose general auspices planning takes shape. Engineers, professional planners, lawyers, and financial experts will find the discussions of interest, but insufficient to fully specify either a technological or an administrative construct. (Which, in any event would not need to be fully specified, in the "classic" context, until Step 2, Design, was completed.)

Earlier versions of both documents were presented to attendees of a December 1-2, 1995, Assumption College (Worcester, Massachusetts) conference entitled *Managing Small-Scale, Alternative and On-site Wastewater Systems: Opportunities, Problems and Responsibilities*. Proceedings from that conference are also available from the *ad hoc* Task Force for Decentralized Wastewater Management.

A Summary of Decentralized Wastewater Planning

The organization of this document follows that of the three phases of the older "facilities planning" process, namely, (1) needs assessment; (2) development and screening of alternatives (particularly regarding problem areas or areas of special concern within the planning area or "district"); and (3) overall, integrated evaluation of alternative plans, their area-specific subplans, and the plan's separate components: technological, administrative, and financial.

However, even before Phase I (Needs Assessment) commences, a "Plan of Study" is drawn up by a Lead Agency. This procedure is discussed in the first chapter. The Lead Agency may be a Board of Selectmen; it may be a Wastewater Planning Committee established by a Board of Selectmen or a Municipal Council; it may be a department or board within a town, such as the Board of Health. If the planning area or district crosses jurisdictional boundaries, the Lead Agency will be jointly established, or the role may be assumed by a division of a regional planning entity. Not only does the Lead Agency create, or lead in the creation of, a Plan of Study, but it establishes liaison with other municipal and state (and possibly federal) agencies such as the local Planning Board and Conservation Commission, the state's Department of Environmental Protection and MEPA office; and offices of relevant federal/state/local partnerships such as the Massachusetts Bays Program. The Lead Agency will assess the need for, hire, and then steer the activities of consulting engineers or planners, which will be required if the project is of any real complexity. Indeed, if hired, these consultants would typically draft the plan. The Lead Agency will budget the planning process. Finally, and very importantly, it will establish a Citizens Advisory Committee representative of the municipality's diverse interests; and it will engage in other forms of public discourse such as holding public meetings and hearings.

The introductory chapter also provides discussion of the history of water pollution control in law and circumstance, and provides an overview of the entire planning process. The process described in this document is a very complete one, in general commendable because of its emphasis on comprehensiveness. Such a thorough plan may also be stipulated by the DEP if a community seeks state funding or if it is under a consent order. But much in the way of better management of small systems may be accomplished without such formal, or complete, procedures; thus the process described may, alternatively, be viewed as a "menu" of considerations that a community may wish to explore.

During Phase I, Needs Assessment (covered in Chapter 2), the first task is to establish an overall community profile, which accounts of its present circumstance, and what it is likely to look like at the end of the plan's 20-year design life. The profile will reveal the planning area's topography, geology (especially soils), hydrology of surface and ground waters; and identify environmentally sensitive areas such as groundwater recharge zones, water supplies, wetlands, nitrogen-sensitive embayments, wildlife or plant habitats, and archaeological or historical assets. It will examine present and future demography. Using that analysis, as well as local zoning and development plans, it will then examine present and required water supplies. Finally it will examine existing wastewater flows, loadings, conveyances, and facilities; assess their current status; and project future needs. Last of all, it will identity areas of particular concern regarding wastewater. Such concerns may have to do with environmental sensitivity, population density, the presence of antiquated or failing systems, or areas with severe geological or hydrological limitations to accommodating wastewater flow.

Chapter 3 opens with a discussion of wastewater treatment in general; levels of treatment from the primitive to the advanced, enhanced, alternative and innovative; the types and scales of systems available; and some of the broad principles and processes that go into the development, screening, evaluation, and elimination of options, particularly in the small-scale, and small community, context.

It then moves to a discussion of Phase II, Development and Screening of Alternatives. This process involves matching various areas within the planning district (especially problem areas, or “Areas of Concern”, AOCs), along with their associated environmental and regulatory requirements, against the capacity of broad technological categories to address them. First, for example, what levels of treatment are required for each area: primary, secondary or tertiary? Then, is such treatment best accomplished by creating or further extending centralized treatment, or instead by creating zones where small-scale and community systems provide the solution? For the remaining areas, served by individual systems, the question is whether conventional treatment will suffice, or whether advanced treatment will be required. Thereafter, the environmental impacts of the facilities themselves need addressing. Only after that can more detailed consideration be given to technological factors such as design, reliability, risk, ease of operation, and opportunities for water or energy conservation.

Through a process of elimination the number of technological choices diminishes, and increasing consideration of the surviving ones is given to wastewater technology management (remediation, inspection, and maintenance) and the administrative entities that will specify and enforce such management; the overall costs to implement the plan; and a plan to finance such costs.

Chapter 4 discusses Phase III, the Evaluation of Community-wide Plans. This broader evaluation involves examining the details concerning the establishment of the precise boundaries that separate different types of service areas; the layouts of sewers; the provisions for and location of residuals treatment; the required mechanisms for system management and administration; the overall costs during the entire design life of the system; and, finally, public acceptance of proposals. In Phase III a small number of overall plans are compared and evaluated against each other. The adequacy and cost-effectiveness of each is compared to a "baseline alternative" of maximizing the use of existing facilities. At several junctures, more research may be required, and more effort may need to be expended in bringing the public to consensus. The local or affected public, typically at the ballot box, is ultimately charged with final plan approval.

Chapter 1. INTRODUCTION

1.1 Some History of Water Pollution Control

In 1948 Congress enacted the Federal Water Pollution Control Act which set forth ambient water quality standards and required states to identify polluted water bodies and locate and suppress pollutant discharges. This Act was the first ever environmental legislation enacted by Congress, and its approach was found to be impracticable. Each state went about trying to meet the WPCA standards differently, and while a few states had some success, most found it nearly impossible to determine which polluter caused what pollution. As a result, rivers were being turned into open sewers, aquatic life in lakes and ponds was threatened with extinction, and the purity of our drinking, irrigation and industrial water supplies was endangered. The continued degradation of these important water resources eventually forced Congress to rethink their strategy.

In 1972 Congress enacted the Federal Water Pollution Control Act Amendments. These amendments represented a new approach, the basic concept of which was a prohibition of all discharges of pollutants without a permit. The new approach abandoned the use of ambient water quality standards that limited the concentration of pollutants in the water body and relied on the use of effluent standards instead. The newly formed Environmental Protection Agency (EPA) was then charged with enforcement of these new effluent standards. The standards, however, were set to match the effluent quality achieved by the state-of-the-art technology (passive primary wastewater treatment) and thus prescribed a single technology standard to solve the nation's water quality problems. This approach worked well to protect water quality in some regions, particularly in inland lakes and rivers, but water quality in other areas continued to be degraded.

The 1972 Federal Water Pollution Control Act was amended in 1977 and renamed the Clean Water Act (CWA). At this time, six new goals and objectives were set forth:

1. Elimination of the discharge of pollutants into navigable waters by 1985;
2. Achievement of water quality sufficient to protect fish and recreation by 1983;
3. Prohibition of the discharge of toxic pollutants;
4. Construction of publicly owned wastewater treatment works;
5. Development of area-wide waste treatment management planning; and

6. Development of the technology to eliminate the discharge of all pollutants.

To achieve these goals and objectives, Congress enacted a system of regulations regarding water pollutants and authorized grants for planning, construction of passive primary wastewater treatment plants, and research. By this time, EPA had already embarked on a campaign to clean up the nation's water resources and the order was going out to cities and towns, in some states directly, and in others such as Massachusetts, through state environmental agencies, to come into compliance or face major fines.

Construction of large publicly owned wastewater treatment works, however, was expensive, and many cities and towns found it difficult to comply without financial assistance. It wasn't until 1981, though, that federal subsidies large enough to help cities and towns build large central treatment plants became available. Congress began to recognize that primary treatment levels mandated in the CWA of 1977 were insufficient to protect many water resources. Consequently, they enacted amendments to the CWA in 1981 that called for municipal sewage treatment plants to upgrade in order to meet higher standards that were based on the new state-of-the-art technology, biological secondary treatment. At this time, Congress recognized that increased federal support for wastewater projects was needed to help defray costs associated with plant upgrades and construction of new facilities, and enacted the Federal Construction Grants (CG) Program. The CG Program, which was administered by the EPA, established a facilities planning process through which large subsidies were provided to cities and towns to help them design and build municipal secondary wastewater treatment facilities. The CG Program created significant momentum for *centralized* treatment, and all but established sewering and centralized passive primary/biological secondary wastewater treatment as the nation's preferred method for water pollution control.

In 1987, though, Congress passed the Water Quality Act (WQA). While the WQA added a new goal to the CWA to focus on the importance of controlling nonpoint source pollution, its major impact came with its phasing out of the Federal Construction Grants Program. In place of the CG program, Congress authorized states to create a revolving funds system that could be used to make low-interest loans to cities and towns in need of sewage treatment systems.

Up until this time the Federal Government was carrying approximately 75% of the financial burden associated with the construction of new sewers and large central primary/secondary treatment plants. State Revolving Fund systems (SRF), however shifted that burden to the municipalities. Under the SRF loan systems, cities and towns now bear 75% of the costs, which have been rising in recent years. As a result, many communities, particularly smaller ones that have difficulty obtaining SRF loans, are finding it difficult to obtain public support for new construction of large centralized treatment systems.

Increasing financial constraints as well as other social, demographic and environmental problems associated with the conventional approach to wastewater management point to the need for able to consider a wider range of alternatives. Individual on-site disposal systems (ISDSs), including conventional septic systems, innovative and advanced technologies, as well as shared systems are alternatives that can provide equally good treatment or better depending on the circumstances (i.e. advanced nitrogen removal technologies). These more *decentralized* technologies pose fewer watershed or aquifer recharge problems since they discharge the wastewater effluent locally. In addition, ISDSs and small shared systems may offer land use (e.g. protection of open space) and cost benefits.

The degree to which such decentralized solutions are considered for long-term wastewater management has been limited, however, by the perception that ISDSs are prone to failure, and therefore are to be employed as temporary or interim solutions on the way to eventual sewers. Many "on-site" technologies, however, are proven technologies that will provide long-term protection of public health and the environment, provided they are managed properly. A large percentage of ISDSs currently in use are failing, but not because they don't work. Most of the failures can be attributed to the misapplication of prescriptive codes that result in faulty design or installation in areas inappropriate for on-site disposal (e.g. high groundwater, poor soils), or to inadequate maintenance (i.e. failure to pump tanks). Such problems can be overcome, but it requires that cities and towns take a more comprehensive approach to wastewater planning, and increase their level of commitment to the management of individual on-site and small shared systems.

In addition to better management, their exist, today, new innovative and advanced "on-site" technologies that may provide long-term protection of public health and the environment in situations that, in the past, could best be addressed only through centralized treatment. Managing wastewater using a combination of more advanced on-site technologies, conventional on-site systems and perhaps smaller centralized treatment systems may represent an affordable and environmentally sensitive long-term alternative to extensive sewers and large central treatment plants, particularly in smaller communities with limited fiscal ability. Until now, though, there has been little or no guidance available to help Massachusetts communities develop and evaluate such alternatives. Current state guidelines for wastewater management planning (Guide to Comprehensive Wastewater Management Planning, MDEP), discuss decentralized solutions only briefly and provide inadequate guidance on evaluating this approach . More detailed guidance on how to assess wastewater needs, determine where or under what conditions a more decentralized approach may be appropriate, and how to develop and evaluate decentralized solutions in those areas is needed.

1.2 Purpose and Scope of this Document

Planning how a community will manage their wastewater needs for the next two decades requires a commitment to thorough problem definition and a comprehensive look at resource use and protection, land use, growth and development and other economic, demographic and environmental issues that influence the decision-making process. This is essential to the development and implementation of a wastewater management strategy that will achieve long-term performance of both decentralized and centralized systems, and thereby protect public health and the environment. City and town officials, as well as the public, however, are generally not comfortable with the concept of comprehensive planning, particularly in the context of wastewater management.

The purpose of this document is to provide a guide to wastewater management planning to help Massachusetts communities consider a wider range of wastewater treatment and disposal options to address their wastewater needs. The remainder of Chapter 1 provides city and town officials, planners and engineers, and the public with an overview of the wastewater management planning process to help them see how they might negotiate the process more effectively. Chapter 2 provides guidelines that will enable communities to determine their wastewater needs in a comprehensive manner. Chapters 3 and 4 serve as a guide to the screening (Ch. 3) and evaluation (Ch. 4) of decentralized alternatives.

More specifically, Chapter 2, Guide to Needs Assessment, is designed to help planners and engineers obtain a clear and complete view of a community's wastewater needs and the kinds of issues, including environmental, demographic, economic and political, that impact the development and evaluation of wastewater treatment alternatives. This knowledge will allow community leaders to determine where a centralized or decentralized approach may be most suitable. In some cases, both approaches may appear equally viable, but a detailed screening and evaluation of all the alternatives may suggest otherwise or indicate that a combination of approaches is best.

Chapters 3 and 4 provide the tools needed to adequately identify and evaluate small-scale, alternative and on-site wastewater technologies that may address wastewater problems in areas that may support a decentralized approach. While the latter part of this document focuses on decentralized solutions, the reader is reminded that this approach, as with sewering and centralized treatment, is not always the most appropriate solution. Guidance on the evaluation of centralized alternatives is, however, readily available from state and federal sources, whereas very little guidance is currently available for evaluating decentralized alternatives. A companion document to this one, entitled *Managing Wastewater: Prospects in Massachusetts for a Decentralized Approach*, should be reviewed in conjunction with this one. It discusses the issues and obstacles to the implementation of decentralized management programs and examines the importance of such programs in protecting public health and the environment. It is important to recognize that while this document and the companions to it do not examine alternatives for wastewater residuals (i.e. septage, sludge), alternatives for dealing with wastewater residuals must also be considered concurrently. Guidance on evaluating residuals management options may be obtained from the MA Department of Environmental Protection or the US Environmental Protection Agency.

It is the hope of the Ad Hoc Task Force for Decentralized Wastewater Management that this document when used in conjunction with its companion documents and state guidelines will help Massachusetts communities to develop appropriate solutions for wastewater management, while addressing their needs on site as much as possible. The Task Force also intends these documents to be helpful in developing assurances for municipalities and the MA Department of Environmental Protection that the solutions recommended will provide long-term protection of public health and the environment.

1.3 Comprehensive Wastewater

Management Planning

1.3.1 The Goal

The goal of the wastewater management planning process is to generate a comprehensive plan that will guide the community in the construction, operation, maintenance, and financing of a wastewater treatment system that addresses the wastewater needs of the community. This is most effectively accomplished through the development of a single comprehensive Wastewater Management Plan that considers the physical, social, economic, environmental and other related characteristics of the planning area. Once developed, this plan is recommended to the community for implementation. To gain approval from the community, the plan must demonstrate that the recommended treatment facilities are the "most economical means of meeting the applicable effluent, water quality and public health requirements [over the design life (20 years) of the facilities] while recognizing environmental and other nonmonetary considerations."
The Wastewater Management Plan should be developed through a systematic evaluation of the financial and regulatory feasibility of all practicable centralized and decentralized engineering alternatives that address the demographic, topographic, hydrologic and ecologic characteristics unique to the planning area.

1.3.2 Who Should Be Involved

The key to successful wastewater management planning is active participation and cooperation from all parties to the process from start to finish. Who should be involved in the process is generally determined by the boundaries of the planning area. In cases where the planning area is defined by municipal boundaries or is a subarea within the boundaries of a municipality, parties to the process should include the municipal officials and staff responsible for management of the community, their consultants, regional, state and federal agencies responsible for oversight and regulation of planning and watershed management in the area, other local stakeholders (e.g. watershed associations, civic groups, business and homeowners associations), and most importantly, the local citizens who will ultimately bear the cost of the project and will have final approval over the recommended plan.

In other cases, the planning area may extend across municipal boundaries. This is particularly true in the case of planning efforts initiated to remediate and/or protect the watershed of an important surface water resource or critical underground water supply and its surrounding recharge area which do not often conform to municipal boundaries. In these and similar cases, municipal officials and staff from each of the affected communities should be involved in the planning effort along with the appropriate regional, state and federal agencies, planning and engineering consultants, other interested stakeholders and citizens of the affected communities.

Identifying parties to the process is the responsibility of the project leaders, and every effort should be made to include as many municipal agencies and public interest groups as possible. Project leaders must commit to keeping everyone well-informed and up-to-date on all aspects of the project throughout the planning process. This will help prevent undue interruptions in the planning process, avoid cost over-runs, and insure that the final recommended plan is implementable and acceptable to all parties.

1.3.2.1 Municipal Involvement

Normally, a municipal agency will lead the wastewater management planning project. Oftentimes the lead agency will be one of the following: local Board of Health or Health Department; the Department of Public Works; or the Board of Selectmen. Planning Boards and Conservation Commissions along with their professional staff are also important resource agencies that should be closely involved in the planning effort. One way to insure adequate involvement is to form a "Wastewater Planning Committee" (WPC) that is headed by the lead agency and includes, at a minimum, a representative from each local agency described above. The formation of a WPC is particularly important in planning projects that cross municipal lines.

1.3.2.2 Public Involvement

A quiet, homogenous, wealthy bedroom community with no disagreement about the need for some form of improved wastewater treatment will have very different public involvement needs than a community that has a history of contentious dispute, where there are serious income differences, or where community groups have organized to influence the planning process. In the first case the municipal authorities can probably handle all of the public involvement needs themselves. In the second case, they may need the help of specialists in this area to motivate and perhaps facilitate public involvement.

After the WPC is formed, project leaders, in conjunction with public involvement specialists if needed, should create a Citizen Advisory Committee (CAC) to assist in the planning effort. The CAC should be comprised of local citizens that represent the affected community(s), including economic, environmental, technical, governmental, and general citizen interests. The composition of the CAC should be reviewed by the state Department of Environmental Protection (DEP) to insure public opinion is well represented.

The CAC should be formed very early on in the planning process in order to insure their effectiveness. They should also be given a clear notion of their roles and responsibilities up front. In particular, they should have a review schedule that is tied closely to the technical planning process, they should have access to ALL relevant information, and they should be given adequate time for review and comment. Many CACs flounder because they are treated as an afterthought. When they are properly integrated into the planning process, though, they can provide invaluable assistance in identifying community wastewater needs, evaluating options and obtaining public support. The CAC is the primary vehicle through which public participation and public input are encouraged, which is essential to help assure community approval of the final recommended plan

1.3.2.3 Regulatory Involvement

At the state level, the Bureau of Resource Protection (BRP), Bureau of Municipal Facilities (BMF), and Office of Watershed Management (OWM) at the DEP are responsible for overseeing and regulating the planning process. To obtain funding and insure the project is ultimately permittable by law, the WPC, if one is formed, should actively seek input from DEP's Boston and regional offices very early on and maintain this contact throughout the planning process. In particular, if the community plans to seek loans from the State Revolving Loan Fund to support their wastewater management planning project, they will need to contact BMF which administers the State Revolving Loan Fund and enter into the state facilities planning process.

OWM is responsible for permitting the effluent discharge portions of the wastewater project, and early and frequent contact with OWM staff will help avoid permitting problems that may drive up the cost of the project. While the effluent discharge permits are probably the most critical permits required for wastewater projects with centralized discharges, additional or other permits may be required for more decentralized approaches. The DEP regional offices and BMF can assist in determining what permits will be needed.

1.3.2.4 Professional Involvement

Other important participants in the planning process are professional environmental, engineering and planning consultants. Many small communities do not have full- or even part-time professional environmental scientists, engineers or planners on staff. Consultants are therefore frequently hired by the WPC with input from the CAC to assist with wastewater management planning. Responsibility for carrying out the majority of tasks necessary to develop the comprehensive Facilities and Management Plan then generally falls to the consultants.

It is important for the WPC and CAC to select planning and engineering firms that demonstrate both an openness to and technical expertise with a variety of treatment and disposal approaches, both centralized and decentralized, since it is the responsibility of the project leaders to make sure all feasible options are considered and evaluated adequately. In addition, since participation is such an integral part of the planning process, project leaders or WPCs should ask up front about the consultant's approach to planning. In particular, they should make sure that the consultants are prepared to revise their plans as a result of input from the public participation process. Flexibility on the part of the consultant can be as important as technical competence. These steps will go a long way towards achieving a cost-effective Facilities and Management Plan that will address the wastewater needs of the planning area.

Once the planning and engineering consultants have been selected, they develop a Plan of Study with guidance from the WPC and DEP that lays out all the tasks required to complete the Facilities and Management Plan (see section 1.3.3.1). The planners and engineers, or possibly newly selected consultants, then proceed with the development of the Facilities and Management Plan according to this Plan of Study. It is extremely important for the WPC to maintain a close interactive working relationship with their consultants throughout the development of the plan to insure that the consultants carry out the required tasks according to specifications, and thus, develop a recommended plan that is ultimately implementable.

