35809

DRAFT FEASIBILITY STUDY REPORT

BALLY ENGINEERED STRUCTURES SITE
BALLY, PENNSYLVANIA

"REALISTIC SOLUTIONS FOR HAZARDOUS WASTE PROBLEMS"

REMCOR

DRAFT FEASIBILITY STUDY REPORT

BALLY ENGINEERED STRUCTURES SITE
BALLY, PENNSYLVANIA

PREPARED FOR

ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

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REMCOR, INC.
PITTSBURGH, PENNSYLVANIA

"REALISTIC SOLUTIONS FOR HAZARDOUS WASTE PROBLEMS"

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1.0 INTRODUCTION

This Feasibility Study (FS) Report has been prepared by Remcor, Inc. (Remcor) on behalf of our client, Allegheny International, Inc. (AI). This report is in partial fulfillment of the requirements of an Administrative Order by Consent (Order), issued under Section 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for performance of a remedial investigation/feasibility study (RI/FS) at the Bally Engineered Structures, Inc. (BES) Site in Bally, Pennsylvania. The final Order is dated January 28, 1987 (U.S. Environmental Protection Agency [EPA], January 1987). In preparing this FS Report, Remcor has consulted the following applicable guidance published by the EPA:

- "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, August 1988)
- "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites" (EPA, March 1988).

The BES Site consists of an active manufacturing facility and the aquifer in its immediate vicinity and generally within the Borough of Bally. The site is located approximately 12 miles south of Allentown, Pennsylvania, along Route 100 (Figure 1). An RI was conducted in 1987 and 1988 and is reported in "Draft Final Phase III Remedial Investigation Report - Bally Engineered Structures Site" (Remcor, May 1989). Pertinent site data conclusions relative to the nature and extent of ground water contamination and assessment of public health and environmental concerns have been taken from the RI Report and presented in this document. The RI Report should be consulted for more detailed information.

1.1 PURPOSE AND ORGANIZATION OF THE FEASIBILITY STUDY REPORT

Ground water serves as a primary source of the municipal water supply to the Borough of Bally, Pennsylvania, supplementing springs to the northwest of the Borough. In 1982, chlorinated volatile organic compounds

(VOCs) were detected in both municipal water supply wells (Municipal Well Nos. 1 and 3), resulting in Municipal Well No. 3 being removed from the supply system. The principal chlorinated VOCs contributing to aquifer contamination are 1,1,1-trichloroethane (TCA), 1,1-dichloroethene (DCE), and trichloroethene (TCE).

An RI was conducted to determine the source, as well as the extent, of VOC contamination within the aquifer and to assess concerns relative to public health and environmental receptors. The RI data indicate that routine spillage of solvents at the BES plant from the 1950s until the early 1970s may have been a significant contributor to current aquifer contamination. The RI determined that no ongoing release of VOCs to the aquifer is occurring from the BES facility.

The purpose of the current FS Report is to define remedial action objectives and remediation levels specific to the BES Site ground water contamination. In addition, remedial action alternatives are developed and evaluated to define the optimal approach to site remedial action. Among the evaluation criteria are effectiveness, implementability, cost, and public acceptance. The selected remedial alternative is required by CERCLA to be adequately protective of public health and the environment and to attain applicable or relevant and appropriate requirements (ARARs). ARARs encompass regulations, cleanup standards, or other requirements or guidance promulgated pursuant to federal or state laws to ensure protection of human health and the environment.

The remainder of Chapter 1.0 presents a summary of the aquifer contamination problem and baseline risk assessment. Remedial action objectives and remediation levels are established in Chapter 2.0 of the FS Report, based on review of public health and environmental concerns evaluated in the RI Report (i.e., baseline risk assessment) and the ARARs. General response actions (GRAs) are then defined to address the remedial action objectives. Appropriate remedial technologies are identified and screened for applicability. Due to the absence of an active source at

the BES Site, source control response actions are not appropriate. Actions evaluated in this FS Report focus on either natural attentuation of the aquifer or active restoration of the aquifer and provision of an alternative water supply.

Chapter 3.0 presents a development of remedial action alternatives by assembling appropriate technologies and treatment process options. These alternatives are then subjected to a detailed evaluation.

Chapter 4.0 summarizes the detailed evaluation and provides recommendations for selection of the remedial action alternative at the BES Site.

1.2 SUMMARY OF AQUIFER CONTAMINATION PROBLEM

1.2.1 Description of Current Situation

The BES Site Phase III RI data show that a ground water plume of VOC contamination consisting of TCA, TCE, and DCE extends from the BES plant to the east and northeast. Figures 2, 3, and 4 show VOC isoconcentration contours for the shallow, intermediate, and deep wells, respectively, based on the data collected during the RI. The plume configuration and the presence of increasing levels of VOCs with depth near Municipal Well No. 3 suggest that full-scale pumping of the municipal well had the effect of drawing the VOCs deeper into the aquifer and to the north toward the well. Pumping started in 1979, and Municipal Well No. 3 was removed from the water supply system in 1982.

Based on the initial indication in 1982 that samples from Municipal Well No. 3 contained unacceptable levels of VOCs, use of this well for public water supply was terminated. This action forced the Borough of Bally to use Municipal Well No. 1 and a series of springs to the northwest of the Borough of Bally as the municipal water supply. This operation had previously been used to supply the Borough of Bally from 1959 through

1979, prior to bringing Municipal Well No. 3 on-line. Pumping of Municipal Well No. 3 at reduced rates was continued to permit extraction of the contaminated ground water from the aquifer. This practice was eventually discontinued in March 1987.

In response to the reduced pumping and eventual cessation of pumping at Municipal Well No. 3, the contaminant movement has become more controlled by the natural ground water flow direction to the east. Ground water and contaminant migration have also been influenced by the pumping of Municipal Well No. 1, as well as production wells at the Great American Knitting Mills (Great American Knitting) and Bally Ribbon Company (Bally Ribbon).

A partial dependence on Municipal Well No. 1 has created the need for an alternative water supply. To address this problem, Remcor was retained in 1987 by AI to design and install a wellhead treatment system at Municipal Well No. 3 concurrent with the performance of the RI. Design, permitting, and implementation of an air stripping system has been completed at this time. This treatment system consists of two packed towers with forced draft blowers capable of treating up to 300 gallons per minute (gpm) of ground water. The air stripping system was installed to serve two purposes:

- To permit Municipal Well No. 3 to be used to supplement the municipal water supply
- To serve as a potential ground water extraction and treatment point to control the spread of VOCs and to remove them from the aquifer.

1.2.2 Probable Source of Aquifer Contamination

Additional studies of the aquifer contamination problem were performed in 1983 by the Pennsylvania Department of Environmental Resources (PADER) and the EPA (PADER, March 28, 1983; Zima, et al., September 20, 1985). Although unaware of any sources of the VOC contamination resulting from its activities, BES met with PADER in 1984 and retained

Environmental Resources Management (ERM) in 1985 to perform aquifer characterization studies to determine the source of contamination of Municipal Well No. 3. The results of the ERM study indicated that the BES plant was a likely source of the VOC contamination found in the aquifer (Funk and Smith, October 27, 1986).

Manufacturing activities at the BES plant began in the 1930s with the production of high-quality cabinets and cedar chests by the Bally Case and Cooler Company (BCC). Production facilities were briefly commissioned in the 1940s by the government to assist in the war effort. In the 1950s, the main product line became porcelain-coated meat display cases and porcelain panels for use in constructing building facades. In 1972, BCC was acquired by Sunbeam Corporation (Sunbeam) and became a subsidiary of AI in 1982 with AI's acquisition of Sunbeam. In 1984, BCC was renamed Bally Engineered Structures, Inc. in response to an increased emphasis on the manufacture of insulated panels and product diversification. On June 23, 1987, the business was purchased by BES management, while AI has retained the plant and associated grounds.

Initial use of degreasing agents by BCC was concurrent with the switch to urethane foam as the display case insulating material. To store degreasing agents, a tank with a nominal capacity of 2,000 gallons was installed at the former degreasing area located in the northeastern portion of the plant (current Carpentry Shop). Figure 5 provides a plan of the current BES plant, noting potential source areas investigated in the RI. Prior to the fabrication of the porcelain shells and installation of the foam insulation, an overhead monorail crane was used to dip the entire case into the degreasing tank. Following dipping, the cases were set on the floor and permitted to dry before being returned to the production line. The only solvent used in the former degreasing area tank was TCE. Use of this degreasing tank was discontinued in approximately 1969, with the end of the case manufacturing operations.

A second degreasing area known as the "small parts degreasing area" (Figure 5) has been in use since the early 1960s for degreasing small parts used in interlocking the insulated panels. The tank at this location has a nominal capacity of 600 gallons, but usually contains less than 400 gallons of solvent. Methylene chloride, tetrachloroethene (PCE), and TCA were used in this degreasing tank at various times. No chlorinated solvents have been used in this operation, however, since August 1986.

A variety of chlorinated and nonchlorinated solvents have also been used as flushing agents to clean molds and urethane foam injection nozzles between mold shots in the Foaming Department (Figure 5). This activity has been ongoing since the initial use of urethane foam in the production process in the mid-1960s.

Aerial photographs show four lagoons to have existed on the BES property from 1955 through 1970 (Figure 5). The first series of two lagoons was apparently constructed prior to May 1955 and was backfilled prior to the mid-1960s as the plant buildings expanded to the southwest. At about this time, two additional lagoons were apparently constructed further to the south. The latter two lagoons were eliminated because production of the porcelain-faced meat display cases had ceased in the late 1960s. The present plant office was constructed in this area in 1970. All four lagoons were shallow, diked structures that may have received some spent degreasing solvents.

In advance of the Phase III RI, much of the discussion of potential sources of the VOC ground water contamination from the BES plant had focused on these four lagoons. However, investigation of these former lagoons during the Phase III RI did not identify them as sources of VOC contamination. Likewise, investigations in the vicinity of the two degreasing tanks and of the current Carpentry Shop also did not succeed in identifying a current source of the VOC ground water contamination.

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Because a source had not been located during the Phase III RI, the EPA requested additional source investigations, consisting of a series of 16 soil borings and limited ground water sampling, immediately to the north of the BES plant (Figure 5). The rationale was that shallow wells located immediately north of this area evidence the highest VOC levels found in the shallow portion of the aquifer. This investigation was performed in March 1989 and determined that no current source of VOCs exists in the unsaturated zone soils in this area.

The collective results of the source delineation investigations indicate that none of the suspected source areas is an active source of the current aquifer contamination. This fact suggests that the contamination found in the aquifer may have originated as a result of historic, routine spillage of solvents containing the chlorinated VOCs during their use at BES. These activities would most likely have occurred over a protracted period from the late 1950s until the early 1970s. There is no evidence that this release is ongoing.

1.2.3 Results of Baseline Risk Assessment

1.2.3.1 Contaminants of Concern

Investigation of the BES Site was initiated because chlorinated VOCs were detected at Municipal Well No. 3 in October 1982. The earliest site investigation, performed by the EPA Region III Field Investigation Team (Zima, et al. September 20, 1985), included analysis of environmental samples for in organics and semivolatile organic compounds, as well as VOCs. No contaminants of concern other than VOCs were identified. The focus of subsequent investigations has been primarily on VOCs. Samples collected from Municipal Well No. 3 during the Phase III RI were analyzed for semivolatile organics, with none detected.

The BES plant history indicates use of the chlorinated solvents TCE, TCA, PCE, and methylene chloride. All of these VOCs, as well as DCE and dichloroethane (DCA), which are common decomposition products of TCE and

TCA, respectively, have been detected in the aquifer. Four of these six compounds are probable or possible human carcinogens. Because of their known use at BES, their presence in ground water, and the relationship of some of the compounds to others, the entire set of six VOCs was retained as contaminants of concern in the Phase III RI endangerment assessment.

1.2.3.2 Exposure Assessment

The most probable route of human exposure to contaminants resulting from the BES Site is exposure to VOCs in ground water. All Bally residents (approximately 4,500 individuals) use ground water supplied by the Borough of Bally as their source of potable water. The municipal water supply evidences low levels of VOC contamination, and Bally residents using this water can be exposed to VOCs via ingestion, bathing, showering, dishwashing, and food preparation.

One private well that was determined to be contaminated with VOCs is no longer in use as a potable supply (i.e., Mabel Gehman Well, Figure 3). If not institutionally prohibited, future owners of this property could access this well for potable uses. Other property owners in areas where ground water is contaminated could also install new wells, and exposure to these VOCs could occur.

Bally came to rely on Municipal Well No. 1 to supplement the supply from the springs after Municipal Well No. 3 was taken out of service because of VOC contamination. Under current conditions, Bally residents are, in a worst-case scenario, exposed to the low concentrations of VOCs detected in Municipal Well No. 1. This is considered a worst-case scenario because these concentrations are likely to be reduced by dilution with clean water derived from the springs that supplement the supply. During the spring of the year, the water supply is derived solely from the springs, and exposure to contaminated ground water would be absent.

Upon successful completion of the air stripping treatment system at Municipal Well No. 3, the Borough of Bally intends to use this well as the primary supply well, in addition to continuing to use the springs. After the treatment system is implemented, exposure to VOCs from the water supply will be controlled. The maximum allowable concentrations of the VOCs in the effluent from the air stripping unit at Municipal Well No. 3 are as follows:

- TCE, 1 micrograms per liter (µg/ℓ)
- TCA, 200 µg/ℓ
- DCE, 0.63 µg/ℓ.

This is a conservative assumption because at times the treated water from Municipal Well No. 3 will be diluted by spring water, and, at other times, spring water alone will supply the Borough of Bally.

Ground water from wells located at both Great American Knitting and Bally Ribbon contains low levels of VOCs. No specific source for the VOCs at these wells has been identified. While ground water from the wells is used for process water supply, both companies use municipal water for potable purposes. The process water is used for dying, fixing, and steaming socks at Great American Knitting; at Bally Ribbon it is used for dying and washing ribbon. In both operations, the water is heated, and VOCs in the water are likely to volatilize so that inhalation exposure could occur.

There is a low probability of exposure of aquatic or terrestrial biota to chemicals associated with the BES Site. Land use within the Borough of Bally is largely dedicated to residential, agricultural, and industrial development. The only potential for adverse environmental impact from the site may occur east of Route 100. There is some evidence that ground water may be discharging to the unnamed tributary to the southeast of the BES plant, in the area of MW87-10I and MW87-10D (Figure 2).

One downstream surface water and sediment sample exhibited low levels of VOCs. Two potential routes of exposure to these VOCs are dermal absorption and accidental ingestion by children potentially playing in the stream.

The only potentially sensitive habitat element in the site area is a man-made wetland near Municipal Well No. 3. This wetland is actually an abandoned mill pond fed by the unnamed stream flowing by Municipal Well No. 3. The RI data indicated that there is no potential for discharge of contaminated ground water into this wetland. There are also no known records of any special status federally-listed species in the BES Site area (McCoy, September 9, 1988).

1.2.3.3 Risk Assessment

During the Phase III RI (Remcor, May 1989), risks of both carcinogenic and noncarcinogenic health effects were estimated for all of the exposure pathways identified in the exposure assessment. Risks for the ground water exposure route, which considered ingestion and inhalation during showering, were calculated for a worst-case current municipal water-supply scenario and for worst-case future municipal water supply and hypothetical residential well use scenarios. Other exposure pathways addressed were inhalation of VOCs from process waters at local industries (i.e., Great American Knitting), regardless of contaminant sources, and dermal contact and accidental ingestion of contaminated surface water. Exposure of aquatic biota to contaminated surface water was also considered. A detailed discussion of public health and environmental concerns may be found in Chapter 5.0 of the Phase III RI Report.

Carcinogenic risks were estimated using estimated doses and compound-specific carcinogenic potency factors. The cumulative carcinogenic risk estimated for use of the current municipal system, considering no dilution of water from Municipal Well No. 1 with uncontaminated spring water, is 1.0×10^{-3}, or one additional incidence of cancer in an

exposed population of 1,000 people, based on lifetime exposure. The cumulative carcinogenic risk estimated for the future municipal supply system (treated Municipal Well No. 3) is 3.3×10^{-5}. The estimated carcinogenic risk associated with lifetime use of a private residential well hypothetically installed in a highly contaminated portion of the aquifer is 1.8×10^{-2}, and the estimated carcinogenic risk to children contacting contaminated surface waters is 2.5×10^{-8}. Indoor air contaminant concentrations estimated at Great American Knitting are thousands of times less than those suggested as acceptable in the work place by the American Conference of Governmental Industrial Hygienists (ACGIH).

Noncarcinogenic risks were qualitatively estimated by comparing estimated doses to acceptable, compound-specific reference doses. These comparisons form a numerical ratio known as the Hazard Index (HI). A HI less than one indicates acceptable noncarcinogenic risks. HIs were calculated to be less than one for all exposure scenarios except the hypothetical future use of a highly-contaminated residential well; which would, therefore, present an unacceptable noncarcinogenic health effect risk (Table 1).

Based on water quality criteria, surface water concentrations do not present unacceptable risks to biota. Surface water concentrations detected in the unnamed tributary east of Route 100 were generally two orders of magnitude less than acceptable criteria.

Table 1 summarizes estimated current and potential future health risks that may be attributable to the aquifer contamination in the Borough of Bally.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 REMEDIAL ACTION OBJECTIVES

2.1.1 Contaminated Media and Exposure Pathways

The medium that requires remediation at the BES Site is ground water. The exposure pathway that is most critical is potable use through the municipal supply system. Under the current ground water supply configuration in Bally, residents are exposed to VOCs in ground water extracted at Municipal Well No. 1. This well is used, in conjunction with uncontaminated spring water, for potable water supply within the Borough. The ground water exposure routes that incur the predominant risks are ingestion and inhalation during showering. Worst-case cumulative carcinogenic risks have been calculated for these exposure routes for both the current water supply system and for the proposed future water supply system (Table 1). During the past two years, BES and the Borough of Bally have taken action to provide treatment of ground water from Municipal Well No. 3 as a supplement to the springs. This approach reduces reliance on water from Municipal Well No. 1 as the primary source of supply.

The worst-case for both current and future water supply systems considers no use of (or dilution by) uncontaminated spring water. Although this is not the actual case under either system, the configuration of the supply piping makes it difficult to determine the actual contribution of either source to the water arriving at the tap. A single line carries pumped water to the reservoir and distributes water from the reservoir to the supply system. The estimated worst-case carcinogenic risk with use of the current water supply system is 1.0×10^{-3}. Under the proposed future system (use of treated water from Municipal Well No. 3), the worst-case risk is 3.3×10^{-5}. The risk of noncarcinogenic health effects was estimated to be acceptable for both current and proposed water supply systems.

Potable use of ground water from residential wells within the Borough is not currently taking place. Risks were estimated for the hypothetical future use of wells installed within the most contaminated portion of the aquifer. The estimated carcinogenic risk is 1.8×10^{-2}; the noncarcinogenic risk was estimated to be unacceptable.

2.1.2 Identification of ARARs

ARARs are cleanup standards that must be attained under CERCLA, as amended. ARARs are defined as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site

- Relevant and appropriate requirements are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not technically applicable to a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance at a Superfund site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited (EPA, March 1988).

Compliance with ARARs is necessary at three junctures within the RI/FS process:

- Setting remediation levels

- Setting action-specific requirements related to operating treatment processes

- Managing treatment residuals.

Consistent with these ARAR uses, ARARs fall into the following three categories:

- Chemical-specific ARARs
  - These ARARs are health- or environment-based numerical values limiting the amount of a contaminant that may be discharged to or allowed to remain in the environment. These include, for example, maximum contaminant levels (MCLs) established under the Safe Drinking Water Act (SDWA). These are used for establishing preliminary remediation levels.
- Action-specific ARARs
  - These ARARs are technology- or activity-based limitations that may provide performance standards or practice standards for specific remediation technologies. Permits for construction and operation of a ground water treatment system, already obtained for the current air stripping treatment unit at Municipal Well No. 3 constitute the substantive action-specific ARARs at this site.
- Location-specific ARARs
  - These ARARs place restrictions on activities or concentrations of contaminants in discharges solely because a site is in a special location. (e.g., flood plains, wetlands, historic sites).

In accordance with the EPA Ground Water Protection Strategy, the aquifer which currently supplies potable water to the Borough of Bally is categorized as Class II. The presence of VOCs has affected the suitability of the aquifer for use as a domestic and municipal water supply. The Ground Water Protection Strategy will be considered relevant and appropriate guidance in development of remedial action objectives at this site. Consistent with the established EPA policy of returning contaminated ground water to the "highest beneficial use," chemical-specific ARARs established to protect drinking water supplies will be considered in establishment of remediation levels for the aquifer, as well as for any alternative water supply for the Borough.

Similarly, the PADER permitting authorities exercised in the National Pollutant Discharge Elimination System (NPDES) Discharge Permit, Water Supply Permit, and Air Operating Permit are action-specific ARARs that define acceptable standards for ground water treatment systems considered in defining and selecting remedial action technologies in this FS.

No location-specific ARARs have been identified for the proposed remedial response at the BES Site. Proposed activities will not directly or indirectly result in any adverse affects on any areas of environmental or other special significance.

2.1.2.1 Chemical-Specific ARARs

The applicable chemical-specific ARARs at the BES Site are established by MCLs and Water Supply Permit requirements established by the PADER for those contaminants of concern identified in the RI endangerment assessment. MCLs are applicable, enforceable standards set for public water supply system that are promulgated under the SDWA. MCLs that are proposed (PMCLs), but not yet promulgated, are to be considered when final MCLs are not available. With the exception of methylene chloride, MCLs and PMCLs are available for all contaminants of concern at this site.

In the absence of MCLs and PMCLs, the next ARARs to be considered are Health Advisories (HAs). HAs are nonenforceable contaminant limits published by the Office of Drinking Water. They are published for 1-day, 10-day, longer term (approximately 7 years), and lifetime exposures to chemicals. HAs are published for noncarcinogenic end points of toxicity only. Lifetime HAs are not recommended for Class A and Class B carcinogens because carcinogenic effects are expected to result in more stringent health standards. For Class C chemicals, an additional uncertainty factor of 10 is used to reflect possible carcinogenic effects.

Risk-Specific Doses (RSDs) for carcinogens may also be considered in establishing chemical-specific ARARs. RSDs are derived from cancer potency factors (CPFs), developed by the EPA Carcinogen Assessment Group (CAG) in a series of health assessment documents and by the EPA Environmental Criteria and Assessment Office in a series of health effects assessments. The CPF is the slope of the dose-response curve. The RSD represents an acceptable dose in milligrams per kilogram of body weight per day (mg/kg body weight/day). To calculate the concentration of a carcinogen in ground water in milligrams per liter (mg/ℓ) associated with a given cancer risk level, the following equation is used:

$$\text{Concentration} = \frac{\text{RSD (mg/kg/day)} \times \text{body weight} \times \text{cancer risk level}}{\text{drinking water ingestion rate (liters per day [ℓ/day])}}$$

Body weight is assumed to be 70 kg, and the drinking water ingestion rate is assumed to be 2 ℓ/day.

In accordance with established EPA policy for carcinogens, acceptable remediation levels generally lie within the 10^{-4} to 10^{-7} risk range, with the 10^{-6} risk used in establishing the preferred cleanup levels.

These ARARs are either applicable or to be considered relevant and appropriate relative to the attainment area for ground water remedial action. The attainment area is defined as the area beyond the boundary of the waste source and within the boundary of the contaminant plume. In the absence of a defined source area at the BES Site, the attainment area is generally defined by the lateral limits of the VOC plume.

2.1.2.2 Action-Specific ARARs

Action-specific ARARs relating to the proposed remedial actions at the BES Site fall into two categories:

- Those affecting discharge of VOC-containing ground water to surface water
- Those affecting releases of VOCs to the air.

Applicable action-specific ARARs include NPDES standards for discharge of ground water to surface water. These standards are developed on a compound- and site-specific permitting basis under the Clean Water Act (CWA).

Action-specific ARARs also may be relevant and appropriate for releases of VOCs to ambient air from treatment of contaminated ground water at extraction wells. Regulations to be considered relative to air emissions from ground water treatment units at the BES Site have been defined by the EPA as follows (Abrams, April 6, 1989):

- Part D of the Clean Air Act - This part deals with provisions for nonattainment areas. Berks County is classified as a nonattainment area for ozone. Part D requires that the lowest achievable emission rate (LAER) be achieved. This means that for any source, the emission rate reflects either the most stringent emission limitations contained in the implementation plan of any state for such class or category of source, unless the owner or operator of the proposed source demonstrates that such limitations are not achievable, or the most stringent emission limitation which is achieved in practice by such class or category of source, whichever is more stringent.

  In response to Part D of the Clean Air Act, Pennsylvania established special requirements in Subchapter C, Sections 127.61 to 127.64 of Pennsylvania's Air Resource Regulations for sources located in or significantly impacting nonattainment areas. Relative to VOCs, this applies to any new source with maximum allowable emissions greater than 50 tons per year, 1,000 pounds per day, or 100 pounds per hour, whichever is more restrictive.

- National Ambient Air Quality Standard (NAAQS) for Ozone - The ozone NAAQS is a one-hour standard concentration of 0.12 parts per million (ppm), not to be exceeded more than once per year.

Other guidance to be considered is the Pennsylvania Air Toxic Guidelines (ATGs). This guideline requires that the ambient ground-level concentration predicted for any air toxic substance for an aggregate of sources at a site be equal to or less than one percent of its corresponding ATG. These ATGs represent compound-specific ambient concentration guidelines.

Remcor understands that uncertainties relative to the application of air regulations to CERCLA response actions prohibit establishment of site-specific performance standards for release to ambient air from proposed ground water treatment units at the BES Site. From a technical perspective, information is not available to evaluate whether LAER is relevant or appropriate; the de minimus nature of the anticipated source in the current instance (i.e., less than 100 pounds per hour) indicates that LAER is not applicable. However, the current air stripping treatment system at the BES Site is operating with permit authorization from the PADER Bureau of Air Quality. The final PADER Air Operating Permit for this treatment system will establish acceptable performance standards for air emissions and should, therefore, be incorporated as the primary ARAR for air emissions at this site.

2.1.3 Summary of Remedial Action Objectives

CERCLA requires that remedial actions comply with ARARs and are adequately protective of public health and the environment. Remediation levels for the BES Site will reflect the need to provide a suitable municipal water supply to mitigate current risk, as well as to effect aquifer restoration. Table 2 summarizes remediation levels by medium based on ARARs. The current air stripping treatment system at Municipal Well No. 3 has received permit authorization to operate from the PADER. Limits established in the NPDES permit for discharge of treated ground water to the adjacent stream, as well as limits established in the Water Quality Permit for use of the treated water as a public water supply, provide the primary ARARs for these actions. The permit levels are noted in Table 2.

2.2 ESTABLISHMENT OF GENERAL RESPONSE ACTIONS

This section of the FS establishes appropriate GRAs to address the remedial action objectives outlined for the BES Site. Following definition of GRAs, specific alternative technologies are discussed and screened on the basis of capability of achieving site-specific remediation levels, overall implementability at this site, and cost.

Remedial action objectives defined for the BES Site are as follows:

- Prevent current and future ingestion of ground water containing unacceptable levels of VOCs
- Restore the aquifer within a reasonable time frame to a condition such that levels of the VOC contaminants of concern are below remediation levels consistent with its use as a Class II aquifer.

2.2.1 Prevention of Ingestion of Contaminated Ground Water

GRAs that will address the first response objective include provision of an alternative municipal water supply and institutional control of future use of ground water within the attainment area until such time as the aquifer has been adequately restored.

As discussed in this FS, Remcor was retained by AI in 1987 to evaluate options for provision of an alternative water supply for the Borough of Bally, concurrent with performance of the RI/FS. An air stripping treatment system has been designed, permitted, and installed at Municipal Well No. 3 to address this concern. The rationale for Remcor's recommendation to proceed with treatment at Municipal Well No. 3 via air stripping is documented in Appendix A. The design and the operational testing of the air stripping system is also discussed.

As stated in "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites" (EPA, March 1988), "Institutional controls implemented at the State or Local level that restrict ground water use should be implemented as part of the response action at all sites where exposure poses a threat to human health." There are no current risks via use of domestic wells at the BES Site. However, institutional controls should be implemented within the attainment area to prevent future use of any existing residential wells for drinking water and also to prevent the installation of additional wells for this purpose until the aquifer has been adequately restored. Additional investigation will be required in the pre-design phase of remedial action to better define the limits of the attainment area. Treatment of Municipal Well No. 3 will ensure

the availability of a reliable source of drinking water for those served by the municipal system, which includes all residents within the attainment area as defined by the current data, as well as areas immediately downgradient. Institutional controls on use of domestic wells for future potable use will not inconvenience local residents primarily due to the ready accessibility of a reliable source of potable water from the municipal supply system.

