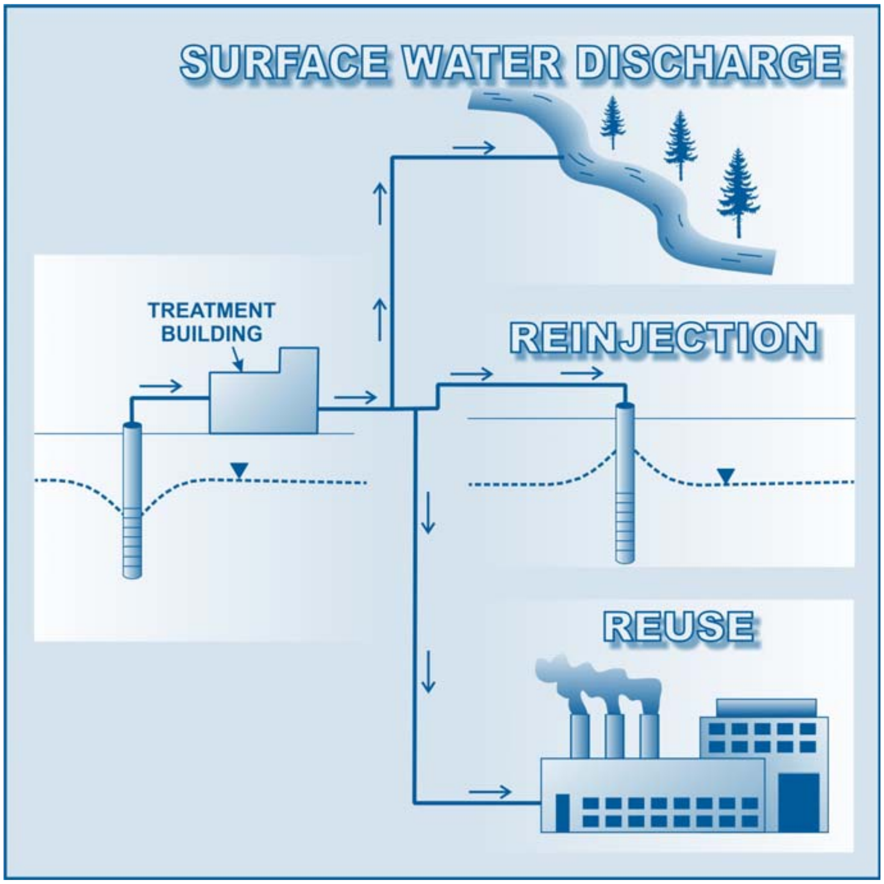
Options for Discharging Treated Water from Pump and Treat Systems



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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This fact sheet is not intended to be a detailed instruction manual. In addition, this fact sheet is not a regulation; therefore, it does not impose legally binding requirements on EPA, States, or the regulated community, and may not apply to a particular situation based upon the circumstances. The document offers technical information to EPA, states and others who manage or regulate long-term ground water remedies as part of any cleanup program. EPA and State personnel may use other approaches, activities and considerations, either on their own or at the suggestion of interested parties. Interested parties are free to raise questions and objections regarding this document and the appropriateness of using these recommendations in a particular situation, and EPA will consider whether or not the recommendations are appropriate in that situation. This fact sheet may be revised periodically without public notice. EPA welcomes public comments on this document at any time and will consider those comments in any future revision of this document.

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PREFACE

This fact sheet discusses potential options for discharging treated water from pump and treat (P&T) systems. It is part of a series of fact sheets that the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) is preparing to assist the ground water remediation community to effectively and efficiently design and operate long-term ground water remedies. This series is available at www.cluin.org/optimization and consists of the following fact sheets, plus others that will be available in the future.

- *Elements for Effective Management of Operating Pump and Treat Systems*
  OSWER 9355.4-27FS-A, EPA 542-R-02-009, December 2002

- *Cost-Effective Design of Pump and Treat Systems*
  OSWER 9283.1-20FS, EPA 542-R-05-008, April 2005

- *Effective Contracting Approaches for Operating Pump and Treat Systems*
  OSWER 9283.1-21FS, EPA 542-R-05-009, April 2005

- *O&M Report Template for Ground Water Remedies (with Emphasis on Pump and Treat Systems)*
  OSWER 9283.1-22FS, EPA 542-R-05-010, April 2005

- *Cost Comparison Framework for Use in Optimizing Ground Water Pump and Treat Systems*, EPA 542-R-07-005, May 2007

- *Optimization Strategies for Long-Term Ground Water Remedies (with Particular Emphasis on Pump and Treat Systems)*, EPA 542-R-07-007, May 2007

The ideas contained in this series of fact sheets are based on professional experience in designing, operating, and optimizing long-term ground water remedies and on lessons learned from conducting optimization evaluations called Remediation System Evaluations (RSEs) at sites with P&T systems. RSEs have been conducted at Superfund-financed sites, Resource Conservation and Recovery Act (RCRA) sites, and leaking underground storage tanks sites. Reports from RSEs conducted by EPA are available at www.cluin.org/optimization.

The content of these fact sheets is relevant to almost any long-term ground water remedy, particularly those that involve P&T. Therefore, these documents may serve as resources for managers, contractors, or regulators of any P&T system, regardless of the regulatory program.

Access to a wider range of EPA documents is available at www.cluin.org.

