Chapter 10

Treated Water Recharge Technologies

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TREATED WATER RECHARGE TECHNOLOGIES

10.1 INTRODUCTION

All wastewater treatment facilities require a means of recharging treated water back to the groundwater system, and the treated water recharge technology needs to be selected to minimize the impacts on nearby surface waters and groundwaters. Potential impacts of large treated water recharge flows include groundwater mounding which may cause flooding on adjacent properties and an increase in pollutant concentrations (depending on treatment standards utilized) in downgradient water bodies. As a result, the following items should be considered when identifying new treated water recharge technologies and sites:

1. The treated water recharge would preferably be located outside of a contributing area to a public water supply (Zone II) to reduce risks to public health; reduce the perception that "drinking waters would be contaminated by wastewater;" and reduce the cost of additional treatment technologies needed to permit treated water recharge in a water supply area.

2. It is preferable to locate the treated water recharge outside of a contributing area to coastal embayments. Even well-treated effluent typically has a 3 mg/L total nitrogen concentration, which can contribute to eutrophication in the embayment if the flow is large enough.

3. Ideally, the recharge could flow directly to the Atlantic Ocean or Cape Cod Bay, thereby having the least impact on water supplies and coastal embayments. This would typically be possible through the use of an ocean outfall, which is currently not allowed by the Ocean Sanctuaries Act.

4. There is often a desire to return the treated water to the area from which it originated, either the sewer service area (political origination) or the water supply contributing area (hydrological origination).

5. Nitrogen attenuation in a watershed has been documented when treated water recharges through freshwater systems. The regulatory community is now considering this type of nitrogen removal as part of an environmental impact analysis and strategy to meet nitrogen limits in coastal embayments. As a result, treated water recharges that cannot avoid contributing areas to water supplies and coastal embayments should be considered in areas that recharge through freshwater systems (ponds, bogs, wetlands, etc.) to take advantage of additional nitrogen removal. This being said, it has been determined that phosphorus loading is an issue within freshwater systems as it is the limiting nutrient (comparable to nitrogen for coastal embayments), and must be removed to avoid creating another/different problem.

6. Treated water recharges must be located where the increased hydraulic loading will not cause flooding at the site or at adjacent properties. This requires sufficient separation between the ground surface and groundwater table so the resultant "groundwater mound" caused by the recharge will not break out above the land surface. Also, the soils at the discharge site must be sufficiently permeable to pass the treated water to the groundwater system without being backed up and flooding the site.

This chapter identifies potential treated water recharge technologies for more detailed evaluation in the next phase of the project. Screening of these technologies will occur in Chapter 14. The identification and review of potential sites for water supply, wastewater treatment, and treated water recharge facilities is in Chapter 11.

10.2 IDENTIFICATION OF TREATED WATER RECHARGE TECHNOLOGIES

A. **Sand Infiltration Beds.** Sand infiltration beds (also called rapid infiltration beds) are open basins designed to allow treated water to flow across the bottom of the basin and percolate through the sand bed, into the unsaturated zone, and then to the groundwater (see Figure 10-1). Bed maintenance is relatively easy because the bed is exposed at the surface and the sand surface can be raked or replaced if the sand becomes plugged with effluent solids. Hydraulic loading rates of 5 gallons per day per square foot (gpd/sf) of bed area are typically allowed by MassDEP unless hydrogeologic tests demonstrate a greater infiltration loading capacity at the specific site.

Treated water recharge in sand infiltration beds has the following advantages:

- Bed construction is relatively simple and typically less expensive than other methods.
- Operation and maintenance (O&M) is relatively easy and O&M costs are lower than other methods.
- Hydraulic loading rates are typically higher than other disposal methods, which allow the beds to take up less area.

Treated water recharge in sand infiltration beds has the following disadvantages:

- Construction of new beds requires the clearing of large areas of land, which may have a visual and environmental impact.
- Infiltration beds do not have secondary uses, such as parking lots and recreational areas.
- Disinfection is typically required.

B. **Subsurface Infiltration.** Large–scale subsurface infiltration facilities typically utilize pump and piping systems to pressure dose infiltration areas (trenches, beds, or galleys) where the treated water percolates to the groundwater, as shown in Figure 10-2. Maintenance and cleaning of these systems is more difficult because the infiltration area is not exposed to the surface and effluent solids cannot be easily removed. Subsurface infiltration beds can have secondary uses, such as parking lots, lawns, playing fields, and recreational areas. Hydraulic loading rates of 2.5 gpd/sf (of trench or galley base plus side walls) are typically allowed by MassDEP unless hydrogeologic tests demonstrate a greater infiltration capacity at the specific site.