Table 1. provides a more extensive listing of those parties that should be involved in the wastewater management planning process.

1.3.3 Overview of the Planning Process

The wastewater management planning process generally consists of the following steps:

1. Development of a Plan of Study
2. Assessment of Wastewater Needs
3. Development and Screening of Area Wastewater Treatment and Disposal Alternatives
4. Detailed Evaluation of a Community-wide Plan

1.3.3.1 Development of a Plan of Study

The Plan of Study (POS) is a guide to the development of the Wastewater

Management Plan. The purpose of the POS is to provide the municipality and state with a common understanding of the scope of work, schedule, and costs of preparing the Wastewater Management Plan. Included in the POS must be a detailed description of the work tasks to be performed that will result in an approvable Wastewater Management Plan, a schedule for completion of the work tasks and outputs, and costs to complete those tasks.

It should be understood that Massachusetts municipalities must obtain approval of their POS from BMF if they wish to be eligible for SRF money to support their planning effort. Municipalities are therefore encouraged to interact closely with staff at BMF during the development of their POS to obtain feedback and guidance on what specific elements should be included in the Scope of Work. This will help avoid delays in obtaining funding for the project. BMF's assistance during the development of the POS will also

TABLE 1. SOME INTEGRAL PARTIES TO THE WASTEWATER MANAGEMENT PLANNING PROCESS

Municipal Participants	*Federal and State Participants*
Health Department/Board	U.S. Environmental Protection Agency
Public Works Department	U.S. Army Corps of Engineers
Board of Selectmen	MDEP Bureau of Resource Protection
Planning Department	MDEP Bureau of Municipal Facilities
Sewer Dept./Commission	MDEP Office of Watershed Management
Water Department	MEPA Unit of the Executive Office of Environmental Affairs
Zoning Board of Appeals	

Conservation Commission
Historical Commission

Public Participants
Local Citizens
Non-Profit Organizations
Business Associations
Homeowners Associations
Other Civic Groups

Regional Participants
Regional Planning Agency
MDEP Regional Office
Watershed Associations

Department of Fisheries, Wildlife and Environmental Law Enforcement
Office of Coastal Zone Management *
Attorney General's Office**

Consultants
Engineers
Planners
Public Involvement Professionals
Soil Scientists
Hydrogeologists
Water Quality Scientists
Toxicologists
Environmental Laboratories

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* Coastal municipalities only
** Those municipalities under consent order to comply with provisions in the Clean Water Act

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help insure that the recommended Facilities and Management Plan ultimately developed is complete and approvable by DEP.

Within the POS, the Scope of Work is sometimes laid out in 3 phases. These phases typically correspond to steps 2, 3 and 4 of the planning process listed above. Thus, Phase I typically describes just the tasks necessary to complete the wastewater needs assessment Phase II describes the tasks that will allow for the preliminary identification and screening of treatment and disposal alternatives, and Phase III describes how the more detailed evaluation of alternatives is to be carried out in order to develop the final recommended plan.

It is extremely important that the Scope of Work laid out in the POS be thoughtfully prepared with careful attention to detail, particularly with respect to the work tasks that address needs assessment, so that useful results are achieved. Input during the development of the POS from local citizens and special interest groups, other communities, and state regulators and managers can help achieve such a comprehensive and useful Scope of Work.

Such input may be obtained, in part, by entering into the Massachusetts Environmental Protection Act (MEPA) review process during this early stage of the wastewater management planning process. The purpose of the MEPA review process is to insure that any adverse environmental impacts arising from a given project are understood by all parties and all reasonable actions to minimize or avoid such impacts are taken. The process is initiated by filing an Environmental Notification Form (ENF) with the MEPA Unit in the Executive Office of Environmental Affairs (EOEA). Filing with MEPA is required for most wastewater management planning projects (for information on requirements for filing consult MEPA Regulations *301 CMR 11*). The ENF provides information on the extent of a given project, its anticipated impacts on natural, agricultural and historical resources and what actions are intended to mitigate those impacts. From the information provided, the MEPA Unit determines if an Environmental Impact Report (EIR) will be required and what the Scope of Work to complete this report should be. Certain projects are "categorically included" (see MEPA Regulations *301 CMR 11*) and automatically require an EIR. For projects that are not "categorically included" MEPA decides, based on the level of anticipated impacts and the degree of public concern, whether an EIR will be necessary.

To determine public concern, the MEPA Unit opens a 20-day public comment and review period that is initiated with the publication of the ENF in the *Environmental Monitor* and local newspapers. The comments received are used to identify community concerns (e.g. protection of sensitive resource areas, regional land use issues) and are generally very useful in identifying other important information or data gaps that may need to be addressed in the planning effort. The comments are examined by the MEPA Unit at EOEA and a decision as to whether or not an EIR will be required is then issued. If one is required, the record of decision will contain a detailed description of the requirements for the EIR Scope of Work. Further scoping sessions with the MEPA Unit that are held to elaborate on these requirements are important in wastewater planning efforts because they will aid project leaders, and the WPC, in refining and developing appropriate work tasks for their project's POS.

Another important advantage of entering the MEPA review process early on in the wastewater management planning process, aside from providing project leaders, and the WPC, with valuable assistance in developing the POS, is that it provides an opportunity to combine the Scopes of Work for the Facilities and Management Plan and the EIR, if one is needed. The recommended Facilities and Management Plan and EIR both have mandatory public review periods. Development of each of these documents separately can greatly increase the time (and money) needed to complete the project. Through the MEPA review process, it may be decided that the project leaders, or WPC, should develop a joint Facilities and Management Plan/EIR and combine the review periods, thereby reducing the cost of the overall planning project.

Professional environmental and civil engineers, and planners, and other consultants, typically work in conjunction with the project leaders, or WPC, and any municipal officials responsible for implementing the Facilities and Management Plan, to develop the Plan of Study/Scope of Work. During the development of this document, the WPC should obtain input from the agencies they represent, as well as any other local and regional agencies/departments/ commissions that may have useful information (e.g. regional planning agency). In addition, project leaders should remember to strongly encourage input from the public, through a CAC as well as through direct solicitation of the public at large (i.e. mass media, public meetings). Their involvement, once again, is essential to achieve community-wide acceptance of the recommended plan that is developed out of the work tasks outlined in the POS.

1.3.3.2 Assessment of Wastewater Needs

Needs assessment is probably the most critical step in the wastewater management planning process. A complete understanding of existing and future wastewater needs of the community is essential to the development of a successful plan for managing municipal wastewater. Needs assessment consists mainly of information and data gathering on topics that should include, but are not limited to, existing water quality problems related to wastewater, land use patterns, growth and economic development plans, existing and future wastewater flows and loadings, location and extent of existing and future water supplies, location and extent of sensitive natural resources, and regulations and permit requirements related to wastewater management in the community. Chapter 2 provides the rationale for looking at these and other critical variables, as well as detailed guidance on how to collect useful information pertaining to each variable.

The services of professional environmental scientists, engineers, and planners are essential to complete a comprehensive needs assessment. Many small municipalities, however, do not have the luxury of full-time professional environmental, engineering and planning staff. The needs assessment, as with the development of the Plan of Study/Scope of Work, is therefore typically carried out by hired consultants with input and assistance from the WPC and CAC.

The information and data gathered by the WPC, and their consultants is used to identify "Areas of Concern" (AOCs) within the community or study area for which wastewater treatment and disposal alternatives must be developed. The data collected during the needs assessment will then help to develop and screen these alternatives in a process that eventually will lead to the development of a comprehensive Wastewater Management Plan for the study area.

The needs assessment must be as thorough as possible to allow for the screening of a wide variety of treatment and disposal technologies, development of acceptable alternatives, and evaluation of suitable management options. Project leaders can save both time and money during this critical phase by encouraging local and regional agencies and their consultants to work together.

Municipal staff and local board members undoubtedly know more about the community than will their consultants who are less likely to be familiar with municipal records and procedures or the layout of the planning area. Without assistance, consultants may spend a great deal of time sifting through municipal records, familiarizing themselves with the area, assembling the relevant information, and digesting the data into a useful format. Local board members and agency staff can speed up this data gathering process and help keep the cost of the project down by compiling and summarizing community records and other information for the consultants, and by assisting the consultants to become more familiar with the planning area and existing data.

It is also important to maintain public involvement during the needs assessment, since community members frequently have knowledge that can speed up the identification of problem areas which may also help keep the cost of the project to a minimum. Informal public meetings and questionnaires, if well constructed, may be useful tools for obtaining public input during this phase. To obtain useful public input though, project leaders must endeavor to educate the public about the process and its progress at regular intervals. This can be accomplished through public meetings, newsletters, radio and television interviews and announcements, and by establishing a repository of information on the project at the local library and/or town hall. Information exchange such as this will promote an understanding of the problems and the reasons that dictate AOCs, and will help members of the community to comprehend the screening process, including the administrative, environmental and monetary reasons why certain technologies may be favored over others as the plan is developed.

Before moving on to the next phase in the planning process, a Needs Assessment Report detailing the AOCs and community wastewater treatment and disposal needs should be reviewed and approved by the WPC and DEP. Approval from project leaders, however, should come only after the CAC and interested citizens and civic groups have reviewed the report and their comments considered and/or incorporated into the report.

1.3.3.3 Development and Screening of Area Wastewater Treatment and Disposal Options

Once the needs assessment is complete, the consulting engineers in conjunction with health department and public works staff may begin to develop and screen alternatives to remedy existing wastewater problems and prevent future public health and environmental problems in the AOCs identified in the Needs Assessment Report. During this iterative process, the results of the needs assessment are drawn on to evaluate treatment and performance goals and identify feasible wastewater treatment and disposal alternatives for each area of concern.

Both decentralized and centralized treatment technologies including conventional and innovative on-site systems, shared systems, conventional and alternative sewers, package treatment plants, central treatment plants, etc. should be examined during the screening process. The criteria used to evaluate these alternatives should include regulatory requirements, treatment level requirements, performance standards, reliability, flexibility, site requirements, relative capital costs, relative operation and maintenance costs, management issues, and more. Chapter 3 of this document provides a detailed description of each of these criteria, as well as specific guidance on how to use these criteria to identify and screen decentralized treatment alternatives.

Through the screening process, the WPC will begin to refine and narrow the number of suitable options for individual AOCs. The alternatives that appear feasible based on the screening are then subjected to a detailed evaluation in the final phase of the planning process before the recommended Wastewater Management Plan is decided (see section 1.3.3.4 below for overview).

At the end of this phase, it may be important to produce an interim report detailing the methods and results of this preliminary screening process to insure the WPC, CAC, DEP and the public have a clear understanding of how decisions were made and why.

1.3.3.4 Detailed Evaluation of Options and Development of an Area-wide Plan

At this stage of the process the overall cost/effectiveness of the alternatives that have the best chance of meeting the treatment and disposal requirements in each area of concern is evaluated in detail. Management issues are examined and the environmental impacts of the remaining potentially feasible alternatives are scrutinized. Through this more detailed evaluation process, all but a few alternatives for each area of concern are eliminated. The alternatives that remain are examined carefully to determine their suitability with respect to the overall planning area. Careful attention is paid to cost and community-wide management options, which may further eliminate some technological alternatives in some AOCs. A draft Facilities and Management Plan is then developed based on the selected technologies and management options.

This is a critical phase in which public opinion plays an important role. That is to say, a lot of owner preference may come into the decision-making process at this stage. For example, project leaders and their consultants may be faced with making a choice between two alternatives that both will work equally well and have similar attributes. The decision may come down to how much homeowners will be expected to do in terms of maintenance. Homeowners may be unwilling to take on certain maintenance responsibilities that are inherent to one and not the other technology, which by default may decide the issue. Financial issues may also force project leaders to make decisions based on homeowner preference. Homeowner preferences, however, are not a clear set of criteria that can be applied to evaluate clear-cut technical options. Instead, those preferences are developed, refined, and sometimes changed altogether based on their experience as participants in the planning process. The preferences of homeowners and other members of the public should have influenced every aspect of the planning process up to this point. If so, and treatment and disposal needs, regulatory requirements, and costs were clearly defined, the recommendations should be evident.

Once the WPC decides on a recommended Wastewater Management Plan, this decision must be finalized. The Plan should contain a detailed description of the selected solutions for each area of concern, including how the treatment technologies function; what levels of treatment they are expected to achieve; how they will be operated and maintained; the costs of installation, operation and maintenance; the methods and procedures for disposal of effluent, and the methods for financing, managing and administering all aspects of the plan. Within the plan should also be a summary of the detailed evaluation of alternatives, including a cost-benefit analysis and the anticipated environmental impacts on sensitive natural, agricultural, archeological, and historical resources of all aspects of the project. In addition, the plan should summarize how each decision was made, including a description of public participation throughout the process.

The recommended plan is usually drafted by the consultants who conducted the work. If the consultants have worked well with the WPC, CAC and the state, and have had the results of each phase reviewed by the local, regional and state agencies involved, the recommended plan should be implementable and permittable by law.

Before the recommended Facilities and Management Plan goes to the state for approval, however, it must be approved by the community. The local citizenry will ultimately bear much of the financial burden, which means their approval of the plan and financing for the project must be secured. This is the primary reason for forming the CAC and initiating public involvement at the outset and maintaining it throughout the planning process. By this time, through repeated opportunities to review and comment on the results of each phase of the planning process as they were completed, the public should be well-educated as to how and why certain decisions have been made. In addition, the public's concerns should be incorporated into the plan. If project leaders, the WPC and the engineering consultants have educated them well and addressed all of their concerns thoughtfully, particularly cost concerns, the probability that the public will accept the final recommended plan at this stage should be relatively high.

Chapter 2. GUIDE TO NEEDS ASSESSMENT

This chapter is designed to provide Massachusetts communities with guidance on how to determine their wastewater treatment and disposal needs. It takes a comprehensive approach to establishing those needs, but the reader should not be put off by this. The intent is to provide a clear indication of each variable that one might possibly need to assess in order to clearly define all the treatment and disposal needs of a particular community or planning area. The information and steps required to establish a community's wastewater needs, however, will surely vary for many reasons; from the scale and scope of the project, to the availability of outside funds, to the perception of the problems at the state level, to the desire, freedom and ability of community institutions and leaders to take their own initiatives. Thus, it is important to recognize that all the actions recommended here may not apply in every case. It is the responsibility of the project leaders, along with their planning and engineering consultants, to go beyond this guide and seek advice from local, regional and state agencies to determine what information and actions recommended in this guide are needed and what may be beyond the scope or funding of the project.

2.1 Developing a Community Profile

The recommended first step towards establishing a community's wastewater needs is development of a community profile detailing, among other considerations, the natural environment, economic pressures, and demographic conditions, all of which play an important role in identifying and delineating areas within a community for which wastewater treatment may be a concern. The community profile will help facilitate the identification of "problem areas" or "areas of concern", and provide the information necessary to establish treatment and disposal needs for these areas. Once treatment needs are established, decentralized (i.e. on-site systems, shared systems, package treatment plants) and centralized (i.e. sewers and large conventional treatment plants) alternatives can be developed and evaluated to find the most cost/effective, environmentally sensitive solution(s).

The objective of the community profile is to provide a summary of the information that will be useful in identifying the types of existing and/or anticipated wastewater related problems and the constraints that will limit the range of feasible technical solutions. The community profile should provide a summary and/or description of: existing wastewater-related water quality and public health problems; current and future land use patterns; existing and future water supplies; sensitive natural resources; existing wastewater facilities, including collection and conveyance systems, treatment plants and on-site systems; current and projected wastewater flows and loadings; and future growth and economic development plans. In addition, the community profile should contain a summary of existing regulations, permit requirements, and institutions that are concerned with wastewater management in the study area. Using this information, areas showing signs of existing wastewater-related problems and currently undeveloped areas that may be threatened with future wastewater impacts can be identified, and treatment and disposal needs determined.

The costs attributable to developing a community profile and delineating problem areas can be kept to a minimum by utilizing secondary sources of data in place of new data collection whenever possible. Potential sources of data include local Planning Boards, Health Departments, Departments of Public Works and Conservation Commissions; environmental labs; engineering firms; local utilities; research institutions and other independent contractors; regional planning agencies; state agencies, including the Department of Environmental Protection, Department of Environmental Management, and Department of Fisheries, Wildlife and Environmental Law Enforcement; and federal agencies, including the U.S. Geological Survey, U.S. Natural Resources Conservation Service, U.S. Environmental Protection Agency, and others. The data collected from these sources should begin to provide an overview of the physical, ecological, economic, demographic and institutional aspects of the study area, and will help determine what other types of data and extent of field work will be required to complete the needs assessment.

The remainder of this chapter provides an extensive description of the kinds of information needed to construct a comprehensive community profile that will allow for the development and evaluation of both decentralized and centralized treatment and disposal alternatives. Each heading represents a category of information for which data should be collected and summarized. These data will provide the basis for delineating AOCs for which development of treatment and disposal alternatives will be necessary.

2.1.1 Natural Conditions and Environmentally Sensitive Areas

The use of subsurface treatment and disposal technologies can be constrained by such things as poor drainage and seasonally high groundwater, whereas the location and extent of environmentally sensitive natural resources will play a role in determining the appropriate use of on-site and alternative wastewater treatment and disposal systems versus central facilities. A summary of the natural conditions in the study area, including an inventory of the location and extent of sensitive natural resources is therefore necessary to help define AOCs and assess the feasibility of centralized versus decentralized approaches to wastewater treatment and disposal.

2.1.1.1 Physical Geology

Physical geology, in this case, refers primarily to topography, soils, and bedrock formation and configuration. Knowledge of these features within and around the study area will provide information essential for understanding groundwater flow, delineating the zones of contribution to sensitive water resources, and for evaluating the feasibility of conveyance systems and subsurface wastewater treatment and disposal alternatives.

Topography refers to the configuration of the land surface or the "lay of the land," particularly with respect to relief and the position of natural and man-made features. The slope of land surfaces and the relative location of prominent features, such as hills and valleys, will influence surface drainage patterns in the study area. This information is important in determining surface recharge areas and zones of contribution for sensitive surface water resources.

Topography also plays a role in subsurface flows. Topographic information, combined with knowledge of *subsurface geology*, soil types, and bedrock location is necessary for modeling the direction of groundwater flow, as well as for delineating aquifers, surface water body recharge areas, and zones of contribution to wells.

Detailed knowledge of *soil type* is important for determining soil percolation rates, which play an important role in assessing the feasibility of on-site wastewater treatment and disposal. By combining this information with knowledge of the underlying bedrock formation, as well as surface and subsurface topography, the feasibility of collection and conveyance for shared systems or more centralized alternatives, in addition to individual on-site alternatives, can be determined.

Information on many aspects of the physical geology of an area may already exist in readily accessible forms. These data should be sought and interpreted prior to initiating any further geological studies to avoid any undue expenses. In many cases, further study beyond collection and summarization of preexisting information may be unnecessary for the purposes of the needs assessment, but may become necessary in specific areas later on during the detailed evaluation of treatment and disposal alternatives.

Information sources

Topographic maps produced on a local scale may exist for the study area. The local municipal surveyor's, or town engineer's office, is one source. Other potential sources of topographic information include nearby research institutions, the regional planning agency and state agencies. U.S. Geological Survey (USGS) maps are a useful ready source of topographic information. The U.S. Geographical Information System produces 7.5 minute quadrangle maps at a scale of 1" = 2000" by state. These maps can be obtained from a USGS office. In some cases, USGS maps may also be locally available in technical supply stores that cater to engineering firms, or from area merchants catering to hikers or paddlers.

Information on the configuration of the underlying bedrock formations may also be obtained from the USGS, or from nearby research institutions or other governmental agencies. Information on soil type can be obtained from soil surveys published for individual states by the U.S. Natural Resources Conservation Service. These surveys provide some information on relief and drainage, in addition to physiography and soil properties such as soil permeability, depth, salinity, and shrink-swell potential. Often times the surveys will contain maps and aerial photographs on which the soil information is superimposed. Soils information may also be included on individual on-site disposal system installation records obtainable from local Health or Engineering Departments, or obtainable from water supply planning reports that discuss the geology particular to the planning area. Soils data and information summarized from these sources may be sufficient, although additional site-specific information for certain AOCs may be necessary to complete the evaluation of alternatives later on in the planning process. This more detailed information may be obtained through individual soil borings which provide more conclusive results on soil type and distribution.

2.1.1.2 Groundwater Hydrology

Knowledge of seasonal groundwater levels in the study area is particularly important for evaluating the feasibility of on-site wastewater treatment and disposal technologies, and will be useful in locating existing problems associated with subsurface treatment and disposal practices. Depth to groundwater plays an important role in defining treatment levels and determining the design and siting requirements for on-site treatment and disposal systems. It can place limitations on the use of subsurface disposal systems and thereby constrain the use of certain technologies. For example, in the region of an underground water supply (aquifer), if groundwater levels are high, the use of on-site systems may be limited to nitrogen removal technologies to protect against nitrate contamination of area drinking water.

