Appendix Q

Remedial Alternatives Cost Analysis

River Terrace Site Feasibility Study

APPROACH USED FOR DEVELOPMENT OF COSTS

The development of costs for alternatives evaluated for River Terrace was based on best engineering judgement and experience, in a consistent manner that included the following steps:

1. An outline of the basic components of each alternative was assembled. Basic components included capital materials that would be purchased or constructed, services that would be purchased or rented, and labor.
2. Quantities of the basic components required were estimated. These estimates were based on previous experience with implementing remedial projects, vendor information, and best professional judgement.
3. The prices for the basic components were estimated using vendor information and existing pricing data. An accuracy range between +50 to –30 percent can be expected for the costs provided (USEPA, 1998).
4. A **Construction Cost Subtotal** was calculated from the estimated quantities and prices for the basic components of the alternatives.
5. A 10 to 15 percent charge for **Mobilization and Demobilization** was added to the Construction Cost Subtotal. This charge includes planning, expediting, transportation of personnel, per diem, and other mobilization costs not explicitly included in the basic component outline.
6. A variable percent charge for **Construction Contingencies** was applied to the Construction Cost Subtotal. The Construction Contingency is comprised of a scope contingency and a bid contingency. . The scope contingency represents project risks associated with an incomplete design. These contingencies represent capital or O&M costs, unforeseeable at the time the feasibility study is prepared, which are likely to become known as the remedial design proceeds. The bid contingency includes variations caused by weather, unexpected site conditions, quantity overruns, modifications, etc. that occur during construction. A 15 percent bid contingency is generally recommended.
7. An **Administrative Charge** of 15 percent was applied to the Construction Cost Subtotal. This charge includes project management and construction management costs. The Administrative Charge also includes other services during construction includeing bid and contract administration, negotiations, and additional engineering and design during construction. Finally, this charge includes permitting and legal fees that include the cost of obtaining the required permits to implement the alternative (e.g., NPDES permits for discharges and permitting for wetland activity).
8. A 20 to 40 percent charge for **Engineering and Design** was applied to the Construction Cost Subtotal. The percentage was varied between 20 and 40 percent to determine a reasonable cost, based on the level of complexity of the design and engineering services required.
9. For some alternatives a **Site Technology Licensing** fee was applied to the Construction Cost Subtotal. The percentage was based on the Licensee's fee structure.
10. The items above were summed and added to the **Construction Cost Subtotal** to arrive at the **Capital Cost Total**.

11. **Annual Operation and Maintenance (O&M)** costs were developed for each alternative. The O&M components included recurring consumable materials that would be purchased or constructed, services that would be purchased or rented, sampling and analysis labor. Quantities of the required basic components were estimated. The estimate was based on previous experience with implementing remedial projects, vendor information, and best professional judgement.
12. A charge of 15 percent of the **Annual O&M Cost Subtotal** was added for annual mobilization and general requirement costs.
13. The **Annual O&M Cost Total** provides a total of the annual cost of O&M and does not include a present-worth analysis.
14. Present-worth analysis was applied to each O&M component sum. The present-worth analysis assumes that 7 percent annual interest can be made on money invested today. The duration of time used for present-worth analysis often varies depending on the remedial alternative. A 15-year duration was assumed for all of the remedial alternatives evaluated except the source treatment alternatives where a 5-year duration was assumed.
15. The present-worth costs of each O&M component were summed to arrive at an O&M Cost Total (**Present Worth @ 15 Years @ 7%**).
16. The Capital Cost Total was added to the O&M Cost Total (Present Worth @ 15 years @ 7%) to arrive at a **Total Present Worth Cost**.

ALTERNATIVE RT-A
NO ACTION (LOWER CONTAMINANT PLUME)

Capital Cost:	None
O&M Costs (Present Worth @ 15 years):	None
Total Present-Worth Cost:	None

Description:

No remedial actions or institutional controls would be implemented. Evaluation of the "no action" alternative is required by CERCLA to provide a baseline against which all other remedial alternatives can be compared. This alternative is applicable to all contaminant types found in water, soil, and wetland environments. Natural processes may eventually reduce contaminant concentrations to acceptable levels, but current and future risk to human health and the environment would remain above ARARs for an extended period of time. No monitoring of groundwater or soil would be conducted to confirm eventual compliance with ARARs. The "no action" alternative is not expected to achieve remedial action objectives.

ALTERNATIVE RT-B
INTRINSIC REMEDIATION (LOWER CONTAMINANT PLUME)

Capital Cost:	$38,000 to $82,000
O&M Costs (Present Worth @ 15 years):	$276,000 to $592,000
Total Present-Worth Cost:	$314,000 to $674,000

Description:

Intrinsic remediation would not involve active remedial technologies. Dilution, absorption, volatilization, and biological degradation would naturally occur to continue attenuating dissolved PCE and its daughter products. Bioremediation of PCE generally occurs under reducing (anoxic) conditions. Groundwater monitoring at River Terrace has indicated the aquifer is anaerobic and empirical evidence indicates that the PCE is attenuating in areas of the lower contaminant plume as discussed in Section 7.

Implementation of this alternative will involve groundwater and surface water monitoring, periodic groundwater modeling, and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. Groundwater monitoring is also proposed to monitor the intrinsic remediation progress.

The intrinsic remediation option is not expected to achieve remedial action objectives and is only included to provide a comparison to the other remedial alternatives.

Assumptions:

- Initial data analysis and modeling would be performed to evaluate the feasibility and restoration time period for intrinsic remediation to achieve remedial objectives.
- Five (5), ten (10), and fifteen (15) years after initial event the data analysis and modeling efforts would be repeated to review the intrinsic remediation progress and determine if remedial action goals will be met in the desired timeframe.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.

ALTERNATIVE RT-C
PERMEABLE REACTIVE BARRIER (LOWER CONTAMINANT PLUME)

Capital Cost:	$612,000 to $1,311,000
O&M Costs (Present Worth @ 15 years):	$236,000 to $507,000
Total Present-Worth Cost:	$848,000 to $1,818,000

Description:

This alternative will require the installation of a permeable reactive barrier across the flow path of the lower contaminant plume. This type of barrier allows the passage of water while prohibiting the movement of contaminants by chemical reactions. The specific type of reaction wall proposed for River Terrace is a zero-valent iron treatment wall. It consists of iron filings mixed with sand. This type of treatment wall is applicable for treatment of chlorinated contaminants such as PCE, TCE, DCE, and VC. As the iron is oxidized, a chlorine atom is removed from the compound by one or more reductive dechlorination mechanisms, using electrons supplied by the oxidation of iron. The process dissolves the iron filings, but the metal disappears so slowly that the remediation barriers can be expected to remain effective for many years.

A 220-foot long treatment wall would be installed approximately parallel to the Kenai River to treat PCE-contaminated groundwater prior to its discharge into the river. Installation of the treatment wall will require a trench approximately 20 feet deep, with a 6-foot deep active treatment layer.

Due to the uncertainty of constructing a permeable reactive barrier by trenching and material placement alone, the use of temporary sheet pile walls to provide safety and geo-support were assumed necessary. Double rows of sheet piling would be used to allow safe vertical excavation to the 20-foot depth. Sheet piling would prevent trench sloughing and make is safer and easier to place the reactive iron material. However, several utilities run through this area and they would need to be relocated or at least temporarily terminated and reconnected after construction.

It was assumed that an iron treatment wall would not result in any aesthetic or deleterious impacts to the Kenai River (e.g., iron staining). A pilot study is recommended to evaluate the reactions of the site water chemistry with that of an iron filing mixture.

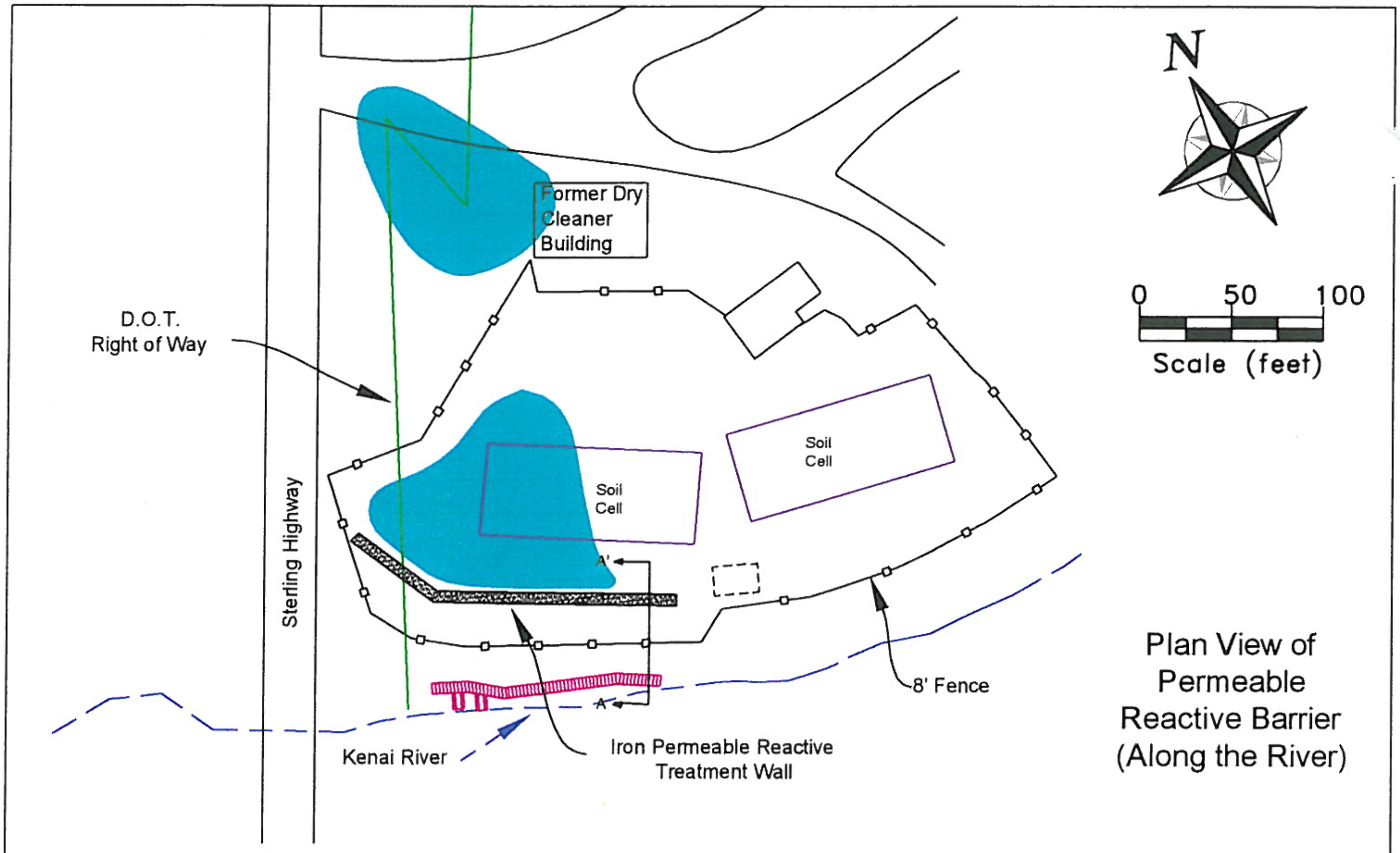
Implementation of this alternative will also involve groundwater and surface water monitoring, and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 15 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met. Although some variations in monitoring techniques may occur between alternatives, the costs will probably not vary much between the options.

Assumptions:

- Dimensions of the treatment wall will be approximately 220 feet long by 2.6 feet wide by 6 feet deep (volume = 3,432 cubic feet).

