**Cut Project Life Cycle Costs**
**Make Design Decisions for the Long Term**

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Operational and maintenance costs generally exceed capital costs for in situ soil and groundwater cleanup systems over the life of a project. Evaluation of life cycle costs in the treatment selection process is of paramount importance to minimize total project costs. Typically, operations and maintenance contribute between 50 and 80 percent of total cost over a four year project life, and these percentages tend to rise each year thereafter. The principal components of operation and maintenance are power, maintenance labor and parts.

A primary pitfall to estimating life cycle costs is a result of improperly sized treatment systems. Conventional hydrological investigations frequently prove inadequate to properly size treatment systems. The earth functions as a filter to purify water for aquifers and streams. These same purification factors compete with a designer's ability to obtain representative design information. This has been demonstrated in part by failure of the Superfund program and an abundance of examples of over- and under-designed systems. Lengthy site investigations with voluminous reports often result in designs that are off by an order of magnitude -- or selection of the wrong remedial technology. Several thousand well volumes should be pumped to adequately predict sustainable flows, drawdowns and contaminant characteristics for full scale soil and groundwater treatment. Short term pump tests and slug tests frequently prove inadequate. Treatment systems need to be demonstrated and expanded in a flexible and modular fashion to ensure efficient design and keep costs down.

Treatment plants are often over-engineered with complicated control systems that are difficult and expensive to operate. Sites are often in remote locations with no full time qualified technical support. Simple designs with minimal controls are a good way to reduce failures and O & M costs.

Life cycle cost increase as the chosen remedial technology increases in complexity. Often, use of lower order treatment systems grouped in series can be more cost-effective than progressing to a higher order technology. Maintenance problems with groundwater treatment begin with water chemistry -- pH, hardness, iron content -- microbiology -- iron bacteria and biological growths, severe weather and silts from formations that tend to clog or lower the efficiency of pumping, air or water extraction, injection and treatment systems. Designing plants that can pass solids or that can be easily cleaned is an economical alternative to pretreatment with filtration, aeration, biological treatment, algaecides, bactericides or sequestering agents for iron scale formation control.

Level switches that fail by clogging or corrosive anaerobic conditions burn out electrical pumps. Float switches in top or bottom filling pneumatic pumps often hang up and need to be cleaned. Diaphragm pumps are designed to pass solids and are generally considered to be the most economical life cycle pumps for many situations.
Biological clogging and dissolved metal pretreatment can be minimized by using oil/water coalescing separators, and low-profile multiple cell diffusers that tolerate high suspended solids loadings without expensive chemical, physical or biological pretreatment.

Systems should be designed to operate over extreme weather conditions-- ambient temperatures from -30 to +40 °C -- to prevent unnecessary system maintenance due to freezing and system component failures due to temperature fatigue. The use of ventilated enclosures and placement of electrical motors and electrical equipment outside the hazard zone, at least 450 millimeters away from fuel storage or dispensing allows the design engineer to specify non-explosion proof equipment, which, in many cases, results in considerable cost savings.

Recovery well pumps are used to provide hydraulic capture for contamination plumes, accelerate free product removal, expose the capillary fringe for bioventing, and provide hydraulic control for uplift associated with biovent and biosparge operations. Some 75 percent of pump and treat costs can be attributed to pump installation, operation and maintenance cost. Diaphragm pumps are considerably less expensive to install and operate than other pumping systems.

Controllerless, dual function downhole diaphragm pumps minimize clogging, level switch failures, motor lead shorts and motor burnout potential from electrical dual pumps. Compressor operation and maintenance costs may be dramatically reduced by using rotary screw compressors rather than reciprocating or other types.

Space limitations historically have restricted the use of diaphragm pumps due to large diameter wells, greater than 450 millimeters. Remtech Engineers, Marietta, GA., makes a downhole controllerless recovery well diaphragm pump that fits in a 150 millimeter recovery well. It can serve as a total fluids and non-aqueous phase skimmer pump, and can run wet or dry without damage. Drawdown or free product recovery may be achieved by adjusting the pump elevation in the well casing to the desired drawdown elevation or free product and water interface. A timer controlled solenoid valve can send a pulse to shock the water table and enhance the mobility of aqueous and non-aqueous phase hydrocarbons.

