CHAPTER 2

PLANNING, FEASIBILITY ASSESSMENT AND SITE SELECTION

2.1 INTRODUCTION

During the early planning stages of a wastewater management project, it is prudent to consider as many alternatives as possible in order to select the technically appropriate and most cost effective process. The feasibility of using pond systems described in this manual depends significantly on site conditions, climate, and related factors. This chapter describes a sequential approach that first determines potential feasibility, land area requirements for treatment and potential sites. The second step is to evaluate these sites, based on technical and economic factors, and to select one or more for detailed investigation. The final step involves detailed field investigations, identification of the most cost-effective alternative and development of the criteria needed for final design. Additional information can be found in Borowitzka & Borowitzka (1988a, b), Crites et al., (2006), Reed et al., (1995) and Shilton (2005).

2.2 CONCEPT EVALUATION

Once the decision to use pond technology has been made, a further review of the types of ponds appropriate to the site should be undertaken. A number of factors must be considered, including but not limited to, required effluent quality, effluent discharge point, site topography, soils, geology, climate and groundwater conditions. Specific information is needed related to geotechnical characteristics, such as surface and groundwater hydrology, proximity to surface water for discharge, site permeability and lining requirements, feasibility of siting the ponds within or outside a flood plain, and presence of bedrock or groundwater within the depth of excavation (Crites et al., 2006).

2.3 RESOURCES REQUIRED

The identification of potential sites is made using the information contained in publicly available sources, such as existing maps and other published documents. Climate data, for example, can be obtained from the National Oceanic and Atmospheric Administration (NOAA) (http://www.noaa.gov/climate.html), at Worldclimate (http://www.worldclimate.com), and at Weather Base (http://www.weatherbase.com). Solar maps can be found at the National Renewable Energy Resources website (http://www.nrel.gov/gis/solar.html). Local or community maps should indicate such features as topographical features, water features such as ponds and streams, flood hazard zones, community layout and land use (e.g., residential, commercial, industrial, agricultural, forest), existing water supply and sewage systems, anticipated areas of growth and expansion, and soil types within the community and adjacent areas. Sources for these maps include the U.S. Geological Survey (USGS) (http://www.usgs.gov/pubprod/), the Natural Resources Conservation Service (NRCS) (http://www.soils.usda.gov/), state agencies, as well as local planning and zoning agencies. Much of this work can now be done using the Geographical Information System (GIS) and most of the layers are now available either for free or at low cost (http://www.gis.com).

2.3.1 Estimating Land Area Required for Treatment Ponds

The area estimate for a pond system will depend on the effluent quality required, the type of pond system proposed and the geographic location. A facultative pond or an integrated system of wastewater ponds in the southern United States will require less area than the same pond or integrated pond system in the northern states. The pond areas given in Table 2-1 are for total project area and include an allowance for dikes, roads and unused portions of the site (after Reed et al., 1995 and F.B. Green, pers. comm.).

The land area required for a community wastewater flow of 3,785 m^3/d (1 mgd) is estimated below for three types of locations: a cold climate, a temperate climate (the mid-Atlantic states), and a warm climate (the southern states). Allowances are made for any preliminary treatment that might be required and for unused portions of the general site area.

Table 2-1. Land Area Estimates for 3,785 m^3/d (1 mgd) Systems.

Treatment System	North (ha*)	Mid-Atlantic (ha*)	South (ha*)
Aerobic	NA**	NA**	13
Facultative	67	44	20
Controlled Discharge	65	65	65
Partial-Mix Aerated	20	15	12
Complete-Mix Aerated	2	2	1
AIWPS®***	12	8	6

* 1 ha = 2.471 ac
** NA = not applicable
***See discussion of land requirements in Chapter 4.

2.4 SITE IDENTIFICATION

The information collected should be used in conjunction with current maps of the community area to determine if there are potential sites for wastewater treatment within a reasonable distance to the source. The potential sites should be plotted on the community maps. Local knowledge regarding land use commitments and costs and a technical ranking procedure should be brought into the decision-making process. Critical factors at this point are how close the site is to the wastewater source and whether there is access to a reuse site (e.g., agricultural fields for use as irrigation supply) or to surface water for final discharge. Characterization of the site soils should be undertaken if percolation to groundwater is a disposal option.