The availability of springs as a second source of potable water to the Borough provides a measure of redundancy for Municipal Well No. 3. Periodic maintenance may be scheduled during periods of the year when the flow from the springs is adequate to satisfy the system demand. Institutional controls relative to conservation of water would permit the springs to meet demand at other times if nonroutine maintenance of the municipal well was required. Such nonroutine maintenance would result in minimal downtime for the municipal well during such times.

To supplement alternative water supply and institutional controls, appropriate general responses to prevent ingestion of contaminated ground water may include the following:

- Abandonment of any existing domestic wells within the attainment area found to contain unacceptably high levels of VOCs

  Currently the data suggest that only the Mabel Gehman Well may require abandonment to eliminate any potential for its use as a drinking water supply in the future

- Ground water monitoring
  - A ground water monitoring program will be required in conjunction with remedial action to monitor attainment of remedial action objectives. Because the attainment area is not fully defined, additional site investigation will be required in the pre-design phase of remedial action to provide this definition. Ground water monitoring would be modified as required to reflect the results of this investigation.

- Community relations/public awareness program
  - Periodic updates regarding the status of aquifer restoration and institutional controls will be required throughout the remedial action implementation to ensure public understanding.

2.2.2 Aquifer Restoration

EPA guidance (EPA, March 1988) indicates that provision of a readily accessible water supply with sufficient redundancy provides additional flexibility in addressing the second major response objective (i.e., aquifer restoration).

Despite a concerted effort in the RI to research history of solvent use and management at the BES plant and to evaluate the potential, active sources of aquifer contamination, no such source areas were found. The data indicate that aquifer contamination may have resulted from routine spillage of solvents used at the BES facility in the 1950s, 1960s, and early 1970s and that no definable source area exists. As such, no source removal or control actions are suggested that would aid in reducing the extent of aquifer restoration response actions.

GRAs identified to address the need for aquifer restoration involve collection and treatment of the VOC plume.

2.3 IDENTIFICATION OF FEASIBLE TECHNOLOGIES AND PROCESS OPTIONS

The purpose of this section is to identify and briefly describe technologies that are feasible for implementation at the BES Site. Technologies considered are those that may implement the GRAs outlined in Section 2.2. The remedial technologies must also satisfy the remedial action objectives presented in Section 2.1.1 and reduce contaminant concentration in the ground water to levels identified in Section 2.1.3. The GRAs and associated technologies examined in this section are summarized in Table 3.

This section focuses on screening of applicable technologies for the treatment of ground water currently being extracted at Municipal Well No. 3. If active aquifer restoration and an alternative water supply are selected as the recommended response actions at this site, the prudent course of action is to continue pumping and treating Municipal Well No. 3 to satisfy both objectives, at least in part. Additional studies will be required to further define the lateral extent of the attainment area, as well as the need for the evaluation of additional ground water extraction and treatment locations. The focus of the current evaluation of technologies on Municipal Well No. 3 in no way prejudices future evaluation of any required treatment schemes should an additional ground water extraction well be necessary. The rationale for this approach is discussed in detail in the introduction to Chapter 3.0.

The various remedial technologies are described in Section 2.3.1 and screened in Section 2.3.2, prefatory to development of remedial action alternatives.

2.3.1 Identification and Screening of Remedial Technologies

The remedial technologies identified in Table 3 are screened in this section for their potential use in the remediation of the BES Site. Table 4 contains a brief description and an assessment of the effectiveness of each of the remedial technologies considered. Table 4 also describes the implementability of each technology and its status in the screening process. Technologies are retained based on their effectiveness at solving the specific problem and their implementability with respect to the site characteristics. Cost becomes a consideration in the screening process only where remediation technologies exhibit similar implementability and effectiveness at significantly different (i.e., at least one order of magnitude) costs. In such cases, the more costly technology is eliminated. Cost is not considered when comparing treatment and nontreatment technologies.

2.3.1.1 Minimal/No-Action Technologies

The technologies associated with the minimal/no-action response option reduce the potential hazards of the site by limiting access to the contaminated ground water and monitoring the extent of ground water contamination. As such, these technologies address prevention of use of contaminated ground water from residential wells. They do not address aquifer restoration or contamination of the municipal water supply, except by permitting natural renovation processes to remain operative. Minimal/no-action responses are required to be evaluated with other remedial alternatives by CERCLA, as amended. Because minimal/no-action responses result in the waste remaining on site, CERCLA mandates periodic review of site status, at least every five years (EPA, March 1988). Monitoring technologies provide adequate information for this review.

Four minimal/no-action technologies were identified for consideration in the remediation of the ground water contamination at the BES Site. These technologies include:

- Ground water monitoring
- Institutional control of ground water use
- Resident relocation
- Selective well abandonment.

Ground Water Monitoring

This technology is a feasible option for tracking the plume of contaminants in the aquifer at the BES Site. Monitoring wells are easily constructed and sampled. A ground water monitoring program would have to be a long-term program. Monitoring would not reduce the toxicity, mobility, and volume (TMV) of the contaminants present, but would allow observation of the migration of contaminants in the aquifer. This information would be of value in predicting future migration of the contaminant plume. Ground water monitoring will be retained for further consideration in conjunction with other remedial technologies in the development of remedial alternatives.

Institutional Control of Ground Water Use

This technology is a feasible option for reducing the potential for contact with contamination at the site. Deed restrictions would be the probable mechanism used to restrict the use of existing wells and the installation of new wells in the attainment area. At the present time, the Mabel Gehman Well is the only domestic well which has exhibited VOCs at levels that may pose an unacceptable risk to human health via ingestion. Use of this well as a potable supply was curtailed in 1985 at the recommendation of PADER. Institutional controls would not reduce the TMV of the contaminants present. This option would have to be implemented in conjunction with ongoing ground water monitoring and further definition of the attainment area in pre-design.

Deed restrictions may be difficult to enforce in a long-term situation. This technology is considered in the screening of feasible technologies and will be included in the development of remedial alternatives to be used in conjunction with other treatment technologies.

Resident Relocation

Relocating the residents currently affected by the contamination in the municipal supply system (approximately 4,500 residents) is not considered a feasible option for reducing the potential for contact with contamination at the site. In addition, this technology does not reduce the TMV of the contaminants present. This option will not be considered in the development of remedial alternatives.

Selective Well Abandonment

Well abandonment, including removal of the well pump and grouting the well casing to the ground surface, may be required at selected wells to ensure that existing wells are not used for domestic water supply in the future. At present, the only well that may be a potential candidate for abandonment is the Mabel Gehman Well.

Technologies associated with the minimal/no-action general responses may supplement other remedial responses. In particular, at the BES Site, ground water monitoring, institutional controls, and selective well abandonment will be considered basic components of remedial responses other than minimal/no-action. In addition, studies dedicated to further define the attainment area and evaluate the effect of continuous pumping at Municipal Well No. 3 may be undertaken in the pre-design phase of remedial action. The minimal/no-action response does not anticipate any additional investigation to define future active aquifer restoration measures.

2.3.1.2 Alternative Water Supply

Technologies appropriate for provision of an alternative water supply are listed and discussed in this section. As noted in this FS, Remcor was retained in 1987 to evaluate these issues pursuant to provision of an alternative water supply for the Borough of Bally. Although this evaluation may not have been performed fully in concert with the RI/FS process, it resulted in the decision to design, construct, and implement a wellhead treatment system at Municipal Well No. 3 to provide an alternative water supply for Borough of Bally. The discussion in this section and in Appendix A is provided to document the decision-making process.

Three alternatives were considered for the provision of an alternative water supply for Borough of Bally in the 1987 evaluation:

- Installation of a new municipal supply well
- Provision of potable water from adjacent municipalities or other existing sources beyond the affected area
- Treatment of existing municipal well.

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Installation of a New Municipal Well

One option under consideration by the Borough of Bally prior to the decision to treat Municipal Well No. 3 was the installation of a new municipal well in an undeveloped area in the northeastern section of the Borough. Remcor questioned this approach because this location is down-gradient of the VOC contaminant plume. Installation of a new municipal supply well at this location may have actually enhanced further migration of the VOC contaminant plume.

Provision of Potable Water From Adjacent Municipalities or Other Existing Sources Beyond the Affected Area

Remcor also considered connections to water supplies from surrounding municipalities to be impractical due primarily to the distance to these supplies. In addition, provision of point-of-use treatment systems or transportation of water to the site from a source beyond the affected area was considered to be more costly and less effective than treatment of the existing municipal supply well.

Treatment of Existing Municipal Well

The air stripping treatment system has been in continuous use since February 6, 1989, with treated water discharged to an adjacent unnamed tributary to west branch Perkiomen Creek. The system has proven its effectiveness over this time frame in reducing VOCs in the treated ground water to the most stringent levels established in either the NPDES Discharge Permit or the Water Supply Permit (Appendix A) issued by PADER. The Borough of Bally intends to begin utilizing this treated ground water in June 1989 to supplement the existing springs and to reduce reliance on Municipal Well No. 1.

An additional argument for treatment of ground water from Municipal Well No. 3, rather than from Municipal Well No. 1, is that during its active pumping from 1979 through 1987 this well demonstrated effectiveness in capturing a portion of the VOC plume. Results of preliminary testing thus far indicate that this well may play a prominent role in ground

water remediation at this site. In addition, extraction and treatment of ground water at the municipal well would aid in reducing the overall TMV of contaminants within the aquifer, consistent with CERCLA and the National Contingency Plan (NCP).

The range of treatment process options associated with ground water extraction is discussed in Section 2.3.1.3.

2.3.1.3 Aquifer Restoration

Containment

Technologies associated with the containment response action may reduce the mobility of the contaminants, but do not reduce the toxicity or volume of these contaminants. These technologies would be implemented to reduce the possibility of exposure by reducing the possibility of further contamination. Continual monitoring of the site is also required when using containment technologies alone. Under CERCLA, as amended, the site must be reviewed every five years to evaluate the effectiveness of ground water remediation.

In general, containment technologies (e.g., vertical barriers) may be appropriate to create preferential ground water migration paths in conjunction with active or passive ground water interception. This technology consists of a low-permeability wall installed below grade and extending into the aquifer to the desired depth. Slurry walls, grout curtains, or steel sheet piles may be used to deter the migration of the ground water contaminants in the horizontal direction. Slurry walls are commonly made of soil/bentonite or cement/bentonite mixtures that are poured into a trench of the desired depth. A grout curtain is commonly constructed by injecting grout into the ground using a row of borings to

form the wall. With this method, it is difficult to ensure that a consistent solid barrier has been created. Sheet pile walls consist of a series of interconnected steel sheets driven into the ground with a vibratory hammer. Leaking joints are a common problem with this type of wall.

The hydrogeologic study of the BES Site, summarized in Section 3.3.3.5 of the RI Report (Remcor, May 1988), determined that a single water table aquifer predominates within the site area. Much of the aquifer lies within a highly fractured limestone fanglomerate. The presence of the fractured flow system and absence of vertical segregation of the aquifer indicate that vertical barriers would be of no value in remedial action at the BES Site. This technology is not retained for further evaluation.

Ground Water Collection

Two technologies were considered for collection of contaminated ground water. They are the use of extraction wells and hydraulic displacement.

- Extraction Wells

This technology consists of pumping ground water from one or more extraction wells within the attainment area. In doing this, the mobility of the contaminants in the ground water is enhanced toward the extraction wells, reducing the potential mobility beyond the current plume limits. The toxicity is unchanged by extraction alone. Also, the volume of contaminated ground water within the aquifer is reduced, but the total volume of contaminated water remains the same. Contaminated water extracted by this means would require further treatment or disposal. Thus, this technology must be used in conjunction with treatment technologies or off-site disposal.

The BES Site currently contains two municipal wells in the attainment area, Municipal Wells No. 1 and No. 3. Each well is capable of pumping water from the aquifer with a sustained yield of 250 to 300 gpm.

Municipal Well No. 3 apparently functioned to capture a portion of the contaminant plume from 1979 to 1987 during its active pumping. During testing of the air stripping treatment system in 1988, the municipal well has also demonstrated effectiveness in removal of contaminated ground water (Appendix A). Extraction wells are considered as a viable option in the technology screening process and will be considered in the development of remedial alternatives in conjunction with other remedial technologies.

- Hydraulic Displacement

Hydraulic displacement is another means of removing contaminated ground water for treatment or disposal. The technology consists of displacing the contaminated water by creating a hydraulic pressure on the water table and forcing the ground water to move and exit the aquifer through designated wells. Hydraulic displacement would be difficult to control in the Bally area because of the presence of the fractured bedrock flow system. This option was considered in the screening of viable remedial technologies, but will not be retained for further consideration due to the applicability of extraction well technology that achieves the same results and is more easily implemented and maintained.

Ground Water Treatment

Treatment technologies are preferred by CERCLA, as amended. In most cases, they reduce the TMV of ground water contaminants following collection and can be tailored to the specific contaminants present. The treatment process options considered in this section are those that are applicable to chlorinated organic wastes in an aqueous phase. Technologies representative of the various treatment means (i.e., physical, chemical, and biological) have been selected for evaluation.

All treatment technologies were screened based on their applicability to treat ground water from Municipal Well No. 3 to levels adequate to provide an alternative source of drinking water to the Borough of Bally and/or for discharge to an adjacent stream. In this application,

Municipal Well No. 3 functions both as a water supply and as a contaminated ground water extraction well.

Additional studies may indicate the need for an additional extraction well or wells. At that point, all treatment options would be reviewed and rescreened for applicability to any additional wells. The selection of specific treatment technologies for development of remedial alternatives at Municipal Well No. 3 is not necessarily intended to establish a precedent for selection of the optimal overall treatment scheme, should any additional extraction wells be required.

- Liquid Phase Ultraviolet Photolysis-Ozonation

The ultraviolet photolysis-ozonation (UV/O_3) process consists of the oxidation of organic compounds with ozone in the presence of UV light. UV light causes the organic compounds to become more reactive. When in this state, the organic molecules can degrade (degradation caused by light is referred to as photolysis) or react. Ozone is a highly reactive compound and also becomes more reactive in the presence of UV light. In an aqueous solution, ozone reacts with water molecules to form hydroxyl radicals. These radicals then attack the organic molecules and break them into carbon dioxide, water, and chlorinated products. Bench-scale studies would be required to ensure that the contaminants at the BES Site are treatable by this process. This technology will be considered in the development of treatment process options as a method of chemically degrading the VOCs.

- Wet Air Oxidation

Wet air oxidation (WAO) is the aqueous phase oxidation of organic compounds with air at elevated temperatures and pressures. The products of the reaction are biodegradable, short-chain, aliphatic compounds, and are expected to require further treatment. WAO units are significantly more expensive when compared to other treatment technologies with similar results. For this reason, this technology will not be considered further in the development of alternative treatment process options.

- Chemical Treatment

Chemical treatment methods include neutralization, oxidation, and reduction reactions. Neutralization of the contaminants present at the BES Site is not a feasible means of treatment. Reduction-oxidation (redox) reactions are used to reduce the toxicity of many toxic organics. The use of oxidating reagents is more common than the use of reducing reagents for treatment due to the high reactivity of reducing reagents. The equipment needed for this treatment technology is relatively simple, thus capital costs are low. Operating costs can become significant depending on the amount of reagent needed to complete the reactions. The use of redox reactions is limited to wastewater containing one or two contaminants because the probability of side reactions and unwanted by-products increases as the number of contaminants increases. This factor would impair implementability of this technology for the BES Site. Therefore, this technology will not be retained for further consideration.

- Liquid-Phase Carbon Adsorption

Carbon adsorption technology is a well developed method of removing dissolved organic contaminants from liquid waste streams. Treatment of the ground water at the BES Site using this technology would consist of passing the water through a series of packed beds containing activated carbon. The VOCs would become bound to the surface of the carbon by a phenomenon referred to as adsorption. This technology is effective at removing most organic compounds. However, complications may arise when treating streams containing multiple contaminants. This is due to competitive effects of the compounds on the pore surface of the carbon. Thus, bench-scale studies must be performed to determine the appropriate operating parameters. Effluent water must be monitored for contaminant levels to ensure that the system is functioning properly and to help predict when the carbon should be replaced or regenerated.

While initially evaluating alternatives for installing a system at Municipal Well No. 3 in 1987, liquid phase carbon adsorption was compared against an air stripping system. Based on the levels of VOCs present in the water, each system was considered a feasible option to meet drinking water standards. In comparing costs, liquid phase carbon treatment operating costs were found to be three to five times higher than air stripping, depending on the VOC loading rate on the carbon. The air stripping treatment process was selected at that time, primarily on the basis of the cost differential.

Liquid-phase carbon adsorption technology is a viable option for use at the BES Site. Systems are readily available and easily implemented on most sites. Because activated carbon can remove dissolved organics to levels below one part per billion (ppb), this technology is very attractive for use on potable water systems. Costs become very important when considering long-term operation (i.e., 30 years). Because this type of treatment is often used for ground water decontamination, it will be considered further in the development of treatment technologies.

- Air Stripping

Air stripping is a mass transfer operation in which dissolved organic compounds in water are transferred to a counter-current air stream. This technology is most effective when the contaminants have high volatility and low water solubility. An air stripping system consists of a packed tower and a blower to provide fresh air. The packing material increases the air to water contact area for increased mass transfer. The contaminated water is pumped to the top of the tower and is distributed over the packing using a spray nozzle. The air is blown into the base of the tower and rises through the packing. The air, along with the contaminants, is released to the atmosphere through the top of the tower.

Air stripping technology is a well developed method of VOC removal from contaminated ground water. This treatment process option is particularly attractive for the BES Site because of the existence of a proven air stripping system at Municipal Well No. 3. In evaluating the cost of the air stripping treatment option for use of Municipal Well No. 3 as a ground water extraction well, it is assumed that no capital costs associated with design and construction will be incurred. This process option is considered viable and will be further considered in alternative development.

•Steam Stripping

Steam stripping technology is very similar to air stripping. The benefits of using steam include the increased volatility of the contaminants and the ability to treat water with higher contaminant concentrations. Using steam in lieu of air requires the installation and operation of a steam generation boiler. This system increases the capital costs and greatly increases operating costs. Because the contaminants at the BES Site are treatable with air stripping, the added cost of generating steam for a steam stripping tower is not justifiable. For this reason, steam stripping will not be retained for further consideration.

• Air Stripping with Vapor-Phase Carbon Adsorption

This treatment technology combines two of the previously mentioned options. The water is treated by means of an air stripping tower, and the effluent gas containing the contaminants is treated with activated carbon to minimize the discharge of VOCs to the atmosphere. Effluent gas from the carbon treatment unit must be monitored for the presence of VOCs to determine when the activated carbon should be replaced. The collection and removal of organics from the gas stream may be required due to quantities and discharge rates of VOCs, surrounding airborne VOC concentrations, and the regulations concerning the release of VOCs to the air. Air stripping with vapor-phase carbon adsorption will be considered further as a treatment process option in the development of

remedial alternatives.

- Air Stripping with Regenerable Vapor Phase Carbon

This technology is a modification of that previously discussed. It incorporates a thermal destruction unit into the vapor phase activated carbon adsorption system. This system is designed to remove VOCs from the air stripper discharge gas stream using activated carbon. When the carbon is fully loaded with VOCs and prior to breakthrough, the carbon bed is regenerated. This is accomplished by blowing a hot gas stream through the carbon bed releasing the VOCs. These organic compounds are then thermally destructed in the "carbon regenerator." To save on energy costs, the vent from the regenerator is used to heat the carbon bed during regeneration.

In most respects, this system behaves exactly like the air stripping with vapor-phase carbon adsorption technology, except that the organics are destroyed on site. The costs associated with this modified system include higher capital costs for the equipment for carbon regeneration, rather than replacement. This option will be considered further in the development of treatment alternatives.

- Distillation

Distillation technology consists of separating dissolved contaminants from the water by partially vaporizing the ground water influent stream and separately recovering the vapors and residue. The volatile compounds are vaporized and condensed on trays. Depending on the number of trays and the amount of energy supplied by the reboiler in the base of the column, the system can be designed to increase the water purity. Distillation is a well-developed technology that has been proven effective for the removal of dissolved chlorinated organics at high concentrations in water. This system, as with stream stripping, has very high capital and operating costs, and is not effective at treating streams with low levels of chlorinated organics. For this reason, distillation will not be considered in the development of alternatives.

- Reverse Osmosis

Reverse osmosis is a membrane separation technology. The process consists of applying pressure to a solution that forces the water molecules to pass through a membrane leaving the larger contaminant molecules behind. The process is derived from the phenomenon called osmosis. This is the natural tendency of molecules of a specific compound to flow across a semipermeable membrane from a less-concentrated solution of that compound to a more-concentrated solution. This concentration difference causes an osmotic pressure to be exerted on the lower concentration side of the membrane. By exerting a pressure greater than the osmotic pressure (i.e., 300 to 1,000 pounds per square inch [psi]) on the solution of higher concentration, this natural flow will be reversed. As the concentration gradient increases, the pressure needed will increase. The final products of this type of operation are a very dilute solution and a concentrated waste solution. The volume of the concentrated waste solution is usually 10 to 20 percent of the initial influent volume.

Constraints associated with reverse osmosis units include the need to clean the membrane after treatment to remove suspended solids and to ensure adequate membrane performance. The use of this type of separator on waters with low contaminant concentrations is questionable. Due to this uncertainty and the added cost of treating the high volume influent ground water flows (i.e., approximately 250 gpm), this option will not be considered further in the development of remedial alternatives.

- Biological Treatment

There are two methods of biological treatment that are generally considered feasible technologies for use in water treatment. They are aerobic and anaerobic biological treatment. Aerobic biological treatment is also called activated sludge treatment. The process consists of allowing microorganisms to degrade the organics via metabolic processes. These microorganisms require the presence of oxygen

to metabolize the contaminants. Aerobic biological treatment is effective on low concentration waste streams, but is restricted in the types of chlorinated organic compounds that are treatable. The spent biomass from this process requires treatment or disposal. The waste stream may also require pretreatment before the biomass can effectively metabolize it. This treatment method will not be considered further for the BES Site due to its uncertain effectiveness with chlorinated hydrocarbons.

The second biological treatment method is anaerobic biological treatment. Microorganisms that do not require oxygen for their metabolic processes do not experience the toxic effects caused by chlorinated hydrocarbons as aerobic microorganisms do. This results in a higher efficiency at treating these compounds. The constraints of using this type of process include a slower, less-reliable degradation process and the generation of methane gas. This process is also better suited to high concentration, low volume waste streams, which is not the case at the BES Site. For these reasons, anaerobic biological treatment will not be considered in the development of alternatives.

Off-Site Disposal

The off-site disposal component of the GRA is broken down into two remedial technologies in this section. The technologies associated with off-site disposal involve the transfer of contaminated materials from the site to another location for disposal or treatment. Off-site disposal must be used in conjunction with some type of collection technology and a monitoring program to aid in characterizing the material prior to disposal. These technologies are designed to reduce the volume and mobility of contaminants, but do not affect their toxicity. Options requiring off-site disposal are required to be consistent with EPA's Off-site Disposal Policy. The disposal must also address any other constraints of the Solid Waste Disposal Act and the CWA.

- Transport to Treatment Center

This technology consists of transporting contaminated water extracted from the well to a location where it can be treated and disposed. This option is only implementable where a licensed treatment facility is within reasonable distance from the site and/or a direct connection to sanitary sewer lines for transmission to a publicly owned treatment works (POTW) capable of treating the discharge is available. The anticipated quantities of extracted ground water (e.g., over 360,000 gallons per day, assuming continuous pumping at about 250 gpm) make transportation prohibitive. The Bally POTW cannot accept the flow volume anticipated. For these reasons, this technology will not be considered further.

- Discharge of Untreated Extracted Ground Water to Surface Water

This remedial technology consists of extracting the contaminated ground water and discharging it directly to the adjacent stream without any form of treatment. Upon discharge to the stream, the VOCs would be subject to volatilization and photolysis or photo-oxidation in the sunlight. The process is a feasible option, but will not be considered further because of the potential for degradation of surface waters proximal to the discharge. Discharge of treated ground water from the Municipal Well No. 3 air stripping treatment is currently regulated by the NPDES permit issued by the PADER Bureau of Water Quality (Appendix A).

2.3.2 Conclusions of Screening Technology

Table 5 contains a summary of the data contained in this section. In addition to Table 4, it provides an easy reference to the pertinent data concerning each option considered and identifies those remedial technologies and treatment process options that have been retained for incorporation into remedial action alternatives in Chapter 3.0.

3.0 DEVELOPMENT AND EVALUATION OF REMEDIAL ACTION ALTERNATIVES

3.1 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

Section 3.1.1 identifies the rationale for development of remedial alternatives at the BES Site. Each specific alternative is defined in Section 3.1.2. The number of different alternatives is limited because of the practical limitations on containment technologies and the absence of an active source of VOCs to the aquifer. The process options for treatment of extracted ground water were screened in Chapter 2.0 to obviate the need to perform additional screening prior to the detailed evaluation presented in Section 3.2.

3.1.1 General Approach

The approach taken to development and evaluation of remedial action alternatives for the BES Site follows that described in "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites" (EPA, March 1988). Remedial alternatives are developed by assembling component technologies and treatment process options from those that passed the screening in Chapter 2.0. These technologies and process options are considered effective in meeting the remedial response objectives defined in Chapter 1.0 and are implementable at the BES Site.

In parallel with the RI/FS, an air stripping treatment system has been implemented at Municipal Well No. 3 to provide a suitable alternative water supply for the Borough of Bally. In configuring and evaluating alternative remedial actions to be implemented at the BES Site, the air stripping treatment system is considered an element of existing site conditions.

In general, there are two classes of response actions (EPA, March 1988) that may be appropriate for remedial action at the BES Site. The first of these is natural attentuation, embodied in the minimal/no action alternative. The second is active restoration of the aquifer. In the absence of an active source of VOCs to the aquifer, active restoration

at the BES Site would consist of ground water extraction at one or more wells within the attainment area. The third class of response, containment, was not found to be applicable to this site because of hydrogeologic conditions (i.e., thick, highly productive aquifer residing primarily within a fractured bedrock flow system), as discussed in the technology screening in Chapter 2.0.

Because of its location within the attainment area, Municipal Well No. 3 may also function as an extraction well for contaminated ground water. Monitoring of VOC concentrations in water pumped from the well since continuous pumping was initiated on February 6, 1989 suggest that this may be the case (Appendix A). The capture zone for Municipal Well No. 3, as well as its ultimate effect on the VOC contaminant plume, cannot be determined presently with the available date. The degree to which Municipal Well No. 3 may contribute to remedial action can best be determined through a period of monitoring. The Borough of Bally intends to begin utilizing treated ground water from this well in June 1989. This source will provide a suitable alternative water supply to meet the demands of the municipality for the near future. All residents within the attainment area have access to the municipal supply system and none are currently using domestic wells as a potable supply.

EPA guidance (March 1988) suggests that three to five alternatives be carried through the detailed evaluation to provide a suitable range of response options and cost. The guidance further suggests that one of the alternatives for Class II ground waters represent a rapid remediation scenario for comparison. In the absence of an active source of VOCs to the aquifer, active remediation at the BES Site will involve one or more extraction wells, with treatment of the extracted ground water. Adequate data are not currently available to predict the optimal configuration or extraction wells, nor to estimate the time frame required for successful aquifer restoration.

The presence of an operational alternative water supply, coupled with appropriate institutional controls to prevent use of contaminated ground water and the absence of an active source of contamination, reduce the urgency of overall aquifer restoration at this site. In consideration of the above, the prudent course of action at the BES Site involves performance of additional studies to evaluate the need for further remedial action prior to implementing any actions beyond the ongoing pumping at Municipal Well No. 3. This approach has provided the framework for development of remedial action alternatives in Chapter 3.0.

It is apparent that if active restoration of the aquifer is selected as the recommended remedial response, additional site investigation required as an element of the additional studies will need to address the following issues:

- Resolution of the limits of the attainment area, especially in the direction of downgradient ground water flow
- Evaluation of the effects of continuous pumping of Municipal Well No. 3 on aquifer contaminant levels
- Determination of the effective capture zone of Municipal Well No. 3 during long-term pumping
- Determination of the appropriate well location and the optimal means of treatment of extracted ground water in the event that an additional extraction well(s) is required.