A general understanding of groundwater flow in the study area may be needed to define aquifers and their recharge areas, subsurface watershed boundaries to surface water bodies and groundwater zones of contribution to wells, all of which are sensitive to wastewater impacts. Groundwater flow data may also be used to locate failed subsurface wastewater treatment and disposal systems that may already be adversely affecting the water quality of these water resources. Before any flow modeling, well installation or groundwater sampling is initiated, all available pre-existing information on the groundwater hydrology of the study area should be compiled and summarized. This information, if it does not by itself provide an adequate understanding of the parameters above, will provide a basis for that understanding and will help minimize the extent of further required studies.

Information sources

Groundwater data and other related hydrogeologic information for the study area may be available from a variety of sources. One source of information is the DEP Geological Information Systems (GIS) lab which maintains standard water resource protection maps that contain aquifer data, including groundwater levels. Another source is the Water Resources Division of the USGS, which collects basic data on groundwater levels, stream flow, and other characteristics of various water resources. This information is maintained in a computerized database called the National Water Data Storage and Retrieval System (WATSTORE). Information pertaining to groundwater can be retrieved from the Ground-Water Site Inventory file within this database.

The National Groundwater Association maintains a computerized database of bibliographic information called Ground Water On-Line that may also be useful. Other sources of groundwater and related hydrogeologic data include federal agencies such as the National Weather Service, U.S. Army Corps of Engineers, Bureau of Land Management, Bureau of Reclamation, Natural Resources Conservation Service, Environmental Protection Agency, Nuclear Regulatory Commission and Department of Energy; state agencies such as the Department of

Environmental Protection, and Office of Coastal Zone Management; and local agencies such as the Health Department, Planning Department, and Conservation Commission. Information on the groundwater hydrology of the study area may also be sought from relevant studies done by research institutions and consulting firms.

In cases where adequate data cannot be obtained from pre-existing information, a groundwater sampling program may be needed. At a minimum, this program should include monitoring of well installations and groundwater sampling.

2.1.1.3 Freshwater Bodies and Associated Watershed Areas

Many communities contain valued natural, recreational, and scenic freshwater bodies such as ponds, lakes, rivers, and streams. These water resources can be home to economically and/or aesthetically valuable species of fish, wildlife and plants, all or some of which may be sensitive to environmental degradation that may result from wastewater discharges.

The location, extent, and designated use/water quality classification of these freshwater resources should be inventoried. An assessment of water quality should then be conducted to look for the existence of high nutrient, bacteria and organic levels, low dissolved oxygen concentrations, and contamination by toxic materials, which may indicate existing problems that could be associated with wastewater disposal. If a water quality problem is noted, it will be necessary to identify the source of the problem to determine if the problem is, indeed, wastewater-related. Surface run-off problems are frequently easier to trace and therefore less expensive to identify. For example, in a limited area of shoreline there may be a problem with high bacteria levels, but the contaminant levels may be high only right after large rain events. This would indicate a surface run-off problem, which may be traced to a combined sewer with overflow problems or perhaps an area of the community with septic system surface break-out problems. On the other hand, the costs associated with identifying a subsurface problem are often higher. For example, if a nutrient enrichment problem is noted, the source of the problem may be surface run-off due to agriculture, it may be due to high numbers of waterfowl in the area; or, it may be due to failing septic systems or leaky sewer pipes somewhere in the watershed. To identify the actual source of this problem and determine if it is wastewater-related may require delineation of the watershed and affected groundwater recharge areas, which can be a very costly undertaking.

Information sources

Existing reports based on studies by the local Conservation Commission, and Planning and Health Departments should be consulted to obtain information on freshwater bodies and associated endangered species habitat. Similar information may be sought from the Massachusetts DEP Division of Wetlands and Waterways, or the Natural Heritage and Endangered Species Program which is administered by the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement. This information combined with information gathered from updated topography maps, GIS maps, interviews of local officials and site visits should provide enough information to identify fresh water bodies and their recharge areas. Aerial photographs, however, if readily and inexpensively available, may be useful for confirming such information.

Aerial photographs, for which there are a variety of sources, represent a relatively accurate way to determine the location, number, and extent of surface water bodies. Sources of aerial photography include the state Highway Department, nearby research institutions, the local Planning Department, and local aerial photography service organizations. If there are major utility rights of way in the study area, the utility company may also have some useful aerial photos and other information. Local offices of the U.S. Natural Resources Conservation Service should also have aerial photographs of the regions they serve and these can be reviewed in their offices.

Another source of aerial photographs is the USGS Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, SD. This is the Federal clearing house for high altitude and satellite photography. Their holdings include photographs obtained from the National Aeronautics and Space Administration (NASA), the National High Altitude Photography Program (NAHP, 1980-1987), and the National Aerial Photography Program (NAPP, 1987-1991). Photographs from these programs which provide systematic high quality coverage of the 48 conterminous United States can be ordered directly from the EROS Data Center.

Finally, if aerial photographs are needed but do not already exist, or they are too out-dated for the study area, a local aerial photography service may be able to take the pictures needed, but other sources should be consulted before money is spent on new data acquisition.

Water quality information may be obtained from several sources, including the Water Resources Division of the USGS; Massachusetts DEP Office of Watershed

Management; Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement; local, regional and state water quality laboratories; as well as from local Conservation Commission studies, Health Department records, historical documents; and other relevant studies conducted by local citizen monitoring groups, nearby research institutions and environmental consulting firms.

It may also be necessary to conduct actual site investigations in areas for which adequate water quality information is not available. In this case, it may be appropriate to develop a surface water quality sampling plan which should be submitted to the Wastewater Planning Committee, the Citizens Advisory Committee and DEP for review. Such plans should be structured to evaluate and monitor actual or potential threats to water quality as identified above. The proposed plan should include a narrative description of the justification for the proposed sampling with locations, timing, procedures and laboratory methodologies.

2.1.1.4 Coastal Resource Areas

Coastal areas, including estuaries, saltwater embayments, salt marshes, beaches and associated dune systems, are environmentally sensitive natural resources that have great commercial and recreational value. For example, estuaries, embayments, and salt marshes support numerous commercially important fish and shellfish species, and are home to many species of waterfowl, some of which are endangered. In addition, these areas are frequently used recreationally for swimming, boating and aesthetic enjoyment. Coastal beaches and dunes are important recreational areas as well, that may provide habitat for endangered shore birds and other aesthetically valuable plant and wildlife species.

The location, extent, and designated use/water quality classification of coastal resources in the study area should be inventoried to aid in identifying potential impacts to these important natural resources later on during the development of the Facilities and Management Plan. In addition, beach closures and shellfish bed closures due to bacterial contamination should be inventoried and existing water quality information, including data on nutrient, oxygen, coliform bacteria, organic and chlorophyll concentrations, summarized. This information can then be used to help identify coastal water bodies with existing problems that may be due to wastewater.

Many coastal water bodies, particularly shallow, poorly flushed embayments, are sensitive to excessive nutrients and coliform bacterial contamination that can occur as a result of a variety of impacts, including wastewater problems in the surrounding watershed. It will be very important to try to identify the source of the water quality problem to determine if wastewater is responsible.

Direct marine discharges, waterfowl, inputs of groundwater contaminated by failing septic systems or leaky sewer lines, as well as agricultural and stormwater run-off, and combined sewer overflows may carry excessive nutrients and coliform bacteria to coastal waters, which in turn, may lead to over-fertilization (eutrophication), and bacterial contamination of the coastal water body. Such inputs can have serious adverse effects on recreational and commercial marine use of these water bodies. For example, eutrophication can cause algal blooms that may lead to low oxygen concentrations, which in turn, may result in loss of valuable fish and shellfish species. Coliform bacterial contamination can lead to the closing of bathing beaches and commercially important shellfish beds, since these bacterial contaminants may indicate the presence of other microbial contaminants that could be a serious threat to public health.

Information sources

Information on the location and extent of coastal resource areas may be obtained from similar sources to the ones described in section 2.1.1.3. Water quality data and information on resource use may be obtained from a variety of sources, including Health Department records; Conservation Commission studies; historical documents; Marine Fisheries and citizen shoreline surveys; and any other relevant studies performed by the regional planning agency, nearby research institutions, state or local water quality laboratories, local or regional utilities or environmental consulting firms. Other sources of water quality information include the Massachusetts Bays Program and Buzzards Bay Project at the Massachusetts Office of CZM; Massachusetts DEP Office of Watershed Management, Division of Wetlands and Waterways, and Division of Marine Fisheries; U.S. EPA; and National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service.

While water chemistry is a good indicator of eutrophication, and potential problems, there are less quantitative indicators that may also be explored. The existence of persistent algal scums, pungent odor production, and fish kills may indicate a eutrophication problem. Information on the occurrence of such events may be sought from local Health Department and Conservation Commission officials, as well as the local citizenry. Water quality information may not exist for a particular water resource, though. In such cases it may be necessary to conduct actual site investigations to assess water quality. A surface water quality sampling plan, similar to the one discussed in section 2.1.1.3, may need to be developed. The sampling plan should be structured similarly to that described earlier and contain a narrative description of the justification for the proposed sampling with locations, timing, procedures and laboratory methodologies.

2.1.1.5 Wetland Buffer Areas

Wetlands are described as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands occur in both freshwater and coastal areas in many forms, such as wet meadows, marshes, bogs, swamps, and flats. Wetlands furnish the essential habitat for many commercially and aesthetically valuable species of waterfowl, mammals, finfish, shellfish and other wildlife. In addition, they provide for natural flood control, flow stabilization of streams and rivers, improved water quality and aquifer recharge.

Wetland vegetation is very efficient at taking up nutrients such as nitrogen and phosphorus, thus allowing wetlands to act as nutrient buffers which provide protection to adjacent surface water bodies from eutrophication. The natural function of wetlands, however, may be altered with nutrient enrichment as the natural progression of dominant species changes due to increased nutrient input. These systems may also be sensitive to bacterial contamination and wastewater-related impacts, in the sense that the wetland habitat may support wildlife that may be sensitive to these contaminants.

Freshwater and coastal wetlands in the study area should be inventoried and their water quality documented so that potential impacts of the developing Facilities and Management Plan to any wetlands in the study area can be evaluated. If water quality problems are identified, the surface drainage areas and groundwater zones of contribution to the affected wetlands should also be defined so that the source of the existing wetlands water quality problem can be located and mitigation measures considered in the development of the Facilities and Management Plan.

<u>Information sources</u>
National Wetlands Inventory (NWI) maps are produced by the U.S. Fish and Wildlife Service and can be obtained from that source or from technical supply stores that cater to the needs of engineering firms. These and other wetlands maps may

also be obtained from the regional planning agency, the DEP Division of Wetlands and Waterways and GIS lab, or the local office of the U.S. Army Corps of Engineers. NWI maps identify the general location and type of wetlands within the quadrangle window of the USGS maps. Aerial photographs may also provide information on the location of wetlands and can be obtained from sources described in section 2.1.1.3.

Results of previous groundtruthing studies should be sought from the local Conservation Commission, the regional planning agency, the DEP Division of Wetlands and Waterways, the U.S. Army Corps of Engineers, and from published research on local wetlands before new data acquisition on wetlands is attempted. Normally, delineation and flagging of wetlands is conducted during the design phase of wastewater facilities construction. However, it may be necessary to conduct a detailed wetland analyses to confirm the presence of wetlands in the study area in cases where wetlands concerns are critical. Typically, such work is carried out on a site-by-site basis by qualified wetland scientists. For a description of potential sources of existing wetlands water quality data, refer to sections 2.1.1.3 and 2.1.1.4. As with freshwater and coastal surface water bodies, a sampling plan may be required to complete a water quality assessment of sensitive wetland buffer areas if such data is needed and is not already available.

2.1.1.6 Open Space, and Critical Wildlife and Plant Habitat

Open space in many communities provides wildlife habitats, scenic views, recreational opportunities and protection of groundwater quality. Some areas (e.g. vernal pools, wildlife sanctuaries, etc.) may support specialized habitats of rare, endangered and other aesthetically valuable species, while other areas are valued for hiking and camping due to the natural beauty of their landscapes and the resident wildlife and plant life (e.g. town open spaces, state and national parklands). The existence of such areas should be determined and mapped, and their critical importance evaluated during the needs assessment to insure long-term maintenance and protection of the integrity of open space and critical wildlife and plant habitat in the study area.

Information sources

Sources of information on critical open space areas may include local Planning Departments, Conservation Commissions and Recreation Departments; and the regional planning agency. Other sources of maps, and wildlife and plant inventory data may include the National Park Service; Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement, Natural Heritage and Endangered Species Program;

Massachusetts Department of Environmental Management, State Parks Department; Massachusetts Audubon Society; and other environmental and recreational organizations.

2.1.1.7 Floodplains

Floodplains are defined as any land area that both adjoins a watercourse or body of water and is subject to inundation. Regulations for construction within a floodplain exist to protect the integrity of these areas in order to prevent the likelihood of floods that result in collateral damage and loss of life. Cities and towns located along waterways and in coastal regions must carefully plan their wastewater treatment and disposal practices within floodplain areas to consider the effects of such projects on the floodplain itself, and more importantly, the potential impacts of flooding on wastewater treatment and disposal systems.

Information sources

Information on the location and extent of floodplains may be obtained from the local Conservation Commission, as well as from flood insurance maps and flood boundary and floodway maps, which are published by the U.S. Federal Emergency Management Agency as part of the National Flood Insurance Program. Information on areas prone to inundation may also be obtained from flood-prone quadrangle maps published by the USGS and from floodplain information reports published by the U.S. Army Corps of Engineers. Regulations for building within floodplains are promulgated at the state level, and enforced at the local level through zoning ordinances or bylaws. For information on the state regulations contact the Office of Environmental Affairs Flood Hazard Management Program.

2.1.1.8 Archeological and Historical Resources

The state and or your community may be interested in protecting the integrity of particular archeological and historical resources that may occur within the planning area. It is essential that these resources be inventoried during the needs assessment so that the Facilities and Management Plan that is developed adheres to rules and regulations put forth to protect such resources.

Information sources

Local historical societies, the Conservation Commission and the Massachusetts Historical Commission should be consulted to determine the location and extent of potentially sensitive archeological and historical sites. Archeological surveys conducted by academic and research institutions may have been previously conducted in some areas. The results of these studies may be sought to help confirm the sensitivity of any such sites.

2.1.2 Existing Water Supply

Surface and subsurface water supplies are environmentally sensitive areas. In order to protect public health these water supplies must be protected from wastewater impacts and other pollution sources. The location, and extent of water supply reservoirs, public and private wellheads, and their surface and subsurface recharge areas should be inventoried. This information will be useful in the development, evaluation, siting and design of appropriate wastewater treatment and disposal technologies in the planning area. In addition, water quality of each water supply area should be examined and the existence of any problems identified. In cases where water quality problems are noted, maps of the water supplies, including their zones of contribution will be useful in tracking down pollution sources which may be wastewater-related.

High concentrations of nutrients, bacteria and parasitic microorganisms may be introduced to the groundwater by leaky wastewater conveyance systems and/or subsurface wastewater treatment and disposal systems. This may represent a real threat to public health if contaminated groundwater contributes to the public or private drinking water supply(s). For example, subsurface wastewater disposal systems may leach nitrate-nitrogen into the water supply. High nitrate-nitrogen concentrations in drinking water have been shown to cause methemoglobinemia, a decreased ability of the blood to transport oxygen. This is a potentially lethal condition in humans, particularly in infants ("blue baby syndrome"). Contamination of water supplies with the parasitic protozoan *Cryptosporidia* is another public health threat that may arise from subsurface wastewater problems. This parasite is present in the intestines of many animals, but may cause gastrointestinal problems in humans, and is particularly deadly to immuno-compromised patients such as those with AIDS. In housing developments with small lots sizes, private wells and on-site wastewater systems, these health threats may be particularly significant. Such sites will be important "Areas of Concern" (AOCs) for which development of wastewater treatment and disposal alternatives may be required. Care should therefore be taken in identifying all areas with such conditions.

<u>Information sources</u>
Information on the locations, extent and water quality of existing surface and subsurface public water supplies within the study area should be available from the local Water Department or though examination of topographical maps and relevant reports and studies. The regional planning agency may also have information pertaining to public

water supplies in the area. Information on public water supply water quality and maps of belowground water supplies and their zones of contribution may also be obtained from the DEP Division of Water Supply and GIS lab. The DEP Division of Water Supply maintains files on approved Zone II delineations around public water supply wells (Zone II represents that area around the well from which recharge can be expected under the most severe hydrologic conditions realistically possible). If approved Zone II area delineations are available, further delineations should not be needed. If approved Zone II areas have not been delineated in the planning area, however, delineations should be carried out in conformance with guidelines established by the Division of Water Supply.

It may be necessary to conduct interviews and consult local planning documents, zoning maps and well and on-site wastewater system installation records to determine the location of private wellheads. It may then be necessary to conduct site visits and sampling to assess water quality of private wells if municipal records are unable to provide this information.

2.1.3 Water Use

Estimates of current and future wastewater flows are generally based on existing water use data. Water use data may also be used to identify existing wastewater problems related to improperly functioning on-site treatment and disposal systems. For example, households experiencing problems with their on-site systems will frequently impose their own restrictions on water use to avoid repair costs. Such restrictions may include limitations on the length of showers, and use of dishwashers and washing machines.

Information on water use will also be important for assessing impacts on groundwater recharge that may result from households switching from on-site systems to centralized sewage systems. One advantage of on-site treatment and disposal systems is that they discharge the water to the ground in the general area from which it came, and thus allow for recharge of the local aquifer. In sewered areas, the water removed from the local aquifer for use in homes and businesses is transported off site for treatment and discharged some distance from the point of origin. Because the treatment and discharge facilities are often located a some distance from the homes and businesses they serve, the effluent is frequently discharged not back into the local aquifer, but into an adjacent watershed. Thus, sewering often results in removal of water from the local watershed without replacement. This is known as an “inter-basin transfer,” and can have important implications for the management of local and regional water supplies.

Information sources

In areas without water use or wastewater flow data, standardized per capita figures for wastewater flows (single family residential on-site system: 110 gallons per day per bedroom; treatment plant: 70 gallons per day per capita) converted to water use (85% of wastewater flow) can be used to estimate residential consumption. However, the preferred method is to fully document water use when records are available.

Water use records are likely to be available only for public water service areas, and may be available from the local Water Department or other public water utility. Where good water consumption data is not available, or where there is a need to desegregate total figures into residential, commercial, and industrial categories, the project leaders, along with their consultants, may need to develop and distribute questionnaires to estimate water use. Questionnaires may also be useful in estimating water use in areas served by private wells, although direct interviews may provide more accurate information.

2.1.4 Current Land Use

Analysis of current land use patterns and trends will aid in determining current wastewater flows and loadings, and help estimate what these will be in the future. In so doing, land use analysis will help identify existing problem areas and potential AOCs. During acquisition of land use data it will be important to identify any designated Areas of Critical Environmental Concern (ACEC) or Districts of Critical Planning Concern (DCPC). Land use in these areas may be restricted in terms of zoning and allowable environmental impacts which may affect decision-making in the development of the Facilities and Management Plan. Other data that should be collected should provide information on residential land use, including household size, lot size, type of housing (e.g. seasonal, year round, rental, etc.), household income, and location and extent of affordable housing; as well as information on non-residential land use, including location, lot size, capacity and type of use (year round or seasonal) of business and professional offices, commercial establishments, industrial facilities, medical service facilities, public recreational facilities and multiple-family dwellings will need to be collected and summarized. These data will provide a basis for flow and loading calculations, and will give an indication of housing density and usage that, in turn, can be used to identify potential problem areas.

Information sources

One of the more useful sources of information on land use is the Municipal Assessor's maps and accompanying database. These maps provide information on current zoning such as commercial, residential, industrial, historic, conservation, general or other, as well as information on lot size and housing density. Lot size and land use classifications from these maps are helpful, but they may not always provide an accurate indication of actual land use. For example, an area classified as municipally-owned tax exempt open space can be anything from conservation land to the site of a public school, the town hall, a municipally-owned park, or even the municipal water supply. The wastewater flows and loadings are very different for each of these uses. The level of treatment that may be required in that area also will vary with some of these uses. It is therefore useful to consult with the Municipal Assessor in person, and cross check land use classification information with other data as discussed in the above sections. Another useful source of similar land use information is the Massachusetts DEP GIS lab. Information on ACECs and DCPCs may be obtained from the local or regional planning agency or the Massachusetts Department of Environmental Management. In cases where land use data is questionable, groundtruthing may be needed.

2.1.5 Current Demographic Conditions

Population changes generally drive the demand for housing and wastewater treatment service in a community. The population within the planning area should therefore be assessed for current population density, average age of the population, its rate of growth, and such things as the average household income. The median and average incomes of a municipality's households are an important factor when examining housing needs and the demand for wastewater treatment. For example, in a relatively affluent community, land may be expensive. High land prices often pressure land owners to subdivide land to the maximum extent possible to increase their return. This could prompt an interest in sewers, particularly where the use of on-site systems may be limited by the predominance of poor soil conditions.