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A. INTRODUCTION

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Federal agencies have conducted optimization evaluations at approximately 100 operating pump and treat (P&T) systems since 2000 and have successfully identified hundreds of potential opportunities for improving effectiveness in protecting human health, reducing operating costs, and speeding progress toward site closure. Several of the opportunities involve the consideration of alternate options for discharging treated water.

This fact sheet presents information on available options for the discharge of water that results from a P&T remedy. The target audience for this fact sheet includes environmental case managers from Federal and State agencies, environmental program managers from private organizations, and environmental contractors involved in the design and/or operation of P&T systems. Discharge options are typically evaluated during the remedy selection and system design phases of the remedy, and discharge alternatives could also be evaluated during routine optimization evaluations that are performed while the remedy is operating.

This fact sheet begins with a discussion regarding the potential value of treated water, followed by detailed descriptions of the following discharge options:

- discharge to surface water
- return of treated water to the subsurface
- discharge to a publicly owned treatment works (POTW) or other existing treatment plant
- reuse of treated water

The term operation and maintenance (O&M) is used throughout this document to describe the activities involved in operating and maintaining a P&T system. For the purpose of this document, "O&M" does not refer to any specific period of time or regulatory status associated with the remedy. For example, the Superfund program generally refers to the first 10 years of a Fund-lead P&T system as Long-Term Response Action (LTRA), and the subsequent period as "O&M". However, in this document both of those time periods are considered to be types of O&M. Also, this document discusses issues regarding permitting for various discharge options. It should be noted that for Superfund sites "permit equivalency" is generally established in lieu of an actual permit.

B. THE POTENTIAL VALUE OF TREATED WATER

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Significant quantities of water may be treated by a treatment plant associated with a ground water P&T remedy. For instance, each 100 gallons per minute (gpm) of remedy pumping would translate to 144,000 gallons per day, or more than 52 million gallons per year. Assuming a typical household might utilize 146,000 gallons per year (*AWWARF, 2005*), the water passing through one treatment plant at a rate of 100 gpm would be the equivalent to the amount of water consumed by approximately 360 households.

It is important to consider the value of the treated water when evaluating discharge options. In some cases, where ground water resources are limited, it may be important to return treated water to the subsurface so that adequate water levels are maintained, or to use the treated water directly for water supply. In other cases, significant costs savings and avoided energy use may be realized by reusing the treated water in place of other water supplies. Examples might include use of treated water for irrigating crops or as cooling water within a factory. In addition, treated water can be utilized to create or augment wetland habitats.

The following sections provide details regarding various options for discharge of treated water. In each case, a section called "Sustainability Considerations" is included to highlight how the specific discharge option relates to the value of the treated water as a potential resource.

C. DISCHARGE TO SURFACE WATER

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General description

Under the National Pollution Discharge Elimination System (NPDES), treated water may potentially be discharged directly to a nearby surface water body or indirectly to surface water through a storm sewer. Figure 1 schematically illustrates this discharge option, and more information is discussed below. General advantages and disadvantages of this discharge option are provided in Exhibit 1.

Figure 1

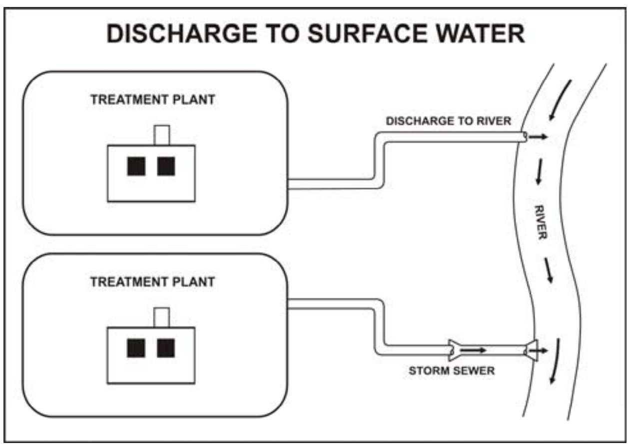

Exhibit 1

Discharge to Surface Water: Advantages and Disadvantages

Potential Advantages

- Discharge is typically not subject to a flow-based fee, but some storm sewer systems may charge a fee.

Potential Disadvantages

- Discharge standards are based on ambient water quality and may be comparable or more stringent than drinking water standards.
- Reporting may be more rigorous than for other discharge options. Environmental toxicity testing may be needed.
- Removal of natural constituents in ground water may required to discharge water.
- Access to a nearby surface water body or storm sewer is needed.
- Public may have negative perception of discharging treated water from a contaminated site to surface water.

System Design, Permitting, and Project Planning

EPA is authorized to implement the NPDES program (and associated permitting) but has authorized several States to implement all or part of the NPDES program in their own State. Information regarding the NPDES program can be found at the following website:

http://cfpub.epa.gov/npdes/index.cfm

For most ground water P&T systems, the NPDES permit includes effluent limits, monitoring and reporting requirements, and site-specific conditions. The permits are obtained by filing a standard application with EPA or the authorized State.

