Table C-1. Screening of Source Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| No Action | None | Not applicable | No action. | All contaminants. | Does not meet regulatory requirements. Potential for continued release of contaminants into groundwater. | Retained for comparison purposes |
| | | Natural attenuation | Soil or groundwater is not treated and is allowed to "naturally' decontaminate itself through dispersion, diffusion, adsorption, hydrolysis, or biodegradation. | Organics. | Depending on the extent of contamination or presence of free phase chemicals, this option will not be effective in source control. Does not meet regulatory requirements by itself. | Eliminated |
| Institutional Controls | Covenants and Permit Programs | Deed/Land restrictions | Restrictions and notification placed in the deeds of impacted property. | All contaminants. | Does not meet regulatory requirements by itself Can be used in combination with other options. | Retained |
| | Access Restrictions | Fencing | Erection of physical barrier to prevent access to surface contamination. | All contaminants. | Does not meet regulatory requirements by itself Can be used with other response actions. | Retained |
| Source Containment | Capping | Clay and soil, bentonite & soil, concrete, or multimedia/RCRA cap | Compacted clay/soil or bentonite/soil/cement covered over source over areas, or concrete slab, or multimedia (clay and synthetic liners) cap. | All contaminants. Prevents surface infiltration of water. | Significantly reduces surface-water infiltration. Does not isolate source material from groundwater. This option will not eliminate downward migration of source material. Need to use horizontal and vertical barriers in conjunction with capping to be effective, which is cost prohibitive. This option will not guarantee complete containment of source. | Eliminated |
| | Vertical barriers | Soil-bentonite or cement-bentonite slurry wall | Trench around areas of contamination and fill with a soil-bentonite or cement-bentonite slurry wall to provide effective barrier to groundwater flow. | All contaminants. Susceptible to attack by pH <=4 and >7 and other highly ionic substances. | Not good for strong acids, bases, strong salts, and some organic chemicals. Has least strength of the slurry walls; requires a large work area. Does not prevent water infiltration. Does not prevent vertical migration of contaminants. Required to maintain negative head (low-volume extraction) inside the barrier to prevent outward migration of contaminants. Requires treatment/disposal of recovered water, | Eliminated |
| | | Grout curtain | Pressure injection of cement, clay, bentonite, alkali, silicate, or organic polymer grout in a regular pattern of drilled holes. Can be installed by stage-up, stage-down, grout port, or vibrating beam method. | Compatibility testing must be conducted for specific contaminants and specific grouts. | Difficult to install in fractured bedrock. More expensive than slurry walls. Also, refer to slurry wall section for additional requirements. | Eliminated |

Table C-1. Screening of Source Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | Rock grouting | Pressure injection of cement, clay, bentonite, alkali, silicate, or organic polymer grout into the fractured rock formations. Best suited for sealing voids in rocks, | All contaminants. Susceptible to attack by pH <=4 and >7 and other highly ionic substances, | Difficult to ensure sealing of flow paths. May need to drill through waste to inject grout. May not be effective. Compatibility testing must be conducted for specific contaminants and specific grouts to ensure all flow paths are sealed. | Eliminated |
| | | Sheet pile wall | Steel, concrete, or wood is used for temporary dewatering for other construction or for erosion protection. | Not good for rocky or coarse, sandy soils. Not effective for corrosive environments. Not as impermeable as slurry walls. | Difficult to Install in bedrock. Also, refer to slurry wall section for additional requirements. | Eliminated |
| | Subsurface horizontal barriers | Grout injection | Involves drilling through the site, or directional drilling from the site perimeter, and injecting grout to form a horizontal or curved barrier. One technique is to drill a pattern of holes across a site, lower a special jet nozzle and erode the soil with a high pressure stream of air and water. A flat circular cavity is then formed and grouted. | All contaminants. Susceptible to attack by pH <=4 and >7 and other highly ionic substances, | Not effective in fractured rock formations. Technology not proven yet for effectiveness. Requires slurry wall or other vertical barriers and surface barrier (cap) in combination to prevent groundwater or surface water in contact with the waste material. Inclined grout walls may be used in place of horizontal and vertical barriers. Effectiveness not fully known for horizontal/inclined grouting. | Eliminated |