Household size and type of housing are also important factors to consider because they influence flow and loading calculations. Household size may change as the average age of the population changes, which in turn, may significantly affect calculations of wastewater flows and loadings over the long term. The relative contribution of different types of housing, on the other hand, can have a profound influence on seasonal variations in flows and loads thereby affecting calculations of peak flows. For example, an area comprised mainly of seasonal, recreational, or occasional use dwellings will have a varying seasonal influence on flows and loadings, whereas an area comprised mainly of year-round residential dwellings will have a more constant influence on flows and loadings.

Information sources
The municipality's annual population census or regional and state census reports should be consulted in addition to or in place of the national census report, since these are likely to provide more detailed and/or more timely data on a municipality's current population density, average age of the population, and its rate of growth. Information on average household income can be obtained in census reports as well, or with the help of consultants who specialize in demographic analyses. Census reports and demographic analyses may also provide information on household type and size.

2.1.6 Existing Wastewater Flows and Loadings

An assessment of existing wastewater flows and loadings throughout the study area will aid in determining the adequacy of existing centralized and decentralized wastewater treatment and disposal facilities, helping to locate potential problem areas for which new or upgraded centralized or decentralized facilities may be warranted. This information will also be necessary to evaluate the cost-benefit of various flow and loading reduction alternatives that may be developed (e.g. industrial pretreatment systems, greywater recycling systems, etc.).

The assessment should include information on the sources of wastewater in the study area. Data collection during the assessment may be simplified by breaking down the study area into sewered and unsewered areas, and then into residential, commercial, institutional and industrial land use categories. This will provide the detail necessary to gain a good understanding of wastewater flows and loadings in the study area.

2.1.6.1 *Sewered Areas*

An historical summary of wastewater flow data, including average flows, maximum 24 hour flows, and instantaneous peak flows on a month-by-month basis for all sewer service areas should be compiled. This will aid in determining any seasonality of flows that could affect later evaluations of existing or planned sewering and centralized treatment. A similar summary providing data on biochemical oxygen demand (BOD), total suspended solids (TSS), and total kjeldahl (TKN) and ammonia (NH_4-N) nitrogen loadings should also be produced for any existing central treatment facilities. This information, combined with information on the number of people and the type of land use in the service area, can provide an estimate of the average per capita loadings by land use category.

Other wastewater sources that affect flows and loadings data include wastewater residuals, such as septage, grease and boat pump-out, and infiltration and inflow (I/I) into collection systems. Flows and loadings due to these other sources must also be quantified. If I/I calculations indicate I/I is excessive, an analysis of I/I must be completed to evaluate opportunities for I/I reductions. I/I is described in more detail in section 2.1.7.1.

Information sources

Sewer bills obtained from the local Department of Public Works may provide information on wastewater flows, although more comprehensive data should be available from existing central treatment facilities, since they are required to maintain regular records of flows and loadings to the plant. From such records, it should be possible to produce an historical summary of wastewater flow data, including average flows, maximum 24 hour flows, and instantaneous peak flows on a month-by-month basis for the sewer service areas. Records from existing central treatment plants should also provide information on biochemical oxygen demand (BOD), total suspended solids (TSS), and total kjeldahl (TKN) and ammonia (NH_4-N) nitrogen loadings

Septage hauler records, boat pump-out records, and other Health Department and DPW records may provide the information needed to determine the contribution of septage, grease, and boat pump-out to flows and loadings. Previous I/I studies done by consultants or municipal engineers may exist and should be sought to evaluate the need for further inquiry.

2.1.6.2 Unsewered Areas

In unsewered areas where wastewater is discharged to the ground through various types of individual on-site treatment and disposal systems, flows and loadings will be more difficult to ascertain. Traditionally, common assumptions for flows and loadings in unsewered areas (i.e. 55 gallons per capita; single family dwelling flows = 110 gpd per bedroom; commercial restaurant flows = 35 gpd per seat) are used in conjunction with demographic and water use data to produce estimates of flows and loadings for these areas.

Information sources

Health Department records, municipal assessor's maps and on-site system installation records and permits may help in estimating flows and loadings in unsewered areas by providing siting and design criteria information. In general, assumptions of flows and loadings may be used to estimate flows, as alluded to above. These assumptions are based on standard values listed in the State Environmental Code Title V: Minimum Requirements for the Subsurface Disposal of Sanitary Sewage (310 CMR 15.000), which can be obtained from the State House Book Store.

2.1.7 Existing Wastewater Collection and Conveyance Systems, and Centralized Treatment Facilities

Information on the location, number, capacity, and performance of existing collection and centralized treatment facilities is needed to evaluate the adequacy of these systems, and their potential to collect and treat additional loads.

2.1.7.1 Collection and Conveyance Systems

Collection and conveyance systems collect sewage directly from dischargers (i.e. homes, business, etc) or septic tank effluent pumped from on-site disposal systems, and transport the material to a treatment facility. Collection and conveyance systems in use today include traditional and small diameter gravity sewers, pressure sewers and septic tank effluent pump systems (see Chapter 3, section 3.1 for a description of these systems). The design and appropriate use of each of these systems depends on many factors including the physical geology of the area, housing density, location of sensitive natural resources, etc. Each system has a set of advantages and disadvantages that play a role in determining the feasibility of centralized versus decentralized wastewater management.

With regard to existing collection and conveyances systems, the sewer pipe diameter, depth, length, layout and age should be summarized so that the hydraulic capacity and performance of the system can be assessed. In the case of gravity sewers, the location and number of pump stations, size and type of pumps will also need to be determined. If not carefully installed and maintained, gravity sewers (large and small diameter) may be prone to infiltration from groundwater which reduces the wastewater carrying capacity of the pipe. Inflow, which simply refers to direct sources of water to the collection system, such as sump pump and building gutter connections, and leaky manholes, may also place unnecessary demands on the system. If calculations of per capita flow to the treatment plant are much less than actual flows to the plant, an infiltration or inflow problem may exist somewhere in the system. In this situation, an analysis of infiltration and inflow (I/I) will be required and options to eliminate inflow and minimize infiltration considered.

Pressure sewers and septic tank effluent systems are less prone to infiltration problems due to their more impervious design. However, because they are under pressure, the systems may leak or breaks may occur which may lead to exfiltration of sewage into surrounding soils. The existence of any exfiltration problems should be determined. These systems are also sensitive to seasonal wastewater flows, since their ability to conduct flows via pressure is dependent on flow volume. Minimum flow conditions for the systems should be determined to assess the effect of existing and future flows on the system.

Information sources

Maps containing information on existing collection and conveyances systems, including the type of system, pipe lengths and diameters, locations of pump stations, and the age of the system will likely be available from the local Department of Public Works or Sewer Commission. The local DPW, Sewer Commission or Department of Health may also have information and data adequate to determine if an I/I or exfiltration problem exists. Their records should therefore be consulted before any new analyses of I/I are recommended.

2.1.7.2 *Centralized Treatment Facilities*

A summary of existing centralized treatment facilities is required to complete an assessment of the adequacy of these systems and their potential to handle future flows and loadings. The summary should describe the facilities' components, such as wastewater pretreatment facilities, primary and secondary treatment facilities, chlorination facilities, septage and odor control facilities, and sludge stabilization and handling facilities. The description of these facilities should include information on total flows and loadings to the facilities, facility capacity and performance, and a summary of existing problems and planned solutions. The location of the facilities, a description of the receiving water for the effluent discharge (i.e. surface water body, groundwater), and the age of the facilities should also be documented. Information on operation and maintenance staffing, revenues and expenditures, and National Pollutant Discharge Elimination System (NPDES) permit requirements may also be required for later evaluations.

Information sources

The U.S. EPA, along with the DEP Office of Watershed Management, is responsible for NPDES permitting. Their records may be consulted to obtain information on the age of the plant, design capacity, and historical performance. Treatment facilities' staff also regularly sample and record data pertaining to performance and flows and loadings; these records should be reviewed and the data summarized. It may also be useful to interview the plant operator and the local official(s) responsible for treatment plant operations. Based on the information compiled through these avenues, it may or may not be determined that a more detailed analysis of plant operation and performance is needed. If such a detailed analysis is required, a sampling program must be developed and reviewed to insure it will provide the necessary information.

2.1.8 Existing On-Site Wastewater Treatment and Disposal Systems

On-site systems normally treat wastewater from individual residential or commercial lots. These systems are defined in the State Environmental Code Title V (310 CMR 15.000) which provides standards for the use of these systems, including minimum requirements for design, installation, operation and maintenance. Today, a variety of on-site technologies are in use, and each has its advantages and disadvantages in terms of performance, siting, design, and operation and maintenance.

The number and location of residential, commercial and other sites served by on-site systems should be documented. Other data including information on the type of system (e.g. pit privy, cess pool, septic system, nitrogen removal system, etc.), age of the system, proximity of the system to sensitive receptors (e.g. private wells, drinking water aquifers, endangered species habitat, nitrogen sensitive embayments, etc.), system capacity, and system performance will also need to be documented. These data may then be used to identify areas that have inadequate or failing systems.

<u>Information sources</u>
Local Board of Health or Health Department records should be consulted to determine which lots are served by on-site systems and how those systems may be performing. Permits on file with the Board of Health, along with installation, repair, and inspection records, should contain information that can help determine the type and design of the system in use, sizing of the system, and its age. Septage hauler records may also provide an indication of performance, since such things as frequent pumping may indicate system failure. In some cases, however, these records may not be adequate and house-to-house surveys may be needed.

Buildings with large on-site systems that have wastewater flows in excess of 10,000 - 15,000 gpd (10,000 gpd for new construction and existing buildings in “sensitive areas”; 15,000 gpd for all other existing buildings), such as schools, hospitals, and apartment complexes, require a groundwater discharge permit from the DEP Office of Watershed Management. OWM records may therefore be more detailed than local records in these cases and should be consulted to determine the adequacy of these larger systems.

2.1.9 Future Growth and Economic Development

Municipality's guide the location and density of development through the adoption of a master plan and zoning bylaws. These plans and bylaws more or less dictate the future pattern and density of residential, commercial and industrial development, as well as dedicated open space within a community. The future growth and economic development plans of a community will therefore play an extremely critical role in determining the long-term demand for wastewater treatment services in a community. These plans will also be important in determining the long-term demand for water supply services which will affect decisions pertaining to wastewater. A clear understanding of future plans for a given community, including estimated population densities and distribution, land use, and water supply services are needed in order to estimate future wastewater flows and loadings, and subsequent treatment and disposal needs.

2.1.9.1 Population Projections and Future Land Use

Knowledge of expected population changes with regard to size and density, location of potential growth centers, and future land use practices are needed to identify areas that are likely to experience an increase or change in their wastewater treatment and disposal needs. This information will be considered in conjunction with that gained in the first part of the community profile ("Natural Conditions and Environmentally Sensitive Areas") so as to identify environmentally sensitive areas, such as future water supplies, that may require protection from the potential impacts of wastewater treatment and disposal alternatives considered for future developments.

Population projections provide an indication of growth rate and maximum population densities, and are important for identifying when future water supply needs and wastewater flows and loads will occur. The available land for development could potentially support an increase in the municipal population that may be independent of other factors influencing population changes. It is therefore important to assess the potential for development in the community.

The developable lot analysis, or "build-out" analysis, is used to assess the level of expected development pressure within the community. This analysis is used to estimate saturation levels of development in a given area within the community, given the municipality's current zoning and future growth plan. It predicts the level of development which is possible in a municipality if it is "built out" according to zoning. Unlike population projections, a build-out analysis does not indicate when development will occur, rather, it indicates how much development may ultimately occur and approximately where it is likely to occur.

Using the results of the build-out analysis, an estimate of the build-out population can be obtained and future wastewater flows and loadings can then be estimated. Population projections based on the build-out analysis, combined with the results of the analysis, will also provide information that may be used to identify sensitive areas that are currently safe from human impacts, but may require protection from future impacts resulting from later development.

Information sources

Estimates of growth rate and population changes may be obtained from the local Planning Department or Regional Planning Agency. To review a municipality's master plan goals and objectives and obtain a summary of local zoning bylaws, the local Planning and Zoning Boards should be consulted. Zoning maps will also provide useful information and should be reviewed.

2.1.9.2 *Future Water Supplies*

The location and extent of future public (i.e. aquifers, surface water reservoirs) and private (i.e. on-site wells) water supplies should be considered during the needs assessment so that wastewater treatment and disposal alternatives developed for the study area can be designed to protect these sensitive future resources. Suitable water supplies for future use will be determined based on their water quality and their ability to serve future development. Likely sources are uncontaminated freshwater bodies, as well as groundwater aquifers and associated recharge areas located in areas that can be protected from contamination, and yet sensibly exploited as a water supply for new development and other areas that may have future needs.

Information sources

Refer to sections 2.1.1.2 and 2.1.1.3 for resources that may provide information on the location and boundaries of potentially suitable surface and groundwater supplies and their zones of contribution. The DEP Division of Water Supply and GIS lab may also be consulted for information on the location and extent of potential water supplies.

2.1.9.3 *Projected Wastewater Flows and Loadings*

Results of an assessment of existing treatment and disposal practices may suggest that in some areas of a community, existing central facilities or on-site systems are adequate to handle current flows and loadings. Thus, under present conditions wastewater may appear to pose no threat to public health or the environment. However, wastewater flows and loadings in these areas may be subject to increase due to expected population increases or changes in development pressure or land use. These increased flows and loadings may exceed the capacity of existing systems and result in harmful impacts in the future if alternatives are not developed. Estimates of future flows and loadings are therefore needed to evaluate the adequacy of existing systems to handle future changes. These projections are also required to develop and evaluate treatment and disposal alternatives for areas that may experience development pressure in the future as identified in the build-out analysis.

Using population estimates, projected land use data, and flows per capita and flows per type of commercial establishment determined during the assessment of current flows, an estimate of future wastewater flows can be determined. Future loadings from these flows, including projected BOD, TSS and nitrogen loadings may be determined similarly.

In addition, projected flows and loadings from wastewater residuals such as septage, grease and boat pump-outs, as well as infiltration must also be estimated. An average septage generation rate for residential and non-residential units may be determined for the study area and then applied to all existing and future unsewered units to obtain an estimate of future septage flows. Restaurants are the major source of trap grease and thus future grease flows are likely to be directly proportional to changes in the number and size of such commercial establishments within the study area. Estimates of infiltration should be based on 200 gpd/inch-mile of sewer pipe less than 20 years old and 500 gpd/inch-mile of sewer pipe in excess of 20 years old.

<u>Information sources</u>

While examples of methods for determining estimates of future flows and loadings are described above, the local Sewer Commission or Department of Public Works, and the Massachusetts DEP-Bureau of Municipal Facilities should be consulted for the appropriate standard values to use and how best to calculate these estimates.

2.1.10 Community Concerns

Any proposed local water pollution remedies will affect the distribution of amenities, benefits and costs in a community. Because of this, proposals will always generate some level of conflict and controversy. This controversy is not an unfortunate side show to the planning process, it is the central source of information and insight into the values, interests, and perceived needs of the community.

Municipal leaders, planners and consultants must work to understand these community concerns so they can integrate them into their wastewater planning efforts. If these concerns are not addressed, citizens and interest groups may challenge the outcome of the planning effort or even the legality of the process itself. Identifying and adapting to community concerns improves the integrity and the implementability of wastewater planning at the same time that it satisfies public desires for democratic decision-making.

Laws and regulations concerning public involvement are an integral part of many aspects of the wastewater management planning process. An active public involvement effort based on these regulations is one of the best ways to identify community concerns during planning. The level of effort needed for public involvement will depend on the costs and scope of the planning effort, the past political and social history of the community, the public's understanding of the wastewater issue, and other related factors. For small projects with minimal financial impact, public involvement efforts can be relatively modest, strictly following the regulations and targeting affected homeowners and taxpayers. For larger projects with broader impacts, an entire community may need to be consulted, and several different levels of public involvement will need to be implemented. In addition to an active Citizen Advisory Committee, there most often is a need for outreach to community and homeowners groups, and ongoing consultation with concerned members of the public in addition to the normal public meetings, hearings, and document comment periods. In communities that are unaware of or unconcerned about wastewater problems, there may be a need to conduct outreach and education before a participatory planning process can even begin. For pollution or planning issues that cross community boundaries, there may be a need for broad involvement and active mediation among competing interests.

In each of these situations, the results of the involvement process will provide constant input to the technical planning process, helping to focus attention on important issues, narrow options or generate new ideas. Coordination and openness are important to integrate public involvement into wastewater planning successfully.

<u>Information sources</u>
The U.S. Environmental Protection Agency, the Massachusetts Department of Environmental Protection, and the MA Executive Office of Environmental Affairs MEPA Unit have all developed guidelines for public involvement in wastewater planning and environmental impact assessment.

Some of these guidelines may be available as separate guidance documents on public involvement.

The experience and knowledge of local planning and municipal officials are a good starting source of information on community concerns. Institutional memories contained in reports, press releases and staff recollections of past planning efforts or recent political controversies should also be considered a valuable source of information.

Gathering information directly from the community is often the best way to start a public involvement process. An initial "community concerns assessment" usually involves a series of interviews with local officials, citizen activists, and members of the general public. These interviews are intended to give planners information about the level of knowledge, interest, and concern among the public. This information can then be used to design an appropriate public involvement process.

2.1.11 Regulatory Considerations

The existing regulations, permit requirements and institutions that are concerned with wastewater management in the study area must be summarized. This information will be important in determining the technical feasibility, schedule, and the estimated cost of the project.

Information sources

Table 2 provides an extensive, although incomplete list of state and federal legislation and programs that either regulate or relate to some aspect of wastewater management in Massachusetts. Your community may also have other, or more stringent regulations and requirements. It is therefore important to consult your municipal and/or county Planning, Zoning and Health Boards, and local Conservation Commission, in addition to the state and federal agencies listed in Table 2 during this early phase of planning to insure all regulations and permit requirements are taken into consideration.

It is also important to realize that regulations may pertain to existing technologies, but may not be applicable to "new" technologies. Such "new" technologies must, nevertheless, receive full consideration in a planning effort even though they may not be recognized under current regulations to insure the best possible solutions are developed.

TABLE 2. SOME POTENTIALLY IMPORTANT STATE AND FEDERAL LEGISLATION AND PERMIT REQUIREMENTS TO BE CONSIDERED DURING WASTEWATER MANAGEMENT PLANNING

MASSACHUSETTS PROGRAMS & LEGISLATION	REGULATION
Areas of Critical Environmental Concern (ACEC)	301 CMR § 11.15
Coastal Wetlands Restriction Act	MGL Ch. 130 § 105
Environmental Penalties Act	
Inland Wetlands Restriction Act	MGL Ch. 131 § 40A
Massachusetts Clean Air Act	MGL Ch. 131 §§ 142A-142J
Massachusetts Clean Waters Act	MGL Ch. 21 § 26-56 and 314 CMR § 1.00 *et seq.* § 4.06; 314 CMR § 3.00 , 4.00 *et seq.*, 5.00, 6.00 *et seq.* and 7.00; 314 CMR § 1.00 *et seq.* § 4.06;
Massachusetts Coastal Zone Management Program	
Massachusetts Environmental Policy Act (MEPA)	MGL Ch. 30 § 61-62H and 301 CMR 11-12
Massachusetts Hazardous Waste Management Act	MGL Ch. 21C § 4 and 310 CMR 30.00 and 30.10 *et seq.* § 106
Massachusetts Historic Commissions	
Massachusetts Natural Heritage and Endangered Species Act	
Massachusetts Wetlands Protection Act	MGL Ch. 131 § 40-40A
National Pollutant Discharge Elimination System (NPDES) Program	
Ocean Sanctuary Act	MGL Ch. 132A § 13-16 and § 18; 302 and CMR 5.00
Scenic Rivers Act	MGL Ch. 21 § 17B
Title 5 (Minimum Requirements for the Subsurface Disposal of Sanitary Sewage)	MGL Ch. 111 § 31 and 310 CMR 15.00

FEDERAL PROGRAMS & LEGISLATION	REGULATION
Coastal Zone Management Act of 1972	P.L. 92-583 or 16 U.S.C. § 1451 *et seq.*
Endangered Species Act (ESA)	16 U.S.C. 1531 *et seq.*
Federal Emergency Management Agency (FEMA)	
Federal Water Pollution Control Act	
Clean Water Act	33 U.S.C. 1251 *et seq.*
National Pollutant Discharge Elimination System (NPDES)	40 CFR 122
Water Quality Act of 1987	
U.S. Army Corps of Engineers Fill Permits	P.L. 92-500 § 404
Marine Protection, Research and Sanctuaries Act of 1972	33 U.S.C. 1401 *et seq.*
National Environmental Policy Act	42 U.S.C. 4321 *et seq.*
National Shellfish Sanitation Program	
Resource Conservation and Recovery Act (RCRA)	42 U.S.C. 6901
Safe Drinking Water Act (SDWA) of 1974	42 U.S.C. 300(f) *et seq.*

2.2 Identifying "Areas of Concern" (AOCs) and Establishing Wastewater Needs

Identification and delineation of problem areas or AOCs is the next step in establishing wastewater needs in the planning area. This step is accomplished using the data which was collected and summarized during the community profile stage. These data should be sufficient to identify areas with existing wastewater related water quality and public health problems, areas in close proximity to sensitive environmental receptors, areas with severe site limitations for use of either collection systems or subsurface treatment and disposal systems, and areas that may experience future flows and loading problems due to development pressure or changes in land use.