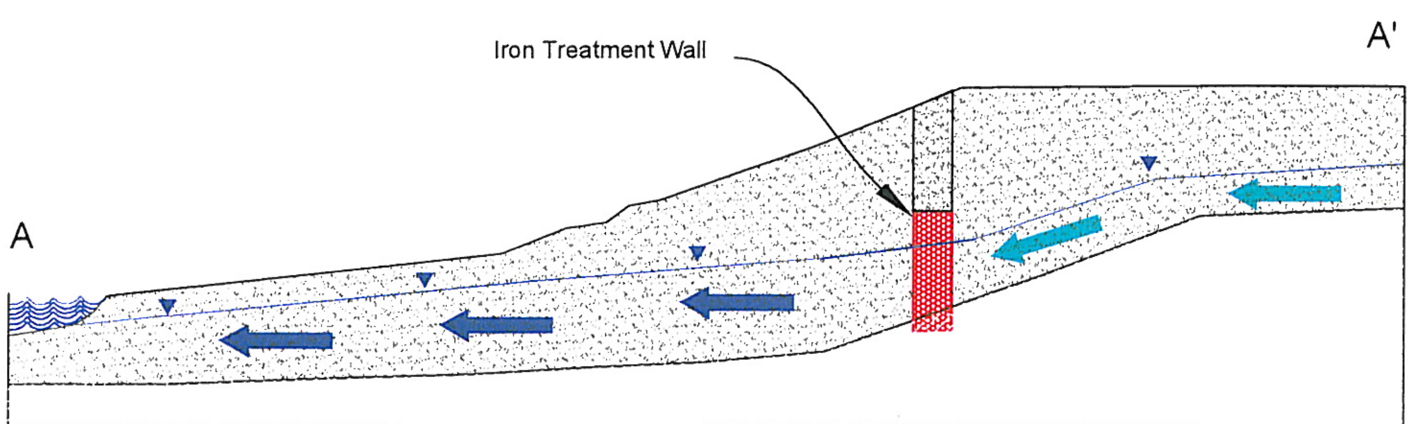
- Half of the 2.6-foot thick wall consists of granular iron, purchased and shipped from the continental United States. Shipment will be by train to Seattle, then by barge to Kenai.
- For construction reasons, the iron will be mixed with processed, cleaned, and screened sand at a 1:1 ratio, resulting in a 2.6-foot thick wall. The sand will be purchased from a local borrow source.
- Dimensions of the trench for installing the treatment wall will be approximately 220 feet long by 2.6 feet wide by 20 feet deep (11,440 cubic feet). The trench will most likely be constructed by backhoe or ladder type trenching equipment.
- Two temporary sheet pile walls approximately 220 long by 22 feet deep are required to assure safety, geo-support, and proper placement of the iron medium.
- After installing the iron reactive treatment wall, the trench will be backfilled 12 to14 feet deep with native soils. The approximate 3,500 cubic feet of soil that was replaced by the iron/sand mixture, and not placed back into the trench, will be taken from the upper soil zone. It is assumed that the upper soil zone PCE contamination levels are significantly below the site ACL for soil and that these soils may be spread on-site.
- A pilot test/treatability study is recommended prior to final design and installation. It is assumed that the iron reactive barrier will successfully transform the PCE and its daughter products to concentrations in the groundwater that comply with the remedial action objectives. This pilot study will assist in the design of a treatment wall that will be effective in achieving the remedial action objectives.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- The Reactive Iron Wall technology is proprietary and requires a licensing fee of 15 percent of the construction costs.

River Terrace RV Park						
Alternative RT-C Reactive Treatment Wall						
Lower Contaminant Plume						
Function	Units	Quantity	Cost Per Unit	Total Cost	Total Cost (- 30%)	Total Cost (+ 50%)
1. Base Construction Estimate						
1.1. Permeable Reactive Barrier						
1.1.1 Iron Medium with Installation	TON	220	$400	$88,000		
1.1.2. Shipping Costs for Iron Medium	TON	220	$180	$39,600		
1.1.3. Clean Sand for Medium Mix	CY	100	$15	$1,500		
1.1.4. Trench, Backfill, and Shoring	LF	220	$90	$19,800		
1.1.5. Install/Remove Sheet Pile Walls	SF	9,680	$25	$242,000		
Total for Permeable Reactive Barrier				**$390,900**		
1.2. HRC Injection Points	EA	20	$750	**$15,000**		
1.3. Fencing	LF	450	$20	**$9,000**		
1.4. Dewatering/Waste Management	LS	1	$15,000	**$15,000**		
1.5. Bench Scale Study	LS	1	$30,000	**$30,000**		
Construction Cost Subtotal				**$459,900**	**$321,930**	**$689,850**
2. Mobilization / Demobilization	%	1	10%	$45,990		
3. Construction Contingency	%	1	20%	$91,980		
4. Administrative Charge	%	1	15%	$68,985		
6. Engineering and Design	%	1	30%	$137,970		
7. Site Technology Licensing	%	1	15%	$68,985		
Capital Cost Total				**$873,810**	**$611,667**	**$1,310,715**
Annual O&M Costs						
Maintenance Support (0.5 hrs per week)	HR	25	$65	$1,625		
Annual O&M Cost Total				**$1,625**		
Present Worth Analysis						
O&M Cost for Years 1 - 15 @ 7%				$14,800		
Monitoring Cost for Years 1 - 15 @ 7%				$323,156		
Total O&M Cost (Present Worth - 15 yrs)				**$337,956**	**$236,569**	**$506,934**
Total Present Worth Cost (15 Yrs @ 7%)				**$1,211,766**	**$848,236**	**$1,817,649**



Plan View of Permeable Reactive Barrier (Along the River)

Cross-section of Permeable Reactive Barrier (Along the River)



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OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	Figure Q.
ADEC Contract No: 18-2-12-12		Drawn By: JAS Checked By: ASN	Project No: 20019

ALTERNATIVE RT-D
IN-SITU AIR SPARGING CURTAIN (LOWER CONTAMINANT PLUME)

Capital Cost:	$298,000 to $639,000
O&M Costs (Present Worth @ 15 years):	$466,000 to $998,000
Total Present-Worth Cost:	$764,000 to $1,637,000

Description:

This alternative consists of installation of an in-situ air-sparging curtain to treat the PCE impacted groundwater before it reaches the Kenai River. Air-sparging involves the injection of air into the contaminated groundwater, creating an underground stripper that removes contaminants through volatilization. This process is designed to operate at high airflow rates in order to effect volatilization (as opposed to the lower airflow rates used to stimulate biodegradation). The area of focus will be at the downgradient edge of the plume, just prior to it entering the Kenai River. If required, soil vapor extraction piping would be used in conjunction with the air sparging wells to control the flow of volatilized PCE.

Implementation of this alternative will also involve groundwater and surface water monitoring and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 15 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met. Although some variations in monitoring techniques may occur between alternatives, the costs will not vary much between the options.

Assumptions:

System Installation

- Forty 2-inch diameter air-sparging wells will be installed to an average depth of 15 feet bgs. Each air sparge well is capable of injecting 5-10 SCFM of air at a maximum pressure of 10 psi, with an estimated radius of influence of 5-10 feet.
- Vapor recovery will be performed by two horizontally buried 3-inch diameter ADS slotted pipes, installed to a depth of 2 to 3 feet bgs. Each vacuum line well will be capable of drawing 100 SCFM. The air-sparging region will be overlaid with an impermeable liner material to prevent short-circuiting and extend the effective area of the vapor extraction lines.
- Installation of 600 lineal feet of horizontal HDPE piping, with associated insulation, valves, gauges, and meters.
- Installation of 400 lineal feet of perforated ADS piping for soil vapor extraction, with associated insulation, valves, gauges, and meters.
- Installation of 800 lineal feet of 4-foot deep, 4-foot wide trenching.
- Installation of prefabricated and weatherized equipment/blower buildings to house the air sparging blowers and vapor extraction blowers with associated controls, valves, and piping.
- The system will be winterized using insulation and heat trace for the piping.

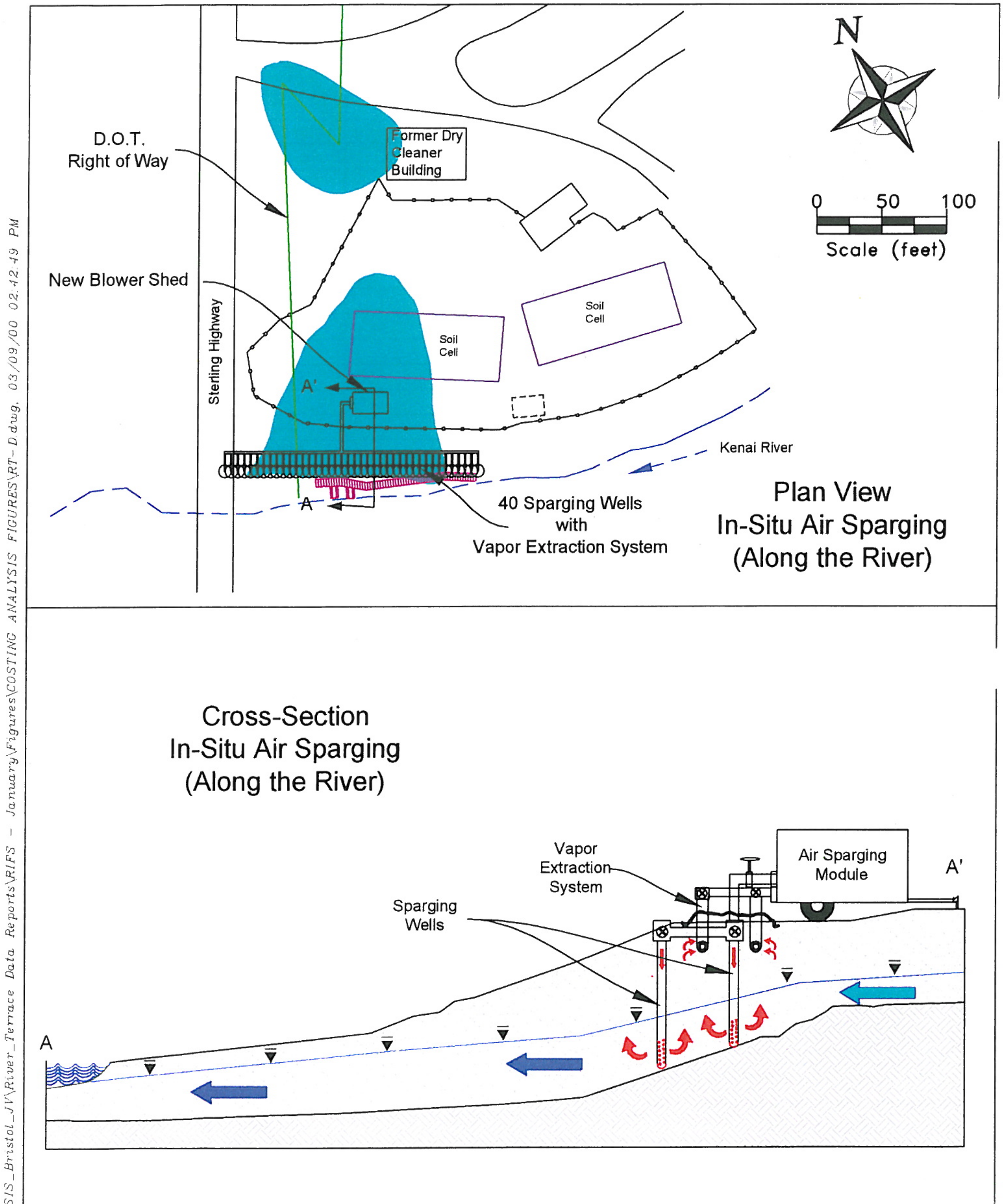
- A pilot test would be conducted prior to full-scale system design and implementation. A pilot test will assist in proper spacing of air sparging wells and will provide an indication of expected PCE removal rates.

