Focused Feasibility Study

Photocircuits Corporation
31 Sea Cliff Avenue
Glen Cove, New York

October, 2006

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Prepared on Behalf of:

Photocircuits Corporation

Prepared By:

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Table of Contents

1.0 INTRODUCTION

This Focused Feasibility Study (FFS) has been prepared by Barton and Loguidice, P.C. (B&L) on behalf of Photocircuits Corporation. The FFS presents and evaluates remedial alternatives for the identified area of subsurface contamination at the 31 Sea Cliff Avenue site located in Glen Cove, New York (site number 1-30-009). The scope of the FFS was described in the letter from B&L to the New York State Department of Environmental Conservation (NYSDEC) dated June 14, 2004; the scope of work was approved by NYSDEC in their letter of September 9, 2004.

Investigation and remediation activities to address subsurface contamination have been performed at this site by consultants to Photocircuits under Consent Order No. W1-0713-94-12 with NYSDEC dated March 31, 1997. The history of these and prior activities is presented in the Background section. Subsequent sections present a focused group of remedial alternatives and evaluate these alternatives along with the current remedial program. The development and evaluation of remedial alternatives was performed in a manner consistent with guidance documents prepared by NYSDEC and the U.S. Environmental Protection Agency (USEPA), as well as the National Contingency Plan (NCP), as provided in the Order on Consent. Finally, a recommended remedial alternative is presented.

2.0 BACKGROUND

Soil and groundwater contamination at the 31 Sea Cliff Avenue site has been characterized by a series of investigations, which are summarized below:

Date	Party	Scope of Activities
1986	H2M (for Kollmorgen)	Preliminary investigation of surface and subsurface soils
1987	H2M (for Kollmorgen)	Hydrogeologic Investigation
1988	H2M (for Kollmorgen)	Groundwater monitoring
1989	H2M (for Kollmorgen)	Continued site investigation
1992	H2M (for Kollmorgen)	Source area investigation
1996	McLaren/Hart (for Photocircuits)	Preliminary site investigation
1998	McLaren/Hart (for Photocircuits)	Remedial Investigation
1999	McLaren/Hart (for Photocircuits)	Additional monitoring well installation

The Order on Consent required the performance of a Focused Remedial Investigation (FRI) and a Focused Feasibility Study. The FRI Work Plan defined the completion criteria for the FRI as:

1. The nature and distribution of contamination attributable to the site has been adequately determined.
2. Site conditions have been sufficiently characterized to properly conduct the Feasibility Study.

The FRI was completed in the summer of 1998, and FRI Report was submitted to NYSDEC in September 1998. The 1998 FRI Report recommended the performance of an Interim Remedial Measure (IRM) for subsurface contamination identified in the vicinity of the bulk chemical storage and drum storage areas (see Figure 1). The FRI proposed the use of air sparging/soil vapor extraction (AS/SVE) to remove volatile organic compounds

(VOCs) in soil and shallow groundwater. An AS/SVE pilot test was conducted in 1999 to determine whether the technology was feasible for this site and to collect data to support the remedial design. Based on the results of the pilot test, it was concluded that application of AS was not feasible.

In 2000, Photocircuits implemented an IRM at the 31 Sea Cliff Avenue site utilizing SVE to extract VOCs from the unsaturated zone. The SVE system included six SVE wells and used a catalytic oxidation unit to treat collected soil vapor. SVE operations were ceased in late 2001 after demonstrating that contaminant removal had reached low, asymptotic conditions. Also in 2000, Photocircuits undertook a pilot test of enhanced bioremediation to address VOCs in groundwater. The pilot test entailed the injection of edible oil substrate (EOS) throughout the pilot study area. Subsequent groundwater monitoring has shown a substantial reduction in VOC concentrations and additional EOS injections were performed in 2002 in response to groundwater monitoring. In 2003, Photocircuits installed a hydraulic control system in the area downgradient of the bioremediation pilot test area. The hydraulic control system consists of four groundwater extraction wells (see Figure 2) equipped with pneumatic pumps. Recovered groundwater is discharged to the sanitary sewer. As documented in quarterly reports, monitoring of groundwater quality and water levels indicates that this system has been successful in providing hydraulic control in the area downgradient of the bioremediation pilot test.

The Consent Order requires a Focused Feasibility Study "evaluating on-Site remedial actions to eliminate, to the maximum extent practicable, all health and environmental hazards attributable to hazardous waste disposal at the Site, as identified in the Focused Remedial Investigation Report".