Anticipated components of such additional studies are as noted:

- Periodic monitoring of water levels and target VOCs in observation wells in the vicinity of Municipal Well No. 3 during continuous pumping of the well
- Installation of additional nested ground water monitoring wells at one or more locations
- Sampling of the new ground water monitoring wells and selected existing wells for target VOCs
- Installation of an aquifer test well and performance of pumping tests utilizing this well and suitable observation wells

The time frame for initiation of the additional field studies for pre-design should provide an adequate period for evaluation of the effects of pumping at Municipal Well No. 3. The need for additional extraction wells can be established prior to conducting these studies. CERCLA, as amended, requires that the effectiveness of ground water remedial actions be evaluated within five years of implementation. A period of from two to three years to monitor pumping at Municipal Well No. 3 would provide an adequate basis for evaluation. The provision of a suitable alternative water supply via treatment at Municipal Well No. 3 affords the necessary flexibility to defer further remedial action for this period of time without risk to public health or environmental receptors.

3.1.2 Definition of Remedial Alternatives

Two basic alternatives have been defined for remedial action at the BES Site:

- Alternative No. 1 - Minimal/No-Action (Natural Attenuation)
- Alternative No. 2 - Ground Water Extraction and Treatment and Alternative Water Supply

The second of these alternatives will involve use of Municipal Well No. 3 both as an alternative water supply and a ground water extraction well. Pre-design studies associated with this alternative will determine the need for additional extraction wells to fully address remedial action objectives within the attainment area.

3.1.2.1 Alternative No. 1 - Minimal/No-Action (Natural Attenuation)

The minimal/no-action remedial alternative consists of the following elements:

- Abandoning appropriate existing private wells in the attainment area (e.g., Mabel Gehman Well)
- Implementing institutional controls (e.g., deed restrictions) on the use of operable private wells and the construction of new wells within the attainment area

- Conducting public education programs to increase public awareness about the presence of these restrictions
- Performing ground water and surface water monitoring to measure contaminant concentrations and migration
- Performing semiannual site inspections
- Performing a site review every five years.

This option does not actively reduce the TMV of the contaminants. Minimal/no-action reduces the risk of the general public's potential of future exposure to contaminants in ground water from private wells by reducing the potential for contact with the contaminated ground water. In the absence of an active source, natural attenuation of VOC contamination would ultimately result in aquifer restoration.

This option utilizes the existing monitoring wells located at the BES Site. The use of Municipal Well No. 3 as an alternative water supply would not be mandated as a part of this option (although this action may occur independent of the recommended CERCLA remedial action). In any event, this alternative does not assume that Municipal Well No. 3 would be pumped continuously as a ground water extraction well.

3.1.2.2 Alternative No. 2 - Ground Water Extraction and Treatment and Alternative Water Supply

This alternative is composed of the following items:

- Abandoning appropriate existing private wells in the attainment area
- Implementing institutional controls on the use of operable private wells and the construction of new wells within the attainment area
- Performing ground water and surface water monitoring to measure contaminant concentrations and migration
- Removing contaminated ground water from the aquifer through continuous pumping of Municipal Well No. 3 (with the potential for installation of additional extraction wells in the attainment area, if required)

- Treating the extracted ground water by one of the treatment options retained for consideration
- Discharging the treated water from Municipal Well No. 3 to the adjacent stream or into the Borough of Bally potable water system, as needed to provide a suitable alternative water supply
- Performing necessary additional studies in the pre-design phase to evaluate the optimal configuration of any additional ground water extraction well(s) required.

Implementation of this alternative reduces the mobility and volume of the contamination within the aquifer. Treatment process options resulting in destruction of the VOCs also reduce the toxicity of the contaminants. This alternative also reduces the risk associated with public use of contaminated water.

The following process options have been identified for Alternative No. 2:

Option No.	Description
2A	UV Photolysis-Ozonation Treatment
2B	Liquid Phase Carbon Adsorption Treatment
2C	Air Stripping Treatment
2D	Air Stripping Treatment with Vapor Phase Carbon
2E	Air Stripping Treatment with Regenerable Vapor Phase Carbon
2F	Air Stripping Treatment with Vapor Phase Catalytic Oxidation

The capital costs associated with this alternative would be significantly reduced if the existing air stripping system were selected as the recommended treatment process. Treated water would be used by the Borough of Bally to supply the potable system and excess treated water would be discharged to the adjacent stream. Existing monitoring wells would be used to monitor the concentration and migration of the contaminants.

3.2 DETAILED ANALYSIS OF REMEDIAL TECHNOLOGIES

This section contains a detailed analysis of each of the remedial options. The analysis is based on the following criteria in accordance with EPA guidance (EPA, August 1988):

- Short-term effectiveness
- Long-term effectiveness
- Implementability
- Reduction of TMV of contaminants
- Cost
- Compliance with ARARs
- Overall protection of human health and the environment
- State and community acceptance.

State and community acceptance of each alternative and process option will be discussed in the final FS document prepared after receipt of public comments. In general, however, state acceptance of the existing pumping and treatment system at Municipal Well No. 3 is documented in their approval of operating permits for the treatment system. Process flow diagrams for each of the treatment options are provided in Figures 6 thru 11.

3.2.1 Analysis of Alternative No. 1 - Minimal/No Action (Natural Attenuation

The minimal/no-action alternative is described in Section 3.1.1 of this report. This option consists primarily of reducing the risk of contact with the contaminants and monitoring the extent and degree of contamination.

3.2.1.1 Short-Term Effectiveness

Implementation of the minimal/no-action alternative is not expected to result in an increased risk to the community or to the environment. Remedial actions contemplated under this alternative (i.e., well abandonment) can be completed expeditiously. The reliability of the abandonment procedure in preventing future access to the well is essentially 100 percent.

During the abandonment of existing private wells in the contaminated zone, workers should be aware of the possibility of organic vapors being released from the well. Field screening instruments would be used to monitor for the presence of any hazardous vapors. Dermal protection may also be warranted for workers closing the well(s). Local residents would be asked to avoid the work areas during closure. The Mabel Gehman well is the only private well that is currently being considered for abandonment.

3.2.1.2 Long-Term Effectiveness and Performance

The risks established for use of the current municipal water supply system (i.e., baseline risks) in Section 1.2.3 of this report would not be actively reduced. As presented in the RI, the estimated worst case carcinogenic risk posed by using the contaminated Municipal Well No. 1 water supply for potable purposes is 1.0×10^{-3}. The non-carcinogenic risks posed by this exposure pathway were estimated to be acceptable.

Elimination of risk to potential future residential well users would be achieved through this alternative by implementing institutional controls. The effectiveness of such controls will depend on strict enforcement.

Long-term management associated with this option would include semi-annual site inspections and site reviews every five years. Ground water and surface water monitoring would also be performed on a long-term basis to monitor contaminant levels and migration.

3.2.1.3 Implementability

Implementation of this option would be very simple. The abandonment of the Mabel Gehman well would consist of removing the pump and pressure grouting the well bore. A bentonite-rich grout would be used to absorb any water in the well during the grouting process. Deed restrictions are easily implemented but difficult to enforce in long-term operation. Use of monitoring wells and residential wells will facilitate implementation of a monitoring program.

3.2.1.4 Reduction of Toxicity, Mobility, or Volume of Contaminants

Because no treatment or containment technologies are included as part of this option, the TMV of the contaminants would not be reduced and exposure due to the migration of VOCs within the aquifer would continue to occur.

3.2.1.5 Cost

Costs associated with the minimal/no-action alternative include costs for grouting existing wells and performing periodic monitoring. Administrative costs for implementing and enforcing deed restrictions, conducting public education programs, and site inspections and reviews must also be considered. The initial capital costs for this option are estimated at $82,800. These costs include implementing deed restrictions, a public awareness program, and abandoning the Gehman well. An annual operating cost of $10,000 is estimated for the monitoring and inspection procedures. Based on a 30-year operating life and an annual inflation rate of 5 percent, the net present cost of this option is $264,000. A breakdown of costs for this option is given in Tables 6 and 7.

3.2.1.6 Compliance with ARARs

This alternative does not comply with ARARs for an alternative municipal water supply. Chemical specific ARARs for aquifer restoration within the attainment area may ultimately be achieved via natural attenuation.

3.2.1.7 Overall Protection of Human Health and the Environment

This alternative provides minimal protection to human health and the environment by restricting access to the contaminated ground water at existing or potential future residential wells. The potential for migration of contaminants remains, but monitoring efforts would aid in establishing future restrictions if necessary. This alternative would result in no reduction in the baseline risk summarized in Section 1.2.3 attributable to continued use of the municipal water supply.

Discharge of treated effluent to the unnamed tributary of West Branch Perkiomen Creek, adjacent to Municipal Well No. 3 has occurred on a continuous basis since February 6, 1989 at a rate of approximately 250 gpm. As discussed in Appendix A, this discharge is regulated by a NPDES permit issued by PADER, and has been monitored for compliance on a weekly basis. Monitoring data indicate full compliance with the NPDES discharge requirements during this period. These data indicate the feasibility of discharge of treated ground water in a manner that is fully protective of the receiving stream relative to water chemistry.

Springs to the northwest of the Borough of Bally provide the primary source of base flow to the drainage. Discharge of treated effluent from the treatment system approximately doubles base flow. Significant alterations in flow typically occur within this drainage in response to storm events. This is true primarily due to modifications made within the watershed some time ago to divert approximately 80 percent of the surface runoff into this drainage. These modifications were apparently made to ensure an adequate source of water for a mill pond that existed at one time approximately 600 feet southeast of Municipal Well No. 3. As discussed in Chapter 4.0 of the RI Report (Remcor, May 1989), this mill pond has been subjected to almost total infilling with silt from the drainage, and currently supports wetland vegetation. The habitat value of this wetland is significantly compromised by its small area and isolation from other vegetated areas. Most of the immediate vicinity has been developed for recreational, residential or industrial use.

The treated water discharged from Municipal Well No. 3, with the start of continuous pumping on February 6, 1989, exhibited an initial turbidity that dissipated within the first hour of operation. The water has been non-turbid throughout the remainder of the pumping. The drainage channel in the vicinity of the current discharge from the treatment system has been scoured during periods of high flows. No

additional scouring has been observed as a result of discharge of the treated water. The wetland area immediately downstream of the discharge acts to moderate high flows from the watershed prior to conveyance of the discharge underneath Route 100.

The addition of treated discharge from the treatment system is not anticipated to significantly alter the current flow regime, other than by increasing base flow. The current channel is adequate to carry the increased flow and the abandoned mill pond acts to moderate any extremes in flow prior to its convenance underneath Route 100. No adverse effects on public health or the environment are anticipated as a result of discharge of the additional flow to this drainage.

3.2.2 Analysis of Alternative No. 2 - Ground Water Extraction and Treatment and Alternative Water Supply

The detailed analysis of Alternative No. 2 focuses initially on the overall response action and then treats each of the process options (i.e., Options 2A through 2F) individually (Sections 3.2.2.1 through 3.2.2.6).

Process option 2C (air stripping) is presently operable at Municipal Well No. 3. Site-specific experience in constructing the treatment system and operation of the municipal well is incorporated in the analysis of the overall alternative. Specific information relative to the performance of the air stripping treatment system is discussed in the analysis of this process option.

Short-Term Effectiveness

Air stripping treatment has been installed at Municipal Well No. 3 and the well has been pumped continuously since February 6, 1989 without any adverse impact on public health or the environment. The primary objective of this treatment system has been to provide a suitable alternative municipal water supply. Tests performed during an extended start-up period from February 6, 1989 to date have demonstrated the effectiveness

of the treatment system in treating ground water to levels appropriate for municipal water supply, as well as for discharge to the adjacent stream (See Appendix A).

The current treatment system is capable of providing treated water to the municipal supply system at any time. The Borough of Bally intends to begin utilization of this treated water in June 1989.

During the course of well abandoning any private residential wells, remediation workers may require specific dermal and respiratory protection. Local residents would be asked to avoid work areas during construction.

Long-Term Effectivenss and Permanence

Municipal Well No. 3 was operated as a supplement to Municipal Well No. 1 and the springs from its inception in 1979 until it was taken off-line in 1982. The well was subsequently pumped to waste until March 1987 by the Borough of Bally. The municipal well, therefore, has a demonstrated history of successful operation. Long-term treatment of ground water for municipal water supply is viable with the current treatment system. The role of Municipal Well No. 3 in aquifer restoration is not yet fully defined. Should Alternative No. 2 be selected as the recommended alternative, additional studies in the pre-design phase will be required to determine the contribution of Municipal Well No. 3 to aquifer restoration, as well as the need for any additional extraction wells to ensure that Alternative No. 2 fulfills the response objectives.

Reduction of Toxicity, Mobility, or Volume of Contaminants

Ground water extraction will remove contaminants from the aquifer and thereby reduce their mobility. The toxicity and volume of the VOCs in the extracted ground water will be reduced to varying degrees by application of one of the six treatment options identified. Further discussion of the TMV reductions obtainable is provided in the detailed analysis of each treatment option.

Cost

The overall cost of Alternative No. 2 is a function of the treatment option selected. Costs presented in the individual evaluation of each process option incorporate the basic cost of performing all actions specified in Section 3.1.2.2, with appropriate modifications to reflect the specific capital and operation and maintenance (O&M) cost for each process option.

Implementability

The fact that Municipal Well No. 3 is currently operating with air stripping treatment attests to the constructibilty and ease of implementation of this alternative. Ground water extraction and treatment at Municipal Well No. 3 has, therefore, been demonstrated to be a readily implementable means of providing a suitable alternative drinking water supply for Borough of Bally. As discussed, monitoring of the effect of pumping on aquifer contaminant levels over a sufficient period of time (i.e., three to five years) in the pre-design phase of remedial action will be necessary to determine the degree to which continuous pumping and treatment at this location will reduce levels of VOCs within the aquifer. A decision to proceed with this option will not preclude implementation of other ground water extraction and treatment options, should they be required.

Compliance with ARARs

Ground water extraction and treatment will comply with ARARs relative to provision of a suitable alternative water supply and discharge of treated water to surface waters. This response action has demonstrated effectiveness at other sites in achieving remediation levels in aquifer restoration. Periodic evaluation of the effectivenss of this alternative at the BES Site will be required pursuant to CERCLA, as amended.

Compliance with ARARs is also discussed in more detail with each of the process options.

Overall Protection of Human Health and the Environment

Provision of a suitable alternative water supply will adequately mitigate the potential for ingestion or contact with contaminated water in the municipal supply system. Institutional controls will ensure that no future use of contaminated domestic wells will occur. Ground water extraction and discharge of treated effluent to surface waters will pose no unaccepable impact to environmental receptors and will be performed in full compliance with applicble regulations (i.e., NPDES discharge permits).

3.2.2.1 Analysis of Process Option 2A - Liquid Phase UV Photolysis-Ozonation Technology

This option provides UV photolysis-ozonation (UV/Ozone) treatment with Alternative No. 2. Figure 6 shows the process flow diagram for this option.

Short-Term Effectiveness

Implementation of this option would not cause an increased risk to the community provided institutional controls are properly administered properly and an alternate municipal water source was available during construction and permitting of the treatment system. Implementation of this system would require that Municipal Well No. 3 be taken off-line from the potable water supply system for a portion of the construction phase. This period would be expected to last approximately three to six months. During the replacement of the pump at Municipal Well No. 3, workers should be aware of the possibility of organic vapors being released from the well. Continuous air monitoring would be undertaken during construction and appropriate personal protective equipment (PPE) would be utilized.

Long-Term Effectiveness

This process would provide adequate treatment capability in long-term operation. Contaminant levels in the water would be reduced to the effluent requirements as specified in the appropriate permits. No releases to the air would be expected because the contaminants are destroyed.

Because O&M of this system is somewhat complex, the possibility of a system malfunction is increased. The overall reliability of the various treatment options must be considered when comparing this option to less complicated treatment methods with similar results.

Implementability

Installation of the treatment system would require the replacement of the current well pump at Municipal Well No. 3. The UV/Ozone reaction unit would arrive on-site, pre-assembled. The existing piping, electrical and control systems would be modified to install the new treatment systems. New pad and foundations would be required while utilizing the existing structure for housing electrical and control systems. All design and permitting would be done prior to bringing the treatment system on-line with the potable water supply system.

Reduction of Toxicity, Mobility, and Volume of Contaminants

UV/Ozone treatment in conjunction with ground water extraction reduces the toxicity, mobility and volume of the contaminants. Mobility and volume reductions are provided by ground water extraction. This treatment technology consists of chemical treatment (as opposed to physical treatment); thus, the contaminants are oxidized to inert products (water and carbon dioxide). Because the contaminants are chlorinated hydrocarbons, chloride products will also result and may require further treatment if concentrations exceed recommended values.

Cost

Capital costs for this option include those costs associated with implementation of the minimal/no-action technologies, and the equipment needed for the UV/Ozone treatment system. These initial costs are estimated to be $793,000. Capital costs for replacement and reconditioning of equipment are expected to be approximately $98,000 every five years. Operating costs for this system are approximately $131,000 per year. The operating cost is largely composed of the electrical costs for the UV lamps and the ozone generator. The net present worth cost of this option is $3.10 million for a 30 year operating life and a five percent discount rate. A breakdown of costs for this option is given in Tables 8 and 9.

Compliance with ARARs

This process option complies with ARARs for municipal water and discharge to surface waters. No air emissions would occur because VOCs are completely destroyed in the treatment process.

Overall Protection of Human Health and the Environment

Protection from dissolved organics in the water pumped to the potable water system is provided by the UV/Ozone treatment system. Because this option reduces the TMV of the contaminants, it provides a great deal of overall protection. Institutional controls proposed as part of the basic alternative provide protection by obviating the future possibility of exposure to untreated ground water from residential wells. This alternative effectively protects the public from hazards created by absorption, ingestion, and inhalation exposure via the municipal water supply. Because no air releases are generated, no risks via this pathway are created. The estimated carcinogenic risk of using the municipal water supply is lowered from 1.0×10^{-3} (baseline case) to at least 3.3×10^{-5}, with adherence to the contaminant levels established in the Water Supply Permit for Municipal Well No. 3 by the PADER (Appendix A).

3.2.2.2 Analysis of Process Option 2B - Liquid Phase Carbon Adsorption Technology

This option provides liquid phase granular activated carbon treatment for Alternative No. 2. Figure 7 provides a process flow diagram for this option.

Short-Term Effectiveness

Implementation of this technology is not expected to result in an increased risk in the short term provided the institutional controls are administered properly and an alternative water supply (e.g., springs) is available to the residents during construction. Implementation of this system would required that Municipal Well No. 3 be taken off-line from the potable water supply system for a portion of the construction phase. This period would be expected to last approximately three to four months. During the replacement of the pump at Municipal Well No. 3, workers should be aware of the possibility of organic vapors being released from the well. Screening instruments would be used to monitor the breathing zone. Effectiveness during the periods when the carbon is approaching saturation would not be reduced if a standby adsorption unit was always available. This setup would allow the operator to bring the standby carbon unit on line and remove the spent bed in a short period of time.

Long-Term Effectiveness and Permanence

Long-term effectiveness should remain high throughout the lifetime of the project with this treatment option. Carbon adsorption is a very effective method of removing low levels of VOCs from ground water. Monitoring of the effluent discharge from the carbon units will identify the most efficient changeout time and maximal carbon usage. In the event that contaminant concentrations in the water rise, the system will retain its effectiveness but the carbon usage will increase with more frequent changeout.

Implementability

Implementability of carbon adsorption system is relatively simple. Granular activated carbon units are pre-assembled and are easily linked. The control system, associated with this treatment technology, is not complex and can be installed in a short period of time. Construction of the system is expected to take two to three months. Carbon adsorption is effective at reducing the volume of contaminants but not their toxicity, thus spent carbon must be disposed of or regenerated.

Cost

Costs for Alternative No. 2 with the liquid phase carbon system are the highest among process options presented here due to the high operating cost associated with carbon replacement. The initial capital expenditure projected for this option is expected to be approximately $584,000. Five year replacement/reconditioning costs are approximately $69,000. The annual operating cost is $258,000. These costs can be converted to a net present worth cost of $4.77 million for a 30 year lifetime and 5 percent discount rate. A breakdown of these costs is given in Tables 10 and 11.

Compliance with ARARs

This treatment option complies with ARARs for water supply and discharge to surface waters. No air emissions would be associated with this treatment option.

Overall Protection of Human Health and the Environment

This option reduces the possibility of contact with contaminated ground water by implementation of institutional controls, and the use of liquid phase carbon reduces the level of contamination in the ground water before it is sent to the potable water system. This protection can be seen in the reduction of risk from 1.1×10^{-3} to at least 3.3×10^{-5} for use of the municipal water supply. Because no vapor effluent is generated, no risk is associated with airborne contaminants.

3.2.2.3 Analysis of Process Option 2C - Air Stripping Technology

This option provides air stripping treatment for Alternative No. 2. Appendix A contains a detailed explanation of the air stripping system currently in use at Municipal Well No. 3. Figure 8 gives the process flow diagram for this option.

Short-Term Effectiveness

Because there is an operational air stripping system at the BES site, implementation of this alternative would not cause an increased risk to the community or the environment in the short-term. This system is capable of 24 hour per day operation and can be initiated immediately.

Long-Term Effectiveness and Permanence

The air stripping system currently in operation at Municipal Well No. 3 has been proven to be effective at reducing the VOC concentrations in the ground water to levels below those required by the Pennsylvania Safe Drinking Water Act of May 1, 1987 (Public Law [P.L.] 206, No. 43); the Clean Water Act, 33 U.S.C., Section 1251, et seq. (the "Act"); and the Pennsylvania Clean Streams Law, as amended, 35 P.S., Section 691.1, et seq. The effectiveness of the air stripping towers at removing VOCs from the ground water to acceptable levels will remain constant unless the contaminant concentrations in the water increase markedly. A determination of the overall effectiveness of this alternative must also consider the risks associated with the release of the VOCs to the air.

Estimated risks were calculated in the RI for future ground water supply conditions that would utilize this alternative, assuming a switch from primary reliance on Municipal Well No. 1 to treated Municipal Well No.3 for potable water supply. The risk was calculated as a worst-case because the total supply was assumed to be derived from Municipal Well No. 3 with no dilution from the springs. The carcinogenic risk for potable water exposure is reduced from 1.0×10^{-3} (current conditions) to 3.3×10^{-5} under this alternative. This reduction is consistent with achieving the contaminant levels specified in the PADER Water Quality Permit.

Risk reduction is accomplished over the long-term by reducing contaminant concentrations in the water used by the public, while also reducing the possibility of residents contacting untreated water at private wells through the use of institutional controls. Long-term management associated with this option includes operation and maintenance of the air stripping system, a ground water monitoring program, and performance of semi-annual site inspections and site reviews every five years.

Carcinogenic risks associated with VOC releases from the stripping towers to the air have been estimated by utilizing an air-dispersion model and actual weather data (i.e., stability classes and wind speeds) from Allentown, Pennsylvania for 1981. Using the nearby residents and children playing in the adjacent ballfield as worst-case receptors, the airborn concentrations were estimated using an air dispersion model. The carcenogenic risk for exposure to these levels was calculated to be in the range of 7.3×10^{-5} to 1.8×10^{-6}. The details of the air-dispersion model and exposure assumptions and calculations are presented in Appendix B.

Implementability

Implementation of this option is demonstrated by the presence of the air stripping system on site.

Reduction in Toxicity, Mobility, and Volume of Contaminants

The air stripping treatment system, in conjunction with other components of Alternative No. 2, is capable of reducing the mobility of VOCs in ground water. Because VOCs are not destroyed but are transferred from ground water to air, no reduction in toxicity of contaminants occurs directly as a result of air stripping. However, VOCs will be subject to some photolytic degradation and dispersion upon release to the air.

Cost

Costs for the air stripping alternative are significantly reduced due to the presence of the operating air stripping treatment system at Municipal Well No. 3. For this reason, no capital costs are required to implement this treatment process option. A capital cost for repairing or replacing equipment of $47,000 every five years is expected. An annual operating cost of $57,700 includes the administrative costs for institutional controls and operation of the air stripping system. These costs represent a net present worth cost of $1.2 million with a discount rate of 5 percent and a 30-year operating life. A breakdown of costs for this option is given in Tables 12 and 13.

Compliance with ARARs

The air stripping process option has demonstrated effectiveness in achieving ARARs for public water supply and discharge to surface waters. Acceptable emissions levels will be established in the PADER Air Operating Permit.

Overall Protection of Public Health and the Environment

The air stripping treatment system provides adequate protection from adverse effects caused by contact with contaminated water. This protection is seen in the reduction in risk associated with use of the current municipal water supply from 1.0×10^{-3} to 3.3×10^{-5} for lifetime use of treated water from Municipal Well No. 3. Air stripping does not, however, provide protection from contact with airborne VOCs. However, the worst-case risk calculated for 30 year exposure to the airborne VOCs is only 7.3×10^{-5} which is within acceptable risk range of 10^{-4} to 10^{-7} established by EPA policy for CERCLA remedial action.

3.2.2.4 Analysis of Process Option 2D - Air Stripping/Vapor Phase Carbon Technology

This option combines ground water extraction with the air stripping treatment option and vapor phase carbon adsorption for treatment of the off-gas containing the VOCs with Alternative No. 2. Figure 9 provides the process flow diagram for this option.

Short-Term Effectiveness

Implementation of this option will require retrofitting of the existing treatment system, estimated to take approximately four to six months. During a portion of this period, the current air stripping system could not function to provide an alternative water supply or as a remedial response action. For this reason, minimal effectiveness would occur in the short term. After completion of the modifications to the air stripping system, the entire treatment system can be operated full time for remedial purposes.

The minimal protection provided during construction is identical to that presented with the minimal/no-action alternative. When the air stripper is operating following the installation of the carbon units, the protection provided for potable water use is identical to that given for the air stripping alternative.

Long-Term Effectiveness and Permanence

Reduction in the risk associated with use of the municipal water supply from 1.0×10^{-3} (current risk) to 3.3×10^{-5} would occur after implementation of this treatment option. The estimated risk associated with inhalation of VOCs emitted from the air stripping towers without gas collection and treatment (Option 2C) would be reduced by approximately two orders of magnitude with Process Option 2D. This reduction in risk associated with air is the result of treating the effluent gas from the air stripping towers with the vapor phase carbon adsorption units based on 99.9 percent removal efficiency.

Implementability

Implementation of this option is greatly facilitated by the existence of an air stripping system on-line at Municipal Well No. 3. This option would require that vapor effluent from the existing stripping towers be vented to vapor phase carbon adsorption units to remove the VOCs before discharging the air. In order to improve the efficiency of the carbon units, a heater would be installed on each air duct leaving the towers to reduce the relative humidity of the air stream prior to adsorption. These modifications to the existing system are expected to take three months for completion. Permits currently applying to the air stripping system would require modifications to account for alterations to the system.

Reduction in Toxicity, Mobility, and Volume of Contaminants

TMV considerations relative to mobility and volume are identical to those with Process Option 2C through collection of VOC emissions on the activated carbon air emissions are essentially eliminated. Regeneration of the spent carbon will be performed by the vendor.

Cost

Initial capital costs for this option include those costs associated with implementation of the minimal-action technologies, modifications to the existing air stripping system, and the first set of activated carbon units. These costs are estimated to be $484,000. Capital costs for replacing or reconditioning equipment are estimated to be $82,000 every five years. Operating costs for the air stripping/vapor phase carbon adsorption option are considerably higher than for air stripping due to the added cost of carbon replacement. The total annual operating cost is estimated to be $189,000. For comparison, these costs can be converted to a net present worth cost of $3.64 million for the 30-year operating life and a discount rate of five percent. A breakdown of costs for this option is given in Tables 14 and 15.

Compliance with ARARs

Treatment with this process option would comply with ARARs for water supply and aquifer restoration. No release of VOCs to ambient air would occur. Spent carbon units would be regenerated by the vendor.

Overall Protection of Human Health and the Environment

Protection from hazards created by contaminated water is provided by the air stripping treatment of the ground water. Protection from inhalation of airborne VOCs is through off-gas collection by the activated carbon units. This process option effectively provides protection from the contaminants affecting the public through absorption, ingestion, and inhalation. The decrease in risk associated with use of ground water from the municipal supply system is identical to that given for the air stripping alternative. The risk associated with inhalation of airborne VOCs is also reduced by about two orders of magnitude in comparison with that calculated for the air stripping option alone.

3.2.2.5 Analysis of Process Option 2E - Air Stripping With Regenerable Vapor Phase Carbon Technology

This process option combines air stripping treatment and vapor phase carbon adsorption for treatment of the off-gas containing the VOCs with Alternative No. 2. It differs from Option 2D in that the carbon is regenerated on site and the VOCs are periodically destroyed in a thermal oxidation unit. Figure 10 provides the process flow diagram for this option.