Subsurface infiltration facilities have the following advantages:

- Disinfection is typically not required prior to discharge unless it is in a water supply recharge area.
- Facilities are contained underground and can have a secondary use, such as parking lots and recreational areas.

They have the following disadvantages:

- Large land areas are required (larger than sand infiltration beds) due to lower hydraulic application rates.
- Pressure dosing is typically required for large systems, which adds capital and O&M costs.
- Extensive site work may be required for construction, particularly if the site is forested.
- Limited access for cleaning and maintenance, which can result in high maintenance and repair costs.
- Effluent filtration is typically required to reduce the risk of plugging the subsurface beds over time.

C. **Spray Irrigation**. Spray irrigation facilities are typically comprised of effluent pumps, distribution piping, and a spraying system consisting of risers and spray nozzles. Treated water is pumped through various distribution lines and discharged via spray nozzles to the surrounding surface area. Figure 10-3 illustrates spray irrigation facilities. Spray irrigation systems have often been used at golf courses and in large remote fields. Application rates for non-golf course areas are typically 2-inches per acre per week. Application rates for golf courses are typically based on the turf management needs.

Treated water recharge using spray irrigation has the following advantages.

- Allows for secondary use of land (i.e., golf courses) as regulated by MassDEP.
- Provides irrigation, reducing clean water demands.
- Provides nitrogen uptake by plant life and reduces need for fertilizers at golf courses.
- Evapotranspiration reduces infiltration volume, thereby creating less potential for groundwater mounding.

Treated water recharge using spray irrigation has the following disadvantages:

- Difficult to find locations suitable for or willing to use spray irrigation.
- Limited cold weather use due to potential freezing problems.
- Spray nozzles may be subject to clogging.

- Requires secondary means of treated water recharge or storage during winter months or at times when the site's secondary use (i.e., golfing) is needed.
- Must meet more stringent MassDEP treatment requirements for reclaimed water use, including requirements of the Class I Groundwater Permit Standards (Safe Drinking Water Standards).
- Large areas are needed. And runoff issues can be created if the proper site is not selected.

D. **Well Injection.** Well injection involves the recharge of treated water to groundwater by pumping the treated water through wells that extend into permeable, saturated, and unsaturated geologic strata, as shown in Figure 10-4. When discharged into saturated strata, this type of discharge can be compared to the reverse of extracting water from a well.

Wells can be designed to recharge a range of wastewater flows depending on site conditions such as depth to groundwater and geological conditions. A potential concern with well injection is the mounding of groundwater in low elevation areas. As a result, well injection requires extensive testing prior to design and construction. This would include hydraulic conductivity tests, hydrogeologic surveys, and pilot testing.

Well injection for treated water recharge has been implemented on a limited basis throughout the United States, and there is limited information on the proper siting, design, construction, and operation of the wells. A pilot test for this technology at the Hyannis Water Pollution Control Facility indicated that injection wells can become plugged with biological growth if the effluent is not chlorinated. Discussions with MassDEP indicate minimal support for the development of this technology because it requires chlorination, which can create secondary impacts to the groundwater such as the formation of disinfection byproducts that can pose potential health risks.

Treated water recharge with well injection has the following advantages:

- The land area required would be much less than the area required for infiltration beds, subsurface infiltration, and spray irrigation.
- The treated water recharge would be occurring below the surface, causing minimal surface disruption.
- Recharge points (wells) could be spread over a large area to minimize groundwater mounding.

- Higher level of treatment is provided prior to discharge at the well.

It has the following disadvantages:

- Effluent filtration and chlorination and/or other high level treatment are needed to minimize plugging in the wells adding to cost and O&M.
- Limited performance data is available and relatively unproven technology in Massachusetts.
- Energy costs for pumping are high.
- Extensive pilot testing would typically be required.

E. **Wick Well Technology.** Wick technology is a relatively new approach to treated water recharge. Wick technology entails the use of larger (3 to 6-foot diameter) wells dug into the aquifer. The wells are filled with stone; treated water is recharged over (or adjacent to) the stone to infiltrate via gravity flow into the underlying aquifer. Figure 10-5 illustrates a wick well setup. There are two wick well installations in southeastern Massachusetts.

Treated water recharge with wick wells has similar advantages and disadvantages to injection wells. Advantages include:

- The land area required would be much less than the area required for infiltration beds, subsurface infiltration, and spray irrigation.
- The discharge would occur below the surface, causing minimal surface disruption.
- Discharge points (wells) could be spread over a large area to minimize groundwater mounding.