| | | Block displacement | A perimeter barrier is constructed by slurry trenching or grouting. Grout is then injected into specially notched holes bored through the site. Continued grout or slurry pumping causes displacement of the block of earth isolated by the perimeter barrier and forms a bottom seal beneath the block. | All contaminants. Susceptible to attack by pH <=4 and >7 and other highly ionic substances, | Not effective in fractured rock formations. Lab and field tested but no detailed analysis at waste sites possible. Its use in full-scale field application is unknown. | Eliminated |
| | Hydraulic Containment | Interceptor Trench | Perforated pipe placed in gravel-filled trench below grade to intercept and convey shallow groundwater (shallow horizontal well). | All contaminants. Dewatering can reduce groundwater coming in contact with the waste material. | May not meet regulatory requirements by itself. Not effective in fractured rock. Requires dewatering/shoring. Requires treatment/disposal of recovered water. Difficult to construct deeper than 15 feet. | Eliminated |
| | | Extraction Wells/Well Points | Using a number of wells to extract groundwater to expose soils in the saturated zone. Hydraulically control the migration of contaminants. | All contaminants. | This option will not reduce surface infiltration; requires a large number of recovery wells; Requires treatment/disposal of recovered water. May not be effective in completely reducing vertical migration of contaminants into bedrock. | Eliminated |

Table C-1. Screening of Source Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| Removal/ Disposal | Excavation | Conventional excavation | Excavation of soil/waste material, screening for containers, waste segregation/sampling, storage, and transportation for treatment/disposal. | Complete source removal method. Non-sparking equipment must be used with any explosive material, | Depth exceeding 15 feet may require sheet piling/dewatering. Also, requires vapor/dust collection, containment, and treatment before disposal. Complete source removal can be effectively achieved. | Retained |
| | On-site disposal | RCRA landfill | Placement of treated or untreated excavated soil in a constructed on-site hazardous waste landfill with synthetic and clay liners and leachate collection and removal (e.g., RCRA Subtitle C landfill). | Depends on LDRs. | Involves excavation of waste/soil, building of a RCRA landfill on-site, placement of waste, and placement of a RCRA cap. Requires extensive permitting and long-term monitoring. LDRs may have to be met. | Eliminated |
| | Off-site disposal | Solid waste landfill (Subtitle D) | Transportation to and disposal of treated soil at a non-hazardous waste landfill (e.g., RCRA Subtitle D landfill). | Non-hazardous waste only. No mixed waste | Waste should be treated (non-hazardous) before disposal. Need to comply with applicable LDRs. | Retained |
| | | RCRA landfill (Subtitle C) | Transportation to and disposal of treated or untreated excavated soil at a hazardous waste landfill (e.g., RCRA Subtitle C landfill), | Hazardous waste only. No mixed waste, | Excavated material could be hazardous. Strict disposal regulations. Can be used to dispose of treated waste (after incineration). | Retained |
| Ex-situ Treatment | Physicochemical treatment (above ground) | Soil washing | Mixing contaminated soil with water, organic solvents, chelating agents, surfactants, acids, and/or bases to rinse out contaminants, followed by rinsewater treatment. Decreases volume of contaminated material, | Hydrocarbons, metals, pesticides, PCBs, VOC/SVOCs, salts, cyanides, corrosives, | Excavated soil and waste containers must be segregated. Washing media must be treated. Excess amount of fine material (clay/silt) increases cost of treatment. Requires on-site utilities. May not receive community acceptance for this project. | Eliminated |
| | | Steam stripping | Passing steam through contaminated soils to drive off volatile contaminants. Off-gas must be collected and treated. Decreases volume of contaminated material. | Volatiles treated. | Excavated soils must be homogenous for process to be effective. Not suitable for metals and inorganics. Extensive treatment of off-gas would be expensive. | Eliminated |