Short-Term Effectiveness

Installation of this equipment is estimated to take four to six months. During a portion of this period, the current air stripping system could not function to provide an alternative water supply or remedial response. For this reason, the effectiveness is considered minimal during this initial period. After completion of the modifications to the air stripping system, the entire treatment system can be operated full time for water supply, as well as ground water extraction and treatment.

The minimal protection provided during construction is identical to that presented with the minimal/no-action alternative. When the air stripper becomes operational with this process option, the protection provided to the municipal water supply is identical to that given for the air stripping alternative.

Long-Term Effectiveness and Permanence

After the four to six month construction period, this treatment option will provide an adequate level of protection for water supply purposes. Protection from adverse effects caused by elevated VOC concentrations can be seen in the reduction in the risk associated with use of the municipal water supply from 1.0×10^{-3} to 3.3×10^{-5}. The risk associated with the airborne VOCs will be reduced approximately two orders of magnitude through collection of off-gases. This risk reduction is based on 99.9 percent removal efficiency, which can be achieved via vapor phase carbon treatment.

Implementability

Implementation of this option is greatly facilitated by the existence of an air stripping system on-line at Municipal Well No. 3. This option would require that the air discharge from the existing stripping towers be routed to vapor phase carbon adsorption units to remove the VOCs prior to being discharged to the air. In order to improve the efficiency of the carbon units, a heater would be installed on each air duct from the towers to reduce the relative humidity of the air stream. Also, a thermal regeneration unit is included to regenerate the spent carbon on site and to destroy the VOCs by thermal oxidation. This significantly reduces the operating costs associated with vapor phase carbon. These modifications to the existing air stripping treatment system would require four to six months to complete. Permits currently applying to the air stripping system would require modifications to account for alterations to the system. These issues are included in the cost estimate prepared for this option.

Reduction in Toxicity, Mobility, and Volume of Contamination

TMV considerations for this process option are the same as those identified for Option 2D. The on-site thermal oxidation unit would ensure destruction of the VOCs, thereby reducing toxicity.

Cost

Initial capital costs for this process option include modifications to the existing air stripping system and the first set of activated carbon units. These costs are estimated to be $992,000. Capital costs for replacing or reconditioning equipment are estimated to be $116,000 every five years. Operating costs for the air stripping/vapor phase carbon adsorption option are considerably higher than for air stripping due to the added cost of carbon replacement. The total annual operating cost is estimated to be $105,000. For comparison, these costs can be converted to a net present worth cost of $2.95 million for the 30-year operating life and a discount rate of five percent. A breakdown of costs for this option is given in Tables 16 and 17.

Compliance with ARARs

This process option complies with all ARARs for water supply and aquifer restoration. There are also no significant air emissions.

Overall Protection of Human Health and the Environment

Protection from hazards created by contaminated water is provided by the air stripping treatment of the ground water. Protection from inhalation of airborne VOCs is ensured by the activated carbon units. This alternative effectively provides protection from the contaminants affecting the public through absorption, ingestion, and inhalation. The decrease in risk associated with use of the municipal water supply is identical to that discussed for the air stripping alternative. The risk associated with airborne VOCs is also reduced by approximately two orders of magnitude in comparison to Option 2C.

3.2.2.6 Analysis of Process Option 2F - Air Stripping/Vapor Phase Catalytic Oxidation Technology

This option provides air stripping treatment and vapor phase catalytic oxidation for treatment of the off-gas containing the VOCs with Alternative No. 2. Figure 11 gives the process flow diagram for this option.

Short-Term Effectiveness

Installation of this equipment is estimated to take four to six months. During a portion of this period, the air stripping system could not function to treat water from Municipal Well No. 3. For this reason, the effectiveness is only minimal for the initial construction period. After completion of the modifications to the air stripping system, the treatment system would be fully operational to address both alternative water supply and ground water extraction and treatment.

The minimal protection provided during construction is identical to that presented with the minimal/no action alternative. When the air stripper becomes operational with this process option, the protection provided for potable water use is identical to that given for the air stripping alternative.

Long-Term Effectiveness

After the four to six month construction period and the modifications are complete, adequate protection will be provided by the system. The risk associated with use of the municipal water supply will be reduced from 1.0×10^{-3} to 3.3×10^{-5}. The risk associated with the airborne VOCs will also be reduced by approximately two orders of magnitude. This increased protection is the result of treating the effluent gas from the air stripping towers with the vapor phase catalytic oxidation unit. This risk reduction is based on 99.9 percent removal efficiency, which can be achieved via vapor phase catalytic oxidation.

Implementability

Implementation of this option is greatly facilitated by the existence of an air stripping system on-line at Municipal Well No. 3. This option would require that air discharge effluent from the existing stripping towers be routed to a vapor phase catalytic oxidation unit to remove the VOCs prior to being discharged to the air. These modifications to the existing system are expected to take four to six months for completion. Permits currently applying to the air stripping system would require modifications to account for alterations to the system. All of these issues are included in the cost estimate prepared for this option.

Reduction in Toxicity, Mobility, and Volume of Contaminants

TMV considerations are identical to those discussed for Option 2E.

Cost

Initial capital costs specific to this option include those costs associated with modifications to the existing air stripping system, and acquisition of the catalytic oxidation unit. These costs are estimated to be $707,000. Capital costs for replacing or reconditioning equipment are estimated to be $110,000 every five years. The total annual operating cost is estimated to be $145,000. For comparison, these costs can be converted to a net present worth cost of $3.28 million for the 30-year operating life and an annual inflation rate of 5 percent. A breakdown of costs for this option is given in Tables 18 and 19.

Compliance with ARARs

Compliance with ARARs is identical to that discussed for Option 2E.

Overall Protection of Human Health and the Environment

Protection from hazards created by contaminated water is provided by the air stripping treatment of the ground water. Protection from inhalation of airborne VOCs is achieved via the catalytic oxidation unit. This alternative effectively provides protection from the contaminants affecting the public through absorption, ingestion, and inhalation. The

decrease in risk associated with use of the municipal water supply is identical to that estimated for other air stripping options. The risk associated with airborne VOCs is reduced by about two orders of magnitude with reference to Option 2C through off-gas collection.

3.2.3 Cost Sensitivity Analysis of Treatment Process Options

The relative net present worth costs for each option presented for Alternative No. 2 at Municipal Well No. 3 are summarized in Table 20 based on five and 10 percent discount rates and 30 year operating life. The two discount rates are used to show a range in costs as they relate to inflation in the future. This section reviews the relative cost sensitivity to:

- Duration of remedial action
- Contamination levels in the extracted ground water
- Variations in operation and capital costs.

This sensitivity analysis is a means of examining the effect of variations in specific assumptions associated with design, implementation, operation, and duration of remedial action for each option.

Overall costs are most sensitive to the period of time required to remediate the aquifer. Using the net present worth cost for 30 years of operation as the base, the costs are reduced by 13 to 17 percent for a 20 year operation and by 33 to 44 percent for a 10 year operation at a discount rate of five percent. The percent reduction is less for discount rate of 10 percent. Since the total volume or extent of contamination in the aquifer has not been determined, 30 years should be used as the assumed remediation period.

The reduction of VOC concentrations in the extracted ground water over a 30 year period would significantly reduce the activated carbon usage and the operational costs associated with regeneration or disposal of spent carbon. For this analysis, a 50 percent reduction of the design VOC

loading after 10 years and 75 percent reduction of design VOC loading after 20 years is used. Table 21 presents the net present worth for all process options with these assumptions. The reduced operating costs for on-site destruction systems would be minimal and are assumed to be negligible. The net present worth costs for liquid-phase carbon and vapor-phase carbon are reduced to 3.9 million and 3.1 million dollars for a five percent discount rate and a 30 year lifetime (Table 21). Liquid-phase carbon would still be the most expensive option but much closer in total costs to other systems that do not release organics to the air. The use of vapor-phase carbon would be very comparable to on-site destruction systems. Air stripping by itself is still the most cost effective method of treatment.

Table 22 presents a comparison of the sensitivity of overall costs to estimated capital costs. A 30 percent reduction or increase in capital cost was assumed over the 30 year lifetime. This thirty percent reduction or increase in costs is presented to show a relative range and its effect. The overall costs over this period increased by 5 to 15 percent depending on the option (Table 22). The net present value costs decreased by 15 to 30 percent for the various options with this reduction in capital. The costs for all process options were greater than over 2.5 million dollars with the exception of air stripping based on a five percent discount rate.

The reduction in operating costs was also calculated assuming a 30 percent reduction or increase in these costs over 30 years. The net present value costs increased 15 to 25 percent for the 30 year life at discount rate of five percent (Table 23). The costs decreased by 16 to 24 percent with the reduction over the same duration and assumed discount rate. Though these percentages are significant, net present worth costs for all options other than air stripping were still in excess of 2.5 million dollars. Air stripping is still the most cost effective system for treatment at Municipal Well No. 3.

4.0

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4.0 SUMMARY AND RECOMMENDATIONS

For the BES Site, the remedial action objectives are defined as follows:

- Prevent current and future ingestion of ground water containing unacceptable levels of VOCs
- Restore the aquifer within a reasonable time frame to a condition such that levels of indicator VOCs are below remediation levels and the aquifer may be suitable for use as a Class II aquifer.

The recommended alternative to achieve these objectives is Alternative No. 2 (Ground Water Extraction and Treatment and Alternative Water Supply) with Process Option 2C (air stripping). This alternative would consist of the following components:

- Selective abandonment of appropriate existing private wells in the attainment area
- Implementing institutional controls on the use of operable private wells and the construction of new wells within the attainment area
- Performing ground water and surface water monitoring to measure target VOC concentrations and migration potential
- Removing contaminated ground water from the aquifer through continuous pumping of Municipal Well No. 3 (with the potential for installation of an additional extraction well or wells in the attainment area, if required)
- Treating the extracted ground water by Process Option 2C (i.e., air stripping)
- Discharging the treated water from Municipal Well No. 3. to the adjacent stream or into the Borough of Bally potable water system, as required to provide a suitable alternative water supply
- Conducting additional studies during the pre-design phase of remedial action to determine the effect of continuous pumping at Municipal Well No. 3 on aquifer contaminant levels, as well as to determine whether an additional extraction well or wells will be required to achieve remediation levels in the attainment area.

The use of the existing air stripping system in conjunction with Municipal Well No. 3 provides an alternative source of drinking water for the Borough of Bally. This extraction and treatment system can also be used as an active measure to remediate the aquifer to a Class II classification. The air stripping system is a proven method of treating contaminated ground water for potable use or discharge to an adjacent stream. The long term costs associated with this option are significantly less than other treatment systems mentioned in the FS and still meet the GRA objectives and ARARs.

Based on an evaluation of the sensitivity of net present worth costs to duration of remedial action, variation in influent VOC levels, and variations in capital and operating costs, Process Option 2C (air stripping) remains the most cost-effective treatment option. Future aquifer studies will be required to define the effectiveness of pumping at Municipal Well No. 3 in remediating the ground water. The availability of a suitable alternative water supply (i.e., treated water from Municipal Well No. 3) and appropriate institutional controls on future ground water use within the attainment area provide the necessary flexibility to fully evaluate the effect of pumping at Municipal Well No. 3 on the VOC contamination. An evaluation period of three to five years would provide an adequate period over which to complete the additional pre-design studies.

5.0 CLOSING

We trust that this FS report has adequately defined and addressed the appropriate remedial objectives and responses for the BES Site. The FS has been prepared consistent with applicable EPA guidance to address remedial action for contaminated ground water at CERCLA sites. Remedial alternatives and options have been evaluated consistent with the CERCLA mandate to adequately protect the public health and the environment, as well as to attain ARARs.

Please feel free to contact us with any questions or comments on this submittal.

Respectfully submitted,

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DRP/JAG:lp

TABLES

TABLE 1

ESTIMATED WORST-CASE RISKS
FOR THE BES SITE

PATHWAY	CARCINOGENIC RISK	NON-CARCINOGENIC
CURRENT RISKS:		
Potable use of current municipal water supply	1.0×10^{-3}	Acceptable(2)
Dermal contact/accidental ingestion of surface water	2.5×10^{-8}	Acceptable
Use of ground water as process water supply for local industries	Risks significantly less than those considered acceptable for workplace exposure	
FUTURE RISKS:		
Potable use of future Municipal Water Supply(1)	3.3×10^{-5}	Acceptable
Potable use of contaminant residential well	1.8×10^{-2}	Unacceptable

Notes:

(1) Assumes primarly reliance on treated water from Municipal Well No. 3.
(2) Acceptability of non-carcinogenic risk based on calculated Hazard Index (HI) less than unity, as documented in text.

TABLE 2

REMEDIATION AND DISCHARGE LIMITS DERIVED FROM ARARS

CONTAMINANT CONCENTRATION ARARs

MEDIUM	TCE	TCA	DCE	PCE	METHYLENE CHLORIDE	1,1-DCA	1,2-DCA
Ground Water	0.005 (MCL)(1)	0.2 (MCL)	0.007 (MCL)	0.005 (PMCL)(2)	0.005 (RSD)(3)	NE (4)	NE
Treated Ground Water	0.001 (MWS)(5)	0.2 (MWS/MCL)	0.007 (MWS/MCL)	NE	NE	NE	NE
Surface Water	0.033 (NPDES)(6)	Monitor Only (NPDES)	0.00063 (NPDES)	0.0014 (NPDES)	Monitor Only (NPDES)	Monitor Only (NPDES)	Monitor Only (NPDES)

(1) MCL - Maximum Contaminant Level

(2) PMCL - Proposed MCL

(3) RSD - Risk Specific Dose

(4) NE - None Established: These compounds have not been detected in Municipal Well No. 3

(5) MWS - Municipal Water Supply Permit

(6) NPDES - National Pollutant Discharge Elimination System Permit

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TABLE 3

TECHNOLOGIES TO BE SCREENED FOR SUITABILITY
BALLY ENGINEERED STRUCTURES SITE
FEASIBILITY STUDY REPORT

RESPONSE ACTION	TECHNOLOGY	CONTAMINATED MEDIA
Minimal/No-Action		
	Ground Water Monitoring	Ground water
	Institutional Control of Ground Water Use	Ground water
	Resident Relocation	Ground water
	Selective Well Abandonment	Ground Water
Alternate Water Supply	Installation of New Municipal Supply Well	Ground water
	Provision of Potable Water From Adjacent Municipalities or Other Outside Sources	Ground water
	Treatment of Existing Municipal Well	Ground Water
Aquifer Restoration Via Ground Water Extraction and Treatment		
Containment	Vertical Barriers	Ground water
Collection	Extraction Wells	Ground water
	Hydraulic Displacement	Ground water

TABLE 3
(Continued)

RESPONSE ACTION	TECHNOLOGY	CONTAMINATED MEDIA
Treatment	Ultraviolet (UV) Photolysis-Ozonation	Ground water
	Wet Air Oxidation	Ground water
	Chemical Treatment	Ground water
	Liquid Phase Carbon Adsorption	Ground water
	Air Stripping	Ground water
	Steam Stripping	Ground water
	Air Stripping with Vapor-Phase Carbon Adsorption	Ground water and emissions to the air
	Air Stripping with Regenerable Vapor Phase Carbon	Ground water and emissions to the air
	Air Stripping with Vapor Phase Catalytic Oxidation	Ground water and emissions to the air
	Distillation	Ground water
	Reverse Osmosis	Ground water
	Biological Treatment	Ground water
Off-Site Disposal	Transport to Treatment Center	Ground water
	Discharge to Surface Water	Ground water

TABLE 4

INITIAL SCREENING OF TECHNOLOGIES FOR SUITABILITY
BALLY ENGINEERED STRUCTURES SITE
FEASIBILITY STUDY REPORT

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
MINIMAL/NO-ACTION:				
• Ground Water Monitoring	Perform water quality analysis on samples taken from predetermined locations to detect the increase or migration of contaminants	- Very effective for monitoring the nature and extent of ground water contamination - Required by regulations to monitor effectiveness of other actions - Does not reduce toxicity, mobility, or volume (TMV)	- Ground water monitoring wells are easily constructed and sampled to compliment those already in place	Maintained for further consideration
• Deed Restrictions	Deeds for property transactions in the affected area would include restrictions on on the use of ground water and well drilling	- Protective by reducing the risk of harm caused by ingestion or skin absorption - Effectiveness is dependent on enforcement in the future - Does not reduce TMV - Requires enactment of appropriate legislation at the local level	- Easily implemented - Difficult to enforce	Maintained for further consideration
• Resident Relocation	Permanently relocate all residents currently living in the affected area	- Protective by removing potential receptors from the contaminated area - Does not reduce TMV	- Difficult to implement from an administrative standpoint - Not warranted on basis of risk - Elimination of exposure is more readily attained by other means	Eliminated. Would not provide timely or cost effective protection

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TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
• Selective Well Abandonment	Plugging specific private wells in the contaminated zone with elevated VOC concentrations	- Protected by removing potential source of risk for specific residents - Does not reduce TMV	- Easily implemented - Enforced through deed restrictions	Maintained for further consideration
PREVENTION OF INGESTION OF CONTAMINATED GROUND WATER:				
• New Municipal Supply Well	Construct a new municipal supply well outside of the affected area	- Effective for providing uncontaminated water to residents - Does not reduce TMV - Effective until new well becomes contaminated	- Equipment is readily available and mechanically simple	Eliminated due to the probability that the new well becomes contaminated
• Potable Supply From Beyond the Affected Area	Water is obtained for use by residents from a source beyond the affected area	- Effective for providing uncontaminated water to residents - Does not reduce TMV - Costly alternative due to trucking costs for water transport	- Easily implemented if a water supply is located near affected area	Eliminated due to the high cost of transport
• Treatment of Existing Municipal Well	Water is extracted from Municipal Well No. 3, treated and made available for potable and non-potable uses	- Effective for providing uncontaminated water to residents - Reduces mobility and volume of contaminants - May reduce toxicity depending on treatment technology used	- Implementability is based on treatment technology used	Maintained for further consideration

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TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
CONTAINMENT:				
• Vertical Barriers	Construct a low-permeability barrier to minimize horizontal migration of contaminants	- Effective for retaining contaminated ground water or diverting ground water around a contaminated zone - Reduces mobility of contaminants - Does not reduce toxicity or volume of contaminants	- Aquifer thickness is such that vertical barriers are not feasible - No source areas have been defined and no active sources are believed to exist based on current data; source control via vertical barriers is not cost effective	Eliminated due to difficulty in implementation and lack of defined sources requiring controls
COLLECTION:				
• Extraction Wells	Collect contaminated ground water from one or more discrete extraction wells. The wells are used to collect and direct contaminated ground water to a discharge point or to modify gradients and change ground water flow direction. This collection system is not a treatment technology, but a removal method that will require subsequent treatment prior to ground water discharge	- Highly reliable for removing ground water - Reduces mobility of contaminants - Does not reduce the toxicity of the contaminants - Can be used to reduce the volume of the contaminated ground water by removal - Not effective in low-permeability areas	- Equipment is readily available and mechanically simple - In particular, at the BES site, Municipal Well No. 3 has been provided with air stripping treatment to serve as an alternate drinking water supply, and could also be used as an extraction well	Maintained for further consideration

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TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
• Hydraulic Displacement	Ground water is forced out of designated wells by applying a hydraulic pressure on the aquifer	- Effective for small contaminated volumes - Reduces mobility of contaminants - Does not reduce the toxicity of the contaminants - Can be used to reduce the volume of the contaminated ground water by removing it - Not effective in low-permeability areas	- Difficult to implement on large, irregularly-shaped contaminant plumes	Eliminated due to difficulty in implementation
TREATMENT:				
• Ultraviolet Photolysis-Ozonation (UV/O_3)	This process consists of chemically oxidizing the organic contaminants with ozone in the presence of UV light	- Effective at oxidizing high concentrations of chlorinated organics - Does not generate hazardous waste effluent streams - VOCs destroyed	- Technology has been proven and has been used at superfund sites - Capital and operating costs compare to technologies with similar capabilities	Maintained for further consideration
• Wet-Air Oxidation (WAO)	WAO involves the aqueous phase oxidation of organic contaminants at elevated temperatures and pressures in a reactor	- Effective in treating a wide range of organic contaminants - Off-gas requires further treatment - VOCs destroyed	- Limited number of mobile treatment vendors - High capital and operating costs compared to technologies with similar capabilities	Eliminated due to the extremely high costs as compared to other treatment processes with similar capabilities

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TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
• Chemical Treatment	A detoxification process that consists of using chemical oxidation reactions to structurally alter or degrade the contaminants present	- Oxidation reactions are effective on a small number of organic contaminants - Excess amounts of reagent could prove to be as harmful as the original contaminant - VOCs destroyed	- Oxidation is difficult to implement in multicontaminant situations due to the possibility of side reactions - Pilot studies required - Disposal/treatment of reaction products may be necessary	Eliminated due to difficulty in implementation and uncertain effectiveness
• Liquid Phase Carbon Adsorption	Removes dissolved organic contaminants from ground water via adsorptions (i.e., surface attachments) between the waste and internal pore surfaces of the activated carbon	- Highly effective and reliable for the removal of VOCs from ground water - Effectiveness is reduced in water with a high solids content	- Available and developed technology - Metals must be removed before activated carbon treatment - Spent carbon adsorbent must be regenerated/disposed - Monitoring of water effluent may be necessary to ensure adequate removal efficiency - Pilot studies required	Maintained for further consideration

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TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
• Air Stripping	Removes dissolved organic contaminants from ground water through contact with a high volumetric flow air stream	- Effective for the removal of VOCs from ground water - Off-gas may require further treatment	- Available and developed technology - Easily implemented - Monitoring of off-gas and water effluent may be necessary to ensure adequate removal efficiency	Maintained for further consideration
• Steam Stripping	Removes dissolved organic contaminants from ground water by contacting it with a high volumetric flow stream of steam	- Effective for the removal of VOCs from ground water - Effluent vapor stream may require further treatment	- Available and developed technology - A steam-generating system is required if on-line steam is not available - Monitoring of vapor stream and water effluent may be necessary to ensure adequate removal efficiency	Eliminated due to the high costs associated with steam generation in comparison with the existing air stripping system

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TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
• Air Stripping with Vapor-Phase Carbon Adsorption	Transfers dissolved organic contaminants from ground water to a vapor stream, which then deposits the contaminants on the internal pore surfaces of activated carbon	- Effective for the removal of VOCs from ground water - Inorganics are usually not treatable with this technology - Off-gas contains minimal concentrations of contaminants	- Available and developed technology - Spent carbon adsorbent must be replaced - Monitoring of off-gas and water effluent may be necessary to ensure adequate removal efficiency - Pilot studies required	Maintained for further consideration
• Air Stripping with Regenerable Vapor Phase Carbon	Transfers dissolved organic contaminants from ground water to a vapor stream, which then deposits the contaminants on the internal pore surfaces of activated carbon. Carbon is regenerated on-site and VOCs are thermally destroyed	- Effective for the removal of VOCs from ground water - Inorganics are usually not treatable with this technology - Off-gas contains minimal concentrations of contaminants - Lower operating cost by regenerating on-site - VOCs are destroyed	- Available and developed technology - Monitoring of off-gas and water effluent may be necessary to ensure adequate removal efficiency - Pilot studies required	Maintained for further consideration

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TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
• Air Strippiing with Vapor Phase Catalytic Oxidation	Transfers dissolved organic contaminants from ground water to a vapor stream which is then passed over a catalytic bed where the contaminants are thermally destructed	- Effective for the removal of VOCs from ground water - Inorganics are not treatable with this technology - Off gas contains minimal concentrations of contaminants - Effective for destroying high concentrations of VOCs in vapor	- Available and developed technology - Monitoring of off-gas and water effluent may be necessary to ensure adequate removal efficiency - Pilot studies required	Maintained for further consideration
• Distillation	This process separates components of a liquid mixture by partially vaporizing the mixture and separately recovering the vapors and residues	- Very effective at removing very concentrated chlorinated organics - Inorganics are usually not treatable with this technology - Vapor stream may require further treatment	- Available and developed technology - Pilot studies required - Not technically or economically practical for low concentrations of contaminants - Steam generation system required	Eliminated due to impracticality for low concentrations of organics

AR301194

TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
• Reverse Osmosis	Dissolved organic contaminants are removed from ground water by exerting a pressure on the water on one side of a membrane greater than the osmotic pressure caused by the contaminant, thus causing the contaminant to accumulate on one side of the membrane	- Effective at concentrating organic wastes in pilot plant tests - Effectiveness for treating organics in low concentrations is uncertain - Produces a concentrated waste stream with 10 to 20 percent of the original volume that would require further treatment - Reduces volume of contaminant but does not reduce toxicity	- Pretreatment requirements could be extensive - Low treatment rate - Treatment of concentrated product stream is required	Eliminated due to uncertain effectiveness for treating large amounts of water with low concentrations of contaminants
• Biological Treatment	Aerobic biological treatment: - Consists of conventional activated sludge processes and modifications of them. Suitable for aqueous streams with low-contaminant levels	- Reduces or eliminates volume and toxicity of organic contaminants - May not be effective in eliminating a wide range of contaminants - Spent biomass requires treatment or disposal	- Mobile treatment units are available - Specific biological method must be determined based on water contents - Low treatment rate	Eliminated due to uncertain effectiveness on chlorinated hydrocarbons
	Anaerobic biological treatment: - Consists of an anaerobic biodegradation process capable of treating aqueous streams with high contaminant levels	- Reduces volume and toxicity of organic contaminants - Effective on high concentrations of contaminants - May not be effective to eliminate a wide range of contaminants	- Mobile treatment units are available - Specific biological method must be determined based on water contents - Low treatment rate	Eliminated due to uncertain effectiveness on low concentration of wastes

AR301195

TABLE 4
(Continued)

RESPONSE ACTION TECHNOLOGY	DESCRIPTION	EFFECTIVENESS	IMPLEMENTABILITY	STATUS
OFF-SITE DISPOSAL:				
• Transport to Treatment Center	Collected ground water is hauled by tank truck to a licensed treatment facility to be treated or disposed	- Effective for reducing the volume of contaminated ground water - Does not reduce toxicity - This process involves transporting wastes to licensed facilities and would be a costly solution	- Implementability dependent on locating a suitable treatment facility at a reasonable distance from the site	Eliminated due to high cost as compared to other solutions with similar or better results
• Discharge to Surface Water	Collected ground water is discharged to the adjacent stream without any form of treatment	- Some VOCs would volatilize upon exposure - Toxicity of organics would be slightly reduced by photolysis or photo-oxidation - Increases contamination of stream	- Implementation of this solution would require demonstration that the environmental effects to stream water ecosystems are minimal - Difficult to obtain administrative approval	Eliminated for untreated ground water but maintained for treatment discharges

AR301196

TABLE 5

TECHNOLOGIES TO BE RETAINED
FOR THE DEVELOPMENT OF ALTERNATIVES
BALLY ENGINEERED STRUCTURES SITE
FEASIBILITY STUDY REPORT

RESPONSE ACTION	TECHNOLOGY	CONTAMINATED MEDIA
Minimal/No-Action	Ground Water Monitoring	Ground Water
	Institutional Control of Ground Water Use	Ground Water
	Selective Well Abandonment	Ground Water
Alternative Water Supply	Treatment of Existing Municipal Well	Ground Water
Aquifer Restoration Via Ground Water Extraction and Treatment		
Collection	Extraction Wells	Ground Water
Treatment	Ultraviolet (UV) Photolysis-Ozonation	Ground Water
	Liquid Phase Carbon Adsorption	Ground Water
	Air Stripping	Ground Water
	Air Stripping with Vapor-Phase Carbon Adsorption	Ground Water and Emissions to the Air
	Air Stripping with Regenerable Vapor Phase Carbon	Ground Water and Emissions to the Air
	Air Stripping with Vapor Phase Catalytic Oxidation	Ground Water and Emissions to the Air
Off-Site Disposal	Discharge to Surface Water	Ground water

TABLE 6
CAPITAL COST SUMMARY
MINIMAL/NO-ACTION ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	INITIAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Plugging the Gehman Well	$2,000			
2. Implementing Deed Restrictions	$10,000			
3. Implementing Public Awareness Program	$15,000			
4. Contamination Monitoring	$45,000			
SUBTOTAL	$72,000			
5. Contingency (15%)	$10,800			
TOTAL CAPITAL COSTS	$82,800		$82,800	$82,800

TABLE 7
NET PRESENT WORTH COST SUMMARY
MINIMAL/NO-ACTION ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	ANNUAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	i=10%
1. Analytical Monitoring Program	$10,000			
2. 5 Year Reviews		$10,000		
SUBTOTAL - ANNUAL OPERATING COSTS	$10,000		$153,725	$94,269
SUBTOTAL - 5 YEAR OPERATING COSTS		$10,000	$27,820	$15,441
TOTAL OPERATING COSTS	$10,000	$10,000	$181,545	$109,710
TOTAL CAPITAL COSTS	$82,800		$82,800	$82,800
TOTAL NET PRESENT VALUE			$264,345	$192,510

TABLE 8
CAPITAL COST SUMMARY
LIQUID PHASE UV/OZONE OXIDATION ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	INITIAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Plugging the Gehman Well	$2,000			
2. Implementing Deed Restrictions	$10,000			
3. Implementing Public Awareness Program	$15,000			
4. Additional Studies	$105,000			
5. Design & Treatability Study Labor	$69,600			
6. Startup & Shakedown	$19,500			
7. Construction - Labor	$63,600			
8. Construction - Materials				
Equipment Costs				
UV/Ozone Reactor & Ozonator	$300,000	$75,000		
Well Pump	$10,000	$10,000		
30 ton crane w/operator (5 day @ $1350/day)	$6,750			
Electrical Modification Costs				
UV/Ozone System	$15,000			
Lights	$1,000			
Electric tracing (600 ft @ $11/ft)	$6,600			
Pump electrical eqpt. costs	$3,000			
Foundation Materials				
Concrete slab (40'x15'x1' @ $225/cy inst.)	$5,000			
Foundation (20 cy @ $300/cy inst.)	$6,000			
Excavation (1 day)	$1,200			
Backfill	$1,000			
Materials				
Instruments	$5,000			
(2) Flowmeters (@ $2400/ea)	$4,800			
Piping (300 ft @ $20/ft)	$6,000			
(10) Valves (@ $500/ea)	$5,000			
Insulation (300 ft @ $10/ft)	$3,000			
Structural Supports	$1,000			
Fencing (150 ft @ $30/ft inst.)	$4,500			
Road Paving (5000 sf @ $3/sf inst.)	$15,000			
Excavation and Backfill	$5,000			
Construction - Materials Total	$404,850			
SUBTOTAL	$689,550	$85,000		
9. Contingency (15%)	$103,433	$12,750		
SUBTOTAL - INITIAL CAPITAL COSTS	$792,983		$792,983	$792,983
SUBTOTAL - 5 YEAR CAPITAL COSTS		$97,750	$271,943	$150,936
TOTAL CAPITAL COSTS	$792,983	$97,750	$1,064,926	$943,919

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TABLE 9
NET PRESENT WORTH COST SUMMARY
LIQUID PHASE UV/OZONE OXIDATION ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	ANNUAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Analytical Monitoring Program	$10,000			
2. Analytical lab analysis for permits (64 @ $100 ea)	$6,400			
3. 5 Year Reviews		$10,000		
4. Labor (1100 hr/yr @ $20/hr)	$22,000			
5. Maintenance	$15,000			
6. Electricity (47 kW)(8760 hr/yr)($.06/kWh)	$24,700			
7. UV/Ozone operating Cost (131,000 MG/yr)($.40/MG)*	$52,560			
SUBTOTAL - ANNUAL OPERATING COSTS	$130,660		$2,008,564	$1,231,720
SUBTOTAL - 5 YEAR OPERATING COSTS		$10,000	$27,820	$15,441
TOTAL OPERATING COSTS	$130,660	$10,000	$2,036,385	$1,247,161
TOTAL CAPITAL COSTS	$792,983	$97,750	$1,064,926	$943,919
TOTAL NET PRESENT VALUE			$3,101,311	$2,191,080

* includes electricity for UV & ozonator, and annual lightbulb changes.