The site-specific discharge limits are developed by EPA or the authorized State by considering standards based on available treatment technologies, water quality, and whole effluent toxicity (WET). Limits are typically derived for the following types of pollutants (in addition to WET):

- toxic pollutants (including the contaminants of concern)
- conventional pollutants (e.g., total suspended solids, pH, oil and grease, etc.)
- non-conventional pollutants (e.g., chlorine and ammonia)

Limits on temperature, dissolved oxygen, and flow rate may also be considered to address concerns regarding aquatic life and erosion control. The large variety of pollutants considered means that treatment criteria may be established for many constituents that are not actually contaminants of concern at the site. As a result, discharge to surface water may require treatment of more constituents than would be required for other discharge options. Exhibit 2 provides a list of constituents that typically have a surface water discharge limit and would be relatively expensive to treat as part of a typical P&T system, yet may not be a contaminant of concern at many sites. If these constituents are in the extracted water at concentrations above discharge standards, additional treatment may be required. It is common for the site team to evaluate the life-cycle costs of such additional treatment and to compare these costs with the costs for other discharge options.

Discharge of treated water to surface water may change the surface water body from gaining (i.e., ground water discharges to the surface water body) to losing (i.e., surface water discharges to ground water). This change in system hydraulics could have a negative or positive effect on the ability of the P&T system to control contaminant migration. If the discharge from surface water to ground water occurs within or upgradient of the plume, it may cause the plume to spread or require a higher extraction rate to provide plume capture. However, if the discharge occurs downgradient, it may help prevent plume migration.

Exhibit 2

Discharge to Surface Water: Potential for Parameters that are not "Constituents of Concern" to Impact Costs

In some cases, parameters that are not considered to be constituents of concern at a site may nevertheless have a concentration limit associated with a permit for discharge to surface water. Examples might include the following parameters:

- iron
- manganese
- arsenic
- other metals (e.g., copper, nickel)
- pH
- ammonia
- nitrate and/or nitrite
- phosphate

In such cases, additional treatment costs may be incurred simply to meet the surface water discharge requirements for these parameters. As a result, other discharge options that do not have similar limits for these parameters may be more cost-effective.

The distance and terrain from the P&T system to the discharge point can also affect the practicability of discharge to surface water. The following parameters are generally favored when selecting this (and other) discharge options:

- a short distance between the P&T system and the discharge point
- minimal infrastructure between the P&T system and the discharge point
- a discharge point that is lower in elevation than the P&T system (allows for gravity discharge rather than forced pumping)

Sampling, reporting, and other ongoing costs generally play a minor role in determining if discharge to surface water is the most appropriate discharge option. The sampling and reporting, which is typically conducted on a monthly basis, is similar to that for other discharge options. In addition, there is usually no ongoing usage fee for discharge to surface water. However, such fees can be substantial when present. For example, discharge to the Thea Foss Waterway in Tacoma, Washington, is one example of where such a fee has been applied (*U.S. EPA 2001*). In that case, a fee of approximately $5,000 per month was applied to the 50 gpm of treated water discharged to the storm sewer, which increased the annual costs of the remedy by approximately $60,000 per year.

Sustainability Considerations

If the treated water is discharged to surface water in a manner that precludes the further beneficial use of that water, such as discharge to a creek that ultimately empties into the ocean, then the value of that treated water as a potential resource may be lost. In some cases, however, the treated water is discharged into a receiving body that serves as a reservoir such that the treated water will eventually be used for drinking water, irrigation, industrial purposes, or some other beneficial use. In these cases, the treated water displaces the use of water from other sources, and therefore helps conserve water as a natural resource.

Treated water can also be used to help restore or replace habitat that was previously lost due to contamination or that is lost due to other aspects of an environmental remedy. The reliable flow of treated water from a P&T system can be used to

Example 1

Discharge to Surface Water at a Rural Site

The site is a former chemical manufacturing facility in a rural setting. Some of the key site conditions relevant to selecting a discharge option are as follows:

- The site is not located near urban infrastructure that would allow for discharge to a storm sewer or POTW.
- Reuse of treated water for industry or agriculture is not viable.
- Due to remedy pumping, seeps that formed a small tributary to a nearby creek may no longer flow, effectively destroying a small riparian habitat.
- There is limited area on site to return water to the subsurface without adversely affecting plume capture.
- With the exception of the presence of contaminants of concern, the extracted water meets typical criteria for discharging to surface water.

Selected Discharge Option

The site team opted to discharge treated water to the area where the seeps historically discharged. The discharge location has been designed to minimize erosion associated with a point discharge. Therefore, this discharge option will replace the riparian habitat that would otherwise be destroyed by pumping. Ongoing costs associated with this discharge option consist of routine sampling of the effluent in association with an NPDES permit and regular filing of a discharge monitoring report.

establish flow in a creek or wetlands or to augment flow in a stream. In these cases, the treated water does not necessarily displace the use of other water or conserve water as a natural resource, but it does provide additional value through the created habitat.

Site teams can incorporate sustainable environmental practices by considering the fate of the treated water when screening discharge to surface water as a discharge option. Example 1 illustrates the use of surface water as an appropriate discharge location for a P&T system because it provides a cost-effective means of discharging treated water while creating a small riparian habitat that was displaced during other aspects of the environmental remedy.

D. RETURN OF TREATED WATER TO THE SUBSURFACE

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General description

Treated water can be returned to the subsurface through infiltration basins, infiltration galleries, or injection wells, as follows:

- An infiltration basin allows treated water to seep through the ground surface in a controlled area.
- An infiltration gallery includes a subsurface network of perforated pipes in trenches that return the treated water below the surface but above the water table.
- An injection well returns the treated water to the saturated zone in either a water table aquifer or a deeper confined aquifer.