3.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The combined purpose of the IRM (SVE), the bioremediation pilot test and the hydraulic control system are to remediate the identified VOC contamination in the soil and groundwater at the 31 Sea Cliff Avenue site. This FFS evaluates whether the current remedial strategy best meets the criteria set forth in state and federal guidance documents for remedy selection or whether a different combination of remedial technologies is better suited to meet those criteria. This determination is made by comparing the current remedial scheme to the list of criteria in the relevant guidance documents. This FFS also develops an appropriate list of remedial alternatives (including combinations of remedial technologies); these remedial alternatives are compared to the same set of criteria. The remedial alternative that best meets these criteria is presented in the final section of this report as the recommended remedial alternative.

3.1 Possible Remedial Technologies

The first step in the development of remedial alternatives is to review the candidate list of remedial technologies that can be applied. Once a list of feasible remedial technologies is developed, remedial alternatives can be assembled that employ one or more of the technologies.

This FFS is based on the premise that the hydraulic control program will continue until other remedial measures sufficiently degrade contaminant mass in key areas of concern on the Site. Accordingly, this FFS concentrates on remedial technologies/alternatives to address the area of higher contaminant concentrations located in the vicinity of the Waste Recovery area. Applicable standards, criteria and guidance for groundwater are identified in Table 1.

The current remedial program entails the in-situ destruction of groundwater contaminants in and near the Waste Recovery area by enhanced anaerobic bioremediation. Given the nature (predominantly chlorinated ethenes and ethanes) and distribution (from the top of the water table to roughly 80 feet below land surface) of the VOCs in groundwater in the Waste Recovery area, the feasible remedial technologies are limited to two basic types: in-situ destruction and extraction.

In-situ destruction by biologic means (biodegradation) falls into two general categories – aerobic and anaerobic. Because of the success of the bioremediation pilot study, enhancement of the existing anaerobic process by addition of substrate and/or other nutrients are considered as a remedial alternative. Because the majority of the contaminants are not readily degraded by aerobic processes, aerobic biodegradation is not considered further. Another possible remedial technology is in-situ destruction of contaminants by non-biological means, i.e. – chemical oxidation. There are several oxidants that have been reportedly employed to destroy chlorinated VOCs in-situ (e.g. - Fenton's reagent, permanganate, peroxide, etc.), which would be considered during the evaluation of this technology.

Removal of contaminant mass in the Waste Recovery Area by extraction (pumping) of contaminated ground water is a feasible remedial technology.

3.2 Remedial Alternatives

By combining the identified technologies with the existing hydraulic control program, three remedial alternatives are available for detailed analysis (in addition to No Action):

Alternative 1: No Action

Alternative 2: Continuation and enhancement of the existing bioremediation program in the Waste Recovery Area by the addition of substrate, coupled with hydraulic control.

Alternative 3: In-situ destruction of contaminants in the Waste Recovery Area by chemical oxidation, coupled with hydraulic control.

Alternative 4: Extraction of groundwater in the Waste Recovery Area, coupled with hydraulic control.

4.0 ANALYSIS OF ALTERNATIVES

NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4030 and the USEPA RI/FS Guidance Document set forth seven criteria for the detailed analysis of remedial alternatives:

- Short-Term Impacts and Effectiveness
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility and Volume
- Implementability
- Cost
- Compliance with Applicable New York State Standards, Criteria and Guidance (SCGs)
- Overall Protection of Human Health and the Environment

Each of the remedial alternatives identified in the previous section is evaluated against the seven criteria.

4.1 Alternative 1: No Action

4.1.1 Description of Alternative

This alternative has been included per NYSDEC and USEPA guidelines, as well as to ensure compliance with the National Contingency Plan (NCP). Under this alternative, the hydraulic control system would continue to be operated, but no further remedial actions would be implemented.

4.1.2 Criteria Assessment

Short-Term Impacts and Effectiveness

The existing bioremediation pilot study has demonstrated short-term effectiveness by significantly reducing VOC concentrations in groundwater the Waste Recovery Area. There will likely be residual bioremediation program activity under Alternative 1, but it is unlikely that SCGs would be achieved, even over an extended period of time. There are not expected to be unusual hazards to workers involved with the implementation of this alternative.