System O&M

- The system will operate 365 days per year for 15 years.
- There will be no requirements for off-gas control or treatment.
- Exhaust stack air samples will be collected 4 times per year for 15 years. Air samples will be analyzed for VOCs using EPA TO-14 method.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

River Terrace RV Park						
Alternative RT-D In-Situ Air Sparging Curtain						
Lower Contaminant Plume						
Function	**Unit**	**Quantity**	**Cost Per Unit**	**Total Cost**	**Total Cost (- 30%)**	**Total Cost (+ 50%)**
1. Base Construction Estimate						
1.1. Sparging Wells						
1.1.1.Trenching and backfill for piping	LF	300	$15	$4,500		
1.1.2. HDPE Piping	LF	600	$0.60	$360		
1.1.3. Sparging Wells	EA	40	$1,500	$60,000		
1.1.4. Installation Labor	MH	300	$40	$12,000		
Total for Sparging Wells				**$76,860**		
1.2 Soil Vaper Extraction System						
1.2.1.Trenching,heat trace, insulation	LF	500	$25	$12,500		
1.2.2. Perforated ADS Piping	LF	400	$2.00	$800		
1.2.3. Impermeable surface barrier	SF	4400	$1.00	$4,400		
Total for Soil Vaper Extraction System				**$17,700**		
1.3. Blower Building	EA	1	$75,000	**$75,000**		
1.4. HRC Injection Points	EA	20	$750	**$15,000**		
1.5. Fencing	LS	450	$20	**$9,000**		
1.6. External Power Supply	LS	1	$15,000	**$15,000**		
1.7. Dewatering/Waste Management	LS	1	$5,000	**$5,000**		
1.8. Pilot Study	LS	1	$30,000	**$30,000**		
Construction Cost Subtotal				**$243,560**	**$170,492**	**$365,340**
2. Mobilization / Demobilization	%	1	10%	$24,356		
3. Construction Contingency	%	1	20%	$48,712		
4. Administrative Charge	%	1	15%	$36,534		
5. Engineering and Design	%	1	30%	$73,068		
Capital Cost Total				**$426,230**	**$298,361**	**$639,345**
Annual O&M Costs						
Maintenance Support (3 hrs per week)	HR	156	$65	$10,140		
Operating Power and Light	LS	1	$20,000	$20,000		
Routine Equip. Replacement and Repair	LS	1	$2,500	$2,500		
Mobilization and General Requirements	%	1	15%	$4,896		
Annual O&M Cost Total				**$37,536**		
Present Worth Analysis						
O&M Cost for Years 1 - 15 @ 7%				$341,875		
Monitoring Cost for Years 1 - 15 @ 7%				$323,156		
Total O&M Cost (Present Worth - 15 yrs)				**$665,031**	**$465,521**	**$997,546**
Total Present Worth Cost (15 Yrs @ 7%)				**$1,091,261**	**$763,882**	**$1,636,891**

Aternative RT-D:Lower Plume



OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	Figure Q-1
ADEC Contract No: 18-2-12-12		Drawn By: JAS Checked By: ASN	Project No: 20019

ALTERNATIVE RT-E
FUNNEL AND GATE SYSTEM WITH IN-WELL AIR STRIPPING (LOWER CONTAMINANT PLUME)

Capital Cost:	$524,000 to $1,122,000
O&M Costs (Present Worth @ 15 years):	$410,000 to $880,000
Total Present-Worth Cost:	$934,000 to $2,002,000

Note: These costs do not include Options A or B.

Description:

This alternative includes collecting and treating the contaminated water without removing it from the shallow ground water zone. A funnel wall, consisting of an impermeable barrier between the hard packed till layer and the ground surface will trap and direct the contaminated groundwater plume to a permeable gate area for treatment. The funnel will most likely be a vertically buried impermeable liner with a gravel-packed drainage trench to enhance groundwater collection and channeling.

The collected groundwater is directed to two diffused air bubble stripping wells that will have baffled chambers. Within each chamber, air is injected into the water by a fine bubble diffuser to enhance volatilization. The diffusion chambers will be constructed to minimize down-gradient groundwater inflow. Depending on engineering constraints, the remediated effluent water may pass directly into the downgradient soils, or be sent through a drainage gallery. The gallery will be perforated piping that allows regulated disbursement of the flow back into the shallow water table. Pumping from the second aeration well may be required to prevent back flow from the down-gradient water table.

This system is intended to intercept the flow of contaminants into the Kenai River and aggressively treat the contaminated shallow ground water. In comparison to the other remedial action alternatives, this alternative has a greater degree of certainty in achieving the desired remedial action objectives. There is greater certainty in the capture of groundwater with an impermeable wall. Air strippers provide one of the most aggressive and controllable methods of treating contaminated water, and they are particularly effective at volatilizing the types of chemical contaminants found at this location.

Due to the uncertainty of constructing an impermeable wall by trenching and geo-membrane placement alone, the use of sheet pile walls to provide safety and and geo-support was assumed for this location. Double rows of sheet piling would be used to allow safe vertical excavation to the 20-foot depth. Sheet piling would prevent trench sloughing and make is safer and easier to place the impermeable liner. However, several utilities run through this area and they would need to be relocated or at least temporarily terminated and reconnected after construction.

It was assumed that off gases from the air stripping operations could be released to the atmosphere without treatment. If off gas concentrations are higher than anticipated additional costs for off gas treatment will be required.

Assumptions:

System Installation

- Installation of a 220-foot long impermeable wall extending to a depth of approximately 22 feet below ground surface.
- Site conditions require the use of sheet pile walls for trenching and emplacement of an impermeable barrier wall. A gravel French drain will be placed on the upgradient side of the wall to assist in directing groundwater flow towards the treatment gate.
- The system will be winterized using insulation and/or heat trace where needed.

System O&M

- The system will operate 365 days per year for 15 years.
- There will be no requirements for off-gas control or treatment.
- Exhaust stack air samples will be collected 4 times per year for 15 years. Air samples will be analyzed for VOCs using EPA TO-14 method.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

Option A: Addition of a Permeable Reactive Barrier

Instead of or in addition to using air stripping to treat the collected water, a permeable reactive barrier could be installed as the treatment gate. It consists of block wall of granular iron filings sandwiched between permeable geo-fabric that would prevent unnecessary clogging of the iron by silt and fines. The thickness of the iron wall is determined by flow rates, concentration and type of contaminate, water temperature, and required retention time. For this cost estimate it was assumed that a similar amount of iron as was required for a continuous wall would be needed for the gate to treat the same amount of contaminant. As a result, the wall would be 40 feet wide, 6 feet high, and 8 feet thick.

By including a passive system with the in-well air stripping system, less electrical energy is required over the long term. Once the levels of contaminate are below the treatment goals, the in-situ active air stripping unit can be turned off for appropriate periods while the passive system continues to treat the groundwater. The addition of the permeable reactive barrier system will increase the capital and total present worth costs by approximately **$201,745**.

Reactive iron wall technology is proprietary and will require a licensing fee of 15 % of construction costs.

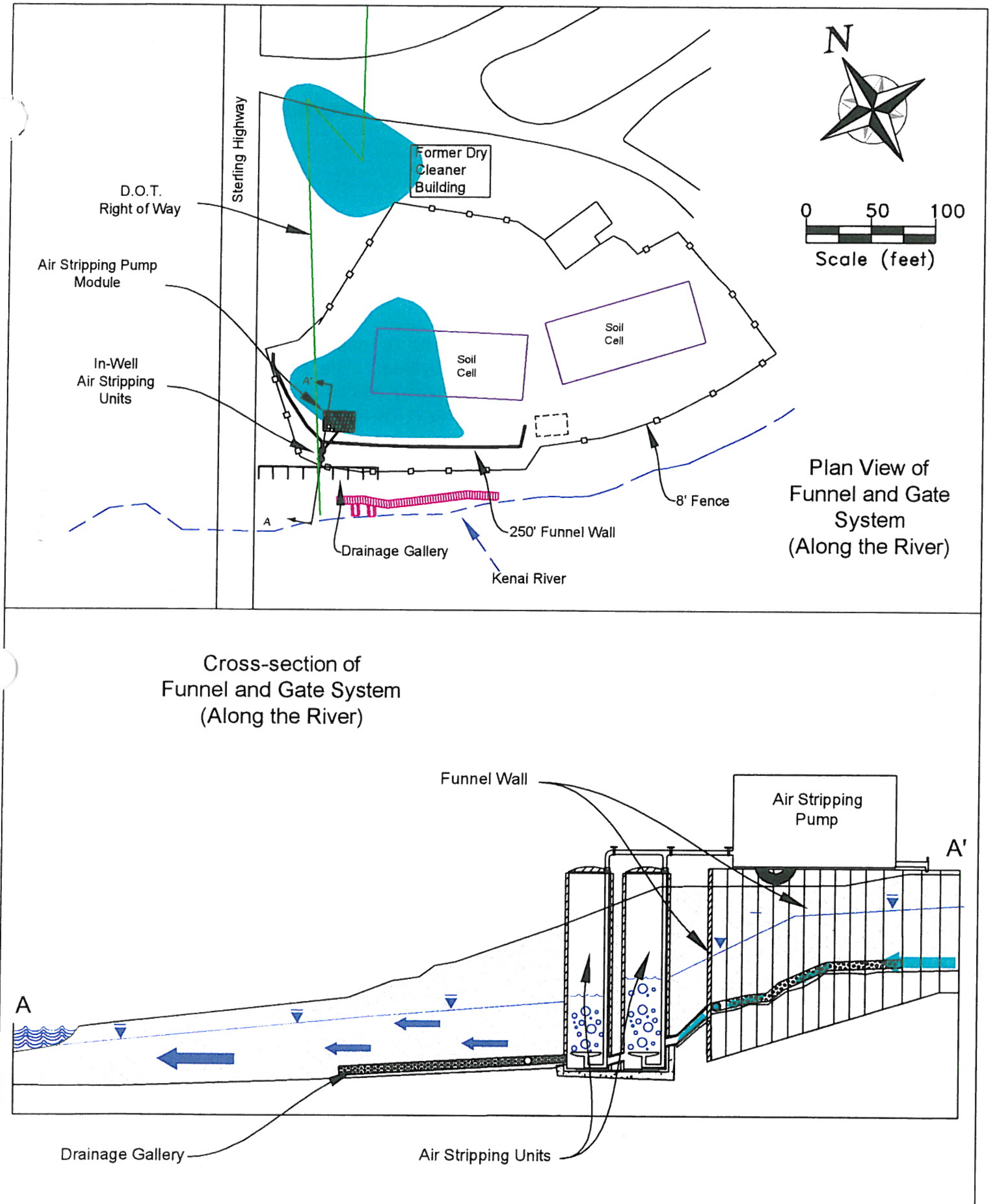
Option B: Ex-Situ Stripping VS In-Well Stripping

Instead of an in-situ air stripping system, a prefabricated air stripping system could be utilized to treat the collected water. An external stripping system would provide greater flexibility and control over the air stripping process. The cost difference to go with an external air stripper would be an increase in the capital and total present worth costs of approximately **$143,375**.