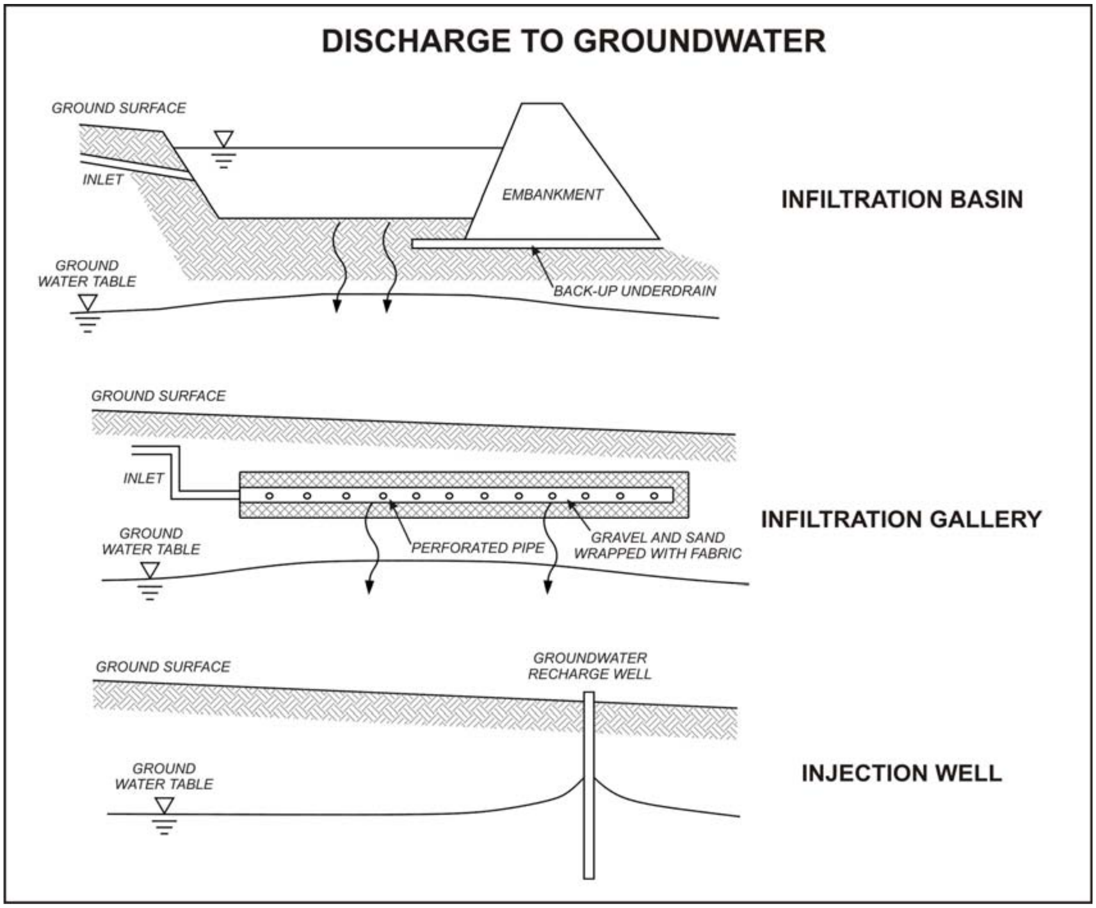
These approaches are schematically illustrated on Figure 2. Advantages and disadvantages for this discharge option are summarized Exhibit 3.

System Design, Permitting, and Project Planning

The return of treated water to the subsurface generally requires a permit authorized by the State. It may also require a permit under the Underground Injection Control (UIC) Program, which regulates the injection of fluids into the subsurface through an injection structure where the depth is greater than the largest surface dimension or through a subsurface fluid distribution system. These structures typically include injection wells, shafts, dug holes, and infiltration galleries but would not include shallow infiltration basins. The injection structures covered by the UIC Program are divided into five classes, and Class V applies to the reinjection of treated ground water.

The U.S. EPA (*U.S. EPA 2005a*) notes that over 30 States have primacy for the UIC Program (i.e., have authorization to administer the UIC Program), and these States have generally incorporated the UIC Program into a broader program for reinjection. For example, New Jersey has primacy for the UIC

Figure 2



Program and uses a Ground Water Discharge NJPDES permit for discharges to ground water. This permit includes the UIC Program components. For the remaining States, EPA has or shares primacy with each State. In such cases, a permit may be needed from the State for a discharge to ground water, and if a Class V UIC structure is used, a UIC permit from EPA would likely apply. For example, EPA implements the UIC program in New York, and two permits would apply for discharge to ground water. One permit is under the New York SPDES program, and the other is under the EPA UIC program. More information on the UIC Program can be found at the following website:

http://www.epa.gov/safewater/uic/index.html

The permits associated with the above-mentioned programs (such as the New Jersey Ground Water Discharge Permit) regulate the construction of the reinjection structure and the monitoring of the treated water that is injected. If reinjection occurs immediately adjacent to a receiving surface water body, the reinjection may also fall under the NPDES program, which as described in the previous section may be implemented by either the U.S. EPA or the State.

The following factors are involved in selecting return of treated water to the subsurface as a discharge option:

- constructability
- maintenance
- role in the ground water remedy
- discharge limits and monitoring requirements

Each of these factors is discussed in more detail below.