2.4.1 Potential for Floods

Locating a wastewater system within a flood plain can be either an asset or a liability, depending on the approach used for planning and design. Flood-prone areas may be undesirable because of variable drainage characteristics and potential flood damage to the structural components of the system. On the other hand, flood plains and similar terrain may be the only deep soils in the area and the only location low enough to permit conveyance by gravity. If permitted by the regulatory authorities, utilization of such sites for wastewater or sludge storage can be an integral part of a flood-plain management plan. Off-site storage of wastewater or sludge should be included as a design feature if the site is to be flooded on an as-needed basis. An example of a design of a wastewater treatment system located in a floodplain can be found in Chapter 4.

Maps of flood-prone areas have been produced by the USGS for many areas of the UnitedStates as part of the Uniform National Program for Managing Flood Losses. The maps are based on the standard 7.5' USGS topographic sheets. They identify areas with a potential of a 1-in-100 chance of flooding in a given year. The hydrologic maps can be obtained from USGS (http://edc2.usgs.gov/pubslists/booklets/usgsmaps/usgsmaps.php). Other detailed flood information is available from local offices of the U.S. Army Corps of Engineers and flood-control districts. If the screening process identifies potential sites in flood-prone areas, local authorities must be consulted to identify regulatory requirements before beginning any detailed site investigation. At the very least, in designing a system within a flood plain, incorporated tank walls, structural openings, motor drives and pumps should be raised so that they are above the 100-year flood level.

2.4.2 Water Rights

Riparian water laws, primarily in states east of the Mississippi River, protect the rights of landowners to use the water along a watercourse. Appropriative water rights laws in the western states protect the rights of prior users of the water basin. Adoption of any of the pond concepts for wastewater treatment can have a direct impact on water rights concerns:

- Site drainage, both quantity and quality, may be affected.
- A zero discharge system, or a new discharge location, will affect the quantity of flow in a body of water where the discharge previously existed.
- Operational considerations for land treatment systems may alter the pattern and the quality of discharges to a water body.

In addition to surface waters in well-defined channels or basins, many states also regulate or control other superficial waters and the groundwater beneath the surface. State and local discharge requirements for the proposed project should be determined prior to the development of the design. If the project has the potential to generate legal questions, a water rights attorney should be consulted.

2.5 SITE EVALUATION

The next phase of the site and system selection process involves developing field surveys to confirm map data and field testing in order to provide the data needed for design. It also includes making an estimate of capital and operation and maintenance costs so that the sites identified can be compared. A design concept and a site are selected for final design based on these results. Each site evaluation must include the following information:

- Property ownership, physical dimensions of the site, current and future land use
- Surface and groundwater conditions: location and depth of water supply wells and injection wells, surface water flooding or surface water bodies within one mile of the proposed site, fluctuation in groundwater levels, other potential drainage problems
- Quality and use of groundwater, e.g., is area designated as a wellhead protection area or other critical recharge zone?

- Characterization of the soil profile to the depth of the first limiting condition such as the seasonal high water table, aquitard, or bedrock, or bottom of the excavation, whichever is deeper
- Reclamation of the site describing the existing vegetation, historical causes for disturbance, previous reclamation efforts, historical site contamination from anthropogenic or natural sources, need for grading or other terrain modification
- Current and future land use of adjacent properties
- Environmental impact and habitat evaluation

2.5.1 Soil and Groundwater Characterization

Table 2-2 presents a sequential approach to field testing to define the physical and chemical characteristics of the on-site soils. In addition to the on-site test pits and borings, exposed soil profiles in road cuts, borrow pits, and plowed fields on or near the site should be examined and a preliminary geotechnical investigation of the highest ranked potential sites should be undertaken.

Backhoe test pits to a 3 m depth, or to 6 - 8 m for deeper ponds, such as AIWPS® Advanced Facultative Pond with stable methane fermentation zones (Oswald and Green, 2000), are recommended, where soil conditions permit, in each of the major soil types on the site. These samples should be reserved for future testing. The walls of the test pit should be carefully examined to define the characteristics of the soil (Reed and Crites, 1984a; U.S. EPA, 1980c; U.S. EPA, 1984; Silva-Tulla and Flores-Berrones, 2005; Crites et al., 2006). The test pit should be left open long enough to determine if there is groundwater seepage and the highest level attained should be recorded. Equally important is the observation of any indication of seasonally high groundwater, most typically demonstrated by mottled or hydric soils (Vasilas et al., 2010).

Soil borings should penetrate to below the groundwater table if it is within 10 - 15 m of the surface. At least one boring should be located in every major soil type on the site. If generally uniform conditions prevail, one boring for every 1 - 2 ha is recommended for large-scale systems. For small systems (<5 ha), three to five shallow borings spaced over the entire site should be sufficient.