TABLE 10
CAPITAL COST SUMMARY
LIQUID PHASE CARBON ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	INITIAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Plugging the Gehman Well	$2,000			
2. Implementing Deed Restrictions	$10,000			
3. Implementing Public Awareness Program	$15,000			
4. Additional Studies	$105,000			
5. Design & Treatability Study Labor	$51,000			
6. Startup & Shakedown	$19,500			
7. Construction - Labor	$52,400			
8. Construction - Materials				
Equipment Costs				
(2) 20,000 lb Carbon vessels (@ $60,500/ea)	$121,000	$40,000		
(1) Carbon transfer tank	$40,000	$10,000		
Well Pump	$10,000	$10,000		
30 ton crane w/operator (5 day @ $1350/day)	$6,750			
Electrical Modification Costs				
Lights	$1,000			
Electric tracing (600 ft @ $11/ft)	$6,600			
Pump electrical eqpt. costs	$3,000			
Foundation Materials				
Concrete slab (40'x15'x1' @ $225/cy inst.)	$5,000			
Foundation (20 cy @ $300/cy inst.)	$6,000			
Excavation (1 day)	$1,200			
Backfill	$1,000			
Materials				
Instruments	$5,000			
(2) Flowmeters (@ $2400/ea)	$4,800			
Piping (300 ft @ $20/ft)	$6,000			
(10) Valves (@ $500/ea)	$5,000			
Insulation (300 ft @ $10/ft)	$3,000			
Structural Supports	$3,000			
Fencing (150 ft @ $30/ft inst.)	$4,500			
Road Paving (5000 sf @ $3/sf inst.)	$15,000			
Excavation & Backfill	$5,000			
Construction - Materials Total	$252,850			
SUBTOTAL	$507,750	$60,000		
9. Contingency (15%)	$76,163	$9,000		
SUBTOTAL - INITIAL CAPITAL COSTS	$583,913		$583,913	$583,913
SUBTOTAL - 5 YEAR CAPITAL COSTS		$69,000	$191,960	$106,543
TOTAL CAPITAL COSTS	$583,913	$69,000	$775,872	$690,456

AR301202

TABLE 11
NET PRESENT WORTH COST SUMMARY
LIQUID PHASE CARBON ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	ANNUAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Analytical Monitoring Program	$10,000			
2. Analytical lab analyses for permits (64 @ $100 ea)	$6,400			
3. 5 Year Reviews		$10,000		
4. Labor (750 hr/yr @ $20/hr)	$15,000			
5. Maintenance	$10,000			
6. Electricity (48 kW)(8760 hr/yr)($.06/kWh)	$25,229			
7. Carbon Replacement (174,000 lbs/yr @ $1.10/lb)	$191,400			
SUBTOTAL - ANNUAL OPERATING COSTS	$258,029		$3,966,538	$2,432,416
SUBTOTAL - 5 YEAR OPERATING COSTS		$10,000	$27,820	$15,441
TOTAL OPERATING COSTS	$258,029	$10,000	$3,994,358	$2,447,857
TOTAL CAPITAL COSTS	$563,913	$69,000	$775,872	$690,456
TOTAL NET PRESENT VALUE			$4,770,230	$3,138,313

AR301203

TABLE 12
CAPITAL COST SUMMARY
AIR STRIPPING ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	INITIAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Plugging the Gehman Well	$2,000			
2. Implementing Deed Restrictions	$10,000			
3. Implementing Public Awareness Program	$15,000			
4. Additional Studies	$105,000			
5. Equipment Reconditioning/Replacement				
Pump Reconditioning				
Well Pump		$10,000		
Transfer Pump		$1,000		
Booster Pump		$2,000		
Packing Replacement		$8,000		
Blower Replacement		$20,000		
Recondition/Replacement Total		$41,000		
SUBTOTAL	$132,000	$41,000		
6. Contingency (15%)	$19,800	$6,150		
SUBTOTAL - INITIAL CAPITAL COSTS	$151,800		$151,800	$151,800
SUBTOTAL - 5 YEAR CAPITAL COSTS		$47,150	$131,173	$72,805
TOTAL CAPITAL COSTS	$151,800	$47,150	$282,973	$224,605

TABLE 13
NET PRESENT WORTH COST SUMMARY
AIR STRIPPING ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	ANNUAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Analytical Monitoring Program	$10,000			
2. Analytical lab analyses for permits (64 @ $100 ea)	$6,400			
3. 5 Year Reviews		$10,000		
4. Labor (600 hr/yr @ $20/hr)	$12,000			
5. Maintenance	$3,000			
6. Electricity (50 kW)(8760 hr/yr)($.06/kWh)	$26,280			
SUBTOTAL - ANNUAL OPERATING COSTS	$57,680		$886,683	$543,744
SUBTOTAL - 5 YEAR OPERATING COSTS		$10,000	$27,820	$15,441
TOTAL OPERATING COSTS	$57,680	$10,000	$914,503	$559,185
TOTAL CAPITAL COSTS	$151,800	$47,150	$282,973	$224,605
TOTAL NET PRESENT VALUE			$1,197,476	$783,790

AR301205

TABLE 14
CAPITAL COST SUMMARY
AIR STRIPPING/VAPOR PHASE CARBON ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	INITIAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Plugging the Gehman Well	$2,000			
2. Implementing Deed Restrictions	$10,000			
3. Implementing Public Awareness Program	$15,000			
4. Additional Studies	$105,000			
5. Design & Treatability Study Labor	$48,900			
6. Startup & Shakedown	$19,500			
7. Construction - Labor	$41,300			
8. Construction - Materials				
Equipment Costs				
Carbon vessel & pre-heater	$70,000	$20,000		
Carbon transfer tank	$25,000	$10,000		
(2) New blowers (2000 scfm ea)	$20,000	$20,000		
Replace stripper packing	$8,000	$8,000		
Well Pump		$10,000		
Transfer Pump		$1,000		
Booster Pump		$2,000		
Electrical Modification Costs				
Lights	$1,000			
Electric tracing (400 ft @ $11/ft)	$4,400			
Heater utility connection costs	$5,000			
Foundation Materials				
Concrete slab (30'x20'x1' @ $225/cy inst.)	$5,000			
Excavation (1 day)	$1,200			
Materials				
Instruments	$5,000			
Piping (200 ft @ $20/ft)	$4,000			
(6) Valves (@ $500/ea)	$3,000			
Insulation (200 ft @ $10/ft)	$2,000			
Structural Supports	$1,000			
Fencing (150 ft @ $30/ft inst.)	$4,500			
Road Paving (5000 sf @ $3/sf inst.)	$15,000			
Excavate & Backfill	$5,000			
Construction - Materials Total	$179,100			
SUBTOTAL	$420,800	$71,000		
9. Contingency (15%)	$63,120	$10,650		
SUBTOTAL - INITIAL CAPITAL COSTS	$483,920		$483,920	$483,920
SUBTOTAL - 5 YEAR CAPITAL COSTS		$81,650	$227,152	$126,076
TOTAL CAPITAL COSTS	$483,920	$81,650	$711,072	$609,996

TABLE 15
NET PRESENT WORTH COST SUMMARY
AIR STRIPPING/VAPOR PHASE CARBON ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	ANNUAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Analytical Monitoring Program	$12,400			
2. Analytical lab analyses for permits (64 @ $100 ea)	$6,400			
3. 5 Year Reviews		$10,000		
4. Labor (750 hr/yr @ $20/hr)	$15,000			
5. Maintenance	$5,000			
6. Electricity (50 kW)(8760 hr/yr)($.06/kWh)	$26,280			
7. Natural Gas (750 MCF/yr)($5.08/MCF)	$3,800			
8. Carbon Replacement (60,000 lbs/yr @ $2/lb)	$120,000			
SUBTOTAL - ANNUAL OPERATING COSTS	$188,880		$2,903,548	$1,780,555
SUBTOTAL - 5 YEAR OPERATING COSTS		$10,000	$27,820	$15,441
TOTAL OPERATING COSTS	$188,880	$10,000	$2,931,369	$1,795,996
TOTAL CAPITAL COSTS	$483,920	$81,650	$711,072	$609,996
TOTAL NET PRESENT VALUE			$3,642,441	$2,405,992

AR301207

TABLE 16
CAPITAL COST SUMMARY
AIR STRIPPING/VAPOR PHASE REGENERABLE CARBON ALTERNATIVE
BKS FEASIBILITY STUDY

ITEM	INITIAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Plugging the Gehman Well	$2,000			
2. Implementing Deed Restrictions	$10,000			
3. Implementing Public Awareness Program	$15,000			
4. Additional Studies	$105,000			
5. Design & Treatability Study Labor	$67,200			
6. Startup & Shakedown	$19,500			
7. Construction - Labor	$50,900			
8. Construction - Materials				
Equipment Costs				
CADRE System *	$480,000	$60,000		
(2) New blowers (2000 scfm ea)	$20,000	$20,000		
Stripper base plate & packing	$8,000	$8,000		
Well Pump		$10,000		
Transfer Pump		$1,000		
Booster Pump		$2,000		
30 ton crane w/operator (5 day @ $1350/day)	$6,750			
Electrical Modification Costs				
Lights	$1,000			
Electric tracing (400 ft @ $11/ft)	$4,400			
Heater utility connection costs	$5,000			
Foundation Materials				
Concrete slab (40'x15'x1' @ $225/cy inst.)	$5,000			
Foundation (20 cy @ $300/cy inst.)	$6,000			
Excavation (1 day)	$1,200			
Backfill	$1,000			
Materials				
Piping (200 ft @ $20/ft)	$4,000			
Utility Piping (500 ft @ $30/ft)	$15,000			
(10) Valves (@ $500/ea)	$5,000			
Insulation (200 ft @ $10/ft)	$2,000			
Insulation (1000 sf @ $3/sf)	$3,000			
Structural Supports	$1,000			
Fencing (150 ft @ $30/ft inst.)	$4,500			
Road Paving (5000 sf @ $3/sf inst.)	$15,000			
Excavation & Backfill	$5,000			
Construction - Materials Total	$592,850			
SUBTOTAL	$862,450	$101,000		
9. Contingency (15%)	$129,368	$15,150		
SUBTOTAL - INITIAL CAPITAL COSTS	$991,818		$991,818	$991,818
SUBTOTAL - 5 YEAR CAPITAL COSTS		$116,150	$323,132	$179,348
TOTAL CAPITAL COSTS	$991,818	$116,150	$1,314,950	$1,171,166

AR301208

TABLE 17
NET PRESENT WORTH COST SUMMARY
AIR STRIPPING/VAPOR PHASE REGENERABLE CARBON ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	ANNUAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Analytical Monitoring Program	$12,400			
2. Analytical lab analysis for permits (64 @ $100 ea)	$6,400			
3. 5 Year Reviews		$10,000		
4. Labor (1100 hr/yr @ $20/hr)	$22,000			
5. Maintenance	$20,000			
6. Electricity (50 kW)(8760 hr/yr)($.06/kWh)	$26,280			
7. Fuel Costs (1500 MCF/yr)($5.08/MCF)	$7,600			
8. Carbon Replacement (5,000 lbs/yr @ $2/lb)	$10,000			
SUBTOTAL - ANNUAL OPERATING COSTS	$104,680		$1,609,188	$986,809
SUBTOTAL - 5 YEAR OPERATING COSTS		$10,000	$27,820	$15,441
TOTAL OPERATING COSTS	$104,680	$10,000	$1,637,008	$1,002,250
TOTAL CAPITAL COSTS	$991,818	$116,150	$1,314,950	$1,171,165
TOTAL NET PRESENT VALUE			$2,951,958	$2,173,415

TABLE 18
CAPITAL COST SUMMARY
AIR STRIPPING/VAPOR PHASE CATALYTIC OXIDATION ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	INITIAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Plugging the Gehman Well	$2,000			
2. Implementing Deed Restrictions	$10,000			
3. Implementing Public Awareness Program	$15,000			
4. Additional Studies	$105,000			
5. Design & Treatability Study Labor	$67,200			
6. Startup & Shakedown	$19,500			
7. Construction - Labor	$53,500			
8. Construction - Materials				
Equipment Costs				
Catalytic Oxidation Reactor	$225,000	$40,000		
(2) New blowers (2000 scfm ea)	$20,000	$20,000		
Replace stripper packing	$8,000	$8,000		
Gas/Gas Heat Exchanger	$15,000	$15,000		
Well Pump		$10,000		
Transfer Pump		$1,000		
Booster Pump		$2,000		
30 ton crane w/operator (5 day @ $1350/day)	$6,750			
Electrical Modification Costs				
Lights	$1,000			
Electric tracing (200 ft @ $11/ft)	$2,200			
Foundation Materials				
Concrete slab (20'x15'x1' @ $225/cy)	$2,500			
Foundation (20 cy @ $300/cy)	$6,000			
Excavation (1 day)	$1,200			
Backfill	$1,000			
Materials				
Piping (100 ft @ $20/ft)	$2,000			
Utility Piping (500 ft @ $30/ft)	$15,000			
(6) Valves (@ $500/ea)	$3,000			
Insulation (200 ft @ $10/ft)	$2,000			
Insulation (2000 sf @ $3/sf)	$6,000			
Structural Supports	$1,000			
Fencing (150 ft @ $30/ft inst.)	$4,500			
Road Paving (5000 sf @ $3/sf inst.)	$15,000			
Excavation & Backfill	$5,000			
Construction - Materials Total	$342,150			
SUBTOTAL	$614,350	$96,000		
9. Contingency (15%)	$92,153	$14,400		
SUBTOTAL - INITIAL CAPITAL COSTS	$706,503		$706,503	$706,503
SUBTOTAL - 5 YEAR CAPITAL COSTS		$110,400	$307,136	$170,469
TOTAL CAPITAL COSTS	$706,503	$110,400	$1,013,638	$876,972

AR301210

TABLE 19
NET PRESENT WORTH COST SUMMARY
AIR STRIPPING/VAPOR PHASE CATALYTIC OXIDATION ALTERNATIVE
BES FEASIBILITY STUDY

ITEM	ANNUAL COST	COST EVERY 5 YEARS	NPV (N=30 yrs) i=5%	NPV (N=30 yrs) i=10%
1. Analytical Monitoring Program	$12,400			
2. Analytical lab analysis for permits (64 @ $100 ea)	$6,400			
3. 5 Year Reviews		$10,000		
4. Labor (1100 hr/yr @ $20/hr)	$22,000			
5. Maintenance	$15,000			
6. Catalyst Replacement	$10,000			
7. Electricity (50 kW)(8760 hr/yr)($.06/kWh)	$26,280			
8. Natural Gas (10,500 MCF/yr)($5.08/MCF)	$53,340			
SUBTOTAL - ANNUAL OPERATING COSTS	$145,420		$2,235,462	$1,370,861
SUBTOTAL - 5 YEAR OPERATING COSTS		$10,000	$27,820	$15,441
TOTAL OPERATING COSTS	$145,420	$10,000	$2,263,282	$1,386,302
TOTAL CAPITAL COSTS	$706,503	$110,400	$1,013,638	$876,372
TOTAL NET PRESENT VALUE			$3,276,920	$2,263,274

TABLE 20
COST SENSITIVITY TO CHANGE IN DURATION OF REMEDIAL ACTION
BES FEASIBILITY STUDY

ALTERNATIVE	NPV (n=30 yrs)		NPV (n=20 yrs)		NPV (n=10 yrs)	
	i=5%	i=10%	i=5%	i=10%	i=5%	i=10%
Alternative No.1 - Minimal/No-Action	$264,000	$193,000	$230,000	$182,000	$174,000	$154,000
Alternative No.2 - Ground Water Extraction and Treatment						
Option 2A - Liquid Phase UV/Ozone	$3,101,000	$2,191,000	$2,664,000	$2,056,000	$1,952,000	$1,704,000
Option 2B - Liquid Phase Carbon Adsorption	$4,770,000	$3,138,000	$3,978,000	$2,891,000	$2,687,000	$2,249,000
Option 2C - Air Stripping	$1,197,000	$784,000	$1,000,000	$723,000	$677,000	$564,000
Option 2D - Air Stripping with Vapor Phase Carbon Adsorption	$3,642,000	$2,406,000	$3,044,000	$2,220,000	$2,070,000	$1,737,000
Option 2E - Air Stripping with Regenerable Vapor Phase Carbon Adsorption	$2,952,000	$2,173,000	$2,581,000	$2,059,000	$1,976,000	$1,762,000
Option 2F - Air Stripping with Vapor Phase Catalytic Oxidation	$3,277,000	$2,263,000	$2,790,000	$2,112,000	$1,998,000	$1,721,000

AR301212

TABLE 21
COST SENSITIVITY TO DECREASE IN CONTAMINANT LEVELS
FOR EXTRACTED GROUND WATER
BKS FEASIBILITY STUDY

ALTERNATIVE	NPV FOR DESIGN CONCENTRATIONS		NPV FOR DECREASING CONCENTRATIONS OF CONTAMINATS (1)	
	i=5%	i=10%	i=5%	i=10%
Alternative No.1 - Minimal/No-Action	$264,000	$193,000	$264,000	$193,000
Alternative No.2 - Ground Water Extraction and Treatment				
Option 2A - Liquid Phase UV/Ozone	$3,101,000	$2,191,000	$3,101,000	$2,191,000
Option 2B - Liquid Phase Carbon Adsorption	$4,770,000	$3,138,000	$3,899,000	$2,780,000
Option 2C - Air Stripping	$1,197,000	$784,000	$1,197,000	$784,000
Option 2D - Air Stripping with Vapor Phase Carbon Adsorption	$3,642,000	$2,406,000	$3,096,000	$2,182,000
Option 2E - Air Stripping with Regenerable Vapor Phase Carbon Adsorption (2)	$2,952,000	$2,173,000	$2,952,000	$2,173,000
Option 2F - Air Stripping with Vapor Phase Catalytic Oxidation (2)	$3,277,000	$2,263,000	$3,277,000	$2,263,000

(1) Contaminant levels are assumed to drop 50% every 10 years.
(2) Change in cost is assumed to be negligable.

AR301213

TABLE 22
COST SENSITIVITY TO CHANGE IN TOTAL CAPITAL COSTS
BRS FEASIBILITY STUDY

ALTERNATIVE	NPV		NPV FOR 30% INCREASE IN CAPITAL COSTS		NPV FOR 30% DECREASE IN CAPITAL COSTS	
	i=5%	i=10%	i=5%	i=10%	i=5%	i=10%
Alternative No.1 - Minimal/No-Action	$264,000	$193,000	$289,000	$217,000	$240,000	$168,000
Alternative No.2 - Ground Water Extraction and Treatment						
Option 2A - Liquid Phase UV/Ozone	$3,101,000	$2,191,000	$3,421,000	$2,782,000	$2,474,000	$1,908,000
Option 2B - Liquid Phase Carbon Adsorption	$4,770,000	$3,138,000	$5,003,000	$4,537,000	$3,345,000	$2,931,000
Option 2C - Air Stripping	$1,197,000	$784,000	$1,282,000	$1,113,000	$851,000	$716,000
Option 2D - Air Stripping with Vapor Phase Carbon Adsorption	$3,642,000	$2,406,000	$3,856,000	$3,429,000	$2,589,000	$2,223,000
Option 2E - Air Stripping with Regenerable Vapor Phase Carbon Adsorption	$2,952,000	$2,173,000	$3,346,000	$2,557,000	$2,525,000	$1,822,000
Option 2F - Air Stripping with Vapor Phase Catalytic Oxidation	$3,277,000	$2,263,000	$3,581,000	$2,973,000	$2,526,000	$2,000,000

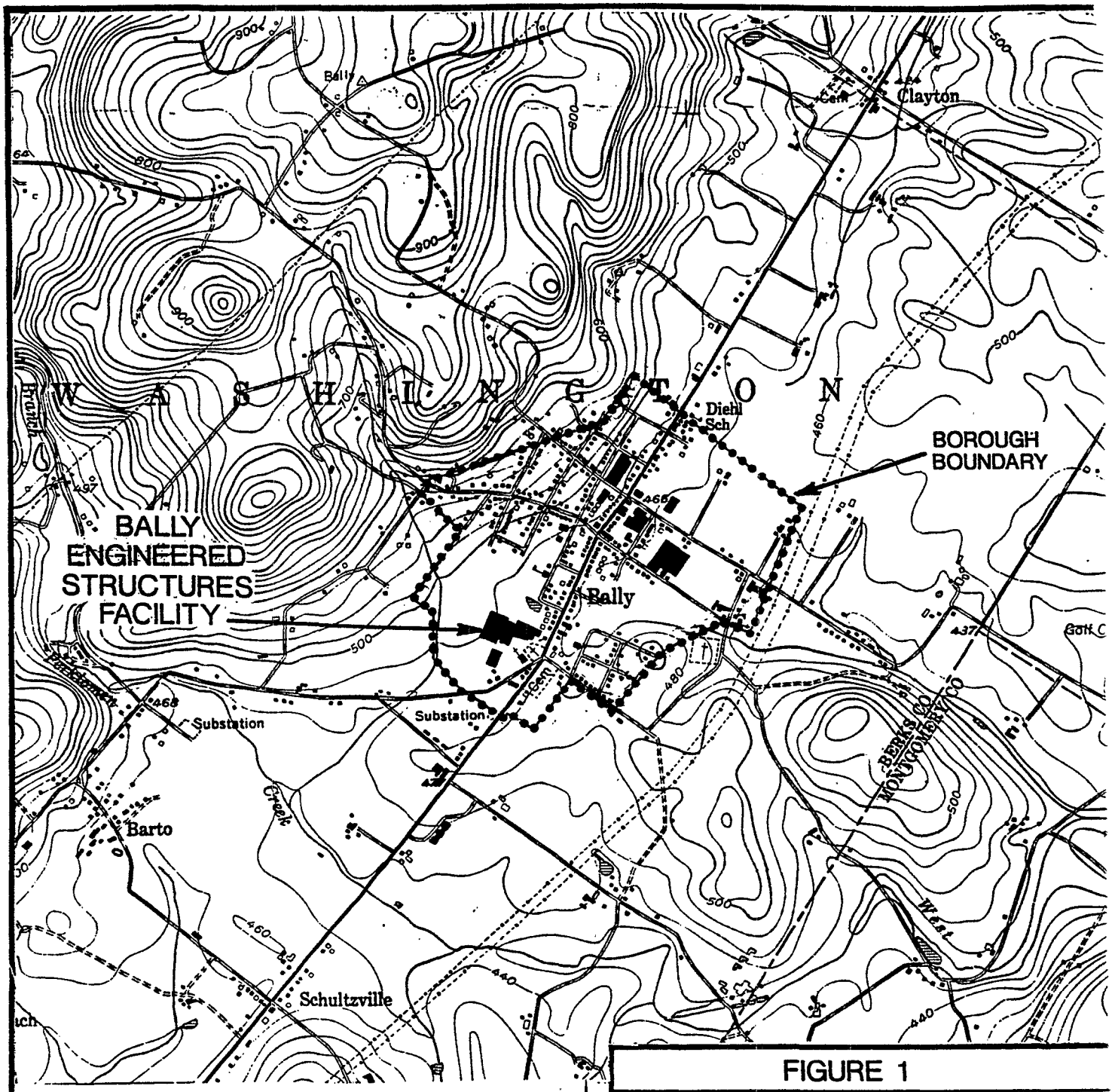
AR301214

TABLE 23
COST SENSITIVITY TO CHANGE IN ANNUAL OPERATING COSTS
BES FEASIBILITY STUDY

ALTERNATIVE	NPV		NPV FOR 30% INCREASE IN OPERATING COSTS		NPV FOR 30% DECREASE IN OPERATING COST	
	i=5%	i=10%	i=5%	i=10%	i=5%	i=10%
Alternative No.1 - Minimal/No-Action	$264,000	$193,000	$310,000	$221,000	$218,000	$164,000
Alternative No.2 - Ground Water Extraction and Treatment						
Option 2A - Liquid Phase UV/Ozone	$3,101,000	$2,191,000	$3,704,000	$2,561,000	$2,499,000	$1,822,000
Option 2B - Liquid Phase Carbon Adsorption	$4,770,000	$3,138,000	$5,960,000	$3,868,000	$3,580,000	$2,409,000
Option 2C - Air Stripping	$1,197,000	$784,000	$1,463,000	$947,000	$931,000	$621,000
Option 2D - Air Stripping with Vapor Phase Carbon Adsorption	$3,642,000	$2,406,000	$4,514,000	$2,940,000	$2,771,000	$1,872,000
Option 2E - Air Stripping with Regenerable Vapor Phase Carbon Adsorption	$2,952,000	$2,173,000	$3,435,000	$2,469,000	$2,469,000	$1,877,000
Option 2F - Air Stripping with Vapor Phase Catalytic Oxidation	$3,277,000	$2,263,000	$3,948,000	$2,675,000	$2,606,000	$1,852,000

AR301215

FIGURES



2000 0 2000 4000

scale feet

N

REFERENCE:

USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE, EAST GREENVILLE, PA, 1956, PHOTOREVISED 1969 AND 1973. SCALE 1:24000