River Terrace RV Park						
Alternative RT-E Funnel and Gate With Options						
Lower Contaminant Plume						
Function	**Unit**	**Quantity**	**Cost Per Unit**	**Total Cost**	**Total Cost (- 30%)**	**Total Cost (+ 50%)**
1. Base Construction Estimate						
1.1. Impermeable Wall						
1.1.1. Trench, Backfill, and Shoring	LF	220	$90	$19,800		
1.1.2. Furnish Gravel Backfill	TON	80	$14	$1,120		
1.1.3. Install Impermeable Liner	SF	4400	$5	$22,000		
1.1.4. Install Sheet Pile Walls	SF	9680	$25	$242,000		
Total for Impermeable Wall				**$284,920**		
1.2. In-Well Active Stripping Unit						
1.2.1. Vertical Air Stripping 60" Chamber	EA	2	$3,500	$7,000		
1.2.2. Air Pipes	LF	100	$15	$1,500		
1.2.3. Air Nozzles (Fine Bubble Diffusion)	EA	2	$500	$1,000		
1.2.4. Blower Building w/controls	EA	1	$40,000	$40,000		
1.2.5. Installation Labor	LS	1	$10,000	$10,000		
Total for In-Situ Active Stripping Unit				**$59,500**		
1.3 Disposal Cell for Excavated Mat.						
1.3.1. Constructed Disposal Cell	CY	50	$20	$1,000		
1.3.2. Construct Treatment Facility	LS	1	$5,000	$5,000		
Total for Disposal Cell				**$6,000**		
1.4. HRC Injection Points	EA	20	$750	**$15,000**		
1.4. Fencing	LF	450	$20	**$9,000**		
1.5. External Power Supply	LS	1	$15,000	**$15,000**		
1.6. Dewatering/Waste Management	LS	1	$15,000	**$15,000**		
Construction Cost Subtotal				**$404,420**	**$283,094**	**$606,630**
2. Mobilization / Demobilization	%	1	15%	$60,663		
3. Construction Contingency	%	1	25%	$101,105		
4. Administrative Charge	%	1	15%	$60,663		
5. Engineering and Design	%	1	30%	$121,326		
Capital Cost Total				**$748,177**	**$523,724**	**$1,122,266**
Annual O&M Costs						
Maintenance Support (3 hrs per week)	HR	156	$65	$10,140		
Operating Power and Light	LS	1	$10,000	$10,000		
Routine Equip. Replacement and Repair	LS	1	$5,000	$5,000		
Mobilization and General Requirements	%	1	15%	$3,771		
Annual O&M Cost Total				**$28,911**		
Present Worth Analysis						
O&M Cost for Years 1 - 15 @ 7%				$263,319		
Monitoring Cost for Years 1 - 15 @ 7%				$323,156		
Total O&M Cost (Present Worth - 15 yrs)				**$586,475**	**$410,532**	**$879,712**
Total Present Worth Cost (15 Yrs @ 7%)				**$1,334,652**	**$934,256**	**$2,001,978**

River Terrace RV Park						
Alternative RT-E Funnel and Gate With Options						
Lower Contaminant Plume						
Function	Unit	Quantity	Cost Per Unit	Total Cost	Total Cost (- 30%)	Total Cost (+ 50%)
OPTIONS						
Option A. Permeable Reactive Barrier						
A.1. Iron Medium with Installation	TON	137	$400	$54,912		
A.2. Shipping Costs for Iron Medium	TON	137	$180	$24,710		
A.3. Excavate, Const. Frame	LS	1	$15,000	$15,000		
A.4. Permeable Geomembrane Filter	SF	1250	$5	$6,250		
A.5. Markup and Contingency Factors	%	1	85%	$85,742		
A.6. Technology Licensing Fee	%	1	15%	$15,131		
Total for Permeable Reactive Barrier				**$201,745**		
Option A: Total Present Worth Cost				**$1,536,397**	**$1,075,478**	**$2,304,595**
Option B. External Air Stripper						
B.1. Containerized Stripping System	EA	1	$65,000	$65,000		
B.2. Shipping Costs	LS	1	$10,000	$10,000		
B.3 Trenching with Piping and Insulation	LF	100	$25	$2,500		
B.4. Markup and Contingency Factors	%	1	85%	$65,875		
Total for Stripping Facility				**$143,375**		
Option B: Total Present Worth Cost				**$1,418,527**	**$992,969**	**$2,127,790**

Alternative RT-E:Lower Plume



OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	Figure Q-3
ADEC Contract No: 18-2-12-12		Drawn By: JAS Checked By: ASN	Project No: 20019

ALTERNATIVE RT-F
EXTRACTION WELLS WITH AIR STRIPPING (LOWER CONTAMINANT PLUME)

Capital Cost:	$235,000 to $503,000
O&M Costs (Present Worth @ 15 years):	$558,000 to $1,196,000
Total Present-Worth Cost:	$793,000 to $1,699,000

Description:

This alternative uses groundwater extraction wells to capture and direct shallow-groundwater flow to an above ground treatment system. The collected water will be pumped to the surface for treatment with air stripping equipment. Once treated, the water will probably be returned to a drainage gallery in the river alluvium along the Kenai River.

Air strippers work by introducing air into contaminated water to maximize the air-water interface and volatilize contaminants. Three general types of air strippers are: packed tower, low-profile tray, and diffused bubble air strippers.

In the packed tower air-stripping system, water is pumped to the top of a tower and allowed to trickle over packing inside. As the water flows downward over the packing, it spreads more thinly, creating a greater surface area. These thin films of water are met by a counter-flow of air blown in from the bottom of the tower. Packed towers are typically tall large units that must be stationary for operation. This is the oldest form of air stripping and is still widely used.

Low-profile tray air strippers represent a large portion of the air strippers used at newer remediation sites. The most common type of low-profile air stripper is the tray-type unit in which a shallow layer of water is allowed to flow along one or more trays. Air is blown through hundreds of holes in the bottom of the trays to generate a froth of bubbles that significantly enhance contaminant volatilization. Manufacturers often claim 99 percent removal rates from tray air strippers. Additionally, low-profile systems are much smaller than the packed tower type and are more resistant to media failure due to clogging (iron fouling). They are often configured on a mobile platform with all necessary ancillary devices to provide a complete portable water treatment solution.

Diffused air strippers are typically a series of tanks, or a single tank with a series of baffles. Air is introduced from the bottom by fine bubble diffusers to enhance volatilization. They are often more economical, since diffused air bubble type strippers may be built for a site-specific application using locally procured components. Such systems are probably less efficient than the prefabricated, packed tower or low profile type systems.

Of the three types of air-stripping systems mentioned above, the low-profile tray air stripping system appears to be the best choice for River Terrace because of its portability, ability to be housed, and efficiency. Several companies rent or lease self-contained trailers with all operational equipment included. These trailers can be kept at optimum operating temperature throughout the cold winter months. Packed towers can easily freeze at low temperatures, and insulating them is costly.

This system is intended to intercept the flow of contaminants into the Kenai River and aggressively treats the contaminated shallow ground water. Air strippers provide one of the most aggressive and controllable methods of treating contaminated water, and they are particularly effective at volatilizing the types of chemical contaminants found at this location.

It was assumed that off gases from the air stripping operations could be released to the atmosphere without treatment. If off gas concentrations are higher than anticipated, additional costs for off gas treatment will be required.

This alternative, unlike the other alternatives, may contain significant regulatory issues and costs associated with the above ground treatment and discharge of treated wastewater -- re-injection to shallow groundwater or, especially, into a storm water or sanitary sewer system. The use of extraction well will also not be as effective as an impermeable barrier in preventing the flow of contaminated groundwater towards the Kenai River.

Assumptions:

System Installation

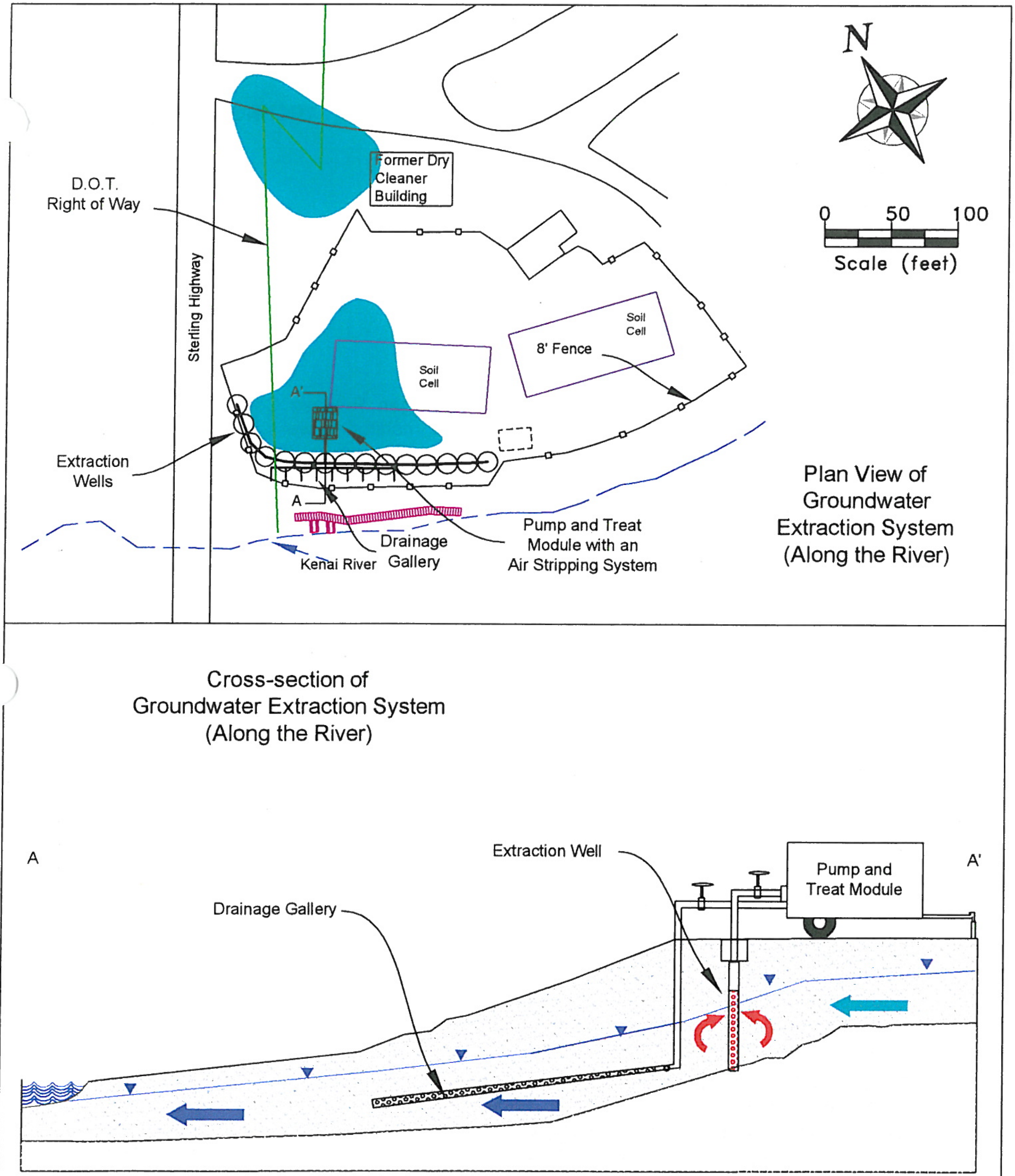
- Fifteen 2-inch diameter groundwater extraction wells will be installed to a depth of 15 feet bgs. Each well is estimated to produce approximately one gpm of water, with an estimated radius of influence of 15 feet. The wells would extend for a distance of 230 feet from the KRBO to beyond MW-5.
- Two liquid ring pumps will be used to extract and pull groundwater from the extraction wells.
- Installation of 600 lineal feet of horizontal HDPE piping, with associated insulation, valves, gauges, and meters.
- Installation of 300 lineal feet of 4-foot deep, 4-foot wide trenching.
- Installation of a prefabricated and weatherized equipment building to house the liquid ring pumps, water holding tank, and tray air-stripper equipment.
- A drainage gallery will be required to disperse the treated water back into the groundwater table.
- The system will be winterized using insulation and/or heat trace where needed.
- The groundwater extraction wells will provide sufficient removal of contaminated groundwater to prevent any water that passes the extraction wall from exceeding the remedial action objectives. Special construction techniques, such as constructing a permeable trench in the till layer, may be required to minimize the amount of groundwater that escapes the extraction wells.