| | | Stabilization/solidification | Use of fly ash, Portland cement, clays, kiln dust, silicate-based material, sorbents, thennoplastics, or surface microencapsulation to immobilize contaminants and solidify, soils. Decreases mobility of contaminants. | Good for metals, low-level rads, asbestos, acceptable for low-level VOCs, SVOCs, PCBs, and pesticides (<20% by volume). Also sometimes used solely for structural stabilization. Salts, nitrates, sodium, arsenates, borates, phosphates, iodates, sulfide, carbohydrates, and sulfates may interfere with curing process. May be applicable for transporting materials for off site disposal | May increase waste volume. Potentially requires deed restrictions. | Retained |

Table C-1. Screening of Source Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | Macroencapsulation | Contaminated material is loaded into an overpack. A lid is then welded onto the container to form a seam-free encapsulate. Decreases mobility of contaminants. | All contaminants (organics and inorganics). | Macroencapsulated material/waste will require secure disposal area. Does not completely eliminate liability. | Retained |
| | | Solvent extraction | Use of solvents, including water and tertiary amines, to extract contaminants. Decreases volume of contaminated material. | All contaminants, as long as they're soluble in the solvent being used. | Solvent must be treated. May produce toxic gas emissions. Some of the material may still be in containers and can not be recovered. Not applicable for metals contaminated material. | Eliminated |
| | | Acid extraction | Washing of soil with an acid to remove heavy metals from contaminated soil. Decreases volume of contaminated material. | Metals. | Not appropriate for alkaline soils if it would take a vast amount of acid. Not applicable for VOCs. | Eliminated |
| | | Chemical oxidation | Use of ozone/UV light, hydrogen peroxide, hypochlorite, chlorine, or potassium permanganate to oxidize contaminants. Decreases toxicity of contaminants. | Benzene, phenols, most organics, cyanide, arsenic, iron, manganese. | Bench- and/or pilot-scale testing necessary to determine appropriate chemical feed rates and retention times. Undesirable byproducts may be formed. Applicable for soils contaminated with low concentrations of organics. | Eliminated |
| | | Chemical reduction | Use of ferrous sulfate, sodium sulfate, sulfur dioxide, iron (+2), aluminum, zinc, or borohydride to reduce contaminants. Decreases toxicity of contaminants. | Chromium, mercury, lead, silver, PCBs, unsaturated hydrocarbons. | Well-demonstrated for treatment of lead, mercury, and chromium. Bench- and pilot scale studies necessary for more complex waste streams. | Eliminated |
| | Thermal treatment | Low-temperature thermal treatment/stripping | Low-temperature heating and agitation to drive off volatile contaminants coupled with collection and treatment of gases and condensate. Decreases volume of contaminated material. | Some halogenated and non-halogenated SVOCs (low molecular weight). | For thermal treatment in general, the breakeven point for treating waste on site is about 10,000 yd3 of waste. Material must be sized prior to treatment. Not applicable to metals. | Eliminated |
| | | Vitrification | Combining excavated soil with molten glass and cooling to a stable, noncrystalline solid. This method encapsulates and strips or destroys contaminants. Decreases mobility of contaminants. | Potentially applicable for VOCs, SVOCs, cyanides, corrosives, non-volatile metals, and radiologicals. | Applicable for soils/waste of homogeneous nature. Homogenizing waste/containers and providing vapor controls can be cost prohibitive. Not fully demonstrated technology. | Eliminated |
| | | Incineration | Combustion in a rotary kiln incinerator, fluidized-bed incinerator, infrared incinerator, or circulating bed combustor. Decreases toxicity of contaminants. | Hydrocarbons, pesticides, PCBs, VOCs, SVOC (metals or salts create additional treatment problems). | Most commonly used method for treatment of organic contaminated soils. Soils with some hazardous metals at high concentrations may not be accepted for incineration. Material must be sized before treatment. | Retained |