Groundwater encountered during test borings should be analyzed for general chemistry (pH, conductivity, nitrate, metals, and major ions using drinking water methods (see http://www.epa.gov/ogwdw/methods/methods_inorganic.pdf or 40 CFR 141) to establish background conditions. Seeps, perched saturated zones, depth of mottled zones, and depth to the seasonal high water table should be recorded on the site plan.

2.5.2 Buffer Zones

Prior to the site investigation, state and local requirements for buffer zones or setback distances should be researched to ensure that there is adequate area on site or that additional acreage can be obtained. Most requirements for buffer zones or separation distances are based on aesthetic considerations and to avoid potential complaints. A number of studies have been conducted at both conventional and land treatment facilities on aerosols and the results indicate that there is very little, if any, health risk to adjacent populations (Sorber et al., 1976; Reed, 1979; Sorber et al., 1984). Therefore, designing extensive buffer zones for aerosol containment is not recommended.

Most wastewater ponds and natural lakes are holo- or dimictic, overturning for a period during the spring and fall, which brings deeper anaerobic or anoxic water and bacterial solids to the surface, releasing volatile, odiferous compounds into the atmosphere. A typical requirement in these cases is to locate such ponds at least 0.4 km from human habitations.

Table 2-2. Sequence of Field Testing, Typical Order, reading from left to right (Crites in Asano and Pettygrove, 1984)

Comments	**Test Pits**	**Soil Borings**	**Infiltration Tests[a]**	**Soil Chemistry[b]**
Type of Test	Backhoe pit, inspect road cuts	Drill or auger log review of local wells for soil data and water level	Basin method[c] if possible	NRCS[d] Surveyed
Data needed	Depth of profile, texture, structure, restriction layers	Depth to ground water, depth to barrier	Infiltration rate	Nitrogen, phosphorus, metals, other potential site specific contaminants
Estimate	Need for hydraulic conductivity tests	Groundwater flow direction	Hydraulic capacity	Soil amendments, crop limitations
Then test for	Hydraulic conductivity, if needed	Horizontal conductivity, if needed		Quality of any percolate
Estimate	Loading rates	Groundwater mounding, drainage needs		Depends on site, soil uniformity, character of waste
Number of tests	3-5/site, more for large sites, lack of soil uniformity	3-5/site, more for lack of soil uniformity	2/site, more for large site or lack of soil uniformity	

[a]Required only for land application of wastewater; some definition of subsurface permeability needed for pond and sludge systems
[b]Typically needed for land application of sludges or wastewaters
[c]Crites et al., 2006
[d]Natural Resources Conservation Service

2.6 SITE AND PROCESS SELECTION

At this point, the evaluation procedure will have identified potential sites for a particular treatment alternative and field investigations will have been conducted to obtain data for the feasibility determination. Evaluation of the field data will determine whether the site requirements are adequate. If site conditions are favorable, it can be concluded that the site is at least a candidate for the intended concept. If only one site and related treatment concept emerge from this screening process, the focus can shift to final design and perhaps additional detailed field tests to support the design process. If more than one site for a particular concept, and/or more than one concept remains technically viable after the screening process, it will be necessary to do a preliminary analysis to identify the most cost-effective alternative.

The design criteria presented in later chapters should be used to develop the preliminary design of the concept. The design should then be used as the basis for a preliminary cost estimate for capital and operation/maintenance that should include the cost of purchasing the land as well as pumping or transport costs to move the wastes from sources to the site. In many cases the final selection of process or type of pond system will also be influenced by the social and institutional acceptability of the proposed site and treatment facility to be developed on it.

2.7 DESIGN CRITERIA OF MUNICIPAL WASTEWATER TREATMENT PONDS

Most states have design criteria for wastewater treatment ponds, but the depth of detail provided by each state varies widely (see Appendix A). Detailed sets of criteria are provided for the State of Nebraska, and the State of Iowa as examples. The Recommended Standards for Wastewater Facilities, known as the 10 States Standards, published by The Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (Health Research, Inc., 2004), or a modification of these standards, is often cited as a reference.

2.8 STATE DESIGN STANDARDS

2.8.1 10 States Standards

The 10 States Standards recommend a minimum separation of 1.2 m between the bottom of the pond and the maximum groundwater elevation and a minimum separation of 3 m between the pond bottom and any bedrock formation. For a conventional facultative treatment pond system design, an average five day biochemical oxygen demand (BOD_5) loading from 17 - 40 kg/ha/d for the primary pond(s) with a detention time of 90 - 120 d is recommended. Controlled discharge facultative treatment pond systems have different requirements (see Chapter 7).