System O&M

- The system will operate 365 days per year for 15 years.
- There will be no requirements for off-gas control or treatment.
- Exhaust stack air samples will be collected 4 times per year for 15 years. Air samples will be analyzed for VOCs using EPA TO-14 method.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

River Terrace RV Park						
Alternative RT-F Extraction Wells and Air Stripping						
Lower Contaminant Plume						
Function	Unit	Quantity	Cost Per Unit	Total Cost	Total Cost (- 30%)	Total Cost (+ 50%)
1. Base Construction Estimate						
1.1. Extraction Wells						
1.1.1.Trenching with insulation for piping	LF	300	$25	$7,500		
1.1.2. HDPE Piping	LF	600	$0.60	$360		
1.1.3. Wells	EA	15	$1,500	$22,500		
Total for Stripping Wells				**$30,360**		
1.2 Pumping and Stripping Facility						
1.2.1. Containerized Stripping System	EA	1	$100,000	$100,000		
1.2.2. Installation Labor	LS	1	$10,000	$10,000		
Total for Equipment Facility				**$110,000**		
1.3. Drainage Field	LF	200	$36	**$7,200**		
1.4. HRC Injection Points	EA	20	$750	**$15,000**		
1.5. Fencing	LF	450	$20	**$9,000**		
1.6. External Power Supply	LS	1	$15,000	**$15,000**		
1.7. Dewatering/Waste Management	LS	1	$5,000	**$5,000**		
Construction Cost Subtotal				**$191,560**	**$134,092**	**$287,340**
2. Mobilization / Demobilization	%	1	10%	$19,156		
3. Construction Contingency	%	1	20%	$38,312		
4. Administrative Charge	%	1	15%	$28,734		
6. Engineering and Design	%	1	30%	$57,468		
Capital Cost Total				**$335,230**	**$234,661**	**$502,845**
Annual O&M Costs						
Maintenance Support (6 hrs per week)	HR	312	$65	$20,280		
Operating Power and Light	LS	1	$20,000	$20,000		
Routine Equip. Replacement and Repair	LS	1	$5,000	$5,000		
Mobilization and General Requirements	%	1	15%	$6,792		
Annual O&M Cost Total				**$52,072**		
Present Worth Analysis						
O&M Cost for Years 1 - 15 @ 7%				$474,267		
Monitoring Cost for Years 1 - 15 @ 7%				$323,156		
Total O&M Cost (Present Worth - 15 yrs)				**$797,423**	**$558,196**	**$1,196,135**
Total Present Worth Cost (15 Yrs @ 7%)				**$1,132,653**	**$792,857**	**$1,698,980**

Alternative RT-F:Lower Plume



OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	Figure Q-4
		Drawn By: JAS	Project No:
ADEC Contract No: 18-2-12-12		Checked By: ASN	20019

ALTERNATIVE RT-G
REDUCTIVE ANAEROBIC BIOLOGICAL IN-SITU TREATMENT TECHNOLOGY (RABBIT)
(LOWER CONTAMINANT PLUME)

Capital Cost:	$636,000 to $1,363,000
O&M Costs (Present Worth @ 5 years):	$559,000 to $1,198,000
Total Present-Worth Cost:	$1,195,000 to $2,561,000

Description:

This alternative consists of in situ injection of Hydrogen Release Compound (HRC) through approximately 100 injection points and 80 monitoring wells. HRC injection results in anaerobic bioremediation of chlorinated solvents such as PCE and TCE. HRC offers a passive and possibly low-cost approach to in-situ remediation. HRC is a moderately flowable material that can be injected under pressure into an aquifer using various drilling and direct push technologies. It can maintain dechlorinating conditions in the aquifer for six months to one year or more, depending on site characteristics. HRC provides time-release hydrogen source to accelerate the reduction of anaerobically degradable contaminants.

Advantages of this technology include the elimination of aboveground treatment and processing equipment, and reduced disruption to the site. Since chlorinated hydrocarbon sources are difficult to locate, a large number of injection wells, placed in a grid pattern, will most likely be required to address the entire source contamination area. An HRC barrier wall consisting of 80 monitoring wells (2 rows of 40 wells each) used as injection points is recommended to ensure the halt of contaminants migrating towards the Kenai River. To ensure that this barrier wall remains active at all times, replacement of the HRC is recommended at least two times per year. It is expected that annual replacement of the HRC in the source treatment areas will be required to maintain reductive anaerobic biological treatment conditions for the source treatment area.

Because introduction of the HRC may lead to anaerobic impacts to the Kenai River, a series of 50 4-inch diameter injection wells located between the river and the HRC injection wells will be used to assist in re-oxygenating the groundwater. An Oxygen Release Compound (ORC) will be added to the wells at least two times per year during the same period that HRC injections are being conducted.

Because this alternative includes aggressive treatment of the contaminant source area, it is estimated that the RAOs can be achieved in five years. However, unknown contaminant source areas and site conditions may extend the required treatment time.

Implementation of this alternative will also involve groundwater and surface water monitoring and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 5 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met. Although some variations in monitoring techniques may occur between alternatives, the costs will probably not vary much between the options.

Assumptions:

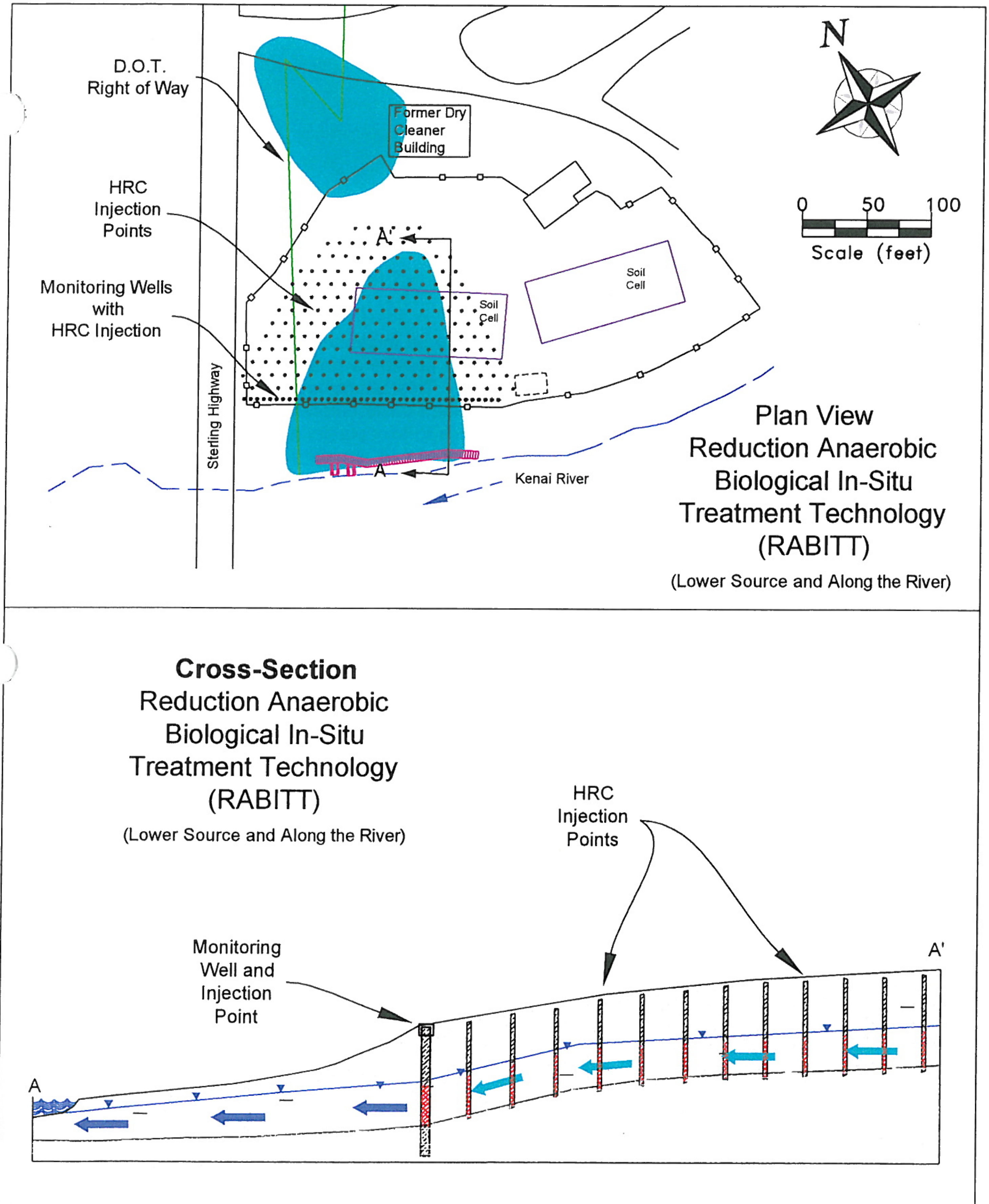
System Installation

- Eighty 4-inch diameter wells will be drilled to a depth of 15 to 20 feet below ground surface. These wells will be used to create a barrier wall for injection of HRC at the lower edge of the contaminant plume. Wells are used to allow for frequent replacement of the HRC. It was assumed that the HRC would be replaced two times per year. Each injection well will receive approximately 48 lbs of HRC per injection.
- Fifty 4-inch diameter wells will be drilled to a depth of 10 feet below ground surface. The wells will be located in a single row between the HRC barrier wells and the Kenai River. It was assumed that the ORC would be replaced two times per year. Each injection well will receive six 4-inch ORC socks per injection.
- One hundred 2-inch diameter injection points will be drilled to a depth of 15 to 35 feet below ground surface. Each injection point will receive approximately 18.5 lbs of HRC, based on the assumption of an active layer of 10 foot deep.
- The design engineer will determine appropriate method of injection.
- HRC injection is a proprietary treatment method that requires a contract with Regenesis Corporation of California.

System O&M

- Replacement of HRC in the 4-inch injection wells will be made two times per year. Each replacement requires the addition of 54 lbs of HRC per well.
- Replacement of ORC in the 4-inch injection wells will be made two times per year. Each replacement requires the addition of six 4-inch ORC socks per well.
- It was assumed the used ORC socks could be disposed of at the local municipal landfill without any added costs.
- Replacement of the HRC within the source treatment area will be required on an annual basis. It was assumed that 25 borings would be installed each year to replace the HRC in the areas of remaining contamination.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

River Terrace RV Park						
Alternative RT-G Reductive Anaerobic Biological In-Situ Treatment Technology (RABITT)						
Lower Contaminant Plume						
Function	**Unit**	**Quantity**	**Cost Per Unit**	**Total Cost**	**Total Cost (- 30%)**	**Total Cost (+ 50%)**
1. Base Construction Estimate						
1.1. HRC Injection						
1.1.1. Drill/install HRC Injection Points	EA	100	$750	$75,000		
1.1.2. Drill/Install HRC Injection Wells	EA	80	$2,500	$200,000		
1.1.3. Hydrogen Release Compound	LBS	9530	$7	$66,710		
1.1.4. Drill/Install ORC Injection Wells	EA	50	$1,500	$75,000		
1.1.5. Oxygen Release Compound	Socks	600	$37.50	$22,500		
1.1.5. Installation Equip and Labor	LS	1	$30,000	$30,000		
Total for HRC/ORC Injection Wells				**$469,210**		
1.2. HRC Injection Points along ROW	EA	20	$750	**$15,000**		
1.3. Dewatering/Waste Management	LS	1	$5,000	**$5,000**		
1.4. Pilot Study	LS	1	$30,000	**$30,000**		
Construction Cost Subtotal				**$519,210**	**$363,447**	**$778,815**
2. Mobilization / Demobilization	%	1	10%	$51,921		
3. Construction Contingency	%	1	20%	$103,842		
4. Administrative Charge	%	1	15%	$77,882		
6. Engineering and Design	%	1	30%	$155,763		
Capital Cost Total				**$908,618**	**$636,032**	**$1,362,926**
Annual O&M Costs						
Replacement of HRC in Wells (2 Times/Yr)	LBS	7680	$7.00	$53,760		
Replacement of ORC in Wells (2 Times/Yr)	Sock	600	$37.50	$22,500		
Replacement of HRC (25 Borings)	LS	1	$25,000	$25,000		
Labor Requirements (150 Hrs per event)	HR	300	$65	$19,500		
Mobilization and General Requirements	%	1	15%	$18,114		
Annual O&M Cost Total				**$138,874**		
Present Worth Analysis						
O&M Cost for Years 1 - 5 @ 7%				$569,411		
Monitoring Cost for Years 1 - 5 @ 7%				$229,262		
Total O&M Cost (Present Worth - 5 yrs)				**$798,673**	**$559,071**	**$1,198,009**
Total Present Worth Cost (5 Yrs @ 7%)				**$1,707,290**	**$1,195,103**	**$2,560,936**



OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	Figure **Q-5**
ADEC Contract No: 18-2-12-12		Drawn By: JAS Checked By: ASN	Project No: 20019

ALTERNATIVE UT-A
NO ACTION (UPPER CONTAMINANT PLUME)

Capital Cost:	None
O&M Costs (Present Worth @ 15 years):	None
Total Present-Worth Cost:	None

Description:

No remedial actions or institutional controls would be implemented. Evaluation of the "no action" alternative is required by CERCLA to provide a baseline against which all other remedial alternatives can be compared. This alternative is applicable to all contaminant types found in water, soil, and wetland environments. Natural processes may eventually reduce contaminant concentrations to acceptable levels, but current and future risk to human health and the environment would remain above ARARs for an extended period of time. No monitoring of groundwater or soil would be conducted to confirm eventual compliance with ARARs. The "no action" alternative is not expected to achieve remedial action objectives.

ALTERNATIVE UT- B
INTRINSIC REMEDIATION (UPPER CONTAMINANT PLUME)

Capital Cost:	$38,000 to $82,000
O&M Costs (Present Worth @ 15 years):	$276,000 to $592,000
Total Present-Worth Cost:	$314,000 to $674,000

Description:

Intrinsic remediation would not involve active remedial technologies. Dilution, absorption, volatilization, and biological degradation would naturally occur to continue attenuating dissolved PCE and its daughter products. Bioremediation of PCE generally occurs under reducing (anoxic) conditions. Groundwater monitoring at the River Terrace Upper Contaminant Plume indicates the aquifer is aerobic and no evidence exists to indicate that the PCE is biodegrading in this portion of the aquifer. However, other intrinsic remediation processes such as dispersion and sorption are present in all aquifer conditions.

Implementation of this alternative will involve groundwater and surface water monitoring, periodic groundwater modeling, and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. Groundwater monitoring is also proposed to monitor the intrinsic remediation progress.

The intrinsic remediation option is not expected to achieve remedial action objectives and is only included to provide a comparison to the other remedial alternatives.

Assumptions:

- Initial data analysis and modeling would be performed to evaluate the feasibility and restoration time period for intrinsic remediation to achieve remedial objectives.
- Five (5), ten (10), and fifteen (15) years after initial event the data analysis and modeling efforts would be repeated to review the intrinsic remediation progress and determine if remedial action goals will be met in the desired timeframe.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.

River Terrace RV Park						
Alternative UT-B Intrinsic Remediaition						
Upper Contaminant Plume						
					Total Cost	Total Cost
Function	Unit	Quantity	Cost Per Unit	Total Cost	(- 30%)	(+ 50%)
1. Base Construction Estimate						
1.1. Initial Intrinsic Evaluation						
1.1.1. Data Analysis	HR	100	$75	$7,500		
1.1.2. Groundwater Modeling	HR	200	$85	$17,000		
1.1.3. Reporting Effort	LS	1	$20,000	$20,000		
Total for Intrinsic Remediation Analysis				**$44,500**		
1.2. Administrative and Permitting	LS	1	$10,000	**$10,000**		
1.3.				**$0**		
Construction Cost Subtotal				**$54,500**	**$38,150**	**$81,750**
2. Mobilization / Demobilization	%	1	0%	$0		
3. Construction Contingency	%	1	0%	$0		
4. Administrative Charge	%	1	0%	$0		
6. Engineering and Design	%	1	0%	$0		
Capital Cost Total				**$54,500**	**$38,150**	**$81,750**
Annual O&M Costs						
			$0	$0		
	LS	1	$0	$0		
Mobilization and General Requirements	%	1	15%	$0		
Annual O&M Cost Total				**$0**		
Present Worth Analysis						
Intrinsic Analysis Review 5, 10, 15 @ 7%				$71,270		
Monitoring Cost for Years 1 - 15 @ 7%				$323,156		
Total O&M Cost (Present Worth - 5 yrs)				**$394,426**	**$276,098**	**$591,639**
Total Present Worth Cost (5 Yrs @ 7%)				**$448,926**	**$314,248**	**$673,389**

ALTERNATIVE UT-C
PERMEABLE REACTIVE BARRIER (UPPER CONTAMINANT PLUME)

Capital Cost:	\$285,000 to \$611,000
O&M Costs (Present Worth @ 15 years):	\$237,000 to \$507,000
Total Present-Worth Cost:	\$522,000 to \$1,118,000

Description:

This alternative would require the installation of a permeable reactive barrier across the flow path of the upper source plume. This type of barrier allows the passage of water while prohibiting the movement of contaminants by chemical reactions. The specific type of reaction wall proposed for River Terrace is a zero-valent iron treatment wall. It consists of iron filings mixed with sand. This type of treatment wall is applicable for treatment of chlorinated contaminants such as PCE, TCE, DCE, and VC. As the iron is oxidized, a chlorine atom is removed from the compound by one or more reductive dechlorination mechanisms, using electrons supplied by the oxidation of iron. The process dissolves the iron filings, but the metal disappears so slowly that the remediation barriers can be expected to remain effective for many years.

A 200-foot long treatment wall would be installed. The wall would start adjacent to the existing Seward Highway catch basins and run northeast, perpendicular to the projected groundwater flow path. Installation of the treatment wall will require a trench approximately 22-24 feet deep, with a 5-foot deep active treatment layer.

Due to the uncertainty of the cohesive strength and stability of the soil conditions (soils consist of cobbles and gravel), a one to one slope on the trench excavation was assumed down to 15 feet below ground surface. Construction of the permeable reactive barrier would be performed by excavating an additional 5 feet of material using trench boxes and supports where needed to stabilize the excavation. The upper 15 feet of soil that are above the water table are assumed uncontaminated and this material will be used to backfill the excavation.

Implementation of this alternative will also involve groundwater and surface water monitoring, and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 15 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met. Although some variations in monitoring techniques may occur between alternatives, the costs will probably not vary much between the options.

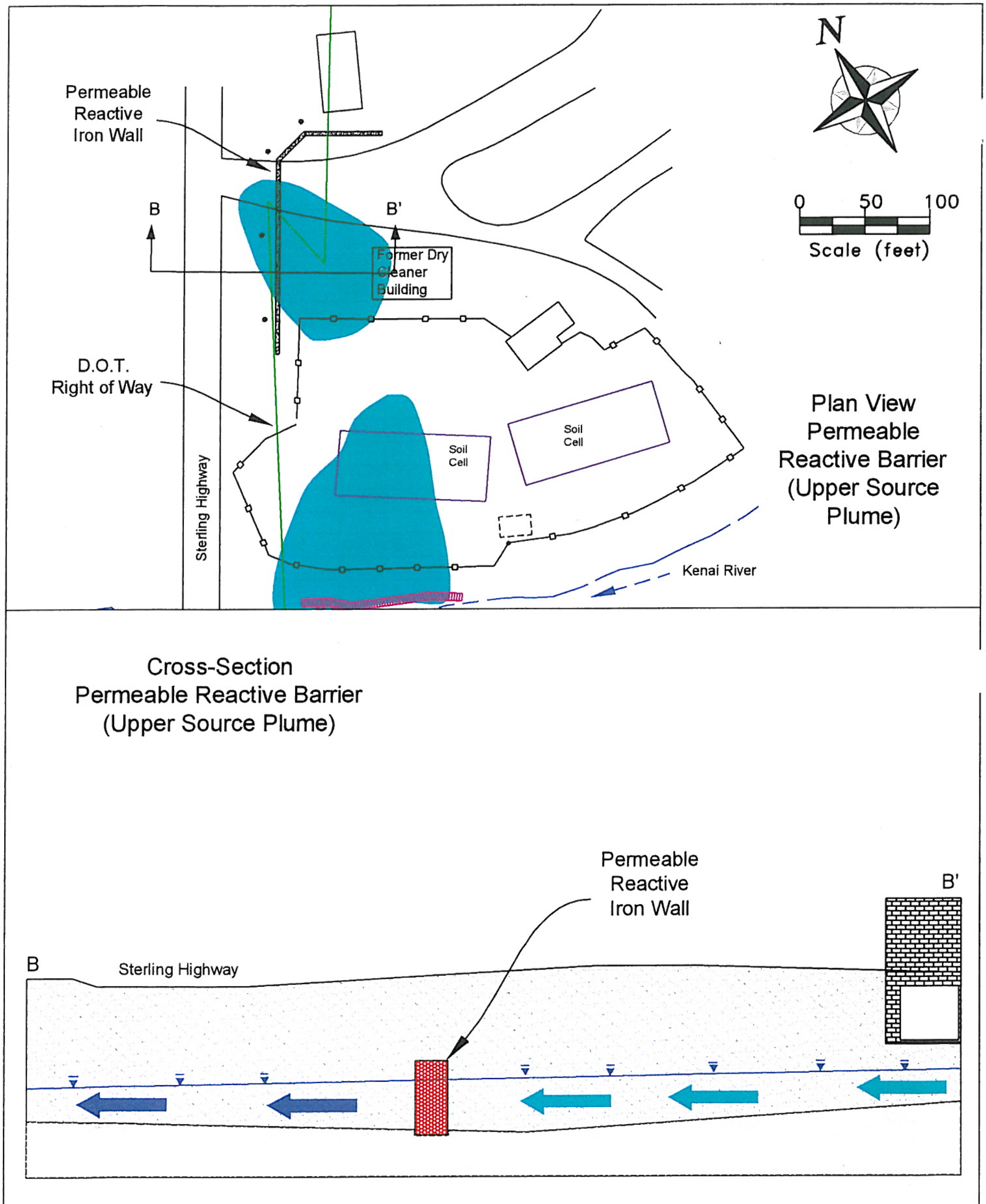
Assumptions:

- Dimensions of the treatment wall will be approximately 200 feet long by 4 feet wide by 5 feet deep (volume = 4,000 cubic feet).
- The wall will consist of granular iron, purchased and shipped from the continental United States. Shipment will be by train to Seattle, then by barge to Kenai.
- For construction reasons, the iron will be mixed with processed, cleaned, and screened sand at a 1:1 ratio, resulting in a 4-foot thick wall. The sand will be purchased from a local borrow source.

- Dimensions of the trench for installing the treatment wall will be approximately 200 feet long by 4 feet wide by 22-24 feet deep. The trench will most likely be constructed by backhoe or ladder type trenching equipment.
- The upper 15 feet of the trench walls will be slopped back at a one to one slope for stability and safety during excavation activities. Trench boxes and bracing will also be used to reduce trench sloughing and make it easier to place the iron material in a uniform matter during the permeable wall construction.
- A pilot test/treatability study is recommended prior to final design and installation. It is assumed that the iron reactive barrier will successfully transform the PCE and its daughter products to concentrations in the groundwater that comply with the remedial action objectives. This pilot study will assist in the design of a treatment wall that will be effective in achieving the remedial action objectives.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- If the wall extends under the trailer park access road, the excavation and repair of a 5-foot wide strip of dirt road may be required.
- The Reactive Iron Wall technology is proprietary and requires a licensing fee of 15 percent of construction costs.