Table C-1. Screening of Source Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | Pyrolysis. | Combustion by radiation in refractory lined chamber in the absence of oxygen, reducing the toxic organic constituents to elemental gas and water. Decreases toxicity of contaminants. | Waste with low BTU content, PCB, dioxin, heavily halogenated organics, nerve gas, pesticides, asbestos, and cyanide. | Not effective for metals. Material must be sized prior to treatment. Not proven to be cost effective. | Eliminated |
| | Biological treatment | Aerobic slurry phase bioreactor | Biodegradation of soils and sludges mixed with water in a soil/water slurry reactor using either naturally-occurring microorganisms or bioaugmentation with specialized inocula. Decreases toxicity of contaminants. | Waste with PCBs, dioxin, heavily halogenated organics, nerve gas, explosives, pesticides, asbestos, and cyanide. Applicable to fine and coarse-textured soils. | Not an effective treatment for metals. Requires stabilization of treated soils if metals are present. Treated material will require dewatering/ treatment/disposal. Not an effective method for soils containing chlorinated organic compounds. | Eliminated |
| | | Anaerobic degradation | Degradation of organics using microorganisms in an anaerobic environment. Decreases toxicity of contaminants. | Organics, metals, pesticides, PCBs, halogenated volatile organic hydrocarbons (some metals, salts, radioactive materials, corrosives, and cyanides may inhibit the process). | Not effective for metals. Possible contaminant migration during treatment. Slow rate of treatment. Not proven to be effective, especially in the presence of free product/DNAPLs. | Eliminated |
| In Situ Treatment | | In-situ mixing/encapsulation | An in-situ method stabilizing contaminants through chemical stabilization/solidification. An auger with spray attachment mixes Portland cement, clays, fly ash, or kiln dust to solidify soils. | Applicable where source is clearly identifiable or confined and can be used in multitude of soil types ranging from granular soils to dense clays or soils containing stones or modest size debris. | This technology is effective for both inorganic/ SVOC contaminated soils. Time required to implement this technology is comparatively lower than excavation/treatment. Can be coupled with in-situ hot-air/steam injection for treatment of volatile compounds. | Retained |
| | | In situ air sparging | Injecting air into soils to enhance volatilization, coupled with collection and treatment of gases and condensate. Decreases volume of contaminated material. | Organics. | Not effective for SVOCs and metals. Due to presence of low- permeability material (clay/silt), air sparging is not feasible. | Eliminated |
| | | Soil flushing | Use of extraction/reinjection system to flushing soil with surfactant or co-solvent to mobilize contaminants in the soil pores for extraction and treatment Decreases volume of contaminated material. | Hydrocarbons, metals, pesticides, PCBs, VOCs, and SVOCs adsorbed to the soil. | Flushed material must be treated before disposal. Cannot flush material inside containers. Potentially applicable for remediation of residually contaminated soils/secondary source. | Retained |

Table C-1. Screening of Source Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | Chemical oxidation | System of injection wells or trenches deliver oxidizing agents to contaminated soils to raise the oxidation state of the contaminant. Often an effective pretreatment for biological treatment, Decreases toxicity of contaminants. | Benzene, phenols, most organics, cyanide, arsenic, iron, manganese. | Bench- and/or pilot-scale testing necessary to determine appropriate chemical feed rates and retention times. Undesirable byproducts may be formed. Has not been widely used in treating hazardous waste. May not be effective in the presence of free-phase liquids. | Eliminated |
| | | Chemical reduction | System of injection wells or trenches to deliver reducing agents to contaminated soils, reducing the oxidation state of the contaminant to reduce toxicity or solubility or to transform it into a form which can be more easily handled. Decreases toxicity of contaminants. | Chromium (VI), mercury, lead, silver, PCBs, unsaturated hydrocarbons. | Well accepted treatment method for some metals. Bench- and pilot-scale studies necessary for more complex waste streams. May not be effective in reducing source material migration. | Eliminated |
| | | Electrical separation (Electrokinetics) | Application of a direct current to remove the contaminants through the mass transfer mechanisms of advection, diffusion, and ion migration. Decreases volume of contaminated material. | Uranium and heavy metals. Has been tested at United Chrome Superfund site near Corvallis, OR. Enhanced hydraulic leaching. | Precipitation of salts and secondary minerals could decrease effectiveness. Not applicable for organics. | Eliminated |