Constructability

It is important that the subsurface materials be able to accept the flow rate of water that is being discharged. Infiltration basins and galleries are typically limited to areas that meet all of the following criteria:

- There is sufficient space to accommodate the discharge flow rate.

- The vadose zone is sufficiently permeable to allow water to percolate to the water table.

- There is a water table aquifer to receive the water.

- There is sufficient distance between the bottom of the injection point and the water table.

If any of these criteria are not met, then an infiltration basin or gallery is likely not an appropriate discharge option. Exhibit 4 notes some of the design criteria for infiltration basins associated with stormwater applications that can be used as a rule of thumb.

Injection wells require less space than infiltration basins or galleries. In addition, injection wells can return water to deeper aquifers that may more readily accept the discharged water.

The quality of the discharged water and the geochemistry of the receiving ground water also play a large role in determining whether or not return of treated water to the subsurface is an appropriate discharge option. Treated water with high solids or metals, such as iron or manganese, can clog an infiltration basin or gallery and increase maintenance requirements. Similarly, microbial activity and/or precipitation of iron, manganese, calcium, or other metals can clog (or foul) an injection well. Fouling of injection wells may occur much more frequently than fouling of extraction wells because the treated water may have higher dissolved oxygen concentrations from aeration during treatment, and this dissolved oxygen can foster the microbial activity and/or the metals precipitation. Potential for fouling can be assessed based on quality of the discharged water and the geochemistry of the receiving ground water.

Maintenance

Unlike other discharge options, such as discharge to surface water or to a POTW, returning the treated water to the subsurface typically involves routine maintenance. The degree of maintenance depends on the rate of fouling. Maintenance may involve removal of sediments, precipitated metals, and other fine solids that clog the basin and reduce infiltration. For infiltration galleries, high pressure jetting may be helpful in removing fines from the perforated piping. However, over time, the gravel and sand surrounding the perforated pipe may need to be replaced. For injection wells, chemical treatments or well redevelopment might be appropriate but are quite expensive if they are conducted frequently. The U.S. Army Corps of Engineers Engineering

Exhibit 3

Return of Treated Water to the Subsurface: Advantages and Disadvantages

Potential Advantages

- Discharge standards are typically similar to drinking water standards, but for some constituents, such as ammonia, standards may be more relaxed than those for discharging to surface water.

- Unlike discharge to surface water, there generally are not requirements to remove some natural ground water constituents prior to returning treated water to the subsurface.

- Returning treated water to the subsurface can be used to augment hydraulic containment or flush a contaminant source. These potential benefits should be considered in the extraction system design.

- Return of treated water to the subsurface helps conserve ground water as a natural resource, which is particularly beneficial in areas where ground water serves as a sole source for drinking water or where dewatering is a concern.

Potential Disadvantages

- Reinjection into the plume may compromise plume capture by spreading the plume. Additional hydrogeological analysis (perhaps including modeling) may be necessary in designing such an approach.

- Reinjection wells and infiltration structures may need more maintenance than other discharge options, especially due to solids or biological fouling.

- There is potential to discharge contaminants that are present at the site, currently unknown to the site team, and not readily treated by the employed treatment technologies. Recent examples might include sites with perchlorate and 1,4-dioxane. This could result in dispersing a contaminant plume and increasing the cost of cleanup.

Pamphlet 1110-1-27 titled *Operation and Maintenance of Extraction and Injection Wells at HTRW Sites* (*USACE 2000*) documents common practices for maintaining and rehabilitating injection wells.

Exhibit 4

Common Design Considerations for Infiltration Basins

The following are common criteria for properly locating and designing infiltration basins. The criteria are generally developed for the purpose of infiltrating stormwater, but many of the criteria apply to returning treated water to the subsurface.

- Allow sufficient distance between the bottom of the infiltration basin and the seasonal high water table (2 feet to approximately 10 feet, depending on local regulations).
- Select an area with a minimum soil infiltration rate of 0.5 inches per hour. The clay content should be less than 20% and clay/silt content should be less than 40% to provide adequate infiltration.
- Allow vegetation growth within basin to promote infiltration.
- Avoid construction of infiltration basins on slopes that are greater than 10%.
- Avoid sediment loading to the infiltration basin to reduce the potential for clogging.
- Design basin area using the infiltration rate and the anticipated flow rate. The area of the basin times the infiltration rate should be greater than or equal to the anticipated flow rate.
- Avoid ponding to foster vegetation growth, minimize anaerobic conditions, and prevent mosquitoes.

The above information has been collected from review of selected best management practice handbooks, including those from California and New Jersey.

- *California Stormwater BMP Handbook*, California Stormwater Quality Association, TC-11, January 2003
- *New Jersey Stormwater Best Management Practices Manual*, Chapter 9.5: Standard for Infiltration Basins, February 2004

A treatment plant can be designed or enhanced to remove metals or other constituents that add significantly to fouling; however, this enhanced treatment might be more expensive to construct and operate than maintaining an infiltration basin, infiltration gallery, or reinjection well. It is often helpful to consider the life-cycle costs of the various options, which includes consideration of annual O&M costs, rather than focusing on the option with the lowest upfront cost.