River Terrace RV Park						
Alternative UT-C Reactive Treatment Wall						
Upper Contaminant Plume						
Function	Units	Quantity	Cost Per Unit	Total Cost	Total Cost (- 30%)	Total Cost (+ 50%)
1. Base Construction Estimate						
1.1. Permeable Reactive Barrier						
1.1.1 Iron Medium (including shipping)	TON	160	$400	$64,000		
1.1.2. Shipping Costs for Iron Medium	TON	160	$180	$28,800		
1.1.3. Clean Sand for Medium Mix	CY	75	$15	$1,125		
1.1.4. Trench, Backfill, and Shoring (5 ft)	LF	200	$60	$12,000		
Total for Permeable Reactive Barrier				**$105,925**		
1.2. Overburden Removal/Replacement						
1.2.1. Excavate uncontaminated soil above water table and slope walls 1:1	CY	2,250	$10	$22,500		
1.2.2. Replace uncontaminated soil	CY	2,250	$10	$22,500		
Total for Removal/Replacement				**$45,000**		
1.3 Rebuild Access Road Cut	LS	1	$3,500	**$3,500**		
1.4. Dewatering/Waste Management	LS	1	$30,000	**$30,000**		
1.5. Bench Scale Study	LS	1	$30,000	**$30,000**		
Construction Cost Subtotal				**$214,425**	**$150,098**	**$321,638**
2. Mobilization / Demobilization	%	1	10%	$21,443		
3. Construction Contingency	%	1	20%	$42,885		
4. Administrative Charge	%	1	15%	$32,164		
6. Engineering and Design	%	1	30%	$64,328		
7. Site Technology Licensing	%	1	15%	$32,164		
Capital Cost Total				**$407,408**	**$285,185**	**$611,111**
Annual O&M Costs						
Maintenance Support (0.5 hrs per week)	HR	25	$65	$1,625		
Total Annual O&M Cost				**$1,625**		
Present Worth Analysis						
O&M Cost for Years 1 - 15 @ 7%				$14,800		
Monitoring Cost for Years 1 - 15 @ 7%				$323,156		
Total O&M Cost (Present Worth - 15 yrs)				**$337,956**	**$236,569**	**$506,934**
Total Present Worth Cost (15 Yrs @ 7%)				**$745,364**	**$521,755**	**$1,118,046**

Alternative UT-C:Upper Plume



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OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	Figure Q-
ADEC Contract No: 18-2-12-12		Drawn By: JAS Checked By: ASN	Project No: 20019

ALTERNATIVE UT-D
IN-SITU AIR SPARGING AND VES GRID
(UPPER CONTAMINANT PLUME)

Capital Cost:	$463,000 to $992,000
O&M Costs (Present Worth @ 10 years):	$624,000 to $1,338,000
Total Present-Worth Cost:	$1,087,000 to $2,330,000

Description:

This alternative consists of in situ air sparging grid to treat the PCE impacted groundwater and soil at the contaminant source area. This alternative would involve injecting air into the contaminated groundwater, creating an underground stripper that removes contaminants through volatilization. This process is designed to operate at high airflow rates in order to effect volatilization (as opposed to the lower airflow rates used to stimulate biodegradation). Soil vapor extraction piping would be used in conjunction with the air sparging wells to control the flow of volatilized PCE. It is estimated that 65 sparging wells and 10 vapor extraction wells are required.

To promote enhanced remediation of the PCE contamination underneath the building, six passive venting wells will be placed through the floor of the building. Each well will have a one-way check valve that allows air to flow into the subsurface but not back into the building. By imposing a negative vacuum around the building with the vapor extractions wells air from inside the building would be drawn through the passive venting wells enhancing the subsurface volatilization of PCE underneath the building.

A pilot test would be conducted prior to full-scale system design and implementation. A pilot test will assist in proper spacing of air sparging wells and will provide an indication of expected PCE removal rates.

Because this alternative includes aggressive treatment of the contaminant source area, it is estimated that the RAOs can be achieved in five years. However, contaminant sources underneath the building and other site conditions may extend the required treatment time.

Implementation of this alternative will also involve groundwater and surface water monitoring and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 10 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met. Although some variations in monitoring techniques may occur between alternatives, the costs will probably not vary much between the options.

Assumptions:

System Installation

- A pilot test will be conducted prior to final design and installation.
- Sixty-five 2-inch diameter air-sparging wells will be installed to an average depth of 22 to 24 feet bgs. Wells will be spaced in a 10-foot by 15-foot grid pattern.

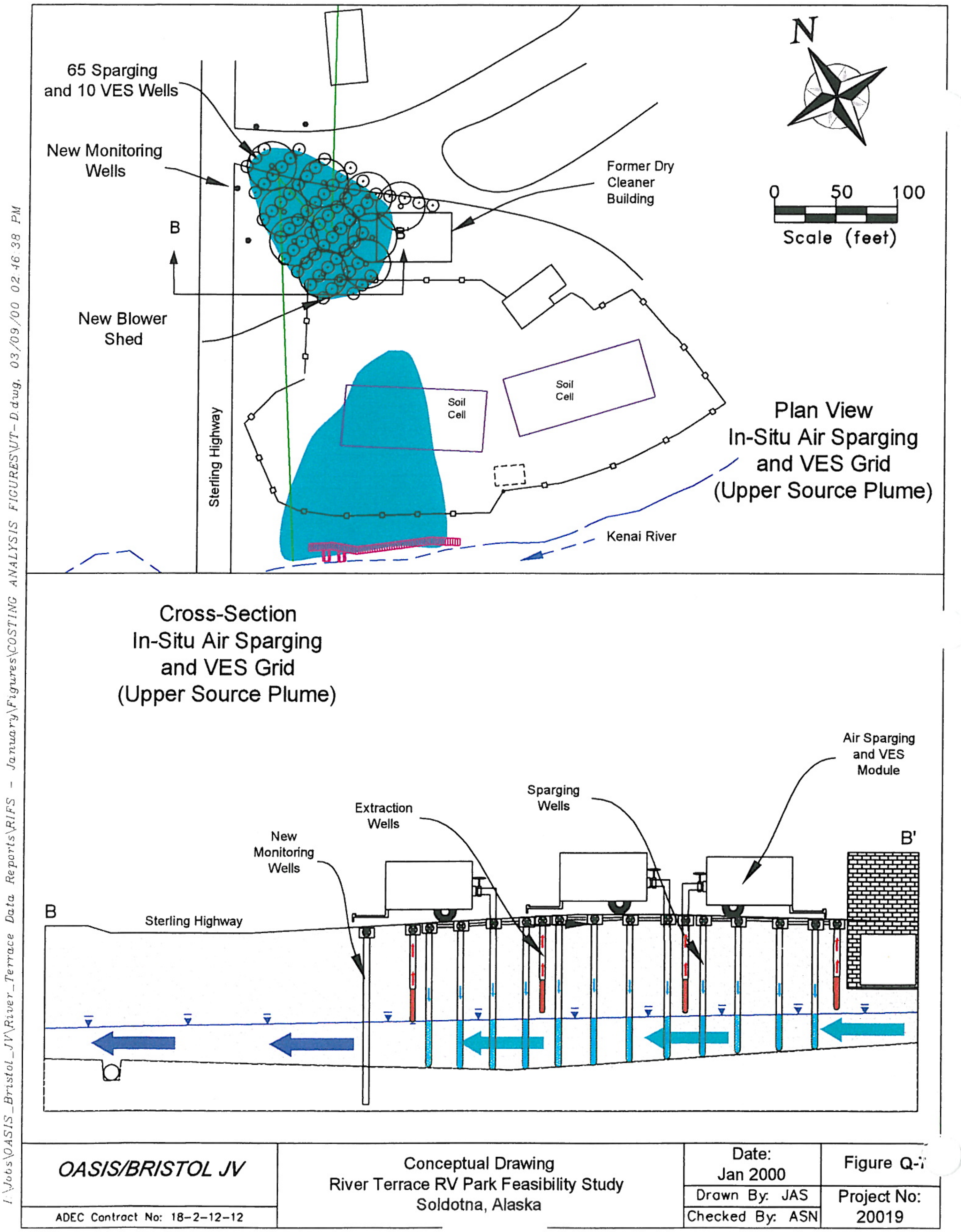
- Each air sparge well is capable of injecting 5 SCFM of air at a maximum pressure of 6 to 8 psi, with an estimated radius of influence of 5 feet. This will require approximately 7 blowers capable of 50 SCFM at these presures.
- Ten 2-inch diameter vacuum extraction wells installed to a depth of 15 to 17 feet bgs. Each well is estimated to be capable of extracting 50 to 100 SCFM with a radius of influence of 40 feet.
- Six 2-inch diameter passive venting wells with one-way check valves will be installed through the floor of the former dry cleaner building.
- Installation of 1500 lineal feet of horizontal HDPE piping for the sparge and vacuum systems, with associated insulation, valves, gauges, and meters. A short section of heat resistant pipe is needed at the output of the air sparge blowers.
- Installation of 500 feet of heat trace and insulation for the vacuum system.
- 1500 lineal feet of trenching and backfill, 4 feet deep, 4 feet wide, for the sparge and vacuum systems piping.
- Installation of two prefabricated and weatherized equipment buildings to house the air sparge blowers, vapor extraction blowers, and associated valves, pipes, and controls.
- The system will be winterized using insulation and heat trace of pipe.

System O&M

- The system will operate 365 days per year for 10 years.
- There will be no requirements of off-gas control or treatment.
- Exhaust stack air samples will be collected 4 times per year for 10 years. Air samples will be analyzed for VOCs using EPA TO-14 method.
- Fifteen wells will be sampled periodically for 10 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

River Terrace RV Park						
Alternative UT-D In-Situ Air Sparging - GRID						
Upper Contaminant Plume						
Function	Unit	Quantity	Cost Per Unit	Total Cost	Total Cost (- 30%)	Total Cost (+ 50%)
1. Base Construction Estimate						
1.1 Sparging Wells						
1.1.1. Trenching and backfill for piping	LF	1000	$15	$15,000		
1.1.2. HDPE Piping	LF	1000	$0.60	$600		
1.1.3. Sparging Wells	EA	65	$1,500	$97,500		
1.1.4. Installaltion Labor	MH	600	$40	$24,000		
Total for Sparging Wells				**$137,100**		
1.2 Soil Vaper Extraction System						
1.2.1.Trenching,heat trace, insulation	LF	500	$25	$12,500		
1.2.2. HDPE Piping	LF	500	$0.60	$300		
1.2.3. VES Wells	EA	10	$1,500	$15,000		
1.2.4. Passive Vent Wells Under Bldg.	EA	6	$1,500	$9,000		
Total for Soil Vaper Extraction System				**$36,800**		
1.4 Blower Building(s)	EA	1	$150,000	**$150,000**		
1.5 Fencing	LF	200	$20	**$4,000**		
1.6. External Power Supply	LS	1	$15,000	**$15,000**		
1.7. Dewatering/Waste Management	LS	1	$5,000	**$5,000**		
1.8. Pilot Study	LS	1	$30,000	**$30,000**		
Construction Cost Subtotal				**$377,900**	**$264,530**	**$566,850**
2. Mobilization / Demobilization	%	1	10%	$37,790		
3. Construction Contingency	%	1	20%	$75,580		
4. Administrative Charge	%	1	15%	$56,685		
5. Engineering and Design	%	1	30%	$113,370		
Capital Cost Total				**$661,325**	**$462,928**	**$991,988**
Annual O&M Costs						
Maintenance Support (6 hrs per week)	HR	312	$65	$20,280		
Operating Power and Light	LS	1	$45,000	$45,000		
Routine Equip. Replacement and Repair	LS	1	$10,000	$10,000		
Mobilization and General Requirements	%	1	15%	$11,292		
Annual O&M Cost Total				**$86,572**		
Present Worth Analysis						
O&M Cost for Years 1 - 10 @ 7%				$608,046		
Monitoring Cost for Years 1 - 10 @ 7%				$284,075		
Total O&M Cost (Present Worth - 10 yrs)				**$892,121**	**$624,484**	**$1,338,181**
Total Present Worth Cost (10 Yrs @ 7%)				**$1,553,446**	**$1,087,412**	**$2,330,168**

Alternative UT-D: Upper Plume



ALTERNATIVE UT-E
IN-SITU AIR SPARGING CURTAIN
(UPPER CONTAMINANT PLUME)

Capital Cost:	$265,000 to $567,000
O&M Costs (Present Worth @ 15 years):	$466,000 to $998,000
Total Present-Worth Cost:	$730,000 to $1,565,000

Description:

This alternative consists of in situ air sparging curtain to treat the PCE impacted groundwater before it leaves the contaminated site. This alternative would involve injecting air into the contaminated groundwater, creating an underground stripper that removes contaminants through volatilization. This process is designed to operate at high airflow rates in order to effect volatilization (as opposed to the lower airflow rates used to stimulate biodegradation). Soil vapor extraction piping would be used in conjunction with the air sparging wells to control the flow of volatilized PCE. It is estimated that 35 sparging wells and 5 vapor extraction wells are required.