| | Thermal treatment | Radio frequency heating | Heating soil mass to enhance volatilization and cause chemical bond cleavage, coupled with collection and treatment of gases and condensate, Decreases volume of contaminated material. | VOC/SVOCs that typically volatilize 80-300°C (not metals or salts). | Currently in pilot- and field-scale demonstration stage. Not fully demonstrated its effectiveness in reducing source material. | Eliminated |
| | | In-situ vitrification | Electrodes inserted into soil to melt soil and volatilize organics, coupled with collection and treatment of gases. This method encapsulates and strips or destroys contaminants. Reduces mobility of contaminants. | Radioactive metals. May be effective for VOCs, SVOCs, PCBs, pesticides, metals, cyanides, and corrosives. | Waste should be homogenized before vitrifying. Application is limited to soils with organic compounds less than 10 percent weight basis. | Eliminated |
| | | In-situ mixing/hot air & steam stripping | In-situ mixing of soil using augers with hot air and steam Injection to enhance volatilization. A specially designed bore hole shroud will be used contain resulting off-gases to be removed under controlled conditions for treatment prior to disposal. | Must have good vapor pressure in soil. Effective for VOCs and possibly some SVOCs. | Applicable to wide range of soil/geologic material. Can be effectively used in the presence of free-phase VOCs. Applicable for treating soils up to 100 feet deep. Requires a second step of in-situ solidification if metals/inorganic compounds are present. | Retained |

Table C-1. Screening of Source Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Waste Disposal Area, Chapel Hill, North Carolina.

| General Response Action | Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | Biological treatment | Aerobic bioremediation | Extracting, adding nutrients and oxidants to, and reinjecting groundwater to enhance aerobic degradation of organics in soils below the vadose zone (e.g., methanotrophes added to treat for chlorinated organics such as PCB), Decreases toxicity of contaminants. | Organics (metals, salts, radioactive material, corrosives, and cyanides may inhibit process). | Limited area and soil types. Not effective for metals. Not effective in areas containing free- phase liquids. Not applicable for most chlorinated aliphatic compounds. | Eliminated |
| | | Anaerobic biodegradation | Degradation of organics using microorganisms in an anaerobic environment. Decreases toxicity of contaminants. | Organics (metals and salts may inhibit process). | Limited area and soil types. Not effective for metals. Can be effective for soils contaminated with chlorinated aliphatic compounds. Not effective in areas containing free-phase liquids or chemical containers/source material. | Eliminated |
| | | Phytoremediation (phytocap) | Installation of trees/vegetation (ex. hybrid poplar trees) which can quickly establish a dense canopy and deep rooting system. The trees and vegetation reduce precipitation from entering the landfill. This is accomplished by intercepting rainfall by the tree canopy and extraction of moisture from the ground due to plant respiration. In addition, an engineering cap system will reduce moisture during non-growing season. | Landfills and soils contaminated with organics and metals. | Tree growth requires approximately 2 years; therefore, it may not be immediately effective. Since the vegetation will not respire during night, continuous prevention of infiltration may not be possible without an engineered cap. In addition, this system is not effective for reducing source material below water table or free-phase liquids. | Eliminated |

Table C-2. Screening of Groundwater Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Disposal Waste Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| No Action | None | Not applicable | No action. | All contaminants. | Does not meet State/Federal regulatory requirements. No action can be used as a baseline for comparing with other alternatives. | Retained for comparison purposes |
| | | Natural attenuation | Groundwater is not treated and is allowed to naturally decontaminate itself through dispersion, diffusion, adsorption, or biodegradation. | Organic and inorganic compounds. | Does not meet regulatory requirements by itself, but may be used in combination with other technologies for groundwater remediation. It can also be as natural remedy for low concentration plumes after remediating the hot spots. | Retained |