Long-Term Effectiveness and Permanence

Alternative 1 would not likely provide long-term effectiveness and permanence, and would not likely achieve SCGs. The continued operation of the hydraulic control system and continued ground-water monitoring program would provide some additional assurance of the effectiveness of this alternative.

Reduction of Toxicity, Mobility and Volume

The toxicity, mobility and volume of contaminants would not be reduced under Alternative 1.

Implementability

Alternative 1 is readily implementable.

Cost

The estimated cost for Alternative 1 is $164,000, which includes the continued operation of the hydraulic control system and continued groundwater monitoring for ten years, based on the projection that the bioremediation program would achieve sufficient contaminant mass reduction to be terminated within that timeframe; a detailed breakdown of the estimated cost is provided in Appendix A.

Compliance with Applicable New York State Standards, Criteria and Guidance (SCGs)

Alternative 1 would likely not comply with New York State SCGs by reducing contaminant concentrations below applicable standards even over an extended period of time.

Overall Protection of Human Health and the Environment

Contaminated groundwater at the Photocircuits site is not being withdrawn for consumption, so there is not an existing exposure pathway. Over time, Alternative 1 would likely not reduce contaminant concentrations below applicable standards. Thus, Alternative 1 does not appear to be in compliance with Overall Protection of Human Health and the Environment.

4.2 Alternative 2: Continuation and enhancement of the existing bioremediation program in the Waste Recovery Area by the addition of substrate, coupled with hydraulic control.

4.2.1 Description of Alternative

Under this alternative, additional substrate would be injected in the subsurface in the Waste Recovery area to support the existing microbial degradation of chlorinated VOCs. The substrate injection would be conducted in the same manner as the 2002 substrate injection event. The injection would employ approximately 10-12 injection points and roughly 5000 gallons of substrate mixture.

4.2.2 Criteria Assessment

Short-Term Impacts and Effectiveness

The existing bioremediation pilot study has demonstrated short-term effectiveness by significantly reducing VOC concentrations in groundwater the Waste Recovery Area. Enhancing the bioremediation program, as anticipated by Alternative 2 would provide short-term effectiveness by achieving SCGs over a period of time. The continued operation of the hydraulic control system and continued ground-water monitoring program would provide additional assurances of the effectiveness of this alternative. There are not expected to be unusual hazards to workers involved with the implementation of this alternative.

Long-Term Effectiveness and Permanence

Alternative 2 would provide long-term effectiveness and permanence through the degradation of the groundwater contaminants and achieving SCGs. The continued operation of the hydraulic control system and continued ground-water monitoring program would provide additional assurances of the effectiveness of this alternative.

Reduction of Toxicity, Mobility and Volume

The toxicity, mobility and volume of contaminants would be reduced and virtually eliminated under Alternative 2. Ongoing ground-water monitoring would provide data to demonstrate this reduction.

Implementability

Based on the results of the ongoing pilot study, Alternative 2 is readily implementable.

Cost

The estimated cost for Alternative 2 is $157,000, which includes the continued operation of the hydraulic control system and continued groundwater monitoring for five years; a detailed breakdown of the estimated cost is provided in Appendix A.

Compliance with Applicable New York State Standards, Criteria and Guidance (SCGs)

Alternative 2 would comply with New York State SCGs by reducing contaminant concentrations below applicable standards over a period of time.

Overall Protection of Human Health and the Environment

Contaminated groundwater at the Photocircuits site is not being withdrawn for consumption, so there is not an existing exposure pathway. Over time, Alternative 2 would reduce contaminant concentrations below applicable standards. Thus, Alternative 2 is in compliance with Overall Protection of Human Health and the Environment.

4.3 Alternative 3: In-situ destruction of contaminants in the Waste Recovery Area by chemical oxidation, coupled with hydraulic control.

4.3.1 Description of Alternative

Under Alternative 3, a chemical oxidant would be injected into the subsurface in the Waste Recovery area. The chemical oxidant would be introduced as an aqueous solution (permanganate, peroxide, or Fenton's Reagent). To introduce the chemical oxidant into the subsurface, a series of injection wells would need to be installed. For estimation purposes, it has been assumed that a minimum of ten wells would be installed at locations throughout the Waste Recovery area, at depths to at least 80 feet below grade; three injection events are assumed.