FIGURE 1

SITE LOCATION MAP

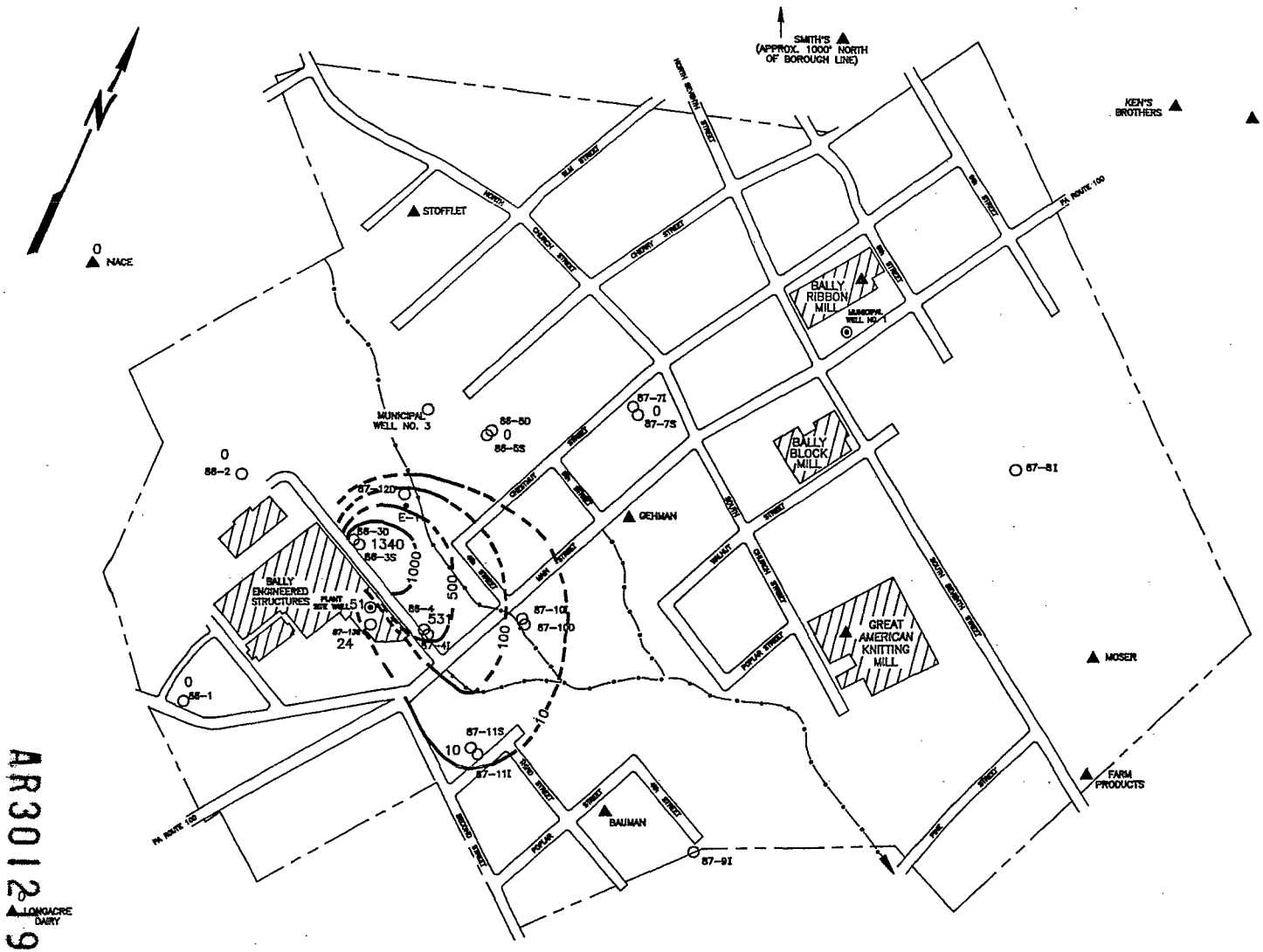
PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	LBL 11-11-88	DRAWING NUMBER
CHECKED	P.V.S. 12/6/88	88548-A2
APPROVED		

REMCOR

AR301218

128579



LEGEND:

NACE ▲	OFF-SITE WELL LOCATION (ESTIMATED LOCATION)
— — — —	BOROUGH LINE
87-10I ○	ERM & REMCOR MONITORING WELLS S = SHALLOW I = INTERMEDIATE D = DEEP
E-1 •	EXPLORATION CORE HOLE
	STREAM

NOTE:

ERM WELL NOMENCLATURE DOES NOT CORRELATE EXACTLY WITH THAT OF THE REMCOR WELLS.

ERM WELLS 86-1, 86-2, 86-3S, 86-4, AND 86-5S ARE SHALLOW WELLS UNDER THE REMCOR SYSTEM. WHILE 86-3D AND 86-5D APPROXIMATE INTERMEDIATE DEPTH WELLS.

ISOCONCENTRATION CONTOURS (DASHED WHERE INFERED) DATA IN PARTS PER BILLION

500 0 500 1000 feet

scale: 1" = 500' (APPROX.)

REFERENCE:

BASE MAP FROM TOPOGRAPHICAL SURVEY, BOROUGH OF BALLY (1975).
MONITORING WELL AND MUNICIPAL WELL LOCATIONS FROM SURVEY BY S.M. NORKEVICH 2/3/88

FIGURE 2

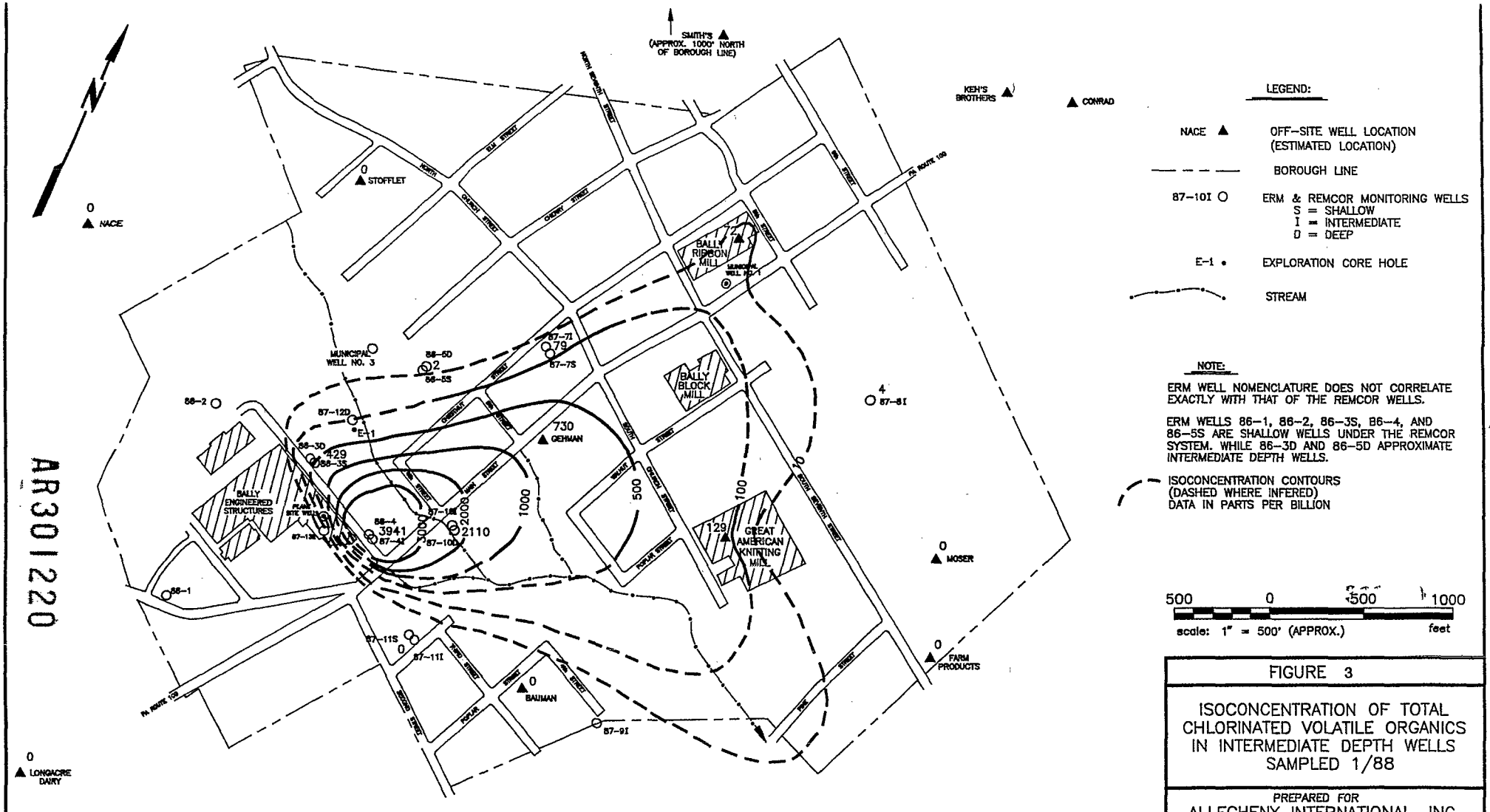
ISOCONCENTRATION OF TOTAL CHLORINATED VOLATILE ORGANICS SHALLOW DEPTH WELLS SAMPLED 1/88

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	L.B.L. 5-3-89	DRAWING NUMBER
CHECKED	5-11-89 PMS	88548-B38
APPROVED		

REMCOR

AR301219



LEGEND:

NACE ▲	OFF-SITE WELL LOCATION (ESTIMATED LOCATION)
— — — —	BOROUGH LINE
87-10I ○	ERM & REMCOR MONITORING WELLS S = SHALLOW I = INTERMEDIATE D = DEEP
E-1 •	EXPLORATION CORE HOLE
	STREAM

NOTE:

ERM WELL NOMENCLATURE DOES NOT CORRELATE EXACTLY WITH THAT OF THE REMCOR WELLS.

ERM WELLS 86-1, 86-2, 86-3S, 86-4, AND 86-5S ARE SHALLOW WELLS UNDER THE REMCOR SYSTEM. WHILE 86-3D AND 86-5D APPROXIMATE INTERMEDIATE DEPTH WELLS.

ISOCONCENTRATION CONTOURS (DASHED WHERE INFERED) DATA IN PARTS PER BILLION

500 0 500 1000 feet

scale: 1" = 500' (APPROX.)

REFERENCE:

BASE MAP FROM TOPOGRAPHICAL SURVEY, BOROUGH OF BALLY (1975).
MONITORING WELL AND MUNICIPAL WELL LOCATIONS FROM SURVEY BY S.M. NORKEVICH 2/3/88

FIGURE 3

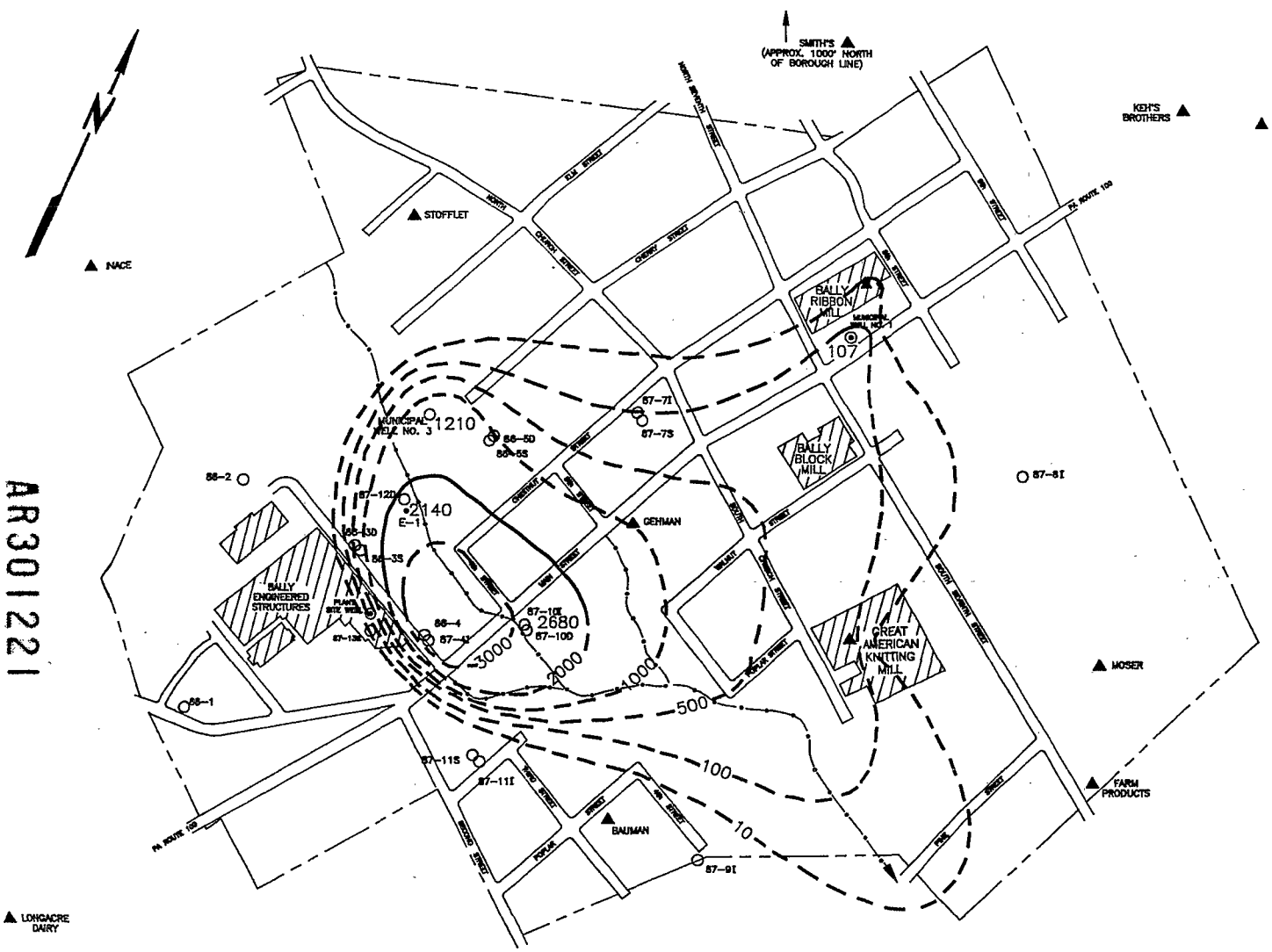
ISOCONCENTRATION OF TOTAL CHLORINATED VOLATILE ORGANICS IN INTERMEDIATE DEPTH WELLS SAMPLED 1/88

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	L.B.L. 5-3-89	DRAWING NUMBER
CHECKED	5-11-89 DMS	88548-B39
APPROVED		

REMCOR

AR301220



LEGEND:

NACE ▲	OFF-SITE WELL LOCATION (ESTIMATED LOCATION)
— — — —	BOROUGH LINE
87-10I ○	ERM & REMCOR MONITORING WELLS S = SHALLOW I = INTERMEDIATE D = DEEP
E-1 •	EXPLORATION CORE HOLE
	STREAM

NOTE:

ERM WELL NOMENCLATURE DOES NOT CORRELATE EXACTLY WITH THAT OF THE REMCOR WELLS.

ERM WELLS 86-1, 86-2, 86-3S, 86-4, AND 86-5S ARE SHALLOW WELLS UNDER THE REMCOR SYSTEM. WHILE 86-3D AND 86-5D APPROXIMATE INTERMEDIATE DEPTH WELLS.

ISOCONCENTRATION CONTOURS (DASHED WHERE INFERED) DATA IN PARTS PER BILLION

500 0 500 1000 feet

scale: 1" = 500' (APPROX.)

REFERENCE:

BASE MAP FROM TOPOGRAPHICAL SURVEY, BOROUGH OF BALLY (1975).
MONITORING WELL AND MUNICIPAL WELL LOCATIONS FROM SURVEY BY S.M. NORKEVICH 2/3/88

FIGURE 4

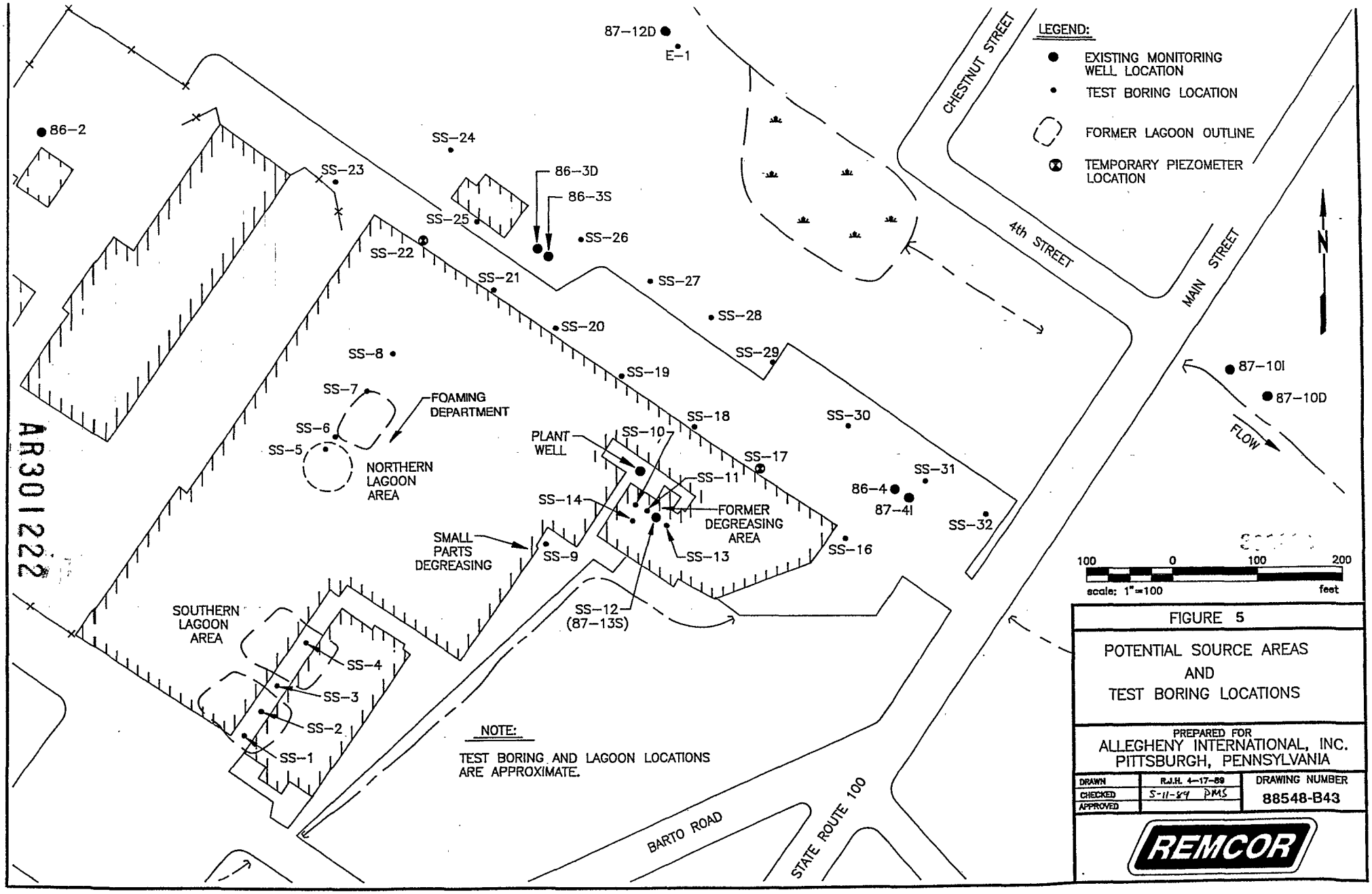
ISOCONCENTRATION OF TOTAL CHLORINATED VOLATILE ORGANICS IN DEEP WELLS SAMPLED 1/88

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	L.B.L. 5-3-89	DRAWING NUMBER
CHECKED	5-11-89 PMS	88548-B40
APPROVED		

REMCOR

AR301221


LEGEND:
EXISTING MONITORING WELL LOCATION
TEST BORING LOCATION
FORMER LAGOON OUTLINE
TEMPORARY PIEZOMETER LOCATION
N
CHESTNUT STREET
4th STREET
MAIN STREET
BARTO ROAD
STATE ROUTE 100
FLOW
87-12D
E-1
86-2
SS-24
SS-23
86-3D
86-3S
SS-25
SS-26
SS-22
SS-21
SS-27
SS-28
SS-20
SS-29
SS-8
SS-19
SS-7
FOAMING DEPARTMENT
SS-6
SS-5
NORTHERN LAGOON AREA
PLANT WELL
SS-10
SS-18
SS-30
SS-17
SS-11
SS-31
86-4
87-4I
SS-14
FORMER DEGREASING AREA
SS-32
SMALL PARTS DEGREASING
SS-9
SS-13
SS-16
SS-12 (87-13S)
SOUTHERN LAGOON AREA
SS-4
SS-3
SS-2
SS-1
87-10I
87-10D
NOTE:
TEST BORING AND LAGOON LOCATIONS ARE APPROXIMATE.
100 0 100 200
scale: 1"=100 feet
FIGURE 5
POTENTIAL SOURCE AREAS AND TEST BORING LOCATIONS
PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA
DRAWN R.J.H. 4-17-89
CHECKED 5-11-89 PMS
APPROVED
DRAWING NUMBER 88548-B43
REMCOR

AR301222

DRAWING NOT TO SCALE

NOTE:
UV = ULTRAVIOLET LIGHT

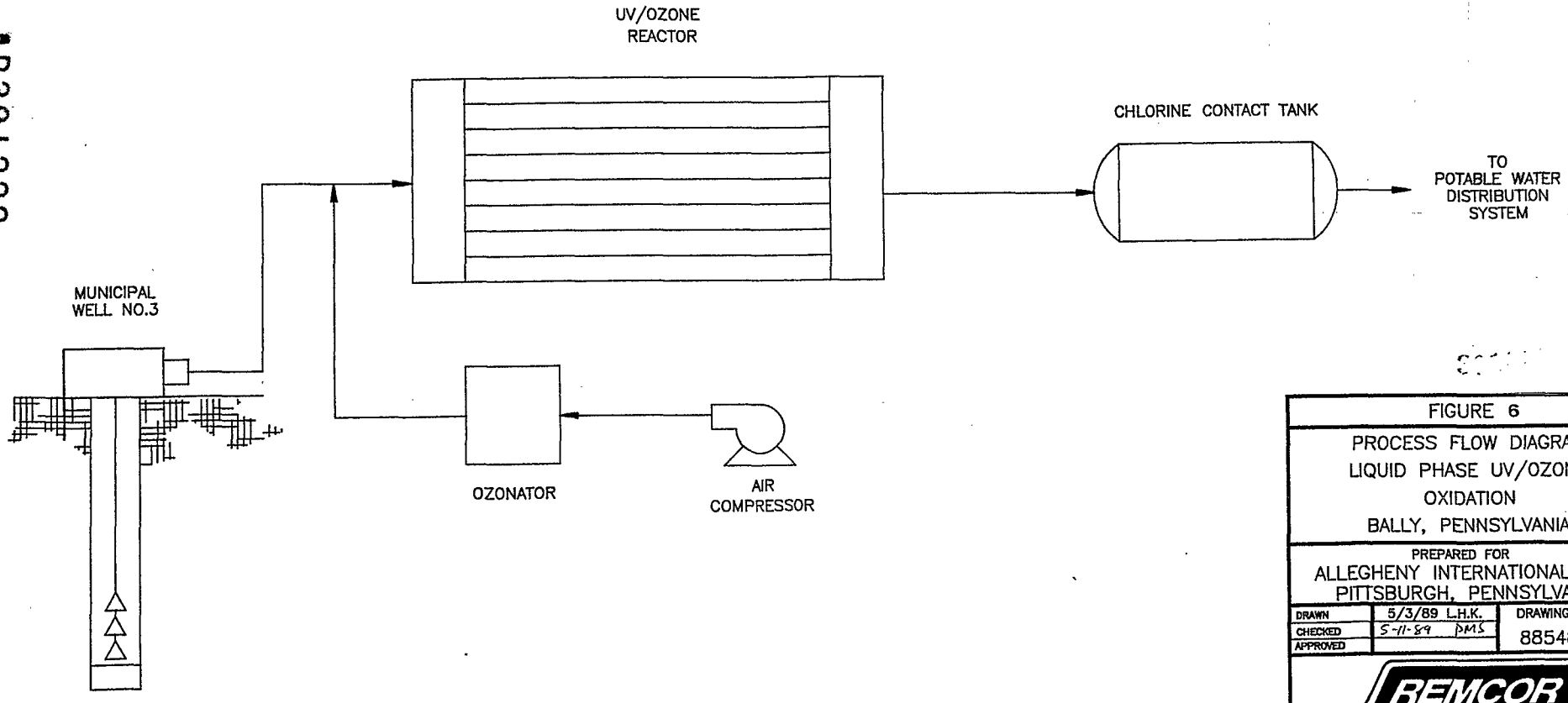


FIGURE 6

PROCESS FLOW DIAGRAM
LIQUID PHASE UV/OZONE
OXIDATION
BALLY, PENNSYLVANIA

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	5/3/89 L.H.K.	DRAWING NUMBER
CHECKED	5-11-89 DMS	88548-B41
APPROVED		

REMCOR

AR301223

DRAWING NOT TO SCALE

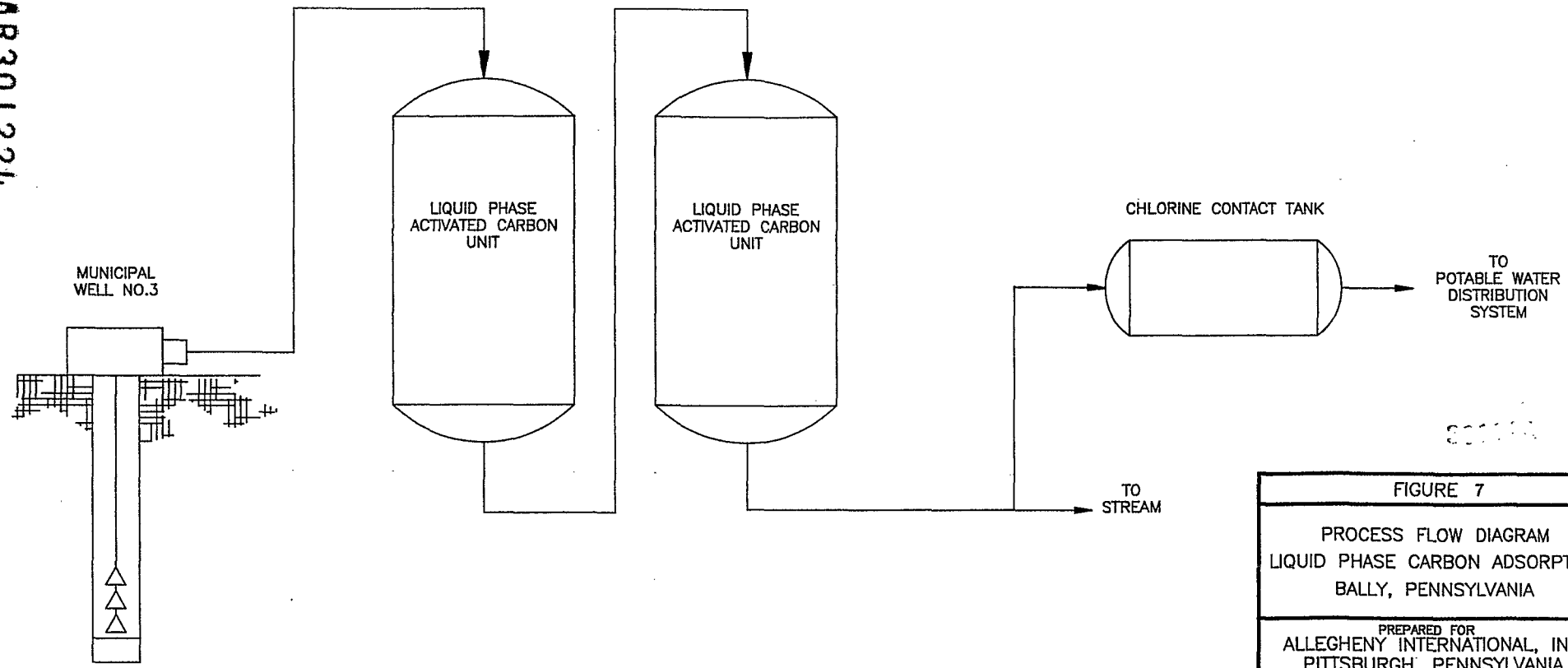


FIGURE 7

PROCESS FLOW DIAGRAM
LIQUID PHASE CARBON ADSORPTION
BALLY, PENNSYLVANIA

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	5/3/89 L.H.K.	DRAWING NUMBER
CHECKED	5-11-89 PMS	88548-B42
APPROVED		