| Institutional Action | Covenants | Deed/water right restrictions | Deeds for property in the area of influence would include restrictions on use of wells. | All contaminants. | Does not meet regulatory requirements by itself, but may be used in combination with other technologies for groundwater remediation. | Retained |
| | Permit programs | Land use restrictions | Implement zoning restrictions to prevent development or restrict land use of land overlying contaminated groundwater. | All contaminants. | Does not meet regulatory requirements by itself, but may be used in combination with other technologies for groundwater remediation. | Retained |
| Collection/Treat-ment/Disposal | Extraction | Extraction wells | A series of vertical and/or horizontal well points, suction wells, ejector wells, or deep wells to extract contaminated groundwater. Good for steep hydraulic gradient, high hydraulic conductivity, and when quick removal not necessary. Could be placed to intercept with discharge areas. | Contaminants that are miscible and move readily with water in aquifers that have high conductivity. | Conventional method for groundwater containment/remediation. | Retained |

Table C-2. Screening of Groundwater Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Disposal Waste Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | Vacuum enhanced recovery (VER) wells | Applying high vacuum to enhance recovery of groundwater. Due to application of vacuum, effective radius of influence of groundwater recovery will be higher than that of a conventional recovery well, resulting in fewer wells, Particularly applicable in low- permeability soils. | In low-permeability soils to increase yield. To cleanup soil contamination. Application of vacuum to remove free product groundwater in shallow depth using drop tube. | May require treatment of vapors generated by the application of vacuum. Increased cost due to added vacuum pump and vapor treatment if required). However, mass recovery of total fluids (vapors/water) will speed up the cleanup process. | Retained |
| | | Interceptor trenches | Perforated pipe in trenches backfilled with porous media to collect contaminated air and groundwater. Serves as a "sink" to hydraulically isolate a plume. Commonly used with a barrier wall or shallow contamination. | Aquifers that have high conductivity. | It is a passive method of groundwater extraction. Effective in shallow aquifers and may require shoring/dewatering if trenching exceeds 15 feet. Not economical to construct a trench in bedrock. | Eliminated |
| | Disposal | Discharge to stream | Extracted water discharged to stream without treatment. | Depends on NPDES requirements (contaminant loading, presence of sensitive ecosystems, etc.). | Most common method to dispose treated wastewater/groundwater. Depending on the classification of the creek, discharge limits can be more stringent than the groundwater standards. | Retained |
| | | Infiltration gallery | Reinjection of extracted water into shallow aquifer after treatment. | Depends on requirements of Non-Discharge permit requirements. | Requires permeable subsoil to infiltrate treated water. Requires large area upgradient of the contaminant plume for infiltration due to clayey subsurface. | Eliminated |
| | | POTW | Extracted water discharged through POTW. | Depends on permit requirements. | Local sewer will accept treated groundwater. UNC may negotiate a direct connection in future. | Retained |
| | Treatment (Physio-chemical) | Precipitation/flocculation | Alteration of chemical equilibria to reduce the solubility of contaminants, transforming some or all of a substance in solution into a solid phase. | Most metals, some anionics (P,S,F). Doesn't work well with organics or cyanide. | This technology can be used to treat iron and manganese as a part of the treatment system. Labor intensive operation. Generates large volumes of sludge. | Retained |

Table C-2. Screening of Groundwater Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Disposal Waste Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | Air stripping | Counter-current mixing of large volumes of air with water in a packed column to promote transfer of VOCs to air. | Volatiles (Henry's Law Constant > .003, e.g., trichloroethane, trichloroethylene, chlorobenzene, vinyl chloride, dichloroethylene). Not applicable for dissolved heavy metals. | Proven method for removal of numerous VOCs. May require vapor-phase treatment (off-gas). Less effective for semi-volatiles. | Retained |