4.3.2 Criteria Assessment

Short-Term Impacts and Effectiveness

Alternative 3 would be short-term effective by significantly reducing VOC concentrations in groundwater the Waste Recovery Area, and achieving SCGs over a period of time. The continued operation of the hydraulic control system and continued ground-water monitoring program would provide additional assurances of the effectiveness of this alternative. The use of chemical oxidants would require special safety procedures for the workers involved with the implementation of this alternative.

Long-Term Effectiveness and Permanence

Alternative 3 would provide long-term effectiveness and permanence through the destruction of the groundwater contaminants and achieving SCGs. The continued operation of the hydraulic control system and continued ground-water monitoring program will provide additional assurances of the effectiveness of this alternative.

Reduction of Toxicity, Mobility and Volume

The toxicity, mobility and volume of contaminants would be reduced and virtually eliminated under Alternative 3. Ongoing ground-water monitoring would provide data to demonstrate this reduction.

Implementability

Alternative 3 is readily implementable, however, there are two important considerations, as follows:

1) For chemical oxidation to be effective, the oxidant must be injected in close proximity to the contaminants mass. Recently published studies (Rivett and Feenstra, 2005; Hrapovic, 2005) indicate that there is a potential for residual contamination following oxidant injection. The cost estimate includes repeated injection events to address this problem.

2) The presence of previously injected substrate from the ongoing bioremediation pilot study would consume injected oxidant. The cost estimate includes injection of excess oxidant to address this problem.

Cost

The estimated cost for Alternative 3 ranges from $695,000 to $830,000, which includes the continued operation of the hydraulic control system and continued groundwater monitoring for five years, based on the projection that chemical oxidation would achieve sufficient contaminant mass reduction to be terminated within that timeframe; a detailed breakdown of the estimated cost is provided in Appendix A. A range of costs is presented for the amount of oxidant (and the associated labor and equipment costs) that would need to be injected to account for the uncertainties in contaminant treatability. To introduce the chemical oxidant into the subsurface, a series of injection wells would need to be installed. For estimation purposes, it has been assumed that a minimum of ten wells would be installed at locations throughout the Waste Recovery area, at depths to at least 80 feet below grade.

Compliance with Applicable New York State Standards, Criteria and Guidance (SCGs)

Alternative 3 would comply with New York State SCGs by reducing contaminant concentrations below applicable standards over a period of time.

Overall Protection of Human Health and the Environment

Contaminated groundwater at the Photocircuits site is not being withdrawn for consumption, so there is not an existing exposure pathway. Over time, Alternative 3 would reduce contaminant concentrations below applicable standards. Thus, Alternative 3 is in compliance with Overall Protection of Human Health and the Environment.

4.4 Alternative 4: Extraction of groundwater in the Waste Recovery Area, coupled with hydraulic control.

4.4.1 Description of Alternative

Under Alternative 4, six extraction wells would be installed in the Waste Recovery Area. The wells would be equipped with electric or pneumatic groundwater recovery pumps. Underground piping would be installed to bring compressed air or electric supply to each well and to convey recovered groundwater to the sanitary manhole that currently receives the discharge from the Hydraulic Control system. It is assumed that the recovered groundwater would not require treatment prior to discharge. However, it is possible that the discharge may require pre-treatment due to either contaminant concentrations or limitations on the ability of the municipal treatment works to accept the increased hydraulic load.

4.4.2 Criteria Assessment

Short-Term Impacts and Effectiveness

Alternative 4 would be short-term effective by reducing VOC concentrations in groundwater the Waste Recovery Area, but Alternative 4 would only achieve SCGs over a long period of time (on the order of decades), if at all. The continued operation of the hydraulic control system and continued ground-water monitoring program would provide some additional assurance of the effectiveness of this alternative. There are not expected to be unusual hazards to workers involved with the implementation of this alternative.

Long-Term Effectiveness and Permanence

Alternative 4 would provide long-term effectiveness and permanence through the removal of the groundwater contaminants, but Alternative 4 would only achieve SCGs over a long period of time (on the order of decades), if at all. The continued operation of the hydraulic control system and continued ground-water monitoring program would provide some additional assurance of the effectiveness of this alternative.

Reduction of Toxicity, Mobility and Volume

The toxicity, mobility and volume of contaminants in the subsurface would be reduced over an extended period of time under Alternative 4. Ongoing ground-water monitoring would provide data to demonstrate this reduction.

Implementability

Alternative 4 is readily implementable, however, there is a wide body of published information that indicates that achievement of SCGs by groundwater extraction may not be possible.