Most, or all, of the problems will have a geographic element, which should lend their display to a map and a list. The list needs to explicitly state what the problem is, how urgent or critical it is, and how now, or in the future, it conflicts with laws, regulations, or zoning ordinances designed to protect human health, the environment, or the quality and character of a neighborhood.

Once an AOC has been identified and a summary of the conditions in that area prepared, the boundaries of the AOC should be clearly established and depicted on a map of the planning area. After reviewing the information available, the need for further data collection may become apparent.

The next step is to establish treatment requirements for the AOC. The treatment requirements, natural conditions in each area, and a consideration of public concerns and any legal issues will dictate the wastewater treatment and disposal needs and will allow the WPC and CAC to establish a prioritization for each AOC.

With this information, it will then be possible to begin the next phase of the planning process, Identification and Screening of Alternatives (see Chapters 3 & 4 for guidance on decentralized alternatives), which consists of developing a range of possible solutions that may address the problems in each AOC. This is a critical juncture at which time preliminary decisions are made as to whether centralized or decentralized solutions, or both, are developed for a given AOC, and what alternatives may be considered.

The solutions that are considered should not be limited to what is currently permittable. Instead, a full range of alternatives should be developed for each AOC to allow for the selection of the best possible solution. Care should also be taken not to eliminate consideration of one approach (e.g. decentralization or centralization) over another too prematurely. In some cases, each approach may be equally viable. It will be important to develop solutions using both approaches, and then compare them to find the most-cost effective solution. In other cases, a combination of approaches may be the best way to address the problem, but this will not be apparent if one approach is prematurely eliminated from consideration.

2.2.1 Areas With Existing Water Quality and Public Health Problems

Existing water quality and public health problems in the study area may be evidence of failing on-site systems, leaky sewer lines, illegal connections to storm drains or other wastewater related problems, or they may be unrelated to wastewater (i.e. contamination due to hazardous waste dumping). Through the data collection process previously completed it should be possible to begin identifying areas with wastewater-related water quality or public health problems. The next step after the problem has been identified, is to establish what treatment level must be attained to correct the problem and insure future protection of public health and water quality.

On-site system failures that result in break-out, household back-ups, or contamination of wells, represent wastewater-related public health problems that may exist in the planning area. These failures may pose a direct threat to public health or they may impact nearby surface water resource or an important drinking water supply via surface run-off or leaching. It is important to determine the cause of these failures since this will impact the types of solutions that should be considered. For example, the failures may be due to a lack of proper maintenance, or poor design and installation procedures. If so, the area may be a candidate for system up-grades, new installations, or simply a better management program, and thus may be an AOC for which decentralized alternatives should be evaluated and management procedures considered in lieu of a centralized approach. On the other hand, site constraints such as poor soils or high groundwater may be the reason for the failures. The site conditions may preclude any further use of on-site systems in the AOC. A centralized approach may, in this case, be the only alternative to achieve required treatment levels and improve water quality. However, it may be that some combination of innovative or advanced on-site systems, shared systems or alternative sewering may address the problem, and perhaps provide the required improvements to water quality in the affected area. Under these circumstances, the WPC would want to retain that particular AOC for development of both centralized and decentralized alternatives.

2.2.2 Environmentally Sensitive Areas

A variety of important natural resources may exist within a given planning area. These may include scenic rivers, nitrogen-sensitive embayments, vernal pools, drinking water aquifers, entire watersheds, archeological sites, endangered species habitat, etc. By this point in the planning process the WPC should have a relatively complete inventory of the resources they wish to protect, and a map indicating their extent and proximity to existing and planned development. The WPC should also have a feel for the potential risk of existing and future wastewater impacts on these resources and an understanding of the treatment levels required to protect the resources from such impacts.

The watershed of a commercially or recreationally important nitrogen-sensitive embayment or critical surface drinking water supply, for example, might be designated as an AOC for which wastewater alternatives may need to be developed to provide long-term protection of water quality. Data on current and future land use, existing and projected wastewater flows and loadings, and natural conditions within the watershed will all play a role in determining required treatment levels for the watershed. They will also suggest what approach to wastewater management may be appropriate. Cross-boundary politics may also be important in this decision-making process, since watershed boundaries, like many natural resource boundaries, may not coincide with the municipal boundaries.

2.2.3 Areas With Severe Limitations to On-site Treatment and Disposal

Some sites within the planning area may present obstacles to certain methods of wastewater treatment and disposal due to topographical constraints (i.e. poor drainage; steep grades), geological constraints (i.e. poor soils; high incidence of ledge), hydrological constraints (high groundwater table), or even land use constraints brought on by public concern. Upon completion of the community profile, it should be relatively apparent what areas have severe limitations to on-site treatment and disposal. The future of these sites with respect to development plans should be of particular concern if they are currently undeveloped, since the type of development, projected flows and loadings, and water use, etc. are needed to establish treatment needs and determine what approaches to wastewater treatment should be considered.

For example, conventional on-site treatment and disposal systems (i.e. Title V systems) may be precluded from use in a particular area due to poor soils and high groundwater, or because lot sizes are extremely small and each lot has a private drinking water well. In order to protect the underground water supplies, the use of on-site systems may have been prohibited through legislation or zoning bylaws. It will be important to examine legislation, zoning bylaws and permit requirements carefully in this situation to determine the desired treatment levels, and assess whether collection and treatment off-site is the only potentially feasible approach for such an area. It may be that innovative or advanced on-site treatment technologies (i.e. mounded or nitrogen removal systems), or small shared systems are potentially feasible. Again, the decision to eliminate examination of one approach over the other should not be made hastily.

2.2.4 Growth and Development Areas

Areas within the community or planning area that will experience future growth and development must have a plan for wastewater management in addition to land use and water use. The community profile should provide satisfactory site assessments and projections of wastewater flows and loadings for any such areas. Wastewater treatment level requirements may be determined based on these projections and those of land and water use, as well as the overall site conditions. After the treatment levels have been determined, and the areas delineated and mapped, the potential for success of a decentralized or centralized approach may be contemplated and a decision made as to what range of alternatives will need to be developed.

Chapter 3. GUIDE TO DEVELOPMENT AND SCREENING OF DECENTRALIZED ALTERNATIVES

Once the Wastewater Planning Committee (WPC) has developed a community profile, assessed current and future wastewater needs, and, within the framework of those needs, identified any especially vulnerable "Areas of Concern" (AOCs) as well as the nature of their problems, it is then in a position to examine which technology, or combination of technologies, will optimally address the problems that the community faces.

For any community undertaking its planning in conjunction with the Massachusetts DEP, the alternatives or options that emerge will be assessed against the "baseline alternative" of optimizing the operation of existing facilities, including various extant combinations of centralized and decentralized service areas. If optimizing the performance of existing facilities is insufficient, either to solve current or future problems, then the next most immediate question is whether the expansion or regionalization of any central facilities (such as a septage treatment plant) is desirable or feasible. Thereafter, the options involved will concern ever smaller facilities, serving smaller areas, until eventually the scale of treatment being examined is that of the individual septic system.

At the same time that consideration is given to the scale, size, and capacity of systems, equal consideration needs to be given to the level of treatment required before discharge, and thus to whether there is need for enhanced or advanced treatment.

However, discussion of the basic choices first requires some background on how the technology is classified and on the terminology employed, which are the initial topics to which this chapter turns. From there, the chapter moves to a description of the procedures and processes involved in developing technological options, and, lastly, to a description of the kinds of specific screening and evaluative criteria employed in the selection process. These range from the most important, first-level criteria concerning the suitability of technological types and size or scale, through criteria concerning much more specific environmental, regulatory, mechanical, administrative, and financial factors. All this is discussed further.

What follows next, however, is a nontechnical briefing on the technology and its nomenclature, as well as on the context in which the terms "centralization" and "decentralization" are used.

3.1 Treatment Technology and Decentralized Alternatives

3.1.1 Steps in Wastewater Treatment

Regardless of the scale or size of a wastewater facility, the treatment involves similar processing steps. (1) The flow is collected, the collection conveyances being called sewers. Even in the case of a conventional, single-dwelling septic system, sometimes referred to as an "Individual Sewage Disposal System," or ISDS, the drainage pipes of the building collect and (conventionally) run in a single stream to the septic tank via a "building sewer." (2) Although collection conveyances are most economical if the flow is simply gravity-driven, sewers may, regardless of the size involved, require pumping or forced flow in some other fashion, such as maintaining negative pressure by a downstream vacuum pump; pumping may be involved even in ISDS designs. (3) After collection, the wastewater is permitted to settle, during which time various microbiological and biochemical decomposition processes begin; gases are released and fluid and solid portions of the stream separate, with solids settling to the bottom of a tank. (4) The fluid components, called effluent, may or may not be subjected to further treatment, including full sterilization, and are ultimately discharged to the land surface or subsurface, or to surface bodies of water large enough to accommodate, dilute, and disperse the stream. (5) The solids left behind are referred to as residuals. In the case of centralized treatment, the residuals are more specifically referred to as "sludge," and in the case of septic tanks, as "septage." Their physical and chemical characteristics are different insofar as sludge is residual to a more complete level of wastewater treatment. However, residuals of any type are still subject to further treatment. At the least they will be dewatered, after which they may be composted, incinerated, or stabilized and applied to land or buried. Even in the context of decentralization, the residuals that result from on-site treatment still must be collected by pump trucks and offloaded at a central site for further treatment. The residual volume will vary greatly depending on the technology chosen, because the treatment processes themselves liquefy or gasify solid components; when residuals are recycled through the process, still additional liquefaction and gasification can result.

Each step outlined above has numerous technological options associated with it. In the planning literature, options are referred to as "alternatives," merely implying a choice among choices, not anything novel. But the same literature, in a somewhat different context, also uses the term "alternative" to mean "novel," a fact to bear in mind when reading this document and related literature.

3.1.2 Scale of Wastewater Treatment

The highest level of division between systems is their scale or size. Historically, there were only two choices of scale. The first, and most traditional for urban areas, was the "central" treatment plant, conventionally managed by a municipal department of public works or sewer commission. Of course, such plants still exist and are still being built and managed that way. For a centralized system wastewater is typically collected in large, gravity sewers (with intermittent pumping stations if required) and treated at a central location. Centralized systems require a great deal of physical and chemical engineering, operation, and maintenance, making them very costly in small communities, especially if the sewer runs are long and serve low-density housing in their course.

At the other end of the scale is the individual sewage disposal system (ISDS), originally consisting simply of a cesspool that did not separate fluid from solid components. Since then, design has evolved into the "modern" septic system, first required for new construction in Massachusetts in 1978. Waste is collected in a theoretically tight septic tank, and effluent drains off separately to a nearby, subsurface leaching area. The leaching area itself develops a "biological mat" that further transforms the waste stream; and the soil beneath the mat acts as a filter as well. In theory, if an ISDS is sited and designed properly, then by the time the effluent stream joins groundwater it is purified, although high levels of nutrients, particularly nitrogen, can remain a problem. More advanced ISDS systems exist as well, and are discussed later.

In recent years, technological choices have come to include scales intermediate between the central plant and the individual septic system. These systems can serve multiple users in apartment buildings, building complexes, neighborhoods, and even small communities or towns. In the recent past, all such systems have been considered to be *alternative* to (conventional) central sewering, and are also referred to as *decentralized* or *on-site* systems. In reality, while the systems may be located very close to the site of waste generation, they need not be precisely on-site, and thus may be referred to as *near-site* systems as well. Nevertheless, the distances wastewater is conveyed, and the number of users served, are small, compared with a conventional central treatment facility.

Another way to possibly make a distinction between decentralized and centralized alternatives might be through Title 5 (310-CMR-15.00, Title

5), which, in its 1995 revision, regulates all subsurface discharging systems with flows of fewer than 10,000 gallons per day (with several grandfathering provisions for preexisting systems of capacities up to 15,000 gpd). As a quick but imprecise rule of thumb, a 10,000 gpd system can handle the wastewater generation of about 200 people averaging about 50 gallons of wastewater per person per day. Any sewage treatment system that discharges to surface waters, and any subsurface discharging system that exceeds the 10,000 gpd threshold, requires either a National Pollutant Discharge Elimination System (NPDES) surface water discharge permit, or a groundwater discharge permit. These permits are issued and conditioned directly by the state DEP. Such systems are regulated not under Title 5 but under several sections of 314-CMR. Thus, a program for managing decentralized systems might not need to handle the details of any 314-CMR system on the grounds that they were already sufficiently, if differently, managed.

A municipality or district might, of course, contain several "314-CMR systems," in which case its wastewater management might still be described as "decentralized," although that portion, or portions, of the management area would be subject to different rules than those applying to Title 5 systems. This may be a very useful managerial distinction in the planning process, particularly if existing administrative entities, under existing charters, are to be retained. This is because publicly-owned 314-CMR systems would typically be managed by a DPW or Sewer Commission, whereas the present "management" of Title 5 systems comes under the authority of Boards of Health. Nevertheless, an overall wastewater plan may need to account of both types of systems, and provide for coordinated oversight of the entire planning area and any administrative turfs within it.

3.1.3 Centralized Elements of Decentralized Programs

Technologically, this document is concerned mainly with either individual or multi-user subsurface sewage systems beneath the 314-CMR discharge threshold, although, excepting the consideration of regulation and administration, the same planning criteria apply to multiple 314-CMR systems as well. Perhaps the best generic term for what is discussed here is *small-scale wastewater treatment* in multiple locations, with additional allowance for the fact that concern with either advanced nutrient-removing, or less costly, wastewater treatment drives much of the interest in decentralized programs.

Nevertheless, centralized components in some degree or form are likely to be part of the decentralized program, and although the focus of this document is not on such components, the following should be borne in mind:

(1) The situation in many municipalities is likely to be complex. The municipality may already have a central facility. That facility may or may not require upgrading in matter of fact; it may or may not have been discovered substandard by the DEP; and it may or may not be under consent decree for remediation. Aside from the question of satisfactory or unsatisfactory performance, the facility may or may not be at capacity. Its capacity (and service area) may or may not be enlargeable. Finally, although the municipality may not contain a preexisting central treatment facility, it may contain areas that might well warrant centralized treatment. In such cases, wastewater planning for the centralized (proposed or real) portions of the municipality needs to proceed apace of planning for the decentralized areas. Indeed, one of the first considerations will be how and where to draw the boundaries between the central and on-site areas. Thus, in reality, "decentralized wastewater planning" may instead be "comprehensive wastewater planning" that simultaneously considers both approaches.

(2) Centralized sewage treatment technology is neither obsolete nor stagnant. Such treatment can be innovative, cost-saving, nutrient-removing, relatively benign environmentally, energy-saving, etc. Indeed, in very small towns, the sorts of technologies considered here as small-scale may actually provide the single (thus, central) facility required of the community. While historically too much emphasis may have been placed on centralized solutions, they too need to be considered as an option or "alternative" to examine during the planning process.

(3) There are various hybrid technologies which have some characteristics of both centralized and decentralized systems. What distinguishes them is the collection technology. These are the so-called "alternative," small-diameter sewers, discussed further below. Such sewers may convey their waste stream to a central treatment plant, in which case, if they carry the *entirety* of the waste, they may be regarded as a novel component of centralized treatment. Such sewers may, however, convey only the effluent from on-site septic tanks to a central location for treatment; in this case effluent treatment is centralized, but residuals collection is decentralized. Finally, such sewers may very much be a part of the small-scale technologies on which this document is focused, and thus are discussed in more detail below. But, again, we raise the caveat that there are many facets and variables in the centralization-decentralization

question that blur the distinction between the two approaches.

(4) Finally, one aspect of a decentralized wastewater management program almost always remains centralized: the handling and treatment of residuals. Various on-site and community technologies, especially advanced ones, can reduce, but not eliminate, the need to collect and treat residuals. Residuals may be fed into central sewage treatment facilities at controlled rates, or central septage (not sewage) treatment facilities may be built whose only purpose is to treat residuals trucked from afar. Moreover, one of the most typical "entries" of a community into proactive, decentralized management might well be to tighten the inspection and pumping requirements of conventional septic systems beyond the minimal standards and recommendations of Title 5. In such circumstances, which may result in more frequent pumping, the demand on a septage receiving facility will increase, perhaps greatly; then level off at a permanently higher volume unless and until there are higher performance demands made on ISDSs themselves, instituted to specifically reduce septage volumes. A discussion of the evaluation and screening of septage treatment facilities is, unfortunately, beyond the scope of this document. It can not, however, be considered to be beyond the scope of the planning process. The very fact that central septage treatment, as well as sludge treatment from package plants (discussed below), must be considered, and that such a facility needs to be found or built, may again suggest that some degree of central sewage treatment be considered at the same time that decentralized alternatives are examined.

All of the above is merely meant to emphasize that only in some circumstances can decentralization be considered in isolation. In many other circumstances one portion of a municipality (particularly a city) may be centralized. Another portion may involve centralized collection of effluent but not residuals. Another may be served by near-site community systems, of either or both the Title 5 or 314-CMR variety. Yet another may be served by Title 5 ISDSs, but within it, one area may be satisfactorily served with conventional septic systems, while another requires advanced nutrient-removing technology or other novel features.

Fortunately, just as it is a rare circumstance that decentralization can be considered in complete or near-complete isolation, it may be equally rare that *all* of the situations described in the previous paragraph simultaneously exist in a given community. They do, or could, for example, in municipalities like Gloucester or Barnstable, which are in the throes of comprehensive wastewater planning.

However, while *comprehensive* wastewater planning may be mandated by the terms of a consent decree, or be generally desirable in the town, something less than such ambitious planning may still greatly improve the wastewater situation. A local Board of Health may take its own initiative regarding tighter regulation of Title 5 systems without having to get involved in anything more (or other) than solving a problem immediately adjacent to the town's shores but distressingly far away from any efficient sewer hook-up. In such a circumstance, the processes described here may be overly ambitious if undertaken in their entirety. They could, instead, be viewed more as a menu, with not every consideration applicable to every situation.

With that as background, what follows next is a description of the *types* of systems generally considered part of decentralized or small-scale programs; and after that, a discussion of the criteria involved in their screening and selection.

3.1.4 Technological Progress in Wastewater Treatment

Both centralized and decentralized wastewater technologies have evolved considerably. At the on-site scale the most primitive systems started as outdoor pit privies. With the coming of indoor plumbing, wastewater still was drained by gravity to an outdoor pit called a cesspool. In urban areas, the first homes with indoor plumbing simply hooked their building sewer to the streetside storm sewers that drained untreated, unseparated waste (as well as the flood waters for which they were installed) to the nearest river, or other open body of water. None of this is *ancient* history.

3.1.4.1 Levels of Treatment

The simplest level of actual "treatment" involves no more than separating fluid and solid components, the fluid being relatively less deleterious, and easier to dispose of, than the residuals. In the typical on-site system, this step, which (in any context) is referred to as *primary treatment,* is reflected in the current "standard" septic system, but recently enough that only in the latter quarter of this century has it come to widely replace the cesspool "standard." The first urban central treatment plants also provided little more than decanting, or primary treatment.

It wasn't until the federal Clean Water Act of 1977 that central plants were compelled to provide at least a level of *secondary treatment.* Even then, waivers could (and can) be obtained depending on the diluting ability, carrying capacity, and uses to which the receiving waters were (are) put. Secondary treatment involves microbiological and biochemical transformation of the liquefied effluent to remove and break down organic compounds, and thus also acts to considerably purify the discharge stream.

Tertiary treatment, sometimes called *advanced treatment,* removes all other contaminants from the effluent to an extent that results in potable, or nearly potable, water. From a public health standpoint, such contaminants may consist of pathogens or toxins. From an environmental standpoint contaminants also include excess levels of plant nutrients such as nitrogen and phosphorous. Such nutrients are chemically released during the breakdown of waste as part of natural environmental cycles. But when they are generated in excess amounts they can cause algal overgrowth, stagnation, and oxygen depletion in receiving waters—a process called eutrophication, which leads to fish kills and other harmful environmental effects. High levels of these plant nutrients in drinking water are also deleterious to human health.

Improvements in the economic efficacy of secondary and tertiary treatment can, and are, being made at all scales of wastewater treatment, from the ISDS to the central treatment plant. Similar improvements are being made in the treatment and handling of residuals. It is chiefly because of the development of such improvements at small scales that decentralized wastewater management is, now, a viable long-term possibility for many areas and communities.