| | | Activated carbon adsorption | Adsorption of contaminants onto activated carbon by-passing water through carbon column. Frequently used after biological treatment, filtration, or air stripping. The carbon becomes a hazardous or solid waste and must be regenerated or disposed of in accordance with regulation. | Mixed organics (volatile organics, semi-volatile compounds, and some pesticides (metals may foul the carbon). | Contaminants with higher molecular weight, lower water solubility, and a neutral or non-polar chemical nature are easily adsorbed on the carbon. For highly concentrated contaminants, this technology may not be cost effective as a sole treatment method. Can be used in combination with other technologies, such as air stripping, for polishing. | Retained |
| | | Reverse osmosis | Use of high pressure to force water through a membrane leaving contaminants behind. Usually a polishing stage for low-flow waste streams. | Dissolved organic and inorganic solids (fluoride, TDS, sodium, salts, metals), | Subject to chemical attack, fouling, and plugging. Pretreatment necessary to get rid of particulates, oil, grease, and film. Not as cost effective as other treatment technologies. | Eliminated |
| | | Steam stripping | Counter-current contact of steam with water in a packed column to strip VOCs and allow recovery in condensate, Thermal or activated carbon treatment of off-gases and condensate. | Organics, some semi-volatiles, ammonia, cyanides. | Costs are typically high compared to other treatment technologies, such as air stripping. | Eliminated |
| | | Ion exchange | Contaminated water is passed through a resin bed where toxic ions are exchanged for relatively harmless ions held by the resin. Different designs allow targeting of specific groups of ions, | All metallic elements when present as soluble species, inorganic anions (halides, sulfates, nitrates, cyanides), organic acids (carboxylics, sulfonics, some phenols), organic amines. | Not suitable for treatment of volatile organics. No dissolved heavy metals were found to exceed the groundwater standard at the site. | Eliminated |

Table C-2. Screening of Groundwater Remediationl Technologies, The University of North Carolina at Chapel Hill, Airport Road Disposal Waste Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | UV/chemical oxidation | Contaminants in water are oxidized to carbon dioxide and water using oxidants such as ozone, hydrogen peroxide, potassium permanganate, calcium or sodium hypochlorite, chlorine gas, and/or UV light. | Cyanide and oxidizable organics (e.g., aldehydes, mercaptans, phenols, benzidine, unsaturated acids, certain pesticides), possibly chlorinated organics (COE treatability study). Some limitations due to contact time. | Oxidation reactions frequently are not complete and may form a more toxic oxidation product. High operation and maintenance (O&M) costs. | Eliminated |
| | | Chemical reduction | Oxidation state of contaminants is reduced using sulfite salts, sulfur dioxide, or base metals (Fe, Al, Zn). Usually followed by precipitation or other treatment. | Hexavalent chromium, mercury, lead, | No dissolved heavy metals were found to exceed the groundwater standard at the site. | Eliminated |
| | | Filtration | Suspended solids removed by forcing fluid through porous medium (usually sand or sand and anthracite or coal). Often proceeded by sedimentation. | Suspended solids. | Only marginally effective in treating colloidal size particles. Must often be preceded by flocculation. May be used in combination other treatment technologies. | Retained |
| | | Sedimentation/ clarification | Gravity causes suspended solids to settle out. | Suspended solids. | Produces large amounts of sludge. Often used with precipitation/flocculation. This technology can be used if high solids are encountered in the extracted groundwater. | Retained |
| | | Electrokinetics | Application of a direct current to remove the contaminants through the mass transfer mechanisms of advection, diffusion, and ion migration. | Metals. | Applicable for metals removal and not applicable for treating organics. Not demonstrated to be effective. | Eliminated |
| | | Neutralization | Adding acid or base to adjust pH of waste. Pretreatment for biological treatment, carbon adsorption, ion exchange, air stripping and redox processes. | All contaminants requiring pH control. | Groundwater is expected to be near neutral at the site. Not applicable for organics. | Eliminated |