Disadvantages include:

- Effluent filtration is needed to provide a high level of nutrient and solids removal to minimize plugging in the wells.
- Relatively unproven technology in Massachusetts. Limited performance data is available.

F. **Drip Irrigation.** Drip irrigation is a subsurface version of spray irrigation. Treated water is used to irrigate agricultural land. Subsurface piping is laid out approximately 6 to 12-inches

below the surface in areas to be irrigated (see Figure 10-6). Recharge of treated water occurs through emitters that are spaced 12 to 24-inches apart; the laterals are spaced at 12 to 24-inch intervals. Water is pumped through the lines under pressure but is discharged slowly through the emitters. The intent of the system is to recharge the water into the root zones of the plants.

Advantages include:

- Can be used in rolling terrain conditions.
- Is associated with water reuse because water is recharged into the root zone of plants or crops.
- Ease of construction if the application is in a large vegetated area with fine-grained soils (few rocks).
- Low delivery rate to minimize water table impacts.

Disadvantages include:

- Effluent must be highly treated to minimize plugging.
- Difficult to monitor emitter performance.
- Periodic backflushing is required. Waste stream must be returned to the collection system or headworks of the WWTF.
- Limited performance data in Massachusetts.
- Facilities must be protected from damage from heavy vehicles.

G. **Ocean Outfall.** This alternative involves the siting, construction, and operation of an ocean outfall for effluent disposal into Cape Cod Bay or the Atlantic Ocean. The Massachusetts Ocean Sanctuaries Act prohibits the discharge of any municipal wastewater into an ocean sanctuary. Cape Cod Bay and the state waters of the Atlantic Ocean off the coast of Eastham are designated ocean sanctuaries. The legislation is strictly imposed and a variance would require action by several state departments and officials. A variance would be given only if it was shown that ocean disposal of wastewater was the only feasible way to protect the public health. Most likely, special state legislation would be needed to gain approval of this type of discharge.

Treated water recharge with an ocean outfall has the following advantages:

- The land area required would be much less than the area required for infiltration beds, subsurface infiltration, and spray irrigation.
- The effluent discharge would be outside of any watershed and would greatly reduce nitrogen loading impacts (eutrophication) to coastal embayments.
- Greater dilution is provided by discharging into a large surface water body.
- Proven technology.

It has the following disadvantages:

- Special legislation required, possibly at the federal level.
- Extensive design and permitting requirements depending on the location of the discharge.
- Possible high public opposition.
- Potential reduction in aquifer recharge.
- Reserve area may be required.
- Effluent disinfection is required.
- Requires a long force main to reach a discharge point.

H. **Wetland Restoration.** In recent years, the innovative technology/management concept of wetland restoration has been considered as a treated water recharge technology. It is the conversion of abandoned cranberry bogs or previously modified wetlands to more diverse wetland settings that can accommodate and will benefit from increased hydrologic flow. It has the primary purpose of improving water quality of the groundwater flowing through the wetland and restoring hydrologic balance to areas that have been impacted by drinking water withdrawals. It can provide natural nitrogen attenuation and thereby protect down-gradient marine waters. It can also provide improved wildlife habitat and improved open-space and recreational areas.

This concept has significant regulatory permitting challenges due to national, state, regional, and local wetland protection regulations that have been written to stop any modifications in wetlands. However, many regulators, municipalities, and citizen groups are recognizing the water-quality and wildlife habitat benefits of converting previously disturbed, monoculture cranberry bogs to more diverse wetland settings.

The concept has been developed and promoted by the Massachusetts Estuaries Project (MEP) as a way to increase natural nitrogen attenuation in the watershed. It is also being considered as a way to reintroduce highly treated wastewater into watersheds that have been impacted by water withdrawals.

One application of this innovative approach of wetland restoration is being investigated by the towns of Barnstable and Yarmouth. The towns are considering the feasibility of introducing a well treated water (with minimal nitrogen and phosphorus) into the subsurface through a leaching area that is adjacent to a long constructed wetland/pond. The constructed wetland/pond is adjacent to a cranberry bog or natural wetland. The subsurface flow will make its way through the wetland/pond and then into the bog/natural wetland. A general schematic of this process is shown in Figure 10-7.

The benefits of wetland restoration include the following:

- Clearing of land is minimal; no change in land use would result.
- Potentially significant nitrogen attenuation.
- Potentially high ecosystem benefits.

The disadvantages include:

- Regulatory hurdles are likely.
- Disinfection of effluent is required.
- Complexity of design.
- Potential long-term maintenance and monitoring requirements.