Cost

The estimated cost for Alternative 4 is $272,000, which includes operation of the extraction system and the continued operation of the hydraulic control system and continued groundwater monitoring for five years; a detailed breakdown of the estimated cost is provided in Appendix A.

Compliance with Applicable New York State Standards, Criteria and Guidance (SCGs)

As previously discussed, Alternative 4 might not comply with New York State SCGs by reducing contaminant concentrations below applicable standards even over an extended period of time.

Overall Protection of Human Health and the Environment

Contaminated groundwater at the Photocircuits site is not being withdrawn for consumption, so there is not an existing exposure pathway. Over time, Alternative 4 would reduce contaminant concentrations, but might not reduce concentrations below applicable standards. Thus, Alternative 4 might not be in compliance with Overall Protection of Human Health and the Environment.

4.5 Comparative Analysis

The previous sections compared the four alternatives against the key criteria set forth in NYSDEC and USEPA guidance documents (a summary of the performance of each alternative against these criteria is provided in Table 2). This section provides an analysis of how well each remedial alternative compares against the criteria relative to one another. Based on a side-by side comparison, it is clear that the No Action alternative (Alternative 1) does not achieve several of the criteria. It is also apparent that groundwater extraction (Alternative 4) does not compare well with Alternatives 2 and 3 in terms of both short-term and long-term effectiveness.

Both Alternatives 2 and 3 generally satisfy each of the seven criteria. The main areas of difference between these two alternatives are the time necessary to degrade the contaminant mass (an aspect of short-term effectiveness) and estimated costs.

In theory, the injection of a chemical oxidant into the subsurface should result in the rapid oxidation of a majority of the volatile organic compounds (VOCs) within the injection zone, whether those VOCs are sorbed to soil particles, dissolved in water and/or present as a separate phase. In practice, the effectiveness of the chemical reaction is limited by the difficulty in injecting the oxidant in the precise interval (both lateral and vertical) where contaminants are present. The action of injecting the oxidant under pressure also has the potential to force contaminants away from the injection zone. Recent articles (Rivett and Feenstra, 2005; Hrapovic, et al, 2005) discuss the behavior of residual contamination (chlorinated VOCs) following oxidant injection (Fenton's Reagent and permanganate) at field sites. Therefore, consideration of timeframes under Alternative 3 can assume rapid destruction of a majority of the contaminant mass, but must also factor in the possible need for additional injections, and incorporate natural attenuation and the action of the hydraulic control system in addressing residual contamination and achieving SCGs.

The bioremediation pilot test has already resulted in an appreciable reduction in contaminant concentrations in the test area. Recent data indicate that biologic degradation of contaminants has slowed, likely due to substrate depletion. Providing additional substrate as contemplated under Alternative 2 would increase biologic activity back to the desired levels. Because of the smaller injection volumes, bioremediation has a much lower potential than chemical oxidation to force contaminants away from the injection area. Ultimately, Alternative 2 would also rely to some degree on natural attenuation and the action of the hydraulic control system to address residual contamination and achieve SCGs.

5.0 RECOMMENDED ALTERNATIVE

In terms of technical issues, the key difference between Alternatives 2 and 3 is that Alternative 3 might reduce the contaminant mass more quickly (possibly some period of months more quickly than Alternative 2, unless additional injections are necessary). Because both Alternatives will rely on natural attenuation and the action of the hydraulic control system in addressing residual contamination, the timeframe for achieving SCGs is the same for either alternative (on the order of years). However, the projected costs for the two Alternatives are appreciably different, with even the low-end costs for Alternative 3 being greater than three times that for Alternative 2. Consequently, Alternative 2 is the recommended alternative for the Photocircuits site.

6.0 REFERENCES

Chapelle, F.H., Bradley, P.M. and C.C. Casey. *Behavior of a Chlorinated Ethene Plume following Source-Area Treatment with Fenton's Reagent*. Ground Water Monitoring & Remediation. Spring 2005. Vol. 25, No.2, pp. 131-141.

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New York State Department of Environmental Conservation. *Technical and Administrative Guidance Memorandum #4030 – Selection of Remedial Actions at Inactive Hazardous Waste Site.* May 1990.

United States Environmental Protection Agency. *Guidance for Conducting Remedial Investigation and Feasibility Studies under CERCLA.* October 1988.