For the development of final design parameters for aerated treatment pond systems, it is recommended that actual experimental data be developed; however, the minimum detention time may be estimated using the following formula applied separately to each aerated cell:

$$t = E / [2.3k_1 \times (100 - E)] \qquad (2\text{-}1)$$

where: t = detention time in days; E = percent of BOD_5 to be removed in an aerated pond; and k_1 = reaction coefficient, aerated pond, base 10. For normal domestic wastewater, the k_1 value may be assumed to be 0.12/d at 20 °C and 0.06/day at 1 °C.

Additional storage volume should be considered for sludge, and in northern climates, for ice cover. If aeration equipment is used, it should be capable of maintaining a minimum dissolved oxygen (DO) level of 2 mg/L in the ponds at all times (Health Research, Inc., 2004).

The 10 States Standards recommend that, at a minimum, a wastewater treatment pond system consist of three cells designed to facilitate both series and parallel operations. The maximum size of a conventional pond cell should be 16 ha. Two-cell systems may be utilized in very small installations. Guidance is also provided on pond construction details.

2.8.2 Summary of Other Criteria

Other criteria to be considered are briefly discussed here.

Freeboard: The minimum and maximum recommended freeboard varies from 0.6 - 0.9 m. Some states allow a 0.3 m freeboard for small systems, while others specify 0.6 m.

Pond Bottom: The majority of the states include a detailed description of the materials that are acceptable for sealing the pond bottom and sides of the dikes. Permissible seepage rate or hydraulic conductivity is specified in all pond criteria; an emphasis is placed on groundwater protection. Natural earth, bentonite, asphalt, concrete and synthetic liners are acceptable in most cases.

Flow Distribution: Design of structures split hydraulic and organic loads effectively between two primary cells is a common requirement. This is frequently expanded to include multiple inlet points to accomplish even distribution of the flow. Most states allow one discharge point from secondary cells, but frequently recommend multiple outlets from primary cells.

Influent Discharge Apron: A common requirement for the influent discharge to a primary cell is that the flow should enter a shallow, saucer-shaped depression and that the end of the discharge line rest on a concrete apron large enough to prevent soil erosion.

Piping and Pipe Connections: In most states, the acceptable type of piping materials is specified, such as ductile iron, plastic or lined pipes. Where pipes penetrate the pond seal, anti-seep collars or similar devices should be used to prevent leaks around the pipes.

Hydraulic capacity frequently is specified as 250 percent of the design maximum day flow rate of the system. Most states specify that the piping must allow for parallel and series operation of multi-cell systems, and that provisions for by-passing each cell be provided. Provisions for draining each cell are also usually required.

Settling Ponds: Settling ponds may sometimes be referred to as polishing ponds, but they are not synonymous. A polishing pond is any pond in the treatment train that follows the facultative pond. A settling pond is usually placed at the beginning of the treatment series, but may also be a pond at the end of the system. The amount of time that effluent is retained in a settling pond can vary from 24 hours to some proportion of the time it takes the water to move through entire system. This can result in a hydraulic residence time (HRT) greater than 10 - 15 d. Most state standards distinguish between the two, but may not provide an explanation of the need for a correctly designed settling pond to help control algae in the effluent before it is discharged (Green, 2009). An HRT of 2 days at average design flow rate will provide better control.

Miscellaneous: All of the criteria specify that some type of fencing be put in place to limit access and discourage trespassing. Some states require only a fence with a few strands of barbed wire to prevent animals from entering the site. Others are more conservative and specify that a chain-link fence with barbed wire strands at the top be installed to discourage access. Gates should be of sufficient width to allow maintenance vehicles to enter the facility and should be provided with a lock.

An all-weather road to the pond site should be built and maintained to allow year-round access for operation and maintenance. The requirement that permanent warning signs are to be placed conspicuously around the site designating the nature of the facility is included in all the state criteria. Signs should be posted every 150 m along the perimeter of the facility.

Flow measurement parameters vary, but in all cases, some type of flow measuring device is recommended or required. Groundwater monitoring wells are required by most states. Pond level gauges are specified by most states. A service building that contains a laboratory and space for storage and maintenance of equipment is required in most criteria.

2.8.3 Criteria for Types of Ponds

As shown in Appendix A, many state guidances do not indicate what criteria are specific to the type and proposed operation schedule of a pond system (e.g., anaerobic, partial-mix, complete-mix, controlled discharge or hydrographically controlled). When seeking advice as to the factors that need to be considered in a specific pond design, it is advisable to consult with the relevant state regulatory agency. For general guidance, the Minnesota, Nebraska, South Dakota, Montana, Wyoming, Tennessee and several other state criteria provide sufficiently detailed information that can be used to develop an appropriate design.