Low profile sparge strippers with large access ports facilitate easy cleanout of fungicides, bactericides and scale removal agents such as hydrochloric acid, hypochlorite solutions, and surfactants. Periodic system cleaning is generally less costly than chemical or mechanical pretreatment. Stripping towers are generally accepted as the least expensive treatment unit operation for VOC removal, followed by diffused air, and plate strippers.

Running multiple treatment units in series minimizes the need for tertiary treatment systems such as carbon adsorption or biological treatment. Activated carbon off-gas treatment is considered Best Available Control Technology. Following the removal of free product, air emissions from solution phase VOC stripping is often below loadings where activated carbon is effective. Sizing carbon off-gas absorbers to handle the air flow rates and pressure drops generally results in very low carbon exhaustion rates with little or no contamination breakthrough detected.

Wherever possible, low pressure vent blowers should be used to minimize power needs and operations and maintenance costs. Regenerative and rotary lobe blowers are inexpensive to purchase and operate. Bioventing costs are reduced by installing multiple function wellheads that serve as drawdown, free product removal and vacuum wells.

Gravity transfer through treatment vessels via hydrostatic heads without level switches or pumps increases reliability and reduces maintenance and energy costs. Large openings for inter-reactor transfer or injection cuts down on potential clog points.

Systems that require minimal training, are simple to operate, and can be repaired by the user without vendor intervention with generic parts can greatly reduce maintenance costs.

A case study demonstrates the steps Remtech Engineers took to minimize life cycle costs at an Air Force Base in Michigan that had JP-4 groundwater contamination 18 meters below grade from a petroleum, oil and lubricant tank farm. Two treatment plants were installed with three 150 millimeter wells feeding each plant to recover free product. Pilot tests conducted (by others) with a dual electrical total fluids and skimmer pump failed after 11 weeks due to iron scale encrustation. A controllerless downhole diaphragm pump was installed in 150 millimeter wells to depress the groundwater table from 0.5 to 1 meter and optimize free product recovery rates. The pumps have been operating for nearly a year with minimal clogging and maintenance problems. The pump shaft O-rings are replaced every two months, and the pumps are cleaned every two to eight weeks.

Remtech Groundwater Treatment System

The pumps are powered by 7,460 watt rotary screw compressors for continuous operation. Very little maintenance has been necessary with rotary screw compressors. Well galleries consist of nylon 11 direct burial discharge lines and butyl air lines housed in polyethylene casings. Galleries are buried 2 meters below the frost line. Ambient temperatures range from -30 to over 35 ° C. Wellhead enclosures are made of insulated fiberglass shells heated with infrared lamps to minimize pump hose connection freezing. A convective ventilator is installed with an eductor tube placed next to the well vault to exhaust vapors from the enclosure. When temperatures dropped below -18° C, several wellhead lines froze due to moisture in the supply air. Dual desiccant air dryers were installed on the compressors to stop moisture related freezing.

Remtech Model 0.25 **Slurp** Pump

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The liquid treatment train consists of a coalescing oil/water separator with an auto skimmer for free product removal. Remtech's low profile air stripper and separator were designed to pass solids and allow cleaning by mechanical brushing, surfactants and bleach rather than chemical pretreatment.

Air emissions were collected by a regenerative blower and passed through two demister filters and two 90 kilogram carbon vapor canisters. Since the vapor loadings were so low, no detectable hydrocarbon breakthroughs were recorded, thereby achieving BACT without filing for permits or requiring carbon replacement. Groundwater chemistry at the base is conducive for iron scaling and iron bacteria formation.

| Parameter | Concentration, ppb |
|---|---|
| Iron | 2,600 |
| Calcium | 72,000 |
| Magnesium | 11,000 |
| Manganese | 670 |
| Sodium | 7,900 |
| Total Dissolved Solids | 220,000 |
| Total Alkalinity | 160,000 |

Gel and slime formation observed in the wells after six months of operation were rehabilitated with HCL and hypochlorite treatment. System maintenance hours ranged from 1.5 to 5 percent of system operational hours.

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