3.1.4.2 Innovative and Alternative Technology

While these improvements have proceeded in many quarters, the incentives to do so have greatly increased since passage of the federal Safe Drinking Water Act in 1974, the Clean Water Act in 1977, their various amendments, and their various recapitulations in state law. In fact, in 1977 the federal Environmental Protection Agency, the EPA, established an "Innovative and Alternative Technology Program" to provide specific incentives for "I/A" technology development. It has since been discontinued, but part of its tradition and part of its lexicon remain; and in various ways the terminology has been picked up in state regulations, general discourse, and documents such as this one.

In the "I/A" context, the terms *advanced* or *enhanced* apply to technologies that either provide full tertiary treatment, or remove nutrients, or both. The term *innovative* refers to novel technology yet to be fully proven, and thus is in some sense still experimental. The term *alternative* refers to novel treatment that has been tested sufficiently to be regarded as fully proven, but still is novel enough *not* to be considered conventional or traditional. As we noted, the EPA lexicon also involves use of the term "alternative" in its facilities planning literature, but in a more conventional sense, meaning that the term simply refers to an option among options. Thus the context of the term must be considered by readers of the literature and those involved in planning.

When it comes to decentralized management, the term *alternative* can actually apply in *both* senses. Long-term, planned-for, decentralized management can be not only an option but a *novel* option. The sense in which the term "decentralized management" is still generally employed is also meant to imply a new approach to circumstances that historically would indicate centralized treatment.

Small-scale technologies are categorized in other ways as well; the division used below is somewhat arbitrary. As previously mentioned, such technologies have recently bloomed. Many of them are proprietary, designed for particular purposes such as nitrogen removal or leaching-area reduction. Others are not proprietary, but still have distinct names reflecting their origin, such as the Wisconsin Mound System or the Waterloo Biofilter, developed at the universities of Wisconsin and Waterloo (Ontario), respectively. (Both universities, not solely but significantly, have been at the forefront of on-site technology development, and can be regarded as resources for those wanting more on-site information.)

It is rare, however, that technologies are discussed so specifically in this document. This is because, during the planning stage of wastewater program development, it is sufficient to identify the scale and level of performance that is needed or desired. But generally a whole *class* of systems (denitrifying individual on-site systems, for example) will satisfy the requirement. Later, during the design stage (which follows the planning stage), technologies may have to be selected more specifically for even more subtle reasons, such as availability, or limitations regarding cost or maintenance, etc.

3.1.4.3 Wastewater Technology Requires Management

Finally, before turning to a discussion of some of these technologies, one more general point requires emphasis. It is known and understood that central treatment plants and 314-CMR systems require routine inspection, monitoring, operational tuning, maintenance, and repair. The qualifications of the operators and their duties are spelled out in the state code and in any conditions attached to their required discharge permits.

The situation is different with Title 5 systems. While the conventional single-household septic system indeed requires some degree of regular inspection, pumping, and maintenance, this fact is not widely appreciated or acted on. The conventional system often is assumed, even by professionals, to require little or no maintenance because of its gravity-driven, passive nature, involving no moving, or seemingly wearable, parts. Unfortunately such systems do fail by the backup or breakout of raw wastewater. Or they may pollute in less obvious ways. Failures in large numbers, in close proximity, can be the very problem that initially drives a community, or the regulatory agencies, to seek centralization.

But, it is known, now, that even minimal improvements in conventional septic systems (for example, truly assuring that the septic tank is watertight), and modest inspection and maintenance programs, can often, in themselves, prevent failure and extend longevity of the system and its leachfield.

With respect to advanced, enhanced, alternative, and innovative technology, the demands for proper installation and maintenance further increase. Such systems almost always involve electrical and mechanical pumps and parts, filters, valves, and other replaceables. They are not "out-of-sight, out-of-mind" immortal technologies the way conventional septic systems are often regarded (however erroneously). Enhanced systems require proactive management, regulated or overseen by some public agency. Thus a "management plan" becomes a necessary part of the "facilities plan" for decentralized systems. The tasks involved are typically beyond those that owners might be expected to directly perform themselves—in the same way that most owners would not be expected, themselves, to clean, tune, and maintain their oil or gas burners. Whether the administrative or regulating agency can require as little as proof that required maintenance has been performed, or whether it chooses to directly involve itself in the inspection and maintenance jobs, is part of what needs to be explored during the planning process. Management requirements and possibilities are discussed later in this document, and in more detail in the companion document to this one.

3.1.5 Technological Options for Decentralized Programs

3.1.5.1 Individual Sewage Disposal Systems (ISDSs)

It is in the area of ISDSs that technology, much of it proprietary, has especially flowered, each system addressing one or more specific environmental or public health concerns. Such developments are especially significant to decentralized management because

ISDSs are by far the most common small system in use.

A conventional system consists of a septic tank in which solids break down and settle. Gases are vented to the roof of the building by a venting conduit that comes off the building's sewer pipe. Grease and other light material, collectively called scum, floats to the top. An outlet blocked off from the scum layer feeds effluent, by gravity, to a "distribution box" and thence to a drainfield, or other subsurface leaching and absorption area, backfilled with crushed stone. Particulates, pathogens, and other contaminants in the effluent are partially, sometimes only slightly, aerated in the field and then filtered by the underlying soil before the effluent stream percolates to the water table. Ideally the soils are moderately permeable, and well aerated in the upper layers. Ideally, the upper surface of the groundwater, called the water table, is well beneath the level of the leachfield so that filtration and purification can occur before the effluent plume joins the groundwater.

The conventional ISDS system is "septic," meaning that the breakdown of the waste in the tank occurs in a poorly aerated (anaerobic) environment by microorganisms that survive in those conditions. If the tank is truly tight there is opportunity to convert considerable portions of the solids into fluid or gaseous components. There are other conditions that affect the performance of the tank, such as its pH, and the presence or absence of harmful household chemicals that interfere with septic breakdown. Adding kitchen (garbage disposal) wastes slows the breakdown process and can overload the tank. Excessive water use can hasten draining to the leachfield of insufficiently decomposed effluent. That in turn can lead to clogging of the leachfield, and thus "ponding" or other hydraulic (flow) failures. There are limits to the capacities at which soils can absorb and filter leachfield pathogens, limits to which the flow can be added to the underlying groundwater without affecting *its* hydraulics. Thus the prescriptive, Title 5 regulations conservatively specify the flow volumes and minimal separation of these systems which discharge to groundwater.

However, the complete breakdown of animal waste involves not only anaerobic but also aerobic phases, ideally in repeated "passes." Large treatment plants may rely initially and chiefly on aerobic biological processes. In the conventional septic system, however, aerobic exposure of the wastewater is limited to the upper layers of the leachfield. Without going deeply into the biochemical processes involved, what is most prone to "escape" septic systems are the plant nutrients, nitrogen and phosphorous, which if uncontrolled can pose public health problems and lead to eutrophication of surface waters. Phosphorous is the critical contaminant for fresh waters, and nitrogen for coastal waters. Phosphorous compounds are readily absorbed in suitable soils, and modification of the leaching area by the addition of limestone may be sufficient to accomplish this end if the soils are otherwise unsuitable.

Unfortunately, nitrogen compounds are not readily absorbed by soil. To "denitrify" the waste stream involves chemically converting nitrogen compounds back to nitrogen gas that escapes to the atmosphere (which is mostly composed of nitrogen). There are several phases in this process. Much of the nitrogen-containing animal proteins and amino acids are reduced to ammonium *an*aerobically. The ammonium (but not the original proteins) can then be converted to nitrates *aer*obically. Nitrates, if then *re*cycled *an*aerobically, are reduced to nitrogen gas. Denitrification is one of the most common goals of enhanced, advanced, and alternative wastewater management, which, at the ISDS level, is discussed next.

The simplest "alternative" modifications of septic systems involve changes in leachfield design. Such changes may be required when there is insufficient conventional leachfield area; where soils are too thin, or too porous, or not porous enough; or where groundwater levels are too high. Artificial leachfield media may be used to more effectively aerate the field or distribute effluent. More efficient, evenly distributed, and aerated effluent also can be obtained with "pressure dosing" pumps; or, if a hillside allows, by the emplacement, in series, of perforated leachfield pipe that forces flow downhill after first one, and then another, uphill chamber is filled. Leachfields function best if allowed to periodically "rest." Thus, two fields may be laid out together, with an "alternator valve" installed in the leachfield piping. If high groundwater or poor soils are a problem, the entire field, pump-fed, may be laid out on a constructed above-grade mound. In all such designs, clean-out and inspection ports may be specified as part of the leachfield piping.

When environmental conditions permit, vegetation can be used as part of the absorption process; in dry climates, through vegetational "evapotranspiration" in which effluent effectively "waters" the roots of overlying trees; in areas with high groundwater, through the design of "artificial wetlands," whose purpose, again, is to take up effluent while additional purification and decomposition of organics takes place. Effluent may, in fact, be applied directly to the land through sprinkler systems or hill surface flooding. It may even, in some cases, be discharged to surface waters. However, alternatives for effluent handling that involve discharge to surface waters or the land surface typically would require disinfection of the effluent first, or, at the least, careful isolation of the site from human contact.

The next two levels up in advanced on-site treatment involve recycling septic tank effluent through an aerobic environment (which enhances nitrification, thus subsequent denitrification in the leachfield), or successively through aerobic and anaerobic environments that enable denitrification to occur fully within the system's components. The typical aerobic phase involves pump-fed, or "dosed," sand filtration in one or several "passes." In some systems the sand-filtered effluent is then recycled through the anaerobic septic tank. There are many variations on these technologies, often proprietary. Some are designed chiefly to accomplish secondary treatment through the use of both septic and aerobic stages; others are designed to accomplish tertiary or near-tertiary treatment, in which large fractions of the nitrogen compounds are ultimately returned to the atmosphere, rather than to groundwater as nitrates.

Finally, there are alternatives to the conventional septic system that might be regarded as "special purpose" or "seasonal use" systems, although they may well be required, and indeed may be the only alternative, for certain kinds of remediation. These are the "tight tank," in which all wastewater is collected and, then, at frequent intervals, pumped and hauled away. Then, there is the waterless toilet, a system that may either incinerate (and boil) the wastewater, or in a more complex, if less energy intensive, design, compost the waste, rendering it innocuous.

Revised Title 5 regulations permit the use of alternative and innovative technologies, albeit with tighter provisions concerning their permissibility, inspection, and maintenance than are applied to conventional septic systems. From least to most restrictive, DEP classifies them as "general use," "provisional use," "remedial use," and "piloting." In one or another of these categories, more than ten alternative systems have been approved under the department's certification program--with more, of course, to come.

In the next three sections, other forms of small-scale wastewater treatment are discussed. For most of them, the term "alternative" is applicable in one or both of its connotations.

3.1.5.2 Small-Diameter Sewers

The conventional sewer, or collection system, is typically a large-diameter pipe, costly to install, and designed for high-volume flows. These sewers tend to rely on gravity, which may require, however, that the stream be periodically lifted at a pumping station. In contrast, alternative, small-diameter plastic piping can be installed at less cost and woven around preexisting structures. If flow volumes to small-scale facilities permit, small-diameter sewers may well be the option of choice. (Such sewers can also be used to extend the service area of a central treatment plant.)

Most typically, small-diameter sewers are used to collect and convey only the effluent from individual septic tanks. They too may be gravity-driven, but more often involve the installation of an effluent pump at each septic tank location. Such collection systems are called STEP systems, after the acronym for "Septic Tank Effluent Pump." (The equivalent gravity-driven system is sometimes referred to as a STEG system.) Small-diameter systems may also be vacuum-forced, which involves step-down regulator valves at each septic tank location, but requires the installation of only one (large) pump at the collection site. Alternative collection also can involve the entire waste stream, rather than just the effluent, or fluid, portion. However, this requires more maintenance-intensive "grinder pumps" (sometimes called GP systems) at each site that homogenize and liquefy all waste material.

These collection systems typically would be part of the community systems described below. The community systems themselves may be used for neighborhoods, office or dwelling complexes, or in multi-building institutional settings. Ownership and management of both the collection system and the common treatment elements is one of the main planning considerations in the decentralized context.

3.1.5.3 Communal Systems

The term "communal" or "cluster" system is used most commonly to refer to neighborhood septic systems, or neighborhood septic systems that have a follow-on aerobic treatment step (such as a sand filter). They still discharge effluent to the ground. While the septic tank itself may be communal (requiring the use of grinder pumps to collect the stream), the more typical cluster system is STEP- or STEG-based, in which the communal element is a common leaching field located "near-site," when truly on-site or individual leachfields are not possible for environmental or lot-size reasons. Secondary or tertiary treatment, as well as any of the alternative effluent discharge options discussed for individual systems, can apply equally to cluster or communal systems. But the more sophisticated the treatment, the more maintenance and monitoring will be required. Still, cluster systems are less management-intensive than the small treatment plants described next.

3.1.5.4 Package Plants

This term generally is used to refer to technology that has been scaled down from central plant technology, in which aerobic treatment is part and parcel of the system, and surface discharge is not uncommon. The systems are prefabricated and usually proprietary. They are sometimes called "mechanical" systems because of their heavier reliance on pumps, blowers, recirculators, chemical and physical treatment stages, etc. They are designed to treat the entire waste stream, not just the effluent. They may provide secondary or even tertiary treatment levels, and are designed for flows of up to about 50,000 gallons per day, or several hundred households. For a very small community, such a plant might well constitute "centralized treatment." These systems typically involve "suspended growth" or "attached growth" aerobic bacterial "contacters." Some of the process names include sequencing batch reactors, oxidation ditches, extended-aeration systems, and trickling filters. These treatment plants can be very "land-efficient" in that they are compact, and do not so extensively rely on the natural surrounds to provide treatment steps; they are also capable of generating very clean effluent. But they are intensive in terms of operation and maintenance requirements, and will consume more power than "natural" systems. Like ISDSs and cluster systems, they generate residuals that need to be hauled away for further treatment and disposal.

3.2 Preliminary Screening of Technologies

3.2.1 General Considerations

3.2.1.1 Procedures and Process

In the simplest cases, the planning region or district as a whole has a single problem that will yield to a single solution. More typically, however, the region will have a variety of problems.

The *process* of finding solutions to them starts with this situation: Insofar as each individual problem area (or AOC) may yield to a variety of solutions, and insofar as there may be many AOCs; then, for the planning district or region as a whole, the number of potential solution combinations will obviously be very large. Unfortunately, the number of AOCs can not be reduced. However, the prospective solutions for each individual area can be preliminarily screened for suitability. This will reduce the number of solution combinations that emerge for the district as a whole. (As an obvious example, consider the wastewater problem in a congested, commercial downtown area where open space for leaching areas is quite limited. Initially, conventional ISDSs, central sewering, package plants, or tight tanks (periodically pumped) might appear to be worth consideration. But only a little thought might show ISDSs rejected out of hand because there simply isn't available space. And with only a little more thought (or public feedback) tight tanks might quickly emerge as an undesirable option as well. Thus only two of the four alternatives will actually survive to require further and formal analysis.)

In a general sense, each prospective solution for each individual problem area is preliminarily screened in three ways. If it fails in any of those ways it can be rejected. These are: (1) the environment (along with the regulations that protect it), (2) the technology (and its suitability to the conditions and scale of the problem), and (3) the human mechanisms required to sustain the technology (which have to do with management and administration). Each surviving "area" technological solution will have a companion management solution. The identification of solutions for each area ends Phase II of the planning process.

Phases I ("Needs Analysis") and II (the preliminary identification and screening of AOC and "local" alternatives) are essentially analytical. In Phase III all surviving local ("area") solutions are examined not separately, but together, so that all the pieces are seen to mesh well, or not mesh well, in a variety of prospective overall plans. As before, some region-wide solutions may be so disjoint that they can be rejected quickly. But others of these syntheses (and their components) will survive quick scrutiny. They are then re-analyzed and evaluated by the same criteria as before, but in more detail and with a higher level of specification. In addition, the plans at this stage are scrutinized especially carefully for the reality of the overall management, cost, and financing provisions.

Ideally, only a handful of potential region-wide plans will emerge from this iterative, recursive process as being almost equally possible and realistic. At several junctures in the process it may emerge that more data are required (and obtained); and at several junctures, public opinion (formal and informal) will need to be sought. In the simplest cases the process may be fairly informal, and may not require full-time professionals to guide it. But, the more complex the situation, the greater the demand for a professional planner and a professional engineer (consultants in smaller towns, salaried staff in larger ones).

Moreover, as the scope of the project increases, the greater will be the demand for *procedural* exactitude. The larger the project, the more likely will be the interest of the federal and state governments, one of which even may have initiated the project through consent order or judicial procedure. In such cases, procedural detail will have been spelled out in the Plan of Study. Although the procedures will vary somewhat depending on the size and nature of the project, and while some aspects of procedure and criteria may only be recommended, others will be required, such as consistency with federal and state law. If the community will be seeking grants or loans, even more aspects of procedure and evaluation criteria will be stipulated.

A general guide such as this one can touch on the typical content of a wastewater plan, and the stipulations and recommendations that guide it, but can't definitively state what is required of a given Plan of Study in any individual case. Not all the criteria mentioned here will apply in every case; and in any event, criteria will vary for many reasons from the complexity and size of the community to the scale and scope of the project; from the availability of outside funds to the perception of the problems at the state level and to the desire, freedom, and ability of community institutions and leaders to take their own initiatives.

Please bear in mind that, for the text that follows, the discussion is focused on decentralized wastewater solutions. There is some consideration of centralized treatment because it may ultimately be the most practicable and cost-effective solution for a community or portions of it; but that is not the specific focus of this document.

3.2.1.2 Principles of Screening and Evaluation

The most general decision-making criteria for wastewater facilities are spelled out in both federal and state regulations and law. For example, the Massachusetts DEP (in 310 CMR 41.00) stipulates that the facilities planning process must show that the selected plan "except for alternative technology, is the most economical means of meeting the applicable effluent, water quality and public health requirements, while recognizing environmental and other non-monetary considerations."

Such stipulations suggest the sorts of criteria to be used during the initial area screening, and later during plan evaluation: Does the technology maximize the existing technological and administrative infrastructure? Does it have conservation benefits (flow and waste reduction, energy recovery, etc.)? Are the plans consistent with other federal, state, and local laws, regulations, and ordinances (for example, the watershed management plan, or nonpoint source pollution plan, of the region)? Is the technology consistent and integral with land-use

plans? What are the costs of the alternatives? Finally, is the plan likely to be acceptable to the public? All these are discussed in more detail below.
As the screening and evaluation proceed, and unanswered questions emerge, the level of detail needed to adequately answer them requires consideration. Then, answers need to be obtained before proceeding.

An objective quest for, and examination of, underlying assumptions is also important. The community, for example, may regard centralized hook-ups as superior, but are they really; and even if they are in some cases, is that true here, in this circumstance? Such systemic bias and hidden assumptions need uncovering so that their appropriateness can really be discussed. This is particularly important in cost analysis. Is every single cost, public and private, in the whole life cycle of the system really accounted for? It can be difficult to compare the costs of different technologies, but neglecting a hidden cost can bias results in unfortunate ways.

For larger projects (costing over $10 million if seeking state assistance) a process called "value engineering" is mandated. Its purpose is to guard against myopic evaluations and assessments. Essentially, when one party (typically a private firm) is hired to do the planning, another firm is contracted to audit and examine the first firm's work. Even when not mandated, seeking the review of other experts can be extremely valuable, in fact, to the point of steering the project in a major change of direction.

3.2.1.3 Special Considerations for Small Communities

Small communities have fewer resources, a smaller tax base, and a smaller professional staff. Much more of their work may be conducted by volunteers on the one hand, and "outside" consultants on the other. The latter may not be familiar enough with the community to intuit or infer much of the local sentiment. More often than not the community may have delayed addressing pollution problems until the point at which it finds itself under consent order. At this juncture it may be easily influenced in directions different from its overall best interests, for it may too readily defer to experts who have their own agendas. Town officials and Citizen Advisory Committees must stay alert and informed, proceed cautiously, and hear different points of view. While complex, a good facilities planning procedure may really work to their benefit, with its emphasis on a comprehensive look at alternatives, including the "baseline alternative" of optimizing its existing scheme.

The small community is more likely to be able to afford only decentralized options (which in any event may be the best for other reasons), thus it should seek consultants and firms with *specific experience* in that area. At the same time, it must be wary of the over-promotion of proprietary technologies or particular approaches. "Value engineering," formal or informal, may be especially important to small communities for this reason too.

Moreover, small communities (and decentralized or alternative technologies) may be specially favored or excepted in various funding or loan criteria. This is something the community will want to find out about, and should expect its consultants to have knowledge of.

Finally, such communities should be alert for opportunities to regionalize. That is, to join forces with nearby communities to take advantage of shared resources and economies of scale. Regionalization may apply particularly to parts of the plan that remain, or are to be, centralized, such as septage treatment. The various criteria discussed generally so far are examined in more detail in the sections that follow.