TABLES

Table 1 Applicable Standards, Criteria and Guidance for Groundwater

Contaminant	Maximum Contaminant Limit (MCL)
1,1-Dichloroethane	5 ug/L
1,2-Dichloroethane	5 ug/L
1,1-Dichloroethene	5 ug/L
cis-1,2-Dichloroethene	5 ug/L
trans-1,2-Dichloroethene	5 ug/L
Chloroethane	5 ug/L
Tetrachloroethene	5 ug/L
2-Chlorotoluene	5 ug/L
4-Chlorotoluene	5 ug/L
1,1,1-Trichloroethane	5 ug/L
Trichloroethene	5 ug/L
Toluene	5 ug/L
Ethylbenzene	5 ug/L
m-Xylene	5 ug/L
o-Xylene	5 ug/L
p-Xylene	5 ug/L
Methylene Chloride	5 ug/L
Benzene	0.7 ug/L
Vinyl Chloride	2 ug/L

MCLs from 10NYCRR Part 5-1 and 6NYCRR Parts 701-703

Table 2 Summary of Performance of the Alternatives against the FS Criteria

Alternative	Short-Term Impacts and Effectiveness	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Implement-ability	Cost	Compliance with SCGs	Overall Protection of Human Health and the Environment
1	Not Effective	Not Effective	Not Effective	Implementable	$164,000	Unlikely	Not compliant
2	Effective	Effective	Effective	Implementable	$157,000	Likely	Compliant
3	Effective	Effective	Effective	Implementable	$695,000 to $830,000	Likely	Compliant
4	Effective	Effective	Effective	Implementable	$272,000	Possible	Not compliant

FIGURES

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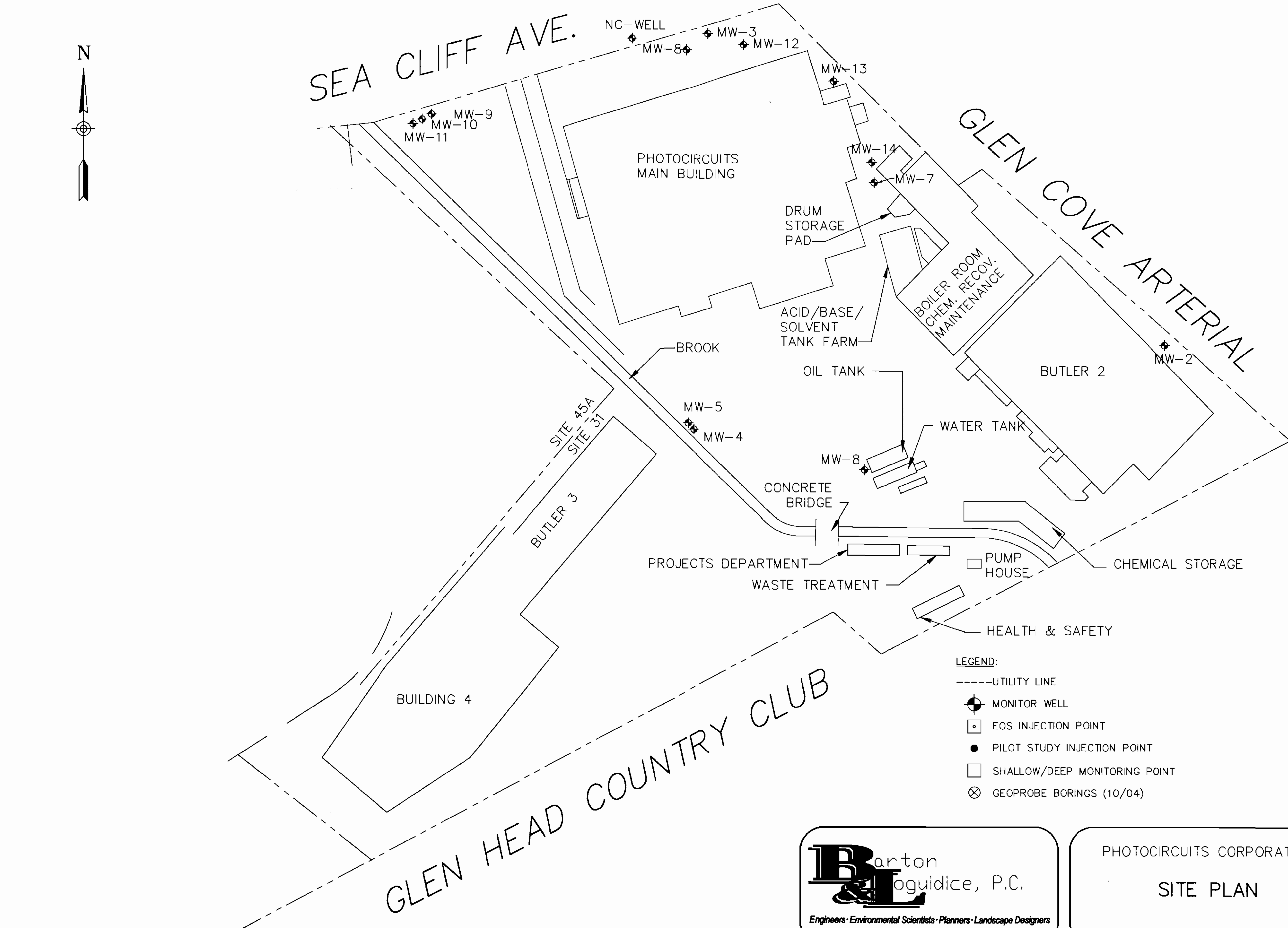