<u>Role in the Ground Water Remedy</u>

The return of treated water to the subsurface can play an important role in the performance of a ground water remedy. The returned water can be designed to positively impact the ground water remedy in the following ways:

- Contaminant flushing can be enhanced by returning treated water upgradient of the plume and extraction system, or in a zone where contamination is present in the unsaturated zone.
- Degradation of remaining contamination in the subsurface can be enhanced through the addition of oxygen and/or nutrients to the returned water.
- Hydraulic containment of impacted ground water can be enhanced by returning treated water to the subsurface and creating a hydraulic divide, particularly downgradient of the extraction wells.
- Negative impacts that might be caused by ground water extraction, such as reduced ground water discharge to wetlands or dewatering of water supply well screens, can potentially be mitigated by returning the treated water to the subsurface.

Evaluation of these impacts may include analysis with ground water modeling.

Return of treated water to the subsurface can also have a negative impact on the ground water remedy in the following ways:

- Frequent fouling of the infiltration or injection structures can result in frequent system shutdowns.

- Returning treated water into the plume can result in spreading of the plume and could compromise plume capture.

- Returning treated water in close proximity to the extraction wells can result in the extraction of treated water rather than contaminated water, which can compromise plume capture and/or slow progress toward aquifer restoration.

<u>Discharge Limits and Monitoring Requirements</u>

The discharge limits associated with return of treated water to the subsurface are determined by each State under its own ground water protection program. Typically, the limits for contaminants of concern are equal to the cleanup standards for those contaminants. If the discharge limits are less stringent, it is generally advisable to treat the water to the cleanup standard so that the treated water does not serve as a continuing "source" of ground water contamination. Because ground water does not support aquatic life like surface water, the discharge limits for some constituents that are not contaminants of concern in ground water may be much higher than the discharge limits for surface water. If returning treated water to the subsurface will prevent costly treatment of these non-contaminant constituents, then it may be more cost-effective compared to discharge to surface water.

Sustainability Considerations

Discharge of treated water to the subsurface may effectively store the treated water as ground water that can be used at a later time. If the treated water is returned to a usable aquifer with similar quality to that of the treated water, then the extracted and treated water has been conserved as a resource. However, if water is extracted from a deep aquifer of high quality (other than the contamination that will be removed by treatment) but is returned to a shallow aquifer of low quality, then the extracted and treated ground water has not been conserved as a resource.

Discharging the treated water to the subsurface to enhance the performance of the ground water remedy may represent a sustainable environmental practice because it offsets the energy and expense of using an alternative to provide the same effect. For example, injecting the treated water upgradient of the plume to enhance contaminant flushing could shorten the duration of P&T operation and reduce overall amount of energy consumed or water extracted. Injecting treated water downgradient of the extraction wells may reduce the flow rate required for capture, which may reduce energy costs associated with pumping and/or treatment.

Example 2 provides an example of returning treated water to the subsurface as an appropriate discharge

Example 2

Returning Treated Water to the Subsurface to Enhance Remedy Effectiveness

A site with a chlorinated solvent plume has trichloroethene (TCE) contamination. Some of the key site conditions relevant to selecting a discharge option are as follows:

- Contaminants of concern (i.e., TCE and associated breakdown products) are easily removed using air stripping or GAC.

- Iron concentrations in the extracted water are approximately 1 mg/L, which is not enough to foul the treatment system if it is properly maintained and cleaned. This concentration meets the criteria for discharging to the subsurface but does not meet the criteria for discharging to surface water.

- Reuse of treated water is not a viable option, and the flow rate is too high for discharging to the POTW.

- Bag filters placed after an air stripper can provide solids removal for reasonable protection of an infiltration gallery, if used.

<u>Selected Discharge Option</u>

The site team opted to discharge treated water to the subsurface to avoid the need to add metals removal to the treatment system in order to meet surface water discharge standards. Although this option will involve regular cleaning of the air stripper and periodic maintenance of an infiltration gallery, those costs are lower than operating and maintaining a treatment system with metals removal.

option for a P&T system because treatment system O&M is substantially reduced relative to other discharge options.

E. DISCHARGE TO THE POTW OR OTHER ON-SITE TREATMENT

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General description

With this option, extracted water is discharged to a publicly-owned treatment works (POTW) through the sanitary sewer line or to a facility's on-site wastewater treatment plant that can provide appropriate treatment. In some cases, discharge can occur with no other treatment needed, and in other cases, pre-treatment may be required to meet the POTW requirements of certain compounds. More information on this discharge option is discussed below, primarily in the context of discharging to a POTW, and general advantages and disadvantages of this discharge option are provided in Exhibit 5.

System Design, Permitting, and Project Planning

Discharge to a POTW is typically negotiated with the local municipality, which issues a permit governing the discharge. Because a POTW is a treatment plant, it generally accepts water with much higher concentrations of organic compounds than would apply at other discharge locations. However, discharges that would interrupt operation or pass through the POTW without adequate treatment are prohibited. In September 2005, EPA provided a revised rule on pre-treatment for discharging to a POTW in a document titled *Streamlining the General Pretreatment Regulations for Existing and New Sources of Pollution (U.S. EPA 2005b).*

Regulations generally stipulate that discharges from some industrial facilities (such as metal finishing) receive pretreatment prior to discharge to a POTW. Ground water remediation systems are not such facilities; however, some ground water remediation systems address such sites, and, therefore, the POTW may use this as a basis for requiring pretreatment. Although this may be appropriate at some sites, at others, it may result in additional expense with little environmental benefit.