Table C-2. Screening of Groundwater Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Disposal Waste Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | Thermal treatment | Wet air oxidation | Aqueous-phase oxidation of dissolved or suspended organic substances at 350- 650°F and 300-3,000 psi. | Streams containing pesticides, herbicides, and other organics or oxidizable inorganics. | Not practical and typically more costly than other treatment technologies. | Eliminated |
| | | Plasma arc torch | Wastes atomized, ionized, and destroyed when they come in contact with a gas that has been energized to its plasma state by an electrical discharge. | Used for destruction of materials containing carbon, hydrogen, and oxygen. | Cannot handle wastes with nitrogen, sulfur, or sodium content. May not be cost effective. | Eliminated |
| | Biological treatment (aerobic) | Activated sludge/trickling filter/rotating biological contactor, aerated lagoon, and engineered wetlands | Enhanced biodegradation in a continuous flow system with recycle of sludge. | Aerobically biodegradable organic compounds. | High maintenance. Not applicable for groundwater with anaerobically degradable compounds. | Eliminated |
| | | Fluidized bed reactor | Biodegradation in a closed bioreactor that contains an expanded bed of high- surface-area support material. Methane is a by-product. | Volatile organics, chlorinated solvents. | Not cost effective. Requires high maintenance. | Eliminated |
| In-Situ Treatment | Physicochemical treatment | Chemical oxidation | System of injection to inject oxidizer such as hydrogen peroxide or ozone to degrade contaminants. | Cyanide and oxidizable organics (e.g., aldehydes, mercaptans, phenols, benzidine, unsaturated acids, certain pesticides), possibly chlorinated organics (COE treatability study). Some limitations due to contact time. | Oxidation reactions frequently are not complete and may form a more toxic oxidation product. This method is becoming a more popular in-situ treatment method. | Retained |
| | | Electrokinetics | Contaminants migrate under the action of an applied electrical field. | Metals. | Technology is not fully demonstrated in the field and is applicable only for metals. | Eliminated |
| | | Air sparging | Injecting air into groundwater to enhance volatilization. Coupled with collection and treatment of gases and condensate. | Good for volatiles in groundwater. Cannot be applied where free product is present. | Limited application in clayey soils and bedrock. Cannot be used where free product/DNAPLS are present. | Eliminated |

Table C-2. Screening of Groundwater Remediation Technologies, The University of North Carolina at Chapel Hill, Airport Road Disposal Waste Area, Chapel Hill, North Carolina.

| General Response Action | Remedial Technology Type | Process Options | Description | Applicability | Limitations | Selection Status |
|---|---|---|---|---|---|---|
| | | Reactive walls/permeable treatment beds | Downgradient trenches backfilled with activated carbon, iron, mulch or other appropriate material to remove contaminants from water. The trench can also be supplemented with iron filings or installing sparging points for reducing contaminants. | Organics, metals. | Could be an economical containment system. Has minimum operation and maintenance requirements. Requires careful evaluation of treatment method. Not applicable in bedrock. Long-term effectiveness is not known. | Retained |
| | Thermal treatment | Steam stripping/injection | Injecting steam into groundwater to enhance volatilization. Coupled with collection and treatment of gases and condensate. | VOCs and some semi-volatile organics. | Requires a cost-effective steam source, which can be expensive. Difficult to apply in bedrock aquifer. | Eliminated |
| | Biological treatment | Bioreclamation/biosparging | System of injection and extraction wells introduce bacteria and nutrients to degrade contamination (aerobic process). | Organics. | Applicable only to aerobically biodegradable compounds and not effective for anaerobically degradable compounds. | Eliminated |
| | | Phytoremediation | Installation of trees or vegetation which establishes a deep rooting system. The plant system can extract contaminated groundwater. The extracted contaminants can be either degraded, bioaccumulated, or evapotranspired. | Organics, inorganics, and metals. | Vegetative growth requires a year or two to be established. May not be effective during night. Not effective for contaminants in the deep groundwater system or DNAPLs. | Eliminated |