REMCOR

AR301224

DRAWING NOT TO SCALE

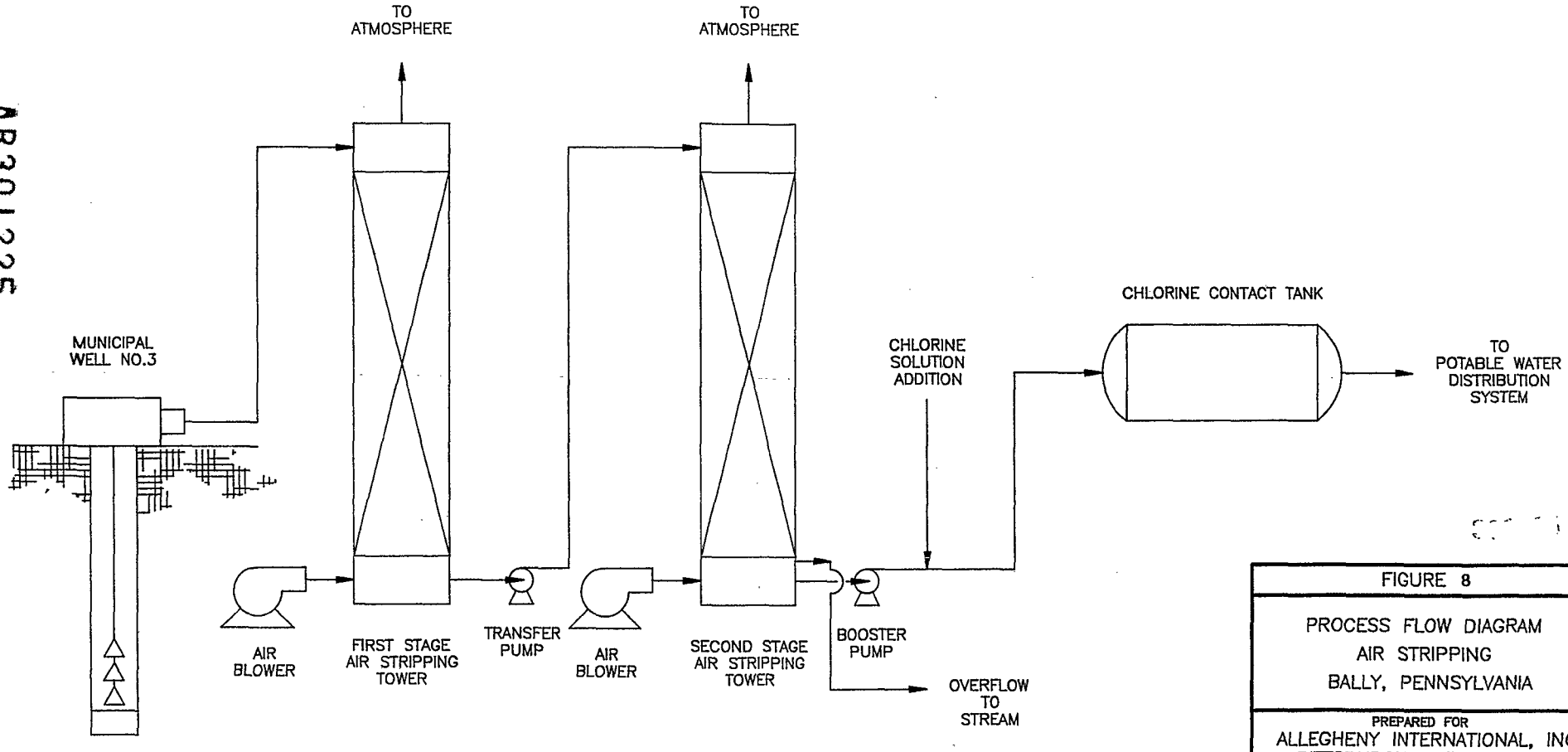


FIGURE 8

PROCESS FLOW DIAGRAM
AIR STRIPPING
BALLY, PENNSYLVANIA

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	4/21/89 L.H.K.	DRAWING NUMBER
CHECKED	5-11-89 PMS	88548-B31
APPROVED		

REMCOR

AR301225

DRAWING NOT TO SCALE

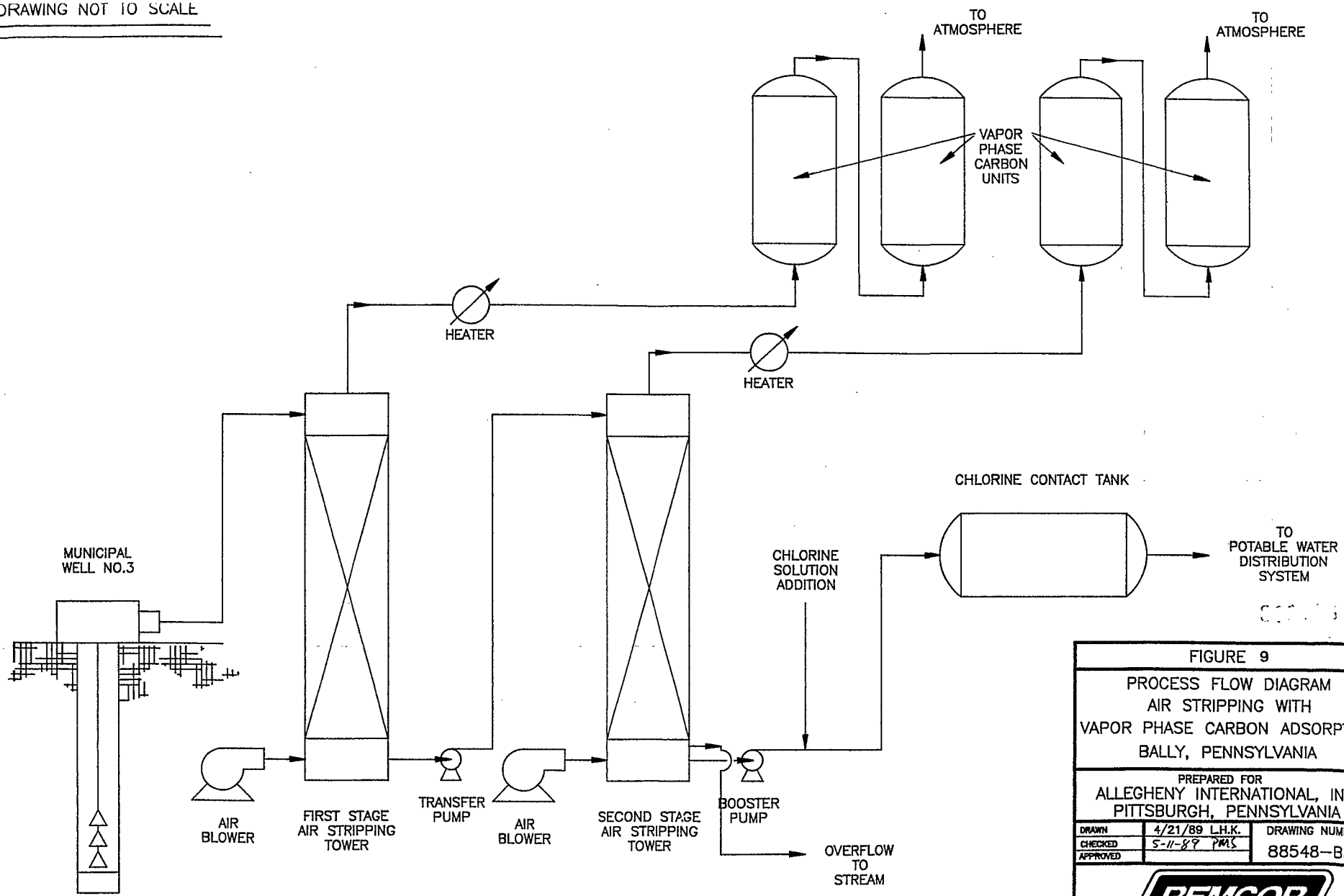


FIGURE 9

PROCESS FLOW DIAGRAM
AIR STRIPPING WITH
VAPOR PHASE CARBON ADSORPTION
BALLY, PENNSYLVANIA

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	4/21/89 L.H.K.	DRAWING NUMBER
CHECKED	5-11-89 PMS	88548-B32
APPROVED		

REMCOR

AR301226

DRAWING NOT TO SCALE

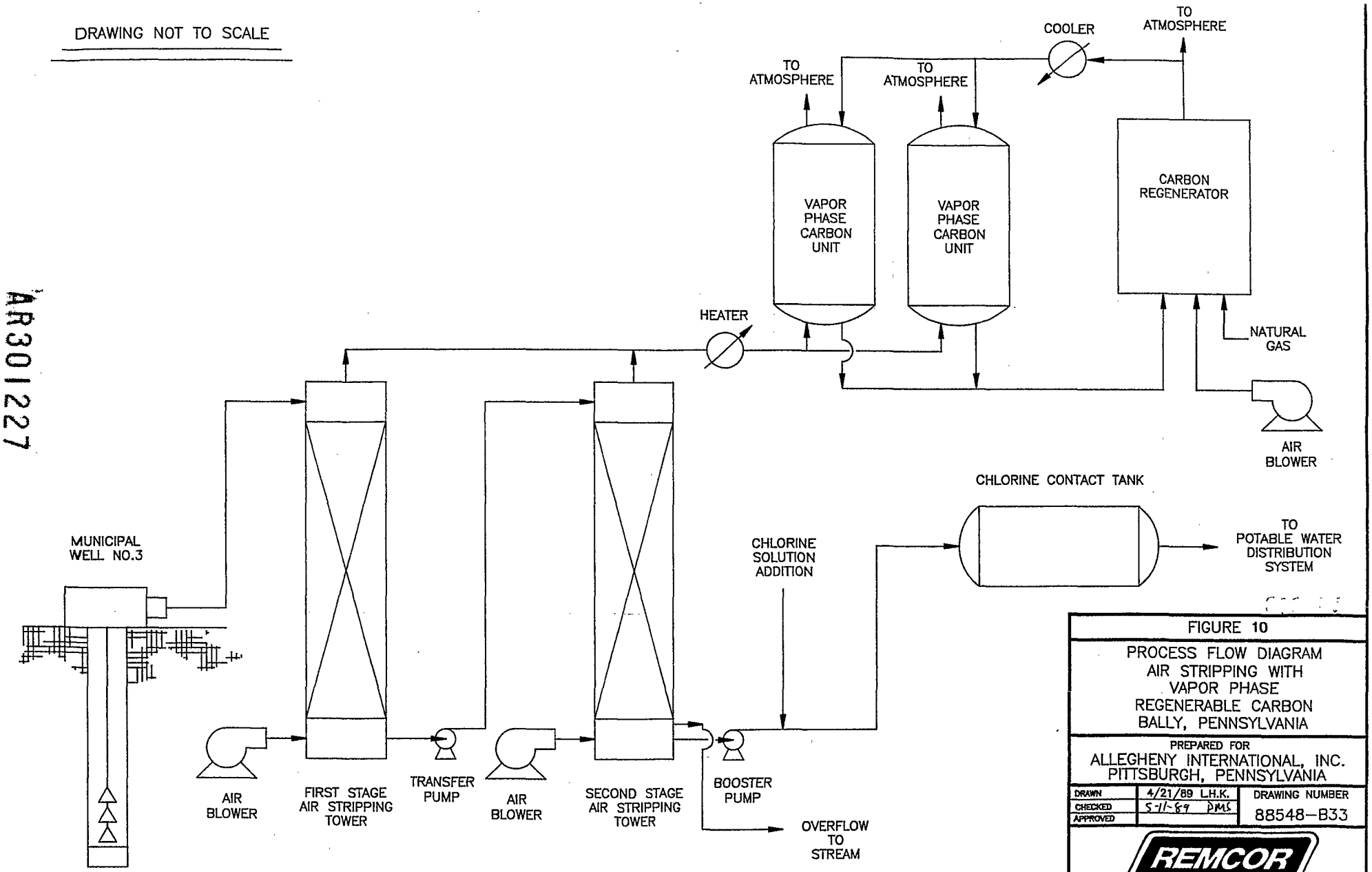


FIGURE 10

PROCESS FLOW DIAGRAM
AIR STRIPPING WITH
VAPOR PHASE
REGENERABLE CARBON
BALLY, PENNSYLVANIA

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	4/21/89 L.H.K.	DRAWING NUMBER
CHECKED	5-1-89 DMS	88548-B33
APPROVED		

REMCOR

AR301227

DRAWING NOT TO SCALE

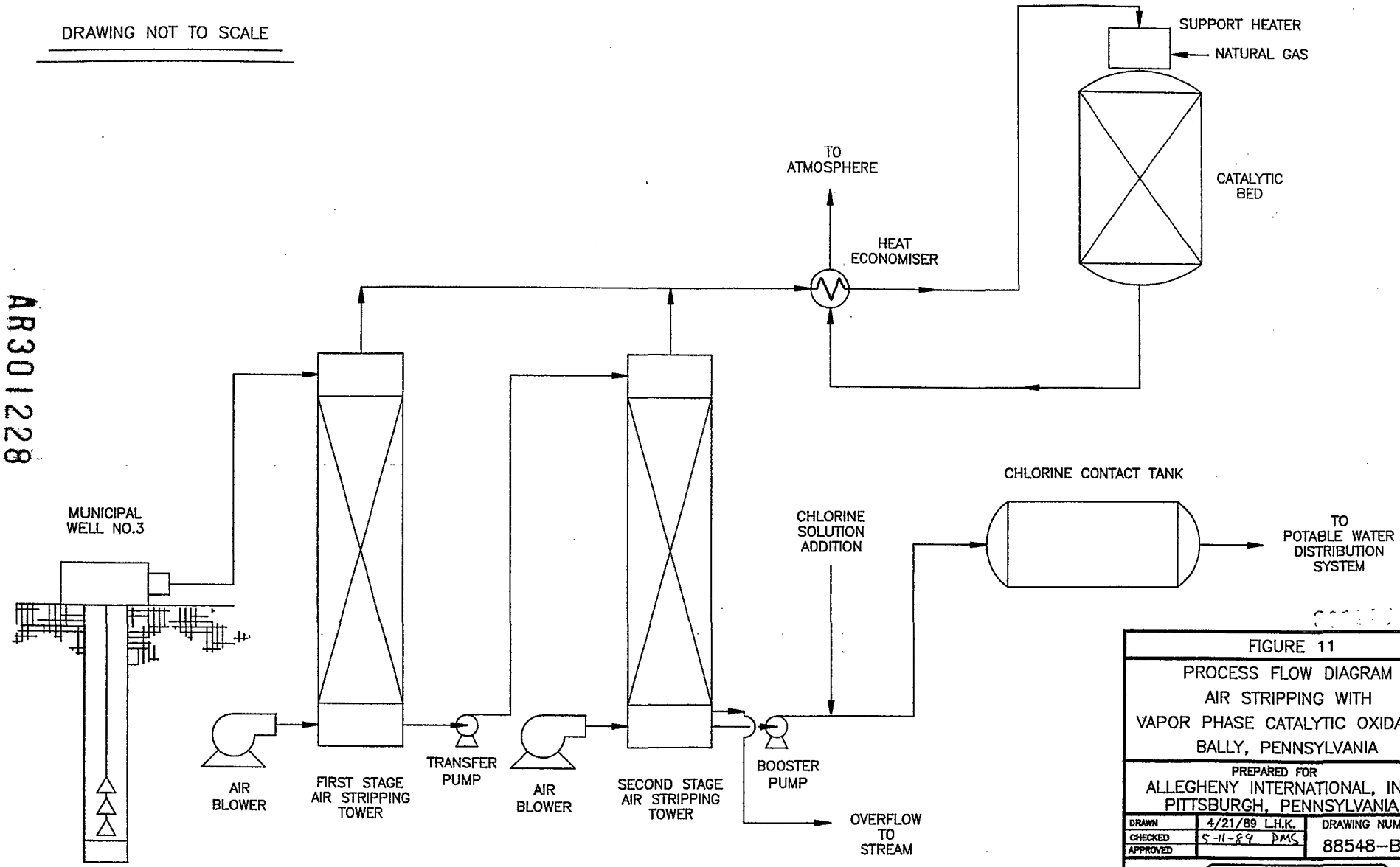


FIGURE 11

PROCESS FLOW DIAGRAM
AIR STRIPPING WITH
VAPOR PHASE CATALYTIC OXIDATION
BALLY, PENNSYLVANIA

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	4/21/89 L.H.K.	DRAWING NUMBER
CHECKED	5-11-89 DMS	88548-B34
APPROVED		

REMCOR

AR301228

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REFERENCES

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APPENDIX

AR301232

APPENDIX A

DESIGN, INSTALLATION AND OPERATIONAL
TESTING OF THE AIR STRIPPING SYSTEM
AT MUNICIPAL WELL NO. 3
BOROUGH OF BALLY
PENNSYLVANIA

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A-4	Borough of Bally, Well No. 3, Air Stripping System, Effluent Concentrations 1989

LIST OF FIGURES

FIGURE NO.	TITLE
A-1	Process and Control Diagram for Air Stripping System, Municipal Well No. 3, Bally, Pennsylvania

APPENDIX A
DESIGN, INSTALLATION AND OPERATIONAL TESTING OF THE AIR STRIPPING SYSTEM AT MUNICIPAL WELL NO. 3 BOROUGH OF BALLY PENNSYLVANIA

A.1.0 INTRODUCTION

Bally Municipal Well No. 3 was constructed by the borough in 1977 to supplement the existing spring water supply and Municipal Well No. 1. Pertinent construction and operational data for the well are as follows:

- Permit No. 0678502
- Drilled in 1977
- On-line in November 1979
- 300 gallons per minute (gpm), 30 horsepower (hp) vertical turbine pump
- Safe yield 0.324 million gallons per day (mgd)
- Disinfection provided via chlorine injection system and a 6,000 gallon contact tank (underground)
- 303 feet total depth
- 10-inch diameter casing
- Pump setting 150 feet below grade
- 300-foot pumping head
- Static water level 35 feet below grade (following drilling).

In 1982, volatile organic compounds (VOCs) were detected in Municipal Well No. 3. The VOCs consisted mainly of 1,1-dichloroethene (DCE), 1,1,1-trichloroethane (TCA), and trichloroethene (TCE). Levels of VOCs increased with continued pumping and Municipal Well No. 3 was removed from service in December 1982, forcing the Borough of Bally to rely on springs and existing Municipal Well No. 1 to supply the community's needs.

Allegheny International, Inc (AI) retained Remcor, Inc. (Remcor) in 1987 to evaluate alternative water supply options for the borough. Following an evaluation of available options, Remcor recommended design and installation of an air stripping system for Municipal Well No. 3 to provide the borough with an alternative source of drinking water.

Remcor's recommendation was based on the following:

- Both municipal wells have demonstrated safe yields sufficient (in conjunction with the springs) to provide an adequate water supply for both current and near-term future needs. Average water usage for the five-year period from 1982 through 1987 was approximately 28 million gallons per year. Water usage had been relatively constant over this period; no residential expansion or industrial development was forecasted that would cause a significant increase in water usage.

- In 1982, Municipal Well No. 1 was found to contain low levels of chlorinated VOCs (i.e., less than 10 micrograms per liter [µg/ℓ]). A trend toward increasing VOC concentrations was evident from 1982 through 1987, indicating the potential need for future treatment of water from this well for potable use. Although VOC levels at Municipal Well No. 3 were approximately three orders of magnitude higher in 1987 than those measured in Municipal Well No. 1, the basic cost of treatment was not significantly different.

- Given the comparative ages of the municipal wells (i.e., Municipal Well No. 1 is approximately 30 years older than Municipal Well No. 3), the equipment and piping currently in place at Municipal Well No. 3 was considered significantly more reliable.

- The proximity of Municipal Well No. 3 to a more highly contaminated portion of the aquifer suggested that pumping of this well may act to contain the spread of VOCs in ground water and to assist in remediation of the aquifer.

- In considering treatment technologies, Remcor evaluated both air stripping and liquid phase carbon treatment. Both technologies were found to be technically feasible and implementable at Municipal Well No. 3. The cost of liquid phase carbon was determined to be approximately three to five times than that of air stripping. In consideration of the cost differential and in the absence of significantly greater reliability or effectiveness in treatment, air stripping was selected as the preferred technology.

Construction of the air stripping tower started in the summer of 1988 with initial startup in September 1988. Operational testing showed that the tower was not meeting the performance requirements outlined in the

design and specifications, and a second tower was installed in December 1988. This system was tested in January 1989 and found to meet all effluent discharge requirements for treated water. Pumping of this well has been ongoing since February 6, 1989 with discharge at a rate of approximately 250 gpm to an adjacent unnamed tributary to West Branch Perkiomen Creek. Weekly monitoring has shown that the effluent from the air stripping towers has consistently met the water quality requirements discussed in this appendix.

The following sections describe the design, permit, construction, and operational testing of the air stripping system for Well No. 3.

"REALISTIC SOLUTIONS FOR HAZARDOUS WASTE PROBLEMS"

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A.2.0 AIR STRIPPING SYSTEM DESIGN

A.2.1 VOC REMOVAL

The air stripping system is designed to remove VOCs from the Municipal Well No. 3 pump discharge to meet the more stringent of either the Drinking Water Supply Permit or the limits established for discharge to surface waters according to the National Pollutant Discharge Elimination System (NPDES) permit. Both permit authorities are administered by the Pennsylvania Department of Environmental Resources (PADER), and are discussed in the following section. The influent levels used to design the system were established by reviewing historical analytical data from Municipal Well No. 3. The design removal requirements for the air stripping system are summarized in Table A-1.

A.2.2 PERMIT SUBMITTAL

The requisite applications for installation of the air stripper were prepared and submitted to the PADER. These included the following:

- Drinking Water Supply Permit
- NPDES Permit
- Part II Water Quality Permit
- Air Discharge Permit.

These applications identified the process design of the system and the mechanical installation requirements. Permit applications previously approved by the PADER were modified in November 1988 to incorporate installation of an additional stripping tower to meet established permit discharge requirements. Revised permits were issued in February 1989. All permits are finalized with the exception of the air discharge permit. This permit was issued as a temporary operating permit to allow for a 120-day startup and final testing period through June 13, 1989. Operational data will be reviewed after this period as the basis for issuance of a final permit by the PADER Bureau of Air Quality.

A.2.3 PROCESS DESCRIPTION

The Municipal Well No. 3 piping system was modified to pump water from the well pump discharge to the top of the first stage stripping column. A new globe valve, in conjunction with the existing turbine flow meter, was provided to control the influent flow to the stripper. Figure A-1 shows the process flow diagram of the Bally air stripping system.

The system consists of two, four-foot diameter columns containing vertical plastic packing to increase the surface area for air-to-water contact. The water is distributed over the top of the packing in the first stage tower via a spray nozzle, and air is introduced into the stripper below the packing by electrically powered blower. As the water flows down the column, the air flows upward through the packing in a counter-current fashion. The VOCs are transferred from the water into the air stream due to their high volatility. The VOCs and the air are discharged out of the top of the column. The treated water falls out of the packing and accumulates in a sump at the base of the first stage air stripper.

The effluent water from the first stage sump is pumped to the top of the second stage tower by means of a transfer pump. A portion of the water is recycled back to the first stage sump to control liquid level. The second stage stripping tower operates like the first stage tower. Any residual organics are removed from the water in this tower and exhausted to the ambient air out of the top of the column. Treated water drains to a sump at the base of the second stage tower.

The system is designed to pump the effluent water from the sump of the second stage tower into the existing potable water system by means of a second stage stripper booster pump. The water can also be pumped through the existing drain line into an adjacent unnamed tributary to West Branch Perkiomen Creek at the approved NPDES outfall. When the stripper booster pump is off, the water overflows from the second stage sump through a new drain line into the adjacent stream.

Water pumped to the potable water system is chlorinated using the existing chlorine booster pump and injection system. The suction piping for the chlorine booster pump has been modified to take the suction from the second stage stripper booster pump instead of the well pump.

A.2.4 EQUIPMENT

The following is a list of new and existing equipment in the system and a brief description of each unit.

A.2.4.1 Existing Well Pump

The existing well pump is a vertical turbine pump, Goulds Model GWT. It is driven by a 30-horsepower (hp), three-phase motor operating on 208 volts. For the installation of the air stripping system, the well pump was modified by removing three, 5.25-inch stages to obtain a design pumping rate of 300 gpm at 225 feet of hydraulic head. Operations showed a maximum actual capacity of approximately 250 gpm at 175 feet of head.

A.2.4.2 First Stage Air Stripper

The first stage air stripper was manufactured by Delta Cooling Towers (Delta) of Fairfield, New Jersey, and is 4 feet in diameter and 24 feet high. The tower contains 18 feet of Delta SH-type polyvinyl chloride (PVC) vertical packing. The stripper is designed to operate at a maximum treatment rate of 300 gpm and a minimum rate of 170 gpm.

A.2.4.3 First Stage Transfer Pump

The first stage transfer pump is a horizontal, centrifugal, 3550 RPM Scott WE 55 pump. It is driven by a 7.5-hp, three-phase motor operating on 208 volts. The pump was designed to transfer water from the first stage sump to the top of the second stage stripper. The rated pump capacity is 300 gpm at 65 feet of head.

A.2.4.4 Second Stage Air Stripper

The second stage air stripper was also manufactured by Delta. This tower is 4 feet in diameter and 32.5 feet high. The tower contains

24 feet of Delta SH-type PVC vertical packing. The stripper is designed to operate at a maximum flow rate of 300 gpm and a minimum flow rate of 170 gpm.

A.2.4.5 Blowers

The fresh air blowers used with the air stripping columns are driven by separate, 7.5-hp, three-phase motors operating on 208 volts. They were designed to provide 8,400 cubic feet per minute (cfm) of air flow at a discharge pressure of 3.0 inches of water column.

A.2.4.6 Second Stage Stripper Booster Pump

The second stage stripper booster pump is a horizontal, centrifugal pump, Goulds Model No. 3196 MT. It is driven by a 25-hp, three-phase motor operating on 208 volts. The pump was designed to deliver treated water at 300 gpm and 150 feet of head.

A.2.4.7 Chlorine Booster Pump

The chlorine booster pump is an existing 3/4-hp pump installed to pump treated water through an educator for chlorine feed. The eductor mixes chlorine with the treated water from the second stage booster pump. The chlorinated water is then pumped to the 6,000-gallon chlorine contact tank. The tank provides 20 minutes of residence time for disinfection of the water before its entry into the potable water system.

A.3.0 INSTALLATION AND OPERATIONAL TESTING

The following section describes the installation, startup, and performance testing of the Bally air stripping system between July 1988 and April 1989. Startup of the system included a testing period for equipment operation and control system interlocks along with performance testing for VOC removal.

A.3.1 INITIAL INSTALLATION OF AIR STRIPPER

In July 1988, Remcor started modifications on Well No. 3 to install the new air stripping system. These modifications included pouring a new foundation, extension of the pump building, and rearrangement of the piping system. The modular air stripping unit was installed in late August 1988.

A.3.2 INITIAL PERFORMANCE TESTING

The initial startup of the air stripping system was conducted on September 21, 1988. Initial efforts involved testing system components prior to collecting samples. After startup and testing of operational interlocks, the treatment system was operated at various inlet and recycle rates. A total of 34 samples were taken and delivered to Spots, Stevens, and McCoy, Inc. (SSM) in Reading, Pennsylvania for analysis for target VOCs (i.e., DCE, TCA, and TCE).

Influent levels to the stripper were approximately 30 percent of those used for design of the air stripper. The design effluent levels for DCE and TCE, however, were not achieved:

	ACTUAL EFFLUENT LEVELS (µg/ℓ)	DESIGN EFFLUENT LEVELS (µg/ℓ)	PERMIT REQUIRED DISCHARGED LEVELS	
			NPDES (µg/ℓ)	WATER QUALITY (µg/ℓ)
DCE	<1 to 2.8	0.6	0.6	7
TCA	4.5 to 18.8	200	N/A	200
TCE	1.0 to 5.5	<1	33	5

Based on design effluent levels, TCA was the only parameter that was well below the design requirements. The levels of TCE and DCE did meet drinking water standards but did not achieve effluent levels required for discharge to the adjacent stream. The initial belief was that there was a mechanical problem with the system and the focus over the next 5 weeks was to identify that problem and remedy it. Remcor collected a total of 80 samples for target VOC analysis to evaluate the performance of the air stripping system over this time period.