The typical discharge limit for total toxic organics (TTO) to a POTW is 2.13 mg/L. At many (but not all) sites, this is higher than the combined influent from the extraction wells, making it possible to implement a "pump and discharge" remedy rather than a P&T remedy. Certain chemicals, such as acetone, 2-butanone (MEK), and 4-methyl-2-pentanone (MIBK), are not included in the calculation of TTO. These compounds, which are all classified as ketones, are difficult to treat with common economical ground water treatment technologies such as air stripping and carbon adsorption. However, they are readily treated by the biological processes used in a POTW. Discharge of these chemicals to the POTW is typically limited to those quantities that will not result in vapors that are harmful to workers. Therefore, for a site where the contaminants are TCE and acetone, it may be most

Exhibit 5

Discharge to the POTW or Other On-Site Treatment: Advantages and Disadvantages

<u>Potential Advantages</u>

- This option often has less stringent discharge standards and monitoring requirements, especially for organics. Generally, municipalities use a discharge limit of 2.13 mg/L for total toxic organics, which is a higher concentration than the influent to many P&T systems.
- Ketones and ammonia, which are difficult to treat with P&T systems, are easily treated by POTWs.
- The POTW provides a secondary treatment for some constituents to prevent (except in extreme cases) damage to surface water receptors.

<u>Potential Disadvantages</u>

- If the POTW is near capacity, it may not accept treated ground water discharge.
- In certain areas where ground water is the sole source of drinking water, return of treated water to the subsurface may be necessary.
- The POTW may be reluctant to accept water that has certain constituents or is relatively "clean" compared to typical sewer water.
- Discharge to a POTW becomes quite costly for high flow rates relative to other options.

cost-effective to treat the TCE with air stripping and discharge the water to the POTW. Acetone is not removed by air stripping but is effectively treated at the POTW.

The practicality of discharge to a POTW or on-site treatment plant is typically limited by the following:

- There may be current or future limitations of the POTW or on-site treatment plant to accept additional flow.

- Constituents in the discharge may not meet the criteria of the POTW or the on-site treatment plant requirements for pretreatment.

- The distance and terrain between the P&T system and a connection point to the POTW or on-site treatment plant may be too far to be cost-effective.

- For discharging to the POTW, the unit cost associated with the discharge, which is typically based on the flow rate, may be too high to be cost-effective.

Each of these factors is site-specific, but one item of note is the discharge fee, which can be a substantial component of annual operating costs for a P&T system that discharges to a POTW. Costs for discharging treated water to a POTW typically range from $0.003 per gallon to $0.03 per gallon (2007 dollars). For a P&T system with a flow rate of 10 gpm and a POTW cost of $0.03 per gallon (i.e., $3 per 100 gallons), this translates to an annual cost of over $150,000 per year. In some cases, the fee may be worth paying if certain aspects of treatment (construction and/or O&M) can be avoided. Therefore, a site team should compare the life-cycle costs of discharge to the POTW with life-cycle costs for other alternatives. Generally, due to cost, the POTW option will compare less favorably with other options as the flow rate increases.

Sustainability Considerations

Discharge to a POTW generally does not conserve the extracted ground water as a resource. The water discharged to the POTW is treated and then typically discharged to surface water. However, by using a POTW (or on-site treatment plant) as a component of the P&T treatment process, unnecessary or redundant treatment components can be eliminated.

Example 3

An Optimization Evaluation Recommendation to Discharge to a POTW

A P&T system, installed over 10 years ago, treats a variety of organic compounds, including ketones, using a bioreactor at flow rate of approximately 8 gpm. The organic contaminant concentrations are relatively dilute (e.g., approximately 1 mg/L). Treated water is discharged to marine surface water. An optimization evaluation suggested a change in the discharge option from surface water to the POTW, citing the following reasons:

- Maintenance and solids handling of the current treatment system requires a full-time operator at a cost of $120,000 per year.

- Partially due to its age, the current treatment system is down more than 20% of the time.

- At a flow rate of 8 gpm and a POTW discharge rate of $0.01 per gallon, discharge to the POTW would be approximately $42,000 per year.

- By discharging to the POTW, operation of the treatment system can be discontinued and maintenance costs decreased to $40,000 per year, representing a cost savings of approximately $38,000 per year.

- There would be no net loss in the potential use of the treated water by discharging it to the POTW because water from the current treatment system is discharged to marine surface water without reuse.

Example 3 illustrates an optimization evaluation recommendation to change the discharge option from surface water to a POTW to reduce annual costs without sacrificing remedy effectiveness.

F. REUSE OF TREATED WATER

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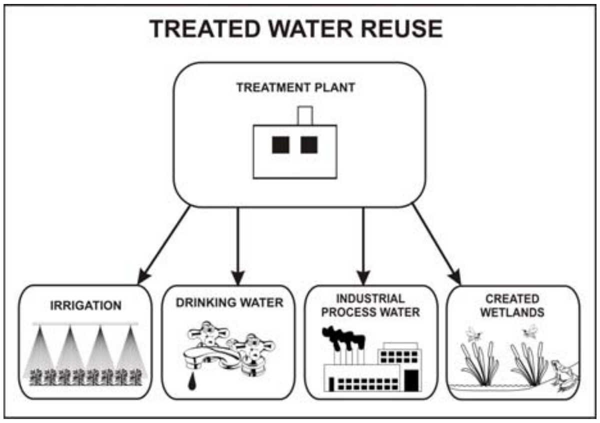
General description

With this option, the treated water is used directly for another application, such as process water for an industrial facility, water for irrigation, creation or enhancement of wetlands, or in some cases, as a potable water supply (see Figure 3). More information on this discharge option is discussed below, and general advantages and disadvantages of this discharge option are provided in Exhibit 6.