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SITE PLAN

GLEN COVE NEW YORK

Figure
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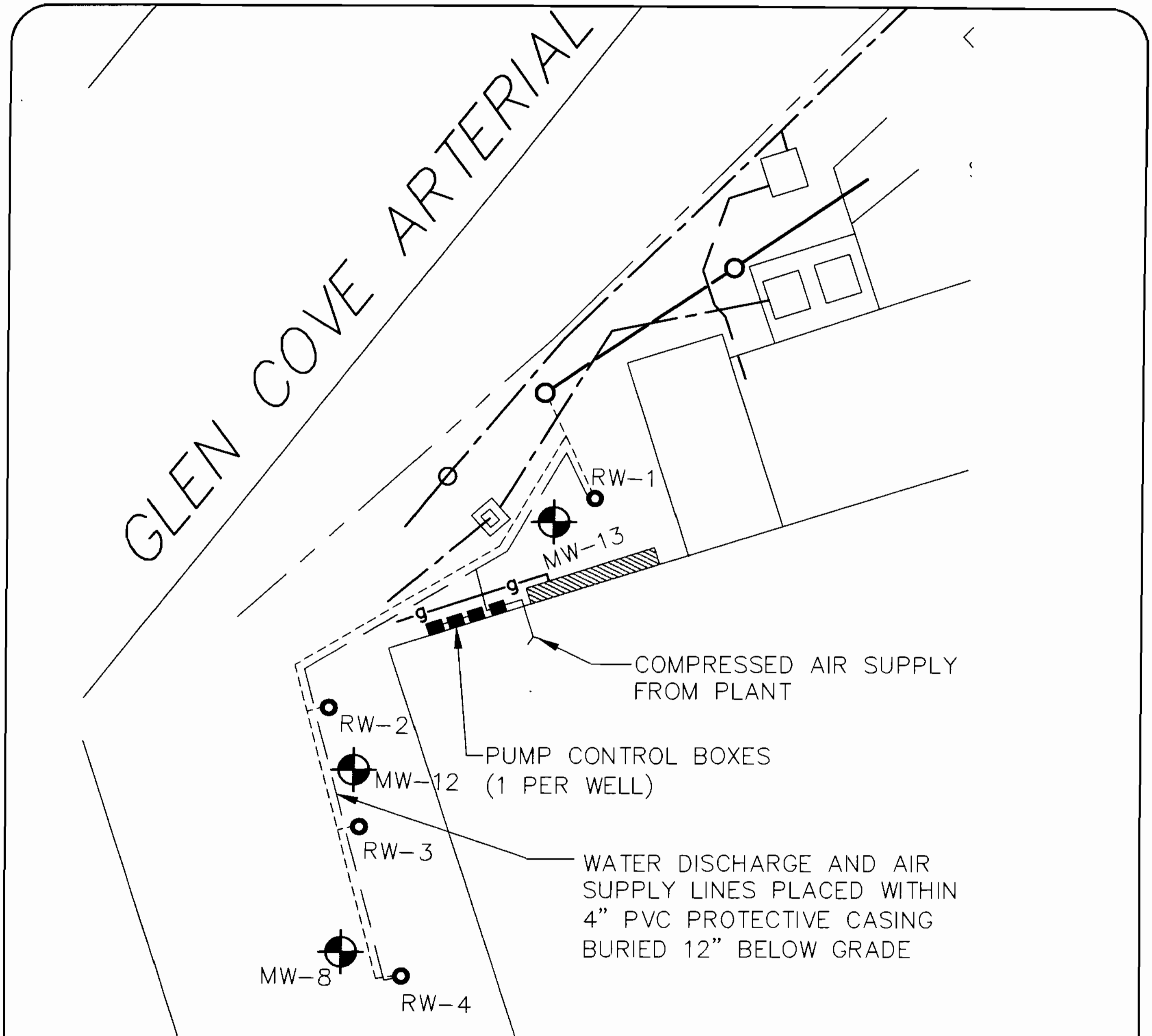