3.2.2 Environmental and Regulatory Considerations

3.2.2.1 Regulatory Factors

Establishing relevant regulatory criteria involves a process called "consistency analysis" in which all laws, regulations, and plans (at any level of government) that might bear on wastewater planning are examined to see exactly how they do bear. The sum of all such requirements constitutes a list of the regulatory criteria against which any chosen technology can be matched in terms of performance and management requirements. If the technology fails on any single criterion it must be discarded or modified until it fits. In rare cases, the reverse may be done: the proposal may, *instead*, be made to change a regulation or zoning bylaw, or to grant a variance.

Obviously the most important regulatory criteria concern public health, water use and supply, water pollution, and environmental protection; as well as the wastewater technologies permitted or specified under the law, and the specifications and stipulations that pertain to their siting, design, operation, monitoring, and maintenance.

Some of the more pertinent regulatory considerations arise in: (1) river basin plans developed through the Watershed Management Program of the DEP, developed pursuant to Section 303(e) of the 1972 Federal Water Pollution Control Act; (2) Massachusetts or regional planning agencies' nonpoint source management plans, developed pursuant to Sections 208 and 319 of the Clean Water Act; (3) local water resource plans developed by the Massachusetts Department of

Environmental Management (DEM); and (4) the Massachusetts Environmental Policy Act (MEPA) and its regulations.

Regulatory or legal criteria may also constrain administrative and institutional choices, and are discussed in that context later, as well as in the companion document to this one.

3.2.2.2 Major Choices and Their Applicability to "Areas of Concern" (AOCs)

As matched against environmental regulations; environmentally-sensitive AOCs; zoning and planning ordinances that pertain to the community; and a first glance at considerations of feasibility and desirability, the basic suitability of broad technological categories is determined as follows: Is there already a centralized treatment portion of the town? If so, should its service area be extended or left intact? If there isn't a central treatment facility, should there be one, now or in the future (and how does septage treatment factor into such a consideration)? In the decentralized area (which may be the totality), are there neighborhoods that, for environmental or lot-size limitations, would appear to require package plants or community systems? In the remaining area where ISDSs are appropriate, again, are there neighborhoods that for environmental or lot-size reasons require enhanced treatment, that is, advanced or alternative systems?

Thereafter, more specific choices are made, with technical specifications and the ambient environmental requirements being ever more stipulated. Only after choices are made at those higher levels can attention finally turn to the ultimate "product" details, such as reliability and ease of operation and maintenance (determined by its history of performance elsewhere); flexibility (in accommodating the unexpected and in its climatic/environmental ranges); and risk (the degree to which the technology is proven). Figure 1 illustrates the general flow of the decision-making process involved.

3.2.2.3 Environmental Impact and Siting

Generally, the whole consideration of small systems devolves on environmental impact, particularly as regards water quality, and how to diminish the impact in sensitive areas. Once the facilities are of any size, however, there is the possibility of deleterious impacts in the immediate vicinity that have little to do with water quality. Such impacts typically would be identified during the MEPA process. If an Environmental Impact Report will be required, involving the MEPA office early will save both time and money, even though it introduces entirely new sets of evaluative criteria. Under MEPA, the plan may be assessed against land-use plans, overlay districts, and other municipal or regional policies where the permissibility or impermissibility of a project is more ambiguous and requires more judgment and public feedback than simple matching to a list of regulations.

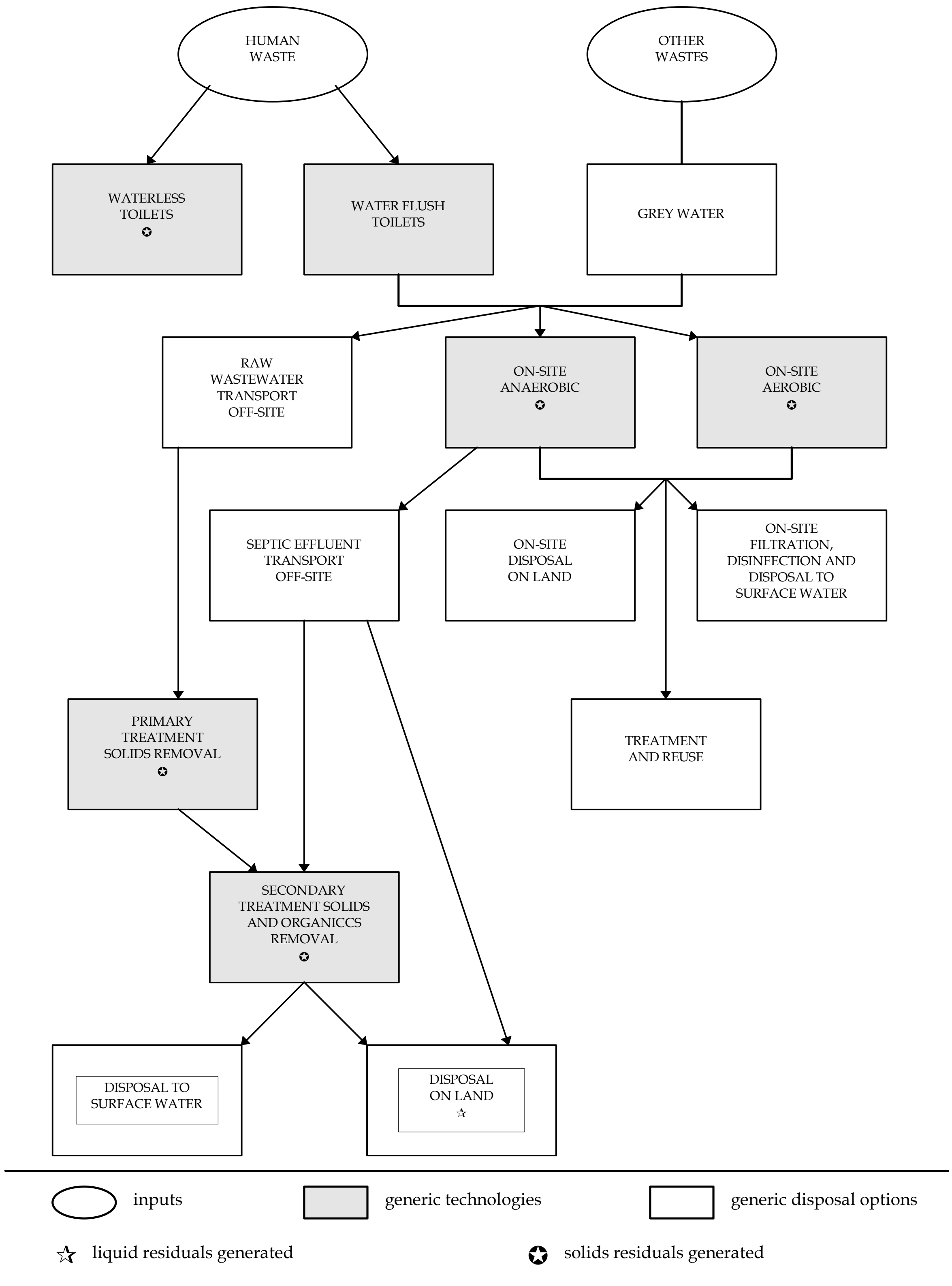
Other factors that may be considered (other than the fundamentals of water quality) include direct environmental impacts on flora and fauna, or on specially protected environmental areas; air pollution, and noise or odor problems; and thus the proximity of facilities to dwellings and other buildings. Also to be considered are the potential displacement of people, and any effects on historical, archaeological, natural, or recreational resources.

Assessment of indirect impacts must consider the effect of the siting and type of facility on growth patterns, growth rates, commercial and residential mix, and the added impacts that such induced patterns might be expected to make on the demand for, or deterioration of, resources. The effects of centralization and decentralization can be expected to be very different. Centralization is generally associated with rapid or over-development, but the use of Title 5 as a growth-limiting device has effects on patterns of development and neighborhood character as well.

In all these cases, a technology need not be abandoned before considering the opportunities to mitigate or abate its effects. But, in some cases an "environmental price" or "tradeoff" may have to be accepted. In any event, such criteria need to be applied not only in the present, but over the projected use of the facilities during the 20-year plan period, or even against a complete "buildout" analysis.

Figure 1.

WASTEWATER TECHNOLOGIES FLOW CHART



3.2.3 Technological Considerations

3.2.3.1 Technological Factors

The detailed evaluation of the technological factors that go into system selection and design require the participation of an engineer or other qualified consultant. Furthermore, much of that analysis really awaits Step II (Design) of the formalized Wastewater Management Planning procedure. Nevertheless, such factors play into the considerations in Step 1. Thus, the kinds of variables assessed are briefly described below.

3.2.3.1.1 Performance and Design

Wastewater facilities, whatever their size, can be viewed as environmental engines, dependent on microbiological processes and other biochemical and environmental conditions. After the need for a given level of treatment has been specified, the site, itself, of the facility must be assessed, right alongside the technology, as to whether it can deliver the treatment required. Generally, this process entails: (1) performance-based criteria, and (2) site-specific design, both of which are routine in the consideration of large systems, but only recently have come into play in the consideration of ISDSs or small systems. Historically such systems have been governed by prescriptive, state-level codes that presume that adequate performance is assured by regulated design criteria. The difficulty with such prescriptions is that they may be insufficient to protect the environment in some circumstances, and are too inflexible in others.

Consequently, on-site management generally entails treating every facility, whatever its size, uniquely. The volume of space required of the facility if discharging to groundwater; setbacks from surface waters or recharge zones; the quality of the soils, in particular their permeability; the depth to groundwater; general hydrology; and pollutant loadings in the area are some of the considerations concerning land alone. One of the most common uses of cluster systems, in fact, is for drawing effluent away from riparian lots to leachfields in more suitable areas.

Aside from soil and hydrology, local vegetation and its ability to denitrify or to be used for evapotranspiration of effluent are considerations. These in turn are, in part, matters of climate; but other aspects of climate such as the ranges and seasonal variation in temperature and precipitation also affect the functioning of the system. Thus the operating ranges of proposed technologies need consideration in that light.

Wider operating ranges are part of the more general consideration of a facility's flexibility; its ability to accommodate variable flows due to seasonal changes in volume of use, or of inflow and infiltration; and its general ability to resist or buffer biological or climatic upset. Such factors are especially important in considering community systems or any type of facility that requires "operation," and operational tuning.

Finally, the esthetics of design, whether, e.g., there are above-ground components such as filters or mounds, will (when all else is satisfied) play a part in technology choice.

3.2.3.1.2 Reliability and Risk

Reliability and low risk of failure are especially important considerations in small communities. Whether systems are publicly or privately owned, it is unlikely that they will be continuously monitored. In general their maintenance, monitoring, and upkeep are more likely to be part-time, and to some degree chronically plagued by funding problems and the difficulty of obtaining and keeping sufficiently qualified personnel.

In on-site contexts, risk will be reduced by assuring that an adequate management plan is in place for any type of system in the district, and that part of the plan involves regular inspection and enforcement of standards. This is especially important if alternative and advanced treatment are required, because such systems are inherently more risky insofar as they are more complicated, require mechanical and electrical components, and may require operational tuning.
Granted the exceptions made for advanced or innovative technologies, risk is reduced chiefly by keeping the technologies as simple as possible, thus minimizing the chance of error in their design or construction, as well as minimizing the risk of component failures. As one example, a gravity-driven system is clearly more inherently reliable than a pump-driven one. And a pump-driven system is more risky (in one sense) if driven by a single vacuum pump than by many individual STEP pumps, for the sudden failure of the single pump becomes an immediate crisis. On the other hand, the existence of many pumps increases the maintenance demands on the entire system; more so still, if the pumps are of the grinder type. The path through such trade-offs is not always clear, but the prospect of a sudden, disastrous failure needs to be avoided. Redundancy of components and leachfields; the ability of systems to still function when portions are pulled "off line"; their general structural durability; and their history and provability in other locations are all considerations in anticipating or handling system failures.

This is not to say that a district may not want to encourage innovation, regardless of its risk or complexity.

But, if so, special oversight and backup plans will be required. The larger the innovative system, the larger the risk, and the more thorough a contingency plan needs to become.

3.2.3.1.3 Ease of Operation and Maintenance

Ease of operation and maintenance is part of "simplicity," its importance the same as that of reliability to small communities. In such communities, if operation and maintenance requirements can be kept to levels that local contractors can fill, perhaps with some degree of training, "staffing" will not be the problem that it could otherwise become. Even in plants that require licensed operators, the ease of process control, the clear outlining of procedures, access to good monitoring and testing facilities, and a good preventive maintenance program are all components of "ease" of operation.

Individual systems vary enormously in their need for routine inspection and maintenance; management programs for each type of system need to be clearly spelled out. In the ISDS context, ease of retrofitting older systems; and in new ones, ease of access through grade-level ports for purposes of inspection, pumping, and component replacement; become important cost considerations in the overall program.

3.2.3.1.4 Conservation and Energy Use

Resources conservation and recovery (whether of water or energy) are obviously important both economically and ecologically. At the ISDS level, water conservation can make an important difference to system functioning. Low-flush toilets, water-conserving faucets and showerheads, the banning of the use of garbage disposals, and the insulation of hot water pipes not only contribute to system longevity, but reduce demand on an ever more expensive commodity: clean drinking water. The ultimate in low-flush toilets is the "no-flush" toilet. If it is of the composting type, there is opportunity to recycle waste. If it's of the incinerating type, it obviously is energy intensive, even as it conserves water.

The energy efficiency of package plants and other small-scale systems varies widely with the process, and an energy analysis should be part of the screening procedure. Such plants also may contain energy recovery (through methane collection) components, and may be able to convert compost into marketable fertilizer as well, although at some energy (and facility) cost.

3.2.3.2 Overall Assessment of Technology as a Matter of Cost

After assessment of the community's needs, the fundamental cost question that arises is whether these needs can be met technologically by the modified use (or more tightly managed use) of existing facilities, or whether altogether new or replacement systems are required. In order to compare the cost of all alternatives, and also to ground any proposals in reality, each alternative needs to be matched against the costs and implications of the "baseline alternative" of optimizing existing facilities, including ISDSs.

This baseline alternative might involve repair and upgrade of an existing central treatment facility while minimizing its sewer extensions to new areas. For problem areas outside the central service area, it might involve the upgrade of existing individual systems to Title 5 requirements; or it might involve a routine inspection and maintenance program for Title 5 systems. Better septage management may be part of the baseline alternative, as may be the institution of waste or flow reduction schemes, water conservation, and pollution prevention measures.

Some background: The 1977 Clean Water Act (and its parallels at state level) emphasizes cost-effectiveness. Indeed, when seeking state funding, the proposed plan must be within 10% of the *most* cost-effective for maximal reimbursal or loan eligibility (with good reason proffered for the overage). In part, this emphasis came about because centralized wastewater treatment in small communities was often showing itself to be unreasonably costly for the resulting environmental gains.

In recognition of that, the facilities planning procedure was modified to stipulate that evaluation of any prospective facilities plans be conducted against a parallel "baseline" evaluation. Originally, the baseline was that of taking no action at all. While the "no action" option was widely regarded as bureaucratic nonsense, it had the intended effects. It forced a focused examination of whether a problem really existed, a reexamination of the premise that individual systems "automatically" failed, the consideration of where and why they might be failing, and the consideration of whether failure was reversible or curable.

Of course, taking "no action" would only rarely be a solution because it is unlikely that the planning process would have been initiated without some indication of troublesome problems. However, taking no action *in certain areas of the district* might well be feasible.

More realistically, taking *minimal action*, instead of *no action*, is what might often suffice. And as mentioned, in Massachusetts, the baseline alternative, against which all other alternatives are to be assessed, is not "no action" but instead, minimal action.

However, it could be that, for some AOCs, the operation of all existing individual systems can not be optimized sufficiently to address the problems, and that some systems may need to be replaced, perhaps with advanced features. If the number of systems needing replacement becomes large, their total cost has to be weighed against the cost of utilizing the alternative of communal or package systems for various clusters of lots. It is on this middle ground where determinations of cost-effectiveness can be most problematical, but also most useful when thoroughly pursued.

In the worst cases, some areas, because of extreme building density, environmental sensitivity, or poor drainage will require altogether new systems for virtually every single lot in the entire area, possibly demanding *advanced* on-site or near-site treatment as well; or, alternative to that, centralized collection and treatment, either conventional or advanced. Such options are likely to be the most costly. Then, finding the most cost-effective among them becomes the job.

In contrast, it could be the case that new facilities are the *most* cost-effective. An example: several municipalities join together as a district (or through intermunicipal agreements) to build a joint, regional septage or sewage facility where capital and operational overhead can be shared over a larger user and taxpayer base.

Detailed cost evaluation involves the averaged cost of a district-wide wastewater system; thus consideration of advanced technology, however expensive, need not be ruled out for any given AOC. But, even from the start, cost requires consideration, and the logical starting place, for both regulators and voters, will be the "no frills" option.

3.2.4 Management and Administrative Considerations

A companion document to this one more thoroughly explores the administrative, management, and financial dimensions of decentralized wastewater treatment, discussing in more detail all of the four subsections that follow. In that document, and this one, a distinction is made between technical or technological activity on the one hand, and organizational or institutional activity on the other. In the planning literature, both these activities are referred to as "management." But here we distinguish between the two.

The first concerns the set of physical facilities. These may include combinations of publicly-owned treatment works or septage facilities, privately-owned package plants and communal systems, and individual septic systems. Some, or all, may involve alternative, or innovative, technology. In most situations virtually all these components will require some degree of professional operation, inspection, maintenance, and repair. Even Title 5 systems *need* some degree of inspection, pumping, and other maintenance (and under 1995 code revisions are required to get some). But in a properly constituted, decentralized district, Title 5 systems might well receive scrutiny and oversight throughout their lifespan that goes beyond requirements of the state code. If the indefinite use of Title 5 systems is being proposed in lieu of a central facility, the DEP itself may require an inspection, pumping, maintenance, and oversight program that goes beyond minimal code requirements.

All the tasks related to the proper functioning or oversight of the physical facilities are referred to as "management" in this document. (The oversight of management activities, themselves, is referred to as "administration.") For each *type* of technology in the district there will need to be a specific management program. Elements of the individual management programs may include site planning, facility design, installation inspection, standards for operation, maintenance and repair, and an inspection program. These will all differ slightly, depending on the mix of technologies and the particular technology under discussion.

For the district plan as a whole there needs to be an *overall* management plan for coordinating and assigning management activities. At this district-wide level, the management plan may need to also include provisions for central facilities, collection systems, overall planning, plans for remediation of existing facilities, and environmental monitoring.

Aside from such technical activities, there are the administrative ones. The most important administrative responsibility is that of assuring that the management plan is executed properly. Related administrative activities include record keeping, billing and collection of user and license fees, certification and training of professionals (public or private), enforcement actions, public education, and policy coordination with other agencies. The *authority* to undertake these activities must flow legally from the government (the public) at various levels, ranging from the state's General Court, to town meeting passage of ordinances, to the creation of intermunicipal or interagency agreements. The authority must be embodied in legally constituted institutions and agencies, of which there may be one or more involved. (For example, a municipality might charge a Sewer Authority with management of central facilities, but charge a Department of Health with management of individual on-site systems.) How such responsibilities are delegated needs to be outlined in the "management plan," and the required legal instruments must either be previously in place, or defined and scheduled in the implementation portion of the plan.

3.2.4.1 Management Requirements

As mentioned, the term "management" (as used here) is confined to the technological requirements for the oversight, operation, and maintenance of a facility or facilities. For any communal or package facility these include routine operations, inspection, plant monitoring, output monitoring, maintenance and repair. Additional management tasks may also include the creation and implementation of a remediation program for systems that are not up to standard; siting and system design of new systems; and the creation of inspection, pumping, and maintenance schedules for the various categories of systems.

Minimal management requirements for wastewater systems are spelled out in the state code. In Massachusetts, for surface discharging systems, or for subsurface discharging systems with flows greater than 10,000 gallons per day (previously 15,000 gpd), the minimum requirements are spelled out by the DEP in various sections of 314-CMR, and in conditions attached to NPDES or groundwater discharge permits. For systems with flows less than 10,000 gpd, minimal inspection and maintenance requirements are specified in Title 5, but are stiffer for alternative systems, and for cluster and communal systems.

However, the local management plan may stipulate still more stringent operation, inspection, and maintenance requirements, and may absolutely need to in critical situations that otherwise would require central sewering. Clearly, greater environmental constraints will dictate tighter operational constraints. But at the same time, imposing unnecessary or highly debatable management activities on system owners will drive the overall costs up, and drive public acceptability down. This is where the flexibility of a comprehensive wastewater management program can pay off, a point that may need emphasizing to the public. Even while there may be areas within the district where standards more stringent than Title 5 would apply, there may be other areas of the district where Title 5's standards are unnecessarily strict, simply because they are prescriptively invariant, thus both too rigid and too conservative. The authority to loosen state-level, prescriptive ISDS standards could be part of the attractiveness of the district approach, if it can be negotiated that prescriptive standards would be replaced with standards based, instead, on system performance and environmental loading limits. Policy discussions concerning this issue are currently going on in Massachusetts.