Figure 3



System Design, Permitting, and Project Planning

The primary applications for reuse of treated water are as follows:

- process or cooling water for industry
- irrigation water
- creation or enhancement of wetlands
- drinking water

Availability of this option is typically determined by the distance and terrain between the P&T system and the specific location for reuse.

The following are some of the factors that apply when considering treated water for industrial process or cooling water:

- The discharge will now be part of plant operations and can have an effect on plant output. Wastewater and air discharge permits may need to be modified if the treated water is used as process water.
- Aspects of treated water unassociated with environmental cleanup, such as hardness, pH, or total solids, may be an important factor in using the treated water as process water. The treatment requirements for using the treated water as process water may be more stringent than treatment requirements for other discharge options, as follows:

Exhibit 6

Reuse of Treated Water: Advantages and Disadvantages

Potential Advantages

- Reuse of treated water reduces or eliminates the need for a facility or organization to use water from other sources, thereby conserving water as a natural resource and potentially reducing utility costs.
- Reuse can be cost-effective relative to other discharge options at some sites.
- Reuse may be viewed positively by the community if water is a scarce natural resource.

Potential Disadvantages

- For use in irrigation, drinking water supply, or wetlands creation/enhancement, specific Federal and State regulations may be applicable, or relevant and appropriate. Additional testing or monitoring relative to other discharge options may be needed.
- Additional system conservatism (e.g., an additional GAC vessel) may be needed compared to treatment systems without direct discharge to human receptors.
- Reusing water in industrial processes may involve additional treatment relative to discharging the water elsewhere. Reused water should be treated to meet the facility standards and any downstream discharge standards. Treating to facility standards may be more costly than discharging to another location and using public water at the facility.
- Facilities may operate on a part-time basis, and the P&T system may need to operate continuously. If continuous extraction with batch treatment during facility hours is not available, reuse may not be feasible.
- A backup discharge point should be available in case the needs of the facility change.
- Contaminants that are undetected using current analytical techniques or contaminants that are present as tentatively identified compounds (TICs) may not be removed by treatment, causing a potential risk to end users of the water.

- The quantity and continuity of the treated water may differ from that required for industrial operations.

- The P&T system flow rate may be lower than the process water needs.

- The maintenance schedule and downtime for the P&T system may make the treated water an unreliable source for process water.

- The P&T system may have a higher flow rate or may operate at times when process water is not needed.

Each of the above scenarios may complicate the use of treated water as process or cooling water, but many of them can be overcome by having a backup or supplementary source of process water, or a backup or supplementary discharge option.

With respect to potential use of treated water for irrigation, wetlands creation/enhancement, or water supply, public perception may play a significant role. For these applications, it is appropriate to obtain community acceptance prior to making substantial investments in the design and construction of the discharge process. Additional failsafes or redundancies that might not be appropriate for other discharge options may also be required. In addition, it is advisable to sample for a wider range of parameters to ensure that additional chemicals are not passing through the treatment system at unacceptable levels.

Sustainability Considerations

The direct reuse of treated water displaces the use of other water, and, therefore, conserves water as a natural resource. Additional energy would also not be used in obtaining water from another source, such as a production well. With the creation or enhancement of wetlands, a new ecological resource is provided.

Example 4 provides an example of using discharge of treated water for irrigation. In the scenario described in the example, reuse for irrigation is an appropriate discharge option for a P&T system because it is cost-effective and displaces the use of other water resources.

Example 4

Use of Treated Water for Irrigation

A P&T system, located in a desert environment, treats approximately 100 gpm of ground water impacted with low levels of VOCs. Some of the key site conditions relevant to selecting a discharge option are as follows:

- A surface water discharge point or storm sewer is not located near the site, and discharging to the POTW is prohibitively costly due to the flow rate.
- Returning ground water to the subsurface is a possibility.
- The site is located near a public golf course that needs frequent irrigation.
- The water table is over 200 feet below ground surface, which makes the electricity for pumping water a significant cost for the P&T system and for the neighboring golf course.
- The treatment technologies are predictable and reliable. The system is designed to treat to “non-detect” levels. Redundancies and failsafes are included to avoid exceedances.

Selected Discharge Option

The site team selected two interchangeable discharge locations. The primary discharge location is to return the treated water to the subsurface, but when irrigation at the golf course is needed, the treated water is preferentially diverted to the golf course irrigation system. These discharge options preserve the value of the treated water by using it for irrigation or returning it to the subsurface. In addition, by using the treated water directly for irrigation, electricity and several thousand dollars per year in electricity costs are saved by avoiding the cost of pumping water for irrigation.

G. SELECTING AN APPROPRIATE DISCHARGE OPTION

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Selecting an appropriate discharge option involves the use of experienced professionals evaluating several criteria, including those mentioned in this fact sheet. This fact sheet provides important considerations, but cannot provide a comprehensive framework for selecting a discharge location, particularly given important site-specific factors that include contaminants of concern, hydrogeology, treatment components, infrastructure, and regulations.

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