A.3.3 FLOWMETER AND PUMP PERFORMANCE

During this initial startup, a discrepancy was noted between the flowmeters and the corresponding pump discharge pressure. During subsequent testing, the flowmeters were calibrated by measuring the discharge flow and recording the pump pressure. The flowmeters, one for inlet to the first stage air stripper and another on the discharge of the booster pump, varied between 7 gpm and 18 gpm depending on the flow rate.

The measured flows also confirmed that the actual operating pump curve was 10 to 20 percent under the predicted one. Though the flowmeters and pump were not performing up to design conditions, this testing did prove that the towers were not being loaded at a higher hydraulic rate than design.

A.3.4 AIR FLOW AND WATER DISTRIBUTION

Along with calibration of the flowmeters and pump curve, the air flow from the column was measured. A measurement of the air discharging from the column showed an average velocity of 600 feet per second which corresponded to a flow rate of 7,500 cfm. The design rate was 8,400 cfm, however, Delta discounted this variation as the basis for the stripping system not achieving the designed treatment efficiency.

The distribution of water across the top of the packing was then reviewed to determine its adequacy. A hydraulic pressure fluctuation

observed at the spray nozzle varied the diameter of the spray cone. This problem was reviewed with the nozzle fabricator, pump manufacturer, and Delta, and no satisfactory answer was found to explain this phenomenon. After analysis of the hydraulics, theoretical design, and the performance of similar installations designed by Delta, no satisfactory explanation could be made as to why the installation of the one air stripping tower could not meet the effluent design criteria.

A.3.5 DESIGN AND INSTALLATION OF SECOND AIR STRIPPER

The decision was made in early November 1988 to expedite the design, fabrication, and installation of an additional air stripper to operate in series with the existing stripper, providing a two stage treatment system and insuring a consistent level of treatment. To reduce the amount of piping modifications, the new air stripper was installed to treat water from the well pump discharge. The design included pumping the effluent from the base of the new stripping tower (1st stage) to the inlet of the existing stripping tower (2nd stage). The system of two air strippers, was designed to treat a design flow of 300 gpm. Permit applications were reviewed and submitted to PADER in early November 1988.

Remcor modified the existing piping and electrical systems and installed a new foundation. The new air stripper was installed in December 1988 and was ready for startup in January 1989.

A.3.6 STARTUP AND OPERATIONAL TESTING OF MODIFIED AIR STRIPPING SYSTEM

As with the startup of the first tower, all operating equipment, interlocks, and transfer systems were checked for proper operation. A total of 12 inlet and outlet samples were taken to characterize the performance of the system. The concentrations of DCE, TCA, and TCE were below 0.1 μg/ℓ in the effluent to the stream (Table A-2).

A.3.7 NO. 3 WELL PUMP CONTINUOUS OPERATIONS TEST

After completion of construction of the air stripping system and operation checkout, continuous pumping was initiated on February 6, 1989 to determine the long-term effect of pumping Well No. 3 on the aquifer. This test is expected to continue until at least June 1989, with the effluent discharged to the stream. This long-term testing was designed to verify treatment on a continuous basis over this time period. Inlet and outlet samples of the air strippers were taken over this period to document the performance of the system.

The initial sample for the test was taken on February 1, 1989, with continuous operations starting on February 6, 1989. The total target VOC (i.e., DCE, TCA, TCE) influent concentration of 1370 μg/ℓ to the stripper was comparable to levels observed during previous operational tests. Over the period of the next six weeks, the VOC concentrations in the influent increased to 11,700 μg/ℓ (see Table A-3). During this same period, the total VOCs effluent concentrations, were found to be less than 2 μg/ℓ (see Table A-4). Municipal Well No. 3 is obviously withdrawing significant quantities of VOCs from the aquifer. There is no reason to assume that the current elevated levels of VOCs in ground water withdrawn at Municipal Well No. 3 will persist. Data relative to the source(s) VOCs in ground water are not adequate to permit an estimate of the quantity of contaminants present in the aquifer. Further monitoring data are required to evaluate this issue. All discharge limitations as outlined by the NPDES and the Water Quality permits are being met, even at the higher influent concentrations.

Influent concentrations are being monitored on a bi-weekly basis to determine if levels will continue above the design levels or will decrease. These operational data are continually being reviewed with the appropriate PADER personnel.

During this operational testing period, personnel from the PADER Water Quality and Drinking Water Departments completed their final inspection

as required by the permits. The Borough of Bally has announced plans to start pumping treated water into the municipal drinking water system in mid-June 1989.

TABLES

TABLE A-1

AIR STRIPPING SYSTEM DESIGN REMOVAL

CONSTITUENT	INFLUENT CONCENTRATIONS (µg/ℓ)	EFFLUENT CONCENTRATIONS (µg/ℓ)	REMOVAL EFFICIENCIES (PERCENT)
1,1-dichloroethylene	588	0.6	99.9
1,1,1-trichloroethane	3,793	200.0	94.7
Trichloroethylene	781	<1	99.9
Chloroform	30	2.0	93.3
Tetrachloroethylene	30	1.4	93.3

TABLE A-2

BOROUGH OF BALLY
WELL NO. 3
AIR STRIPPING SYSTEM STARTUP
JANUARY 1989

SAMPLE NUMBER	WATER TREATMENT RATE (gpm)	SAMPLE IDENTIFICATION	CONCENTRATIONS DCE (µg/ℓ)	TCA (µg/ℓ)	TCE (µg/ℓ)
RBS-101	270 gpm	Inlet 1st Stripper	240	850	230
RBS-102	270 gpm	Inlet 2nd Stripper	11	48	18
RBS-103	270 gpm	Outlet 2nd Stripper	<1	<1	<1
RBS-104	240 gpm	Inlet 1st Stripper	230	880	260
RBS-105	240 gpm	Inlet 2nd Stripper	11	46	17
RBS-106	240 gpm	Outlet 2nd Stripper	<1	<1	<1
RBS-107	205 gpm	Inlet 1st Stripper	180	730	210
RBS-108	205 gpm	Inlet 2nd Stripper	10	42	15
RBS-109	205 gpm	Outlet 2nd Stripper	<1	<1	<1
RBS-110	170 gpm	Inlet 1st Stripper	230	880	250
RBS-111	170 gpm	Inlet 2nd Stripper	10	42	15
RBS-112	170 gpm	Outlet 2nd Stripper	<1	<1	<1

TABLE A-3

BOROUGH OF BALLY
WELL NO. 3
AIR STRIPPING SYSTEM
INFLUENT CONCENTRATIONS 1989

COMPOUND	SAMPLE COLLECTION DATES WITH CONCENTRATIONS IN µg/ℓ(1)										AVERAGE CONCENTRATIONS
	02/01	02/13	02/20	02/27	03/06	03/13	03/20	03/27	04/03	04/10	
1,1-Dichloroethene (DCE)	250	1,100	1,900	2,600	2,600	2,700	2,500	3,100	2,300	2,200	2,125
1,1,1-Trichloroethane (TCA)	890	2,900	2,400	5,000	5,900	5,900	5,000	5,200	5,100	4,300	4,359
Trichloroethylene (TCE)	230	1,400	1,900	2,500	2,900	2,800	2,700	3,100	2,300	2,500	2,233
Totals	1,370	5,400	7,200	10,100	11,400	11,400	10,200	11,400	9,700	9,000	8,717

(1) "µg/ℓ" indicates micrograms per liter.

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TABLE A-4

BOROUGH OF BALLY
WELL NO. 3
AIR STRIPPING SYSTEM
EFFLUENT CONCENTRATIONS 1989

COMPOUND	SAMPLE COLLECTION DATES WITH CONCENTRATIONS IN μg/ℓ[1]									
	02/01	02/13	02/20	02/27	03/06	03/13	03/20	03/27	04/03	04/10
1,1 Dichloroethene (DCE)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,1,1 Trichloroethane (TCA)	<0.1	1	1	1	1	1	0.9	0.8	0.8	0.7
Trichloroethylene (TCE)	<0.1	1	0.7	0.7	0.6	0.8	0.5	0.5	0.5	0.5
Chloroform	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Methylene Chloride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Totals	<0.1	2	1.7	1.6	1.8	1.4	1.3	1.3	1.2	

(1) "μg/ℓ" indicates micrograms per liter.

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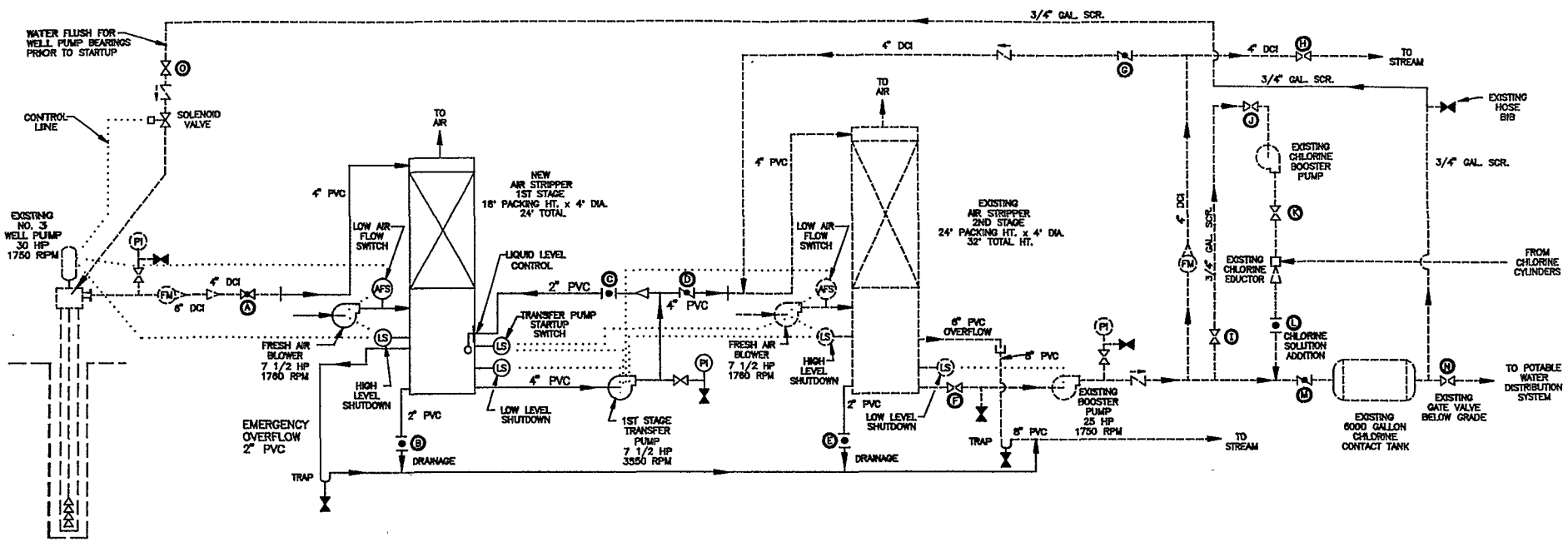

LEGEND:

(PI) PRESSURE INDICATOR	GLOBE VALVE
(LS) LEVEL SWITCH	CHECK VALVE
(FM) FLOW METER	GATE VALVE
NEW PIPING	BUTTERFLY VALVE
EXISTING PIPING & EQUIPMENT	PVC BALL VALVE
DCI – DUCTILE IRON	SAMPLE VALVE
PVC – POLYVINYL CHLORIDE	(AFS) AIR FLOW SWITCH
GAL. SCR. – GALVANIZED SCREWED PIPE	(A) VALVE DESIGNATION
CONTROL WIRING	

FIGURE A–1

PROCESS AND CONTROL DIAGRAM FOR AIR STRIPPING SYSTEM MUNICIPAL WELL NO. 3 BALLY, PENNSYLVANIA

PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN	5/2/89 L.H.K.	DRAWING NUMBER
CHECKED	5-11-89 HMS	88548–B37
APPROVED		

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AR301253

APPENDIX B
AIR DISPERSION MODELING
AND RISK ASSESSMENT

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APPENDIX B

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FIGURE NO.	TITLE
B-1	Receptor Grid, Air Dispersion Modeling, Bally Feasibility Study

APPENDIX B
AIR DISPERSION MODELING AND RISK ASSESSMENT
MUNICIPAL WELL NO. 3
BOROUGH OF BALLY, PENNSYLVANIA

B.1.0 INTRODUCTION

Air dispersion modeling was performed on the effluent vapor streams from the air stripping towers at Bally Municipal Well No. 3 to obtain ground level contaminant concentrations for the surrounding area. These concentrations were then used to estimate the incremental increased lifetime cancer risk as a result of airborne volatile organic compounds (VOCs). The Climatological Dispersion Model - Version 2.0 (CDM-2) from the U.S. Environmental Protection Agency's (EPA's) User Network for Applied Modeling of Air Pollution (UNAMAP) series was used to model the dispersion (Irwin, 1985). The model was run using meteorological data from the Allentown, Pennsylvania weather station for 1981. These data consisted of quarterly averages for wind speeds and directions for six stability classes. The averages were the result of hourly observations made throughout the year. Based on an evaluation of monthly means and extremes reported by the National Oceanic and Atmospheric Administration (NOAA) for the Allentown station (NOAA, 1987), the 1981 data appear to be representative.

B.2.0 MODELING ASSUMPTIONS USED

The CDM-2 modeling program allows the user to create several different dispersion schemes. The options that were used for these analyses are expected to best simulate those conditions at the Bally Engineered Structures (BES) Site. This section contains a brief rationale for each dispersion option chosen, as well as a discussion of the effect on the estimated discharge of VOCs from the air stripping towers currently in operation.

B.2.1 INITIAL DISPERSION OPTION

Initial dispersion occurs when large objects very close to the point of release cause eddy currents to develop and result in considerable vertical dispersion very close to the stack. This effect is expected to occur at the BES Site due to the presence of tall conifers adjacent to the air stripping towers. The initial dispersion option was used in the modeling. Use of this option results in higher concentrations close to the stack (i.e., less than 50 meters) and slightly lower concentrations further away from the stack (i.e., greater than 50 meters). Concentrations calculated for distances less than 50 meters from the stack are considered inaccurate due to the limitations of the model.

B.2.2 BUOYANCY INDUCED DISPERSION AND GRADUAL PLUME RISE OPTIONS

These two phenomena exist when the stack gas temperature is considerably higher than the ambient air temperature. Because the temperature of the ground water (50 to 55 degrees Fahrenheit) is close to the average air temperature, the temperature difference is small and these buoyant effects are not expected to occur at the BES Site. Neither of these options was used during the dispersion modeling. Neglecting buoyant effects may cause the predicted ground level concentrations to be higher than the actual concentrations in the vicinity of the stripping towers. Buoyancy induced dispersion and gradual plume rise cause the effluent

vapor stream to rise higher before vertical dispersion begins, resulting in lower values for the maximum ground level concentrations in the immediate vicinity of the stack.

B.2.3 BRIGGS-URBAN DISPERSION ALGORITHM

The Briggs-Urban dispersion algorithm (Irwin, 1985) was used for calculating ground level concentrations. This algorithm takes into account those effects on dispersion caused by buildings and living conditions in an urban environment. It is expected to be the most realistic scheme available for use, but does not significantly effect the ground level concentrations calculated.

B.2.4 RECEPTOR GRID PATTERN

A grid pattern, 25 meters on-center, was used to locate receptor points during the dispersion modeling. The grid was set up on a north-south/east-west orientation. Locating receptors closer than 25 meters apart is unnecessary as the concentrations do not change drastically over any small interval. The location of the source was chosen as point (4,4) on the grid (Figure B-1).

B.2.5 SYSTEM DESIGN ASSUMPTIONS

Numeric assumptions made during the modeling process are listed in this section. Analytical data reflect influent ground water concentrations to the air stripping system measured on March 6, 1989, one month after initiation of continuous pumping (see Table A-3, Appendix A). While influent levels have exhibited some variability in the past three months of pumping, the levels observed are March 6 are generally typical of worst-case concentrations. Specific numeric assumptions are as follows:

- A ground water treatment rate of 250 gallons per minute (gpm)

- Influent concentrations as noted:

VOCs	CONCENTRATION (ppm)*
1,1-dichloroethene (1,1-DCE)	2.6
1,1,1-trichloroethane (1,1,1-TCA)	5.9
trichloroethylene (TCE)	2.9
Total	11.4

*"ppm" indicates parts per million.

- Air flow rates of 8,400 standard cubic feet per minute (scfm) blown into each air stripping tower

- Distance to the nearest residence is 50 to 55 meters north of the source [point (5,6) in Figure B-1]

- Both towers are modeled as one source (i.e., emissions are additive)

- Stack gas temperature is equal to ambient temperature

- Removal of organics by air stripping is essentially 100 percent efficient (based on a comparison of analyses of water influent to the stage 1 air stripper and that effluent from the stage 2 air stripper).

The most recent Data Quality Level IV analytical data from Municipal Well No. 3 were obtained from sampling performed in January 1988. The January 1988 data indicated levels of the three predominant VOCs significantly less than those found in samples collected after initiation of continuous pumping of Municipal Well No. 3 in February 1989. Specifically, concentrations were as noted in the January 1988 sample:

VOCs	CONCENTRATION (ppm)
1,1-DCE	0.29
1,1,1-TCA	0.84
TCE	0.26

The more recent Level III data from Spotts, Stevens, & McCoy were used as a conservative estimate of Municipal Well No. 3 contaminant levels in the current analysis. There is no, however, no basis upon which to assume that these levels will persist.

B.3.0 MODELING RESULTS

The predicted concentration of total VOCs in ambient air at the nearest current residence [point (5,6) in Figure B-1] is 2.1 micrograms per cubic meter ($\mu g/m^3$). The actual value at this point is expected to be slightly lower due to the conservative assumptions made during the modeling process and the presence of several trees 3 to 5 meters away on the north side of the towers. The effect of these trees on ground level concentrations is only partially reflected through the use of the initial dispersion option. The trees also provide resistance to wind flow in that direction which cannot be accounted for using this model. The concentration of 1,1-DCE (the compound present with the highest carcinogenic potency factor for inhalation risk) at this point is predicted to be 0.5 $\mu g/m^3$. The highest estimated total VOC concentration found outside of a 50-meter radius of the towers is 9.7 $\mu g/m^3$, 50 meters due east of the towers [point (6,4) in Figure B-1]. This relates to an estimated 1,1-DCE concentration of 2.2 $\mu g/m^3$ at this point. These concentrations are also expected to be higher than actual values because of a line of trees along the east side of the towers approximately 40 meters away. Table B-1 contains a summary of the ground level concentrations of all three VOCs at these two points.

B.4.0 AIR RISK BASED ON MODEL RESULTS

Doses and risks were estimated, based on the air modeling results, for potential receptors at the nearest residence and at the point of highest concentration. The calculation of dose for the nearby residence assumes the following:

- A woman (i.e., housewife) exposed 20 hours per day, 7 days per week for 30 years (the assumed period for operation of the air stripping treatment)
- The woman's respiration rate is 21 cubic meters (m^3) per day
- The woman weighs 58 kilograms (kg).

The highest concentrations occur within the ballfield due east of Municipal Well No. 3. The calculation of dose assumes the following:

- Children playing in this area are exposed 2 hours per day, 5 days per week, 20 weeks per year for 5 years
- Respiration rate is 1.6 m^3 per two hours
- Child's weight is 45 kg.

Dose for each compound at the nearby residence is estimated as follows:

$$\text{Dose}_{DCE} = \frac{0.48 \frac{\mu g}{m^3} \times \frac{21\ m^3}{day} \times \frac{20\ hrs}{day} \times \frac{1\ day}{24\ hrs} \times \frac{1\ mg}{10^3\ \mu g} \times 30\ yrs}{58\ kg \times 70\ yrs}$$

$$= 6.2 \times 10^{-5} \frac{mg}{kg\text{-}day}$$

$$\text{Dose}_{TCE} = \frac{0.53 \frac{\mu g}{m^3} \times \frac{21\ m^3}{day} \times \frac{20\ hrs}{day} \times \frac{1\ day}{24\ hrs} \times \frac{1\ mg}{10^3\ \mu g} \times 30\ yrs}{58\ kg \times 70\ yrs}$$

$$= 6.9 \times 10^{-5} \frac{mg}{kg\text{-}day}$$

$$\text{Dose}_{TCA} = \frac{1.09\ \frac{\mu g}{m^3} \times \frac{21\ m^3}{day} \times \frac{20\ hrs}{day} \times \frac{1\ day}{24\ hrs} \times \frac{1\ mg}{10^3\ \mu g} \times 30\ yrs}{58\ kg \times 70\ yrs}$$

$$= 1.4 \times 10^{-4}\ \frac{mg}{kg\text{-}day}$$

Dose of each compound at the ballfield is estimated as follows:

$$\text{Dose}_{DCE} = \frac{2.23\ \frac{\mu g}{m^3} \times \frac{1.6\ m^3}{2\ hrs} \times \frac{2\ hrs}{day} \times \frac{1\ mg}{10^3\ \mu g} \times \frac{100\ days}{yr} \times 5\ yrs}{45\ kg \times 70\ yrs \times 365\ \frac{days}{yr}}$$

$$= 1.55 \times 10^{-6}\ \frac{mg}{kg\text{-}day}$$

$$\text{Dose}_{TCE} = \frac{2.42\ \frac{\mu g}{m^3} \times \frac{1.6\ m^3}{2\ hrs} \times \frac{2\ hrs}{day} \times \frac{1\ mg}{10^3\ \mu g} \times \frac{100\ days}{yr} \times 5\ yrs}{45\ kg \times 70\ yrs \times 365\ \frac{days}{yr}}$$

$$= 1.68 \times 10^{-6}\ \frac{mg}{kg\text{-}day}$$

$$\text{Dose}_{TCA} = 3.51 \times 10^{-6}\ \frac{mg}{kg\text{-}day}$$

Carcinogenic risk is calculated by multiplying the dose by the compound-specific Carcinogenic Potency Factor (CPF). TCA is not a known or suspected carcinogen. The CPFs via the inhalation route for DCE and TCE, respectively, are:

$$1.16\ \frac{kg\text{-}day}{mg} \text{ and } 0.013\ \frac{kg\text{-}day}{mg}$$

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Thus, the compound-specific and cumulative risks for the receptor at the nearby residence are as follows:

- $Risk_{DCE} = (6.2 \times 10^{-5})\ (1.16) = 7.2 \times 10^{-5}$
- $Risk_{TCE} = (6.9 \times 10^{-5})\ (0.013) = \underline{8.9 \times 10^{-5}}$

  Cumulative Risk $= 7.3 \times 10^{-5}$

The compound-specific and cumulative risks for the potential receptors at the ballfield are as follows:

- $Risk_{DCE} = (1.55 \times 10^{-6})\ (1.16) = 1.8 \times 10^{-6}$
- $Risk_{TCE} = (1.68 \times 10^{-6})\ (0.013) = \underline{2.2 \times 10^{-8}}$

  Cumulative Risk $= 1.8 \times 10^{-6}$

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TABLE

TABLE B-1

BOROUGH OF BALLEY
MUNICIPAL WELL NO. 3
AIR STRIPPING SYSTEM
AIR DISPERSION MODELING RESULTS

COMPOUND	CONCENTRATION AT NEAREST RESIDENCE ($\mu g/m^3$)(1)	MAXIMUM GROUND LEVEL CONE ($\mu g/m^3$)
1,1,-dichloroethene	0.5	2.2
1,1,1-trichloroethane	1.1	5.1
trichloroethylene	0.5	2.4
Total	2.1	9.7

(1) "$\mu g/m^3$ indicates micrograms per cubic meter

"REALISTIC SOLUTIONS FOR HAZARDOUS WASTE PROBLEMS"

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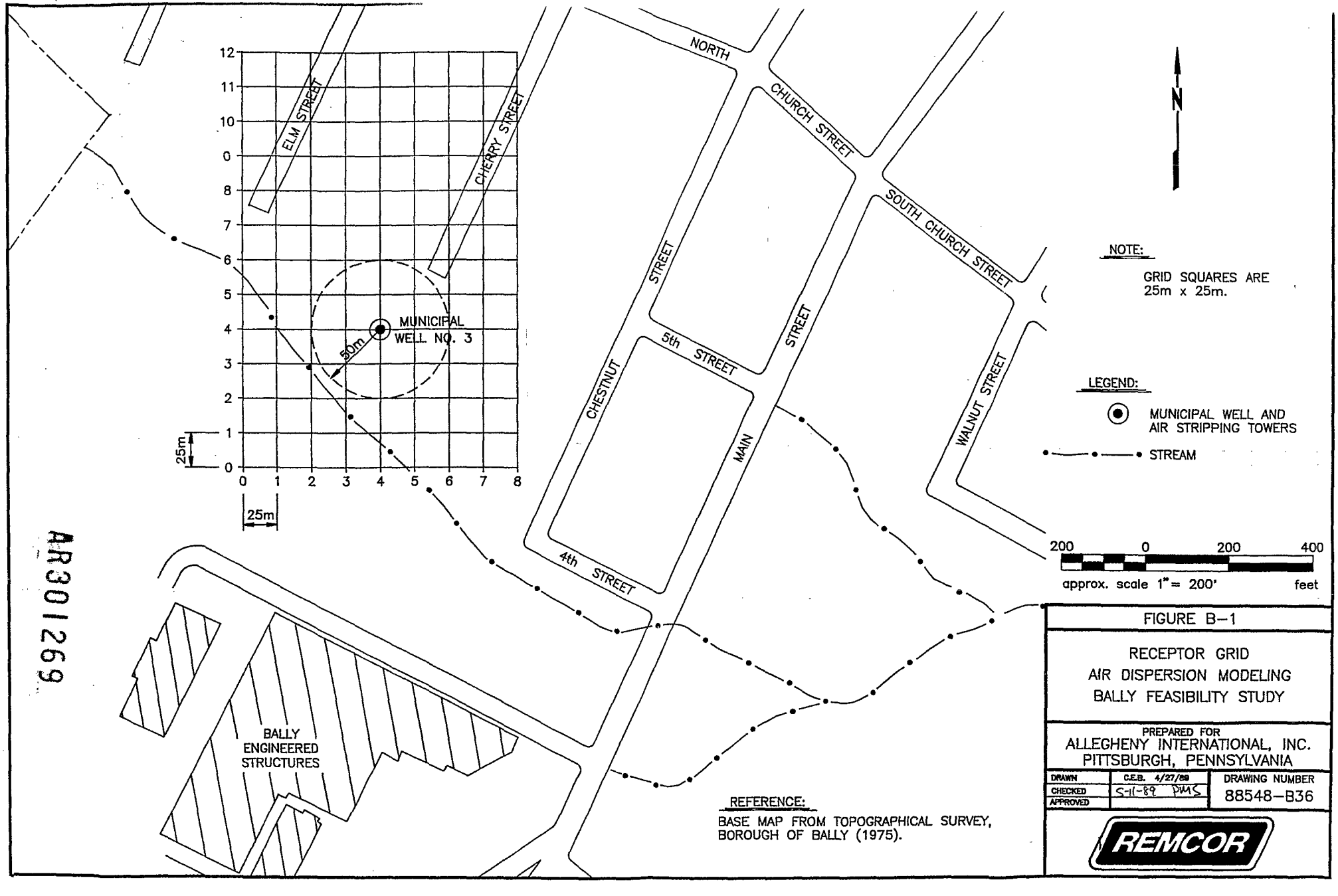
FIGURE


NORTH
CHURCH STREET
SOUTH CHURCH STREET
ELM STREET
CHERRY STREET
CHESTNUT STREET
MAIN STREET
WALNUT STREET
5th STREET
4th STREET
MUNICIPAL WELL NO. 3
50m
25m
25m
BALLY ENGINEERED STRUCTURES
N
NOTE:
GRID SQUARES ARE 25m x 25m.
LEGEND:
MUNICIPAL WELL AND AIR STRIPPING TOWERS
STREAM
200 0 200 400
approx. scale 1" = 200' feet
REFERENCE:
BASE MAP FROM TOPOGRAPHICAL SURVEY, BOROUGH OF BALLY (1975).
FIGURE B-1
RECEPTOR GRID
AIR DISPERSION MODELING
BALLY FEASIBILITY STUDY
PREPARED FOR
ALLEGHENY INTERNATIONAL, INC.
PITTSBURGH, PENNSYLVANIA
DRAWN C.E.B. 4/27/89
CHECKED 5-11-89 DMS
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DRAWING NUMBER 88548-B36
REMCOR

AR301269

APPENDIX B

LIST OF REFERENCES

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