For each type of technology an inspection and maintenance program will need to be specified. If the technologies are proprietary, manufacturers may need to be consulted. If they are not proprietary, advice can be sought from the DEP, consultants, and national data clearinghouses such as the EPA-funded National Small Flows Clearinghouse at the University of West Virginia in Morgantown.

The institution or agency that oversees small systems in the district will want to reserve the right to change inspection and maintenance requirements as local experience dictates. A good management plan might start incrementally with minimal requirements in the most sensitive areas, and work "upward" and outward from there if continued on-site and environmental monitoring so warrants.
How management tasks get performed is an institutional choice discussed below.

3.2.4.2 Institutional Choices

At the institutional (governmental) level, the powers required to effect and successfully execute a management plan may include the ability to own property, enter contracts, make and enforce regulations, obtain access to private property for appropriate purposes, license and train professionals, receive and disburse grants and loans, and set user and licensing fees or assessments.

As with the technology itself the choice of institution(s) that will oversee, implement, and execute the management plan ranges from the preexisting, to modifications of the preexisting, to the creation of an entirely new entity. Detailed considerations involved in this choice are more thoroughly outlined in the companion document to this one.

Briefly, however, insofar as there already are typically preexisting (in the ground) technologies which, in general, are already accompanied by *some* degree of administrative oversight and institutional responsibility; and insofar as this preexisting technology is likely to continue to be utilized in the most cost-effective plan; considerations of administrative continuity and public acceptability may well favor retaining the present institutional structure. Powers and duties of the institutions involved may have to be more clearly spelled out. For example the *tight* management of individual systems would be made legally less risky by legislation or bylaws that strengthened the hand of boards of health or health departments, more readily empowering them to set higher standards, inspect, assess and collect operation permit fees, take more routine kinds of enforcement actions, etc.

Such decisions will depend a great deal on the present performance of the institutions that do exist, for wastewater plans require "provable" management plans and institutional structures to enforce them. The simplest beginning is to match candidate institutions against the necessary powers and authorities itemized above. If a proposed institution has any deficiencies, they need to be rectified (in fact, or on paper in the implementation plan) by taking the necessary legal measures to do so, such as writing and passing legislation, ordinances, or intermunicipal agreements.

Beyond that, one looks at: (1) preexisting (or proposed) institutions with respect to their geographic jurisdiction relative to the plan's geographic boundaries; (2) experience and qualifications of staff relative to their charge; (3) institutional history, whether it has been fractious or cooperative and effective; also, how compatibly it fits with other agencies (such as planning departments) with which it must work; (4) whether it has been responsive and accountable to the public; and, ultimately, (5) whether it is politically acceptable.

Altogether *new* institutions may be called for in cases where a sewer authority and department of health in the same municipality are to share administrative responsibility for the overall plan. In such cases, an overseeing, coordinating, or planning committee or commission may need to be established. Likewise, if regional facilities are to be considered, their administration may require the creation of new regional or district entities.

One relatively new institutional approach is the "On-site Wastewater Management District", or Commission, or program. The fundamental idea behind it is that small systems, especially individual systems, would not pose the problems that they do, if it were only recognized and acted on that they require routine maintenance such as pumping. And that if there were a systematic program to inspect, pump, and otherwise maintain small systems, and if failing systems were identified and remediated, there might never be a need for centralization. The concept is also driven by the flowering of small-scale remediating and advanced technologies now available as alternatives to sewering, but which clearly demand upkeep and maintenance beyond what might reasonably be expected or presumed of an owner. Such districts can be organized in many different ways, on both intra- and intertown levels. These kinds of administrative and managerial structures are discussed at length in the companion document.

Aside from the actual choice of institution is another set of decisions that needs to emerge and be specified during the planning process, but which is tightly linked to institutional structure. These decisions have to do with the degree to which the public institution takes action and responsibility (including ownership) directly or indirectly. And if indirectly, whether through utility-like district-wide contractors, or strictly through the oversight of the actions of individual owners.

In the most organized scheme, the institution might effectively assume all responsibility (even "ownership," at least in the form of easements) for the installation, upgrading, and management of every facility (including ISDSs), charging uniform user fees or assessments. At the least organized, the management requirements of private components in the system would be stipulated in renewable operating permits, the renewal conditioned by proof of pumping or service paid for by the owner. In intermediate schemes, service companies hired by the institution might circuit the district, systematically performing required maintenance. Any of these "pure" schemes may not be practicable because of the great variation in systems, circumstances, and preferred forms of ownership. But a package of all required arrangements needs to be laid out and discussed so that consensus can be sought, and provisions for some basis of community-wide equity established.

The chief advantage to the public of retaining a larger share of public control is the certainty of compliance. The chief advantage of privatization of some tasks is cost savings to the public at large. But it is important to remember that, in estimating system costs, both public and private costs must be accounted of, and that equity in cost allocation will be an important part of public acceptability.

Finally, even in a highly privatized scheme, some administrative functions, such as enforcement and the licensing or certification of professionals, would always remain with the public institution.

3.2.4.3 Financial Requirements

3.2.4.3.1 Financial planning

Capital income can be raised by state or federal public grants or loans (repaid by betterment assessments), local bonds, private loans, cash on hand, and some portion of annual tax revenues. The configuration of the system and how much of it is in private hands can affect public loan and grant qualification. Provisions change continually, but if the various government levels are serious about supporting decentralization, it must in the future become easier to provide ready public financing for the upgrade (and perhaps the construction) of privately-owned facilities, both individual and communal. Several creative devices are discussed in the companion document. Some degree of public financing is already available for upgrading failing Title 5 systems in Massachusetts, in the form of the Betterment Bill. More capital is becoming available through similar devices. Insofar as the situation is not static, the WPC will need to consult with the DEP and other experts on the current situation. The DEP, and other agencies, may also grant money for the purpose of planning; again, the details should be established at the time planning commences.

In addition to financing, outright subsidies for the few unable to pay at all to, e.g., remediate septic systems may be desired. A comprehensive program will need to account of, and budget for, such cases.

Funds for operational and administrative expenses can be raised by user or pumping fees, special tax assessments, or from the general tax base. Some costs can be directly shifted to private owners (who then need to prove they've done whatever maintenance is required in order to get a renewal of a permit to operate). The authority to raise all such revenue needs to be embodied in law.

3.2.4.3.2 Cost mitigation

Of course, there are ways to mitigate costs. Capital needs and operational costs may be reduced by increasing the "privatization" of system components, and by requiring new developments to provide communal or package systems, or to pay development fees. Cost recovery may be obtained by the sale of byproducts such as methane or fertilizer, or by the "rental" of central facilities (such as septage lagoons) to parties outside of the district.

Furthermore, the ease of operation, the maintenance, the staffing requirements, the projected longevity, and the energy efficiency of the facilities vary and need to be considered in cost evaluation.

3.2.4.3.3 Financial evaluation

The main criterion for financial analysis is *cost-effectiveness*, which translates to the lowest possible cost while still giving adequate and sufficient consideration to public health and the environment—those criteria being the highest in the screening order. Detailed financial analysis is very complicated, and can wait for those individual technological and management possibilities that haven't been eliminated on other grounds, and thus still qualify as part of an overall plan. Nevertheless, technologies that are obviously too costly can be ruled out from the beginning.

Given adequate environmental and public health protection, cost-effectiveness translates to total costs, capital and operational, public and private; accounting of any salvage values at the end of the design period; and accounting of all "interests" and monetary movements over the design life of the system. The latter is accomplished by employing a compounding "interest" factor called the "discount rate," generally set by the regulating agencies. Costs must also include the set-aside of capital replacement funds.

It can be very tricky to compare the costs of differing projects. First, it is easy to forget or overlook some of them. If considering some degree of central sewering, e.g., was the (typically) private cost of "hooking up" included? If examining septic systems, how many will have to be replaced within 20 years, and how often must they be pumped? What will pumping cost? This sort of detail is why thorough costing comes later in the process.

Another complication of costing has to do with the procedure of cost-effectiveness analysis (often mistakenly referred to as "cost effective analysis"), in which the costs of different systems are analyzed, summed, and "adjusted" to account for radically differing capitalization and operational schemes. To enable such comparisons, one of two different standard methods is employed to yield comparable figures. They are referred to respectively as the "present worth" and "equivalent uniform annual cost" methods. Financial expertise will be required for such analyses, not merely because of the arithmetic, but because it is so difficult to know or establish the bases for all the costs, and because judgment and true "even-handedness" will be required to truly compare them. The problem is all the more complex in considering the various whole-region plans, which is when the "bottom line" really takes on meaning. This is because it is okay, may even be required, to design "expensively" in some individual problem areas. When it comes to wastewater treatment, in some cases it may be the "poorest" areas that need the limousines.

Remember also that a community need not actually opt for the most cost-effective plan. Esthetics or political impasses may force more costly solutions. But qualification formulas for outside aid will be based on the most cost-effective plan (with a possible 10% excess if justifiable), so any differences must be borne wholly by the community.

3.2.4.3.4 Financial equity

The final set of financial considerations concerns the equity of cost-sharing, where components may be public or private, and capital and operational costs differ from facility to facility, and thus from neighborhood to neighborhood. Whether the public feels that all residents should be treated the "same" or "differently" is something the public will have to decide; but even *if* treated "differently," every attempt at equity should be made. The cost-effectiveness analysis of system components will help establish the basis for equity; and the idea of a wastewater management district (where user fees and betterments may apply across the population), its principles.

3.2.4.4 Public Acceptability

Active, rather than perfunctory, public participation in policy and planning processes is the rule rather than the exception today, and requirements for organized public participation are frequently embodied in law. It is indeed embodied in regulations for wastewater planning procedures if state or federal funds are sought, and is required of NEPA/MEPA as well, whose processes proceed apace of wastewater planning.
The public interface typically established first is a Citizens Advisory Committee (CAC) selected by the "Lead Agency," or Wastewater Planning Committee, that initiates the planning process in consultation with local government and civic groups. Members of the CAC should be selected both for expertise (although a separate Technical Advisory Committee can be formed for that) and for representativeness of town points of view.

But forming a committee is not sufficient. The CAC and the WPC or its consultants will want to hold workshops, prepare brochures, issue press releases, and otherwise keep the community informed and participating. It may issue surveys, via the newspaper or door-to-door; interview individuals; and address local government departments, neighborhood associations, and civic groups. At least one formal public hearing is required before final plan selection at the end of Phase III (of Step 1). But it is unwise leadership that would wait until then before seeking feedback. Another excellent insertion point for a public hearing is at the end of Phase I. During Phase II, informal neighborhood meetings may be held for each problem or Area of Concern, followed by another public hearing.

Public acceptability, too, is not so much a set of criteria as a requirement. Ultimately the voters will *absolutely* determine public acceptability. It is best to know in advance if it's there, and if it isn't, to retool until it is. The participation process is, of course, a tool by which consensus (thus acceptability) is created.

It is the public itself that will determine the criteria by which its acceptance is to be obtained. An open and fair-minded process is part of what it will be looking for. Other matters much on its mind will be similar to those of the planners. Cost, allocation and equity in cost, and accountability and accessibility of institutional personnel will be foremost. The public may also be concerned with the esthetics and location of central facilities, as well as land use and land value impacts. Complete consensus is unlikely, but if bargaining, tradeoffs, and compromise are part of the process, obtaining a majority vote becomes easier.

3.2.5 Summary (Iterations, Elimination, Emergence

Complex technical planning is a difficult process in any instance, in this case made all the more so by the sheer number of players including the public at large.

All the criteria listed above are essentially measures of "workability"; the various problem-area (AOC) options must be eliminated by one or more "workability" criteria until the "most workable" local-area solutions emerge. Field work and public feedback may be required several times to ultimately count a local-area solution in or out.

But the area solutions do not function independently of each other. The boundaries for each technology need firm fixing, and the workability of central system components (such as septage disposal) need matching against the calculated volume generated by local-area technologies.

Starting with several area-wide matrices or prospective plans, the *entire* system (as well as its components) needs to be reexamined in more detail by essentially the same criteria outlined in 3.2. The differences are that positive answers have, by this time, probably been obtained for many of the regulatory, technological, and environmental considerations, and enough "prospective" solutions eliminated, to examine the ones remaining in more detail. Also, major technological issues having been tentatively decided, the focus will shift in Phase 3 to a fuller evaluation of institutional, financial, and political (public) workability.

Chapter 4. GUIDE TO EVALUATION OF COMMUNITY-WIDE ALTERNATIVE PLANS

4.1 Analysis of Alternatives

4.1.1 Boundaries of Service Areas

Once the main decisions have been made as to (1) which areas need central treatment, or the extension of central treatment, and which can be handled with decentralized solutions; then (2) among the decentralized areas, which can be most effectively treated by community or cluster systems and which with individual systems; and (3) in the ISDS area, where conventional systems would suffice, and where advanced systems would be required, the question arises as to how to *precisely* assign the boundaries. Sometimes, environmental boundaries will be distinct enough that the demarcators will be purely natural. If not, paper or computer models of overall expected concentrations and loadings of pollutants and nutrients will aid such decision-making. In other cases, regulatory stipulations on setbacks, distance to surface waters, and depth to groundwater, etc. will fully spell out where the boundaries lie. Likewise, zoning regulations of the town and its plans may well carry wastewater treatment implications, because the effects on development of central, individual, and community systems will be very different.
In still other cases, cost-effectiveness on the larger scale will be the determining factor. If there is an area where it is clearly most effective to centralize, and an outlying area where it is clearly most effective to decentralize, there is an arithmetical procedure called "marginal analysis" that can determine the locus of the line, or boundary, where costs are equivalent on either side.

4.1.2 Overall Facilities Criteria

Along with the boundaries of the service areas, connector points and layout for sewers (conventional or alternative) and the sites of all points of discharge, as well as the location of any central facilities (for septage or sewage treatment, or both), need to be fully specified. Portions of such layouts will have already been discussed in the Phase II analysis; but in Phase III the plan needs more detail in order to analyze the overall cost-effectiveness of various configurations.

More detailed considerations of the requirements and options for residual disposal are put through the same kinds of assessments that were done for area solutions. The compatibility of various components, the ability of central facilities to absorb the combined flow volumes (now and in the future), the costs of transport and pumping, and opportunities for cost-savings by, e.g., combining septage and sludge treatment are examined. The system as a whole needs to be examined in terms of its overall dependability and flexibility as well.

4.1.3 Overall Administrative Criteria

While the management requirements for individual system components will have already been specified, it is only in looking at the plan(s) as a whole that an optimal administrative and institutional configuration can be established, because it is only at this point that the full spectrum of required professional skills and staffing levels can be established. The prospects, or not, for regionalization or sharing of central facilities will have emerged, in which case regional institutions or agreements will need to be specified. By this time, too, the "real politics" and preferences of the public should have emerged, and will steer the establishment of the institutional structure, the desired partition of public and private ownership, and the desired partition of responsibilities and tasks among public employees, utilities, suppliers/installers of proprietary systems, developers, individual contractors, and individual lot owners.

4.1.4 Overall Financial Criteria

As with administration, detailed cost-effectiveness analyses of various plan configurations can not be accomplished before making a wastewater plan(s) for the whole area. Only at this stage can firm differences in costs, and the shares borne by grant or loan providers, town revenues, local bonds, and private parties be spelled out. This partition, which is linked to the institutional questions above, is likely to be of most interest to the public. The impact of costs can be allayed by staging construction phases over time, the details of which may be spelled out in the implementation plan.

There are also opportunities for savings through public-private partnerships, and self-help programs, both of which are encouraged by the EPA. The former involves systematically exploring ways to privatize functions traditionally thought of as governmental, thus pushing capitalization into the private sector, and perhaps enabling efficiencies because of the dedicated and specialized nature of private firm expertise. The latter concerns the opportunities for cost savings by borrowing from the expertise of other municipalities or state agencies, employing local resources, acting as one's own contractor, securing volunteer labor and the loans of equipment, and similar measures.

4.1.5 Overall Impacts and Ranking

Plans surviving to this point will all be acceptable under environmental, public health, and cost-effectiveness criteria. Necessary institutional and financial requirements of each plan will have been spelled out. Plans that don't so qualify will have been dropped, along with any plan that, while otherwise qualifying, is clearly unacceptable to the voting public. In that sense what remains are matters of judgment and preference. But those can be decided by quasi-rational processes as well, which may involve ranking and weighting the preferences. Low risk and high resiliency, for example, might be weighted more heavily than saving the absolute last dollar. But implications for land use, the timeframe and disruption associated with construction elements, continuity with tradition, the town's self-image, and desire for fast or slow development are all factors that the public and the planners need to discuss, rank in order of their importance, and weigh together. If the community is lucky, one particular plan, after some modifications and compromises, will emerge. If more than one remains, additional discussion and weighing of their ramifications, implications, and impacts will be required.

4.1.6 Overall Public Acceptability

A formal public hearing is typically held before the planning group decides on its final plan. If there is not a general feeling of consensus, more work will be required. The reason is that a plan of any complexity at all will require local votes for its implementation. The votes may only deal with funding, but a plan could also require the passage of other local ordinances or zoning bylaws. While the final plan, itself, will assess and evaluate public acceptability, it will be the public that, at the ballot box, ultimately assesses and evaluates the plan.

4.2 Recommended Plan and Its Components

At the end of the recursive planning process described above, a single "Comprehensive Wastewater Management Plan" will emerge. In general terms the plan should contain a detailed description of the selected solutions for each Area of Concern, including a description of facilities and design criteria; what levels of treatment they are expected to achieve; how they will be operated and maintained; the costs of installation, operation, and maintenance; the methods and procedures for disposal of residuals; and the methods for financing, managing, and administering all aspects of the plan. Within the plan should also be a summary of the detailed evaluation of alternatives, including a cost-benefit analysis and the anticipated environmental impacts on sensitive natural, agricultural, archeological, and historical resources of all aspects of the project. In addition, the plan should summarize how each decision was made, including a description of public participation throughout the process, and an implementation schedule.

Some particulars of the plan's actual format may be fixed in regulations or in the stipulated Plan of Study. Whatever its format, however, it will have these major sections: (1) a plan for facilities (hardware) that addresses the community's needs and outlines design criteria; (2) a management plan that covers the operation and maintenance of facilities; (3) an institutional plan that outlines authority, accountability, and responsibility; (4) a financial plan, including a cost-effectiveness analysis; (5) an implementation plan (and schedule) that steers the process into successive steps (typically, "Design" and "Construction"); (6) a description of public participation; and (7) an Environmental Impact Report, if required by the MEPA process. In addition, the Plan of Study may also have stipulated other necessary attachments, studies, or reports.

4.3 Next Steps

Procedurally, the plan would then be submitted for review to other interested agencies as well as to the DEP. While the plan could be submitted to voters beforehand, it is obviously better to take account of any review by other agencies first; and to be able to tell voters that the plan has all necessary approvals except that of the voters themselves.

Following approval by the DEP and voters, the facilities project enters Step 2, Design. Even with the submission of a final plan, the detail required for actual implementation will not have been fully established. In the context of decentralization, the design phase will also include the precise determination of such items as user and licensing fees, because the "design" procedure applies not only to facilities but to the management/institutional/financial portions of the plan as well.
Other implementation steps will proceed apace. New state legislation or local ordinances may still be needed if DEP's approval of the plan was made conditional on such steps when they were itemized in the implementation schedule.

The design phase in many ways will be yet another recapitulation of the alternatingly analytical and synthetic procedure that has been discussed in this document. However, this next time around will be on the finest, and most specified, scale of all. At the least, the way forward will be clear. That is what the plan was for.

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Much of the information on facilities planning covered in this document is repeated in government and consulting reports, and facilities plans. Giving original source attributions for ideas or concepts is not possible in many of these cases, and thus in-text references have been kept to a minimum. Most of the information has, however, been drawn from the sources that follow. Monographic titles, however long or short the work, are set in ***bold, italic***. Analytic works are set in **bold**, with the parent work set in *italic*. Trailing information concerns the "publisher," which in most cases is a government agency that may or may not be able to provide a document directly, but that should be able to explain how to obtain it. Many of the documents drawn on have been photocopies from various repositories, and sometimes have lacked complete bibliographic information. They are often treated as monographs or manuscripts.

Please note that in this listing "EPA" is used as the abbreviation for the U.S. Environmental Protection Agency (Office of Water, Washington, DC 20406). "NSFC" is used as the abbreviation for the National Small Flows Clearinghouse (West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064). The NSFC is an EPA funded information center. Most EPA documents concerning wastewater, as well as many documents from other sources, are available through the NSFC. (This fact is often noted in the references, but the absence of such a notation should not be construed to mean the document is *not* available from NSFC.) The NSFC also publishes several serials, including a newspaper, entitled ***Small flows;*** a newsletter, entitled ***Pipeline;*** and a professional journal entitled ***The small flows journal.*** Some information in this document has been drawn from many issues of those serials in addition to the references listed below. The NSFC is an excellent starting point for anyone researching wastewater management, and can be reached toll free at 800-624-8301.

Finally note that, in all references to "personal communication" (as well as more generally), any errors of fact or interpretation are those of the authors.

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