LEGEND:

o	GROUND WATER RECOVERY WELL
- - - - - -	3/4" PE TUBING (INDIVIDUAL DISCHARGE FOR EACH WELL)
—— ——	3/8" PE TUBING COMPRESSED AIR SUPPLY LINE
—— - ——	ELECTRIC LINE
——g——	GAS LINE
- -O- -	SEWER LINE
⊕	MONITOR WELL

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AS-BUILT LAYOUT
HYDRAULIC CONTROL SYSTEM

GLEN COVE NEW YORK

Figure
2

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APPENDICES

Alternative 1 - No Action

Item	Quantity	Unit Cost	Total
Continued operation of hydraulic control system through 2016	1 ls	$110,000	$110,000
Continued groundwater monitoring through 2016	1 ls	$54,000	$54,000
		Total	$164,000

Alternative 2 - Continued and Enhancement of the Existing Bioremediation Program in the Waste Recovery Area by the Addition of Substrate, Coupled with Hydraulic Control

Item	Quantity	Unit Cost	Total
Continued operation of hydraulic control system through 2011	1 ls	$55,000	$55,000
Continued groundwater monitoring through 2011	1 ls	$27,000	$27,000
Geoprobe Contractor	5 days	$2,000/day	$10,000
Bioremediation Contractor	1 ls	$20,000	$20,000
Materials		$20,000	$20,000
Oversight	1 ls	$15,000	$15,000
Reporting	1 ls	$10,000	$10,000
		Total	$157,000

Alternative 3 - In-Situ Destruction of Contaminants in the Waste Recovery Area by Chemical Oxidation, Coupled with Hydraulic Control

Item	Quantity	Unit Cost	Total
Continued operation of hydraulic control system through 2011	1 ls	$55,000	$55,000
Continued groundwater monitoring through 2011	1 ls	$27,000	$27,000
Injection Wells	10	$10,000	$100,000
Injection Event 1	1 ls	$171,000 to $216,000	$171,000 to $216,000
Injection Event 2	1 ls	$171,000 to $216,000	$171,000 to $216,000
Injection Event 3	1 ls	$171,000 to $216,000	$171,000 to $216,000
			$695,000 to $830,000

Injection Event 1			
Injection Contractor	20 days	$5,000/day	$100,000
Materials	see below		$36,000 to $81,000
Oversight	1 ls	$20,000	$20,000
Reporting	1 ls	$15,000	$15,000
			$171,000 to $216,000
Materials			
Permanganate	18,000 lb	$2/lb	$36,000
Hydrogen Peroxide (5%)	54,000 gal	$1/gal	$54,000
Fenton's Reagent			
Hydrogen Peroxide (5%)	54,000 gal	$1/gal	$81,000
Ferrous Sulfate	27,000 lb	$1 lb	

Assumes an oxidant demand of 12,000 lb (5600 lb soil organic/sorbed contaminant and 400 lb dissolved contaminant x safety/mixing factor of 3)

Alternative 4 - Extraction of Groundwater in the Waste Recovery Area, Coupled with Hydraulic Control

Item	Quantity	Unit Cost	Total
Continued operation of hydraulic control system through 2011	1 ls	$55,000	$55,000
Continued groundwater monitoring through 2011	1 ls	$27,000	$27,000
Engineering	1 ls	$15,000	$15,000
Extraction Wells	6	$60,000/well	$60,000
Pumps and piping	1 ls	$30,000	$30,000
Oversight		$15,000	$15,000
Reporting		$10,000	$10,000
Operating Costs through 2011	5 yrs	$15,000/yr	$75,000
		Total	$287,000