A pilot test would be conducted prior to full-scale system design and implementation. A pilot test will assist in proper spacing of air sparging wells and will provide an indication of expected PCE removal rates.

Implementation of this alternative will also involve groundwater and surface water monitoring and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 15 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met. Although some variations in monitoring techniques may occur between alternatives, the costs will not vary much between the options.

Assumptions:

System Installation

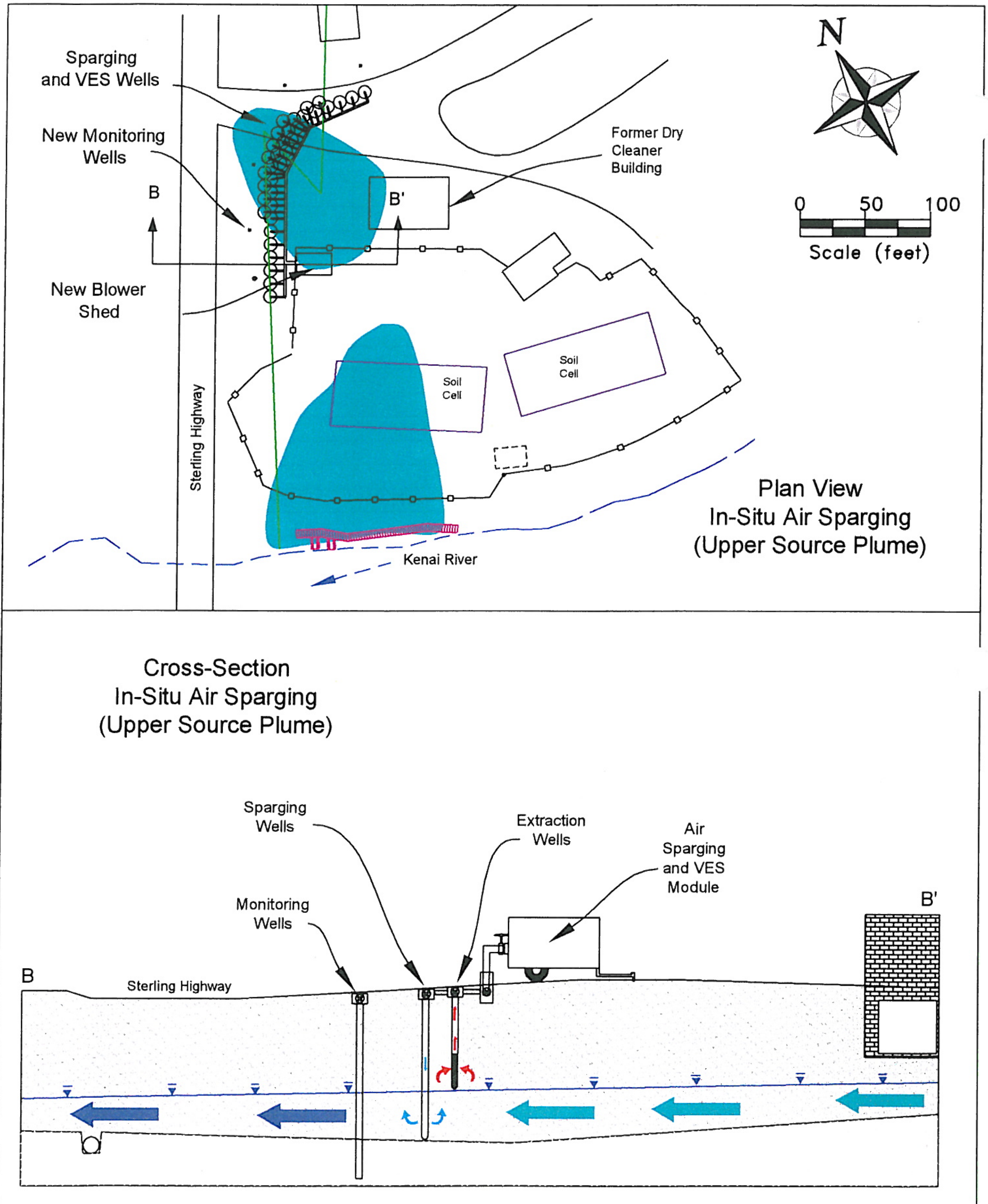
- A pilot test will be conducted prior to final design and installation.
- Thirty-five 2-inch diameter air-sparging wells will be installed to a depth of 22 to 24 feet bgs. Each air sparge well is capable of injecting 5 to 10 SCFM of air at a maximum pressure of 6 to 8 psi, with an estimated radius of influence of 5 feet.
- Five 2-inch diameter vacuum extraction wells will be installed to a depth of 15 to17 feet bgs. Each well will have an estimated capacity to extract 50 to 100 SCFM.
- Installation of 1,000 lineal feet of horizontal HDPE piping for the air sparge and vacuum extraction systems, with associated insulation, valves, gauges, and meters. A short section of heat resistant pipe is needed at the output of the air sparge blowers.
- Installation of 400 feet of heat trace and insulation for the vacuum system.
- Installation of 700 lineal feet of trenching and backfill, 4-feet deep, 4-feet wide, for air sparge and vacuum pipelines.
- Installation of a prefabricated and weatherized equipment buildings to house the air sparge blowers and vapor extraction blowers.

- The system will be winterized using insulation and heat trace for the pipe.

System O&M

- The system will operate 365 days per year for 15 years.
- There will be no requirements for off-gas control or treatment.
- Exhaust stack air samples will be collected 4 times per year for 15 years. Air samples will be analyzed for VOCs using EPA TO-14 method.
- Fifteen wells will be sampled periodically for 15 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

River Terrace RV Park Alternative UT-E In-Situ Air Sparging Curtain Upper Contaminant Plume						
Function	**Unit**	**Quantity**	**Cost Per Unit**	**Total Cost**	**Total Cost (- 30%)**	**Total Cost (+ 50%)**
1. Base Construction Estimate						
1.1. Sparging Wells						
1.1.1. Trenching and backfill for piping	LF	300	$15	$4,500		
1.1.2. HDPE Piping	LF	600	$0.60	$360		
1.1.3. Sparging Wells	EA	35	$1,500	$52,500		
1.1.4. Installation Labor	MH	300	$40	$12,000		
Total for Sparging Wells				**$69,360**		
1.2. Soil Vaper Extraction System						
1.2.1.Trenching,heat trace, insulation	LF	400	$25	$10,000		
1.2.2. HDPE Piping	LF	400	$0.60	$240		
1.2.3. VES Wells	EA	5	$1,500.00	$7,500		
Total for Soil Vaper Extraction System				**$17,740**		
1.3. Blower Building	EA	1	$75,000	**$75,000**		
1.4. Fencing	LF	200	$20	**$4,000**		
1.5. External Power Supply	LS	1	$15,000	**$15,000**		
1.6. Dewatering/Waste Management	LS	1	$5,000	**$5,000**		
1.7. Pilot Study	LS	1	$30,000	**$30,000**		
Construction Cost Subtotal				**$216,100**	**$151,270**	**$324,150**
2. Mobilization / Demobilization	%	1	10%	$21,610		
3. Construction Contingency	%	1	20%	$43,220		
4. Administrative Charge	%	1	15%	$32,415		
5. Engineering and Design	%	1	30%	$64,830		
Capital Cost Total				**$378,175**	**$264,723**	**$567,263**
Annual O&M Costs						
Maintenance Support (3 hrs per week)	HR	156	$65	$10,140		
Operating Power and Light	LS	1	$20,000	$20,000		
Routine Equip. Replacement and Repair	LS	1	$2,500	$2,500		
Mobilization and General Requirements	%	1	15%	$4,896		
Annual O&M Cost Total				**$37,536**		
Present Worth Analysis						
O&M Cost for Years 1 - 15 @ 7%				$341,875		
Monitoring Cost for Years 1 - 15 @ 7%				$323,156		
Total O&M Cost (Present Worth - 15 yrs)				**$665,031**	**$465,521**	**$997,546**
Total Present Worth Cost (15 Yrs @ 7%)				**$1,043,206**	**$730,244**	**$1,564,808**



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OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	Figure Q-
		Drawn By: JAS	Project No: 20019
ADEC Contract No: 18-2-12-12		Checked By: ASN	

ALTERNATIVE UT-F
SOURCE AREA EXCAVATION (UPPER CONTAMINANT PLUME)

Capital Cost:	$1,188,000 to $2,547,000
O&M Costs (Present Worth @ 5 years):	$245,000 to $525,000
Total Present-Worth Cost:	$1,433,000 to $3,071,000

Description:

This alternative consists of excavating the upper plume contaminated soil surrounding and underneath the old dry cleaning building and depositing the soil into treatment cells for remediation. The excavation will encompass an area of approximately 9,000 sq ft with an average depth of 35 feet. Based on soil sample results, it is assumed that the 12 to 14 feet of soil above the water table is uncontaminated. Excavated soils will be placed in on-site soil vapor extraction cells for treatment. Once treated, the soils will be spread on site.

Using a large backhoe, excavation should start with removing the uncontaminated soil above the water table and piling it so that it can be easily placed into the excavation. Once below the water table, localized dewatering will be performed with a pump that will transport the contaminated water to an external air stripping treatment module. It is assumed that the treated water will be approved for disposal into the local sewer system. Dewatering will be kept to a minimum by excavating and filling small sections as the work progresses through the site.

The contaminated material will be transported approximately 200 feet and placed into several soil treatment cells located near the previous treatment cells. The dump trucks will use plastic liners to prevent spillage of contaminated water during transport. The treatment cell will be constructed using soil/concrete berms and be completely lined and covered with impermeable geo-textile (usually lined with 20-mil HDPE). The cell will have a piping network. This network is used to distribute air to the contaminated soils. Blowers are used to force atmospheric air through the piping network and into the contaminated soils. A blower building will house the electrical controls and blowers that will feed air through a piping system to treat the contaminated soil.

Soil vapor extraction cells work by volatilizing the contaminants into the air that is forced through the soil. The air is then often discharged to the atmosphere or passed through a treatment system to remove the volatilized contaminants.

Advantages of this technology include the direct removal of contaminated soils from a portion of the contaminated soil source. Disadvantages include the high costs, and the possibility of missing a large portion of contaminated soil.

Implementation of this alternative will also involve groundwater and surface water monitoring and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 5 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met.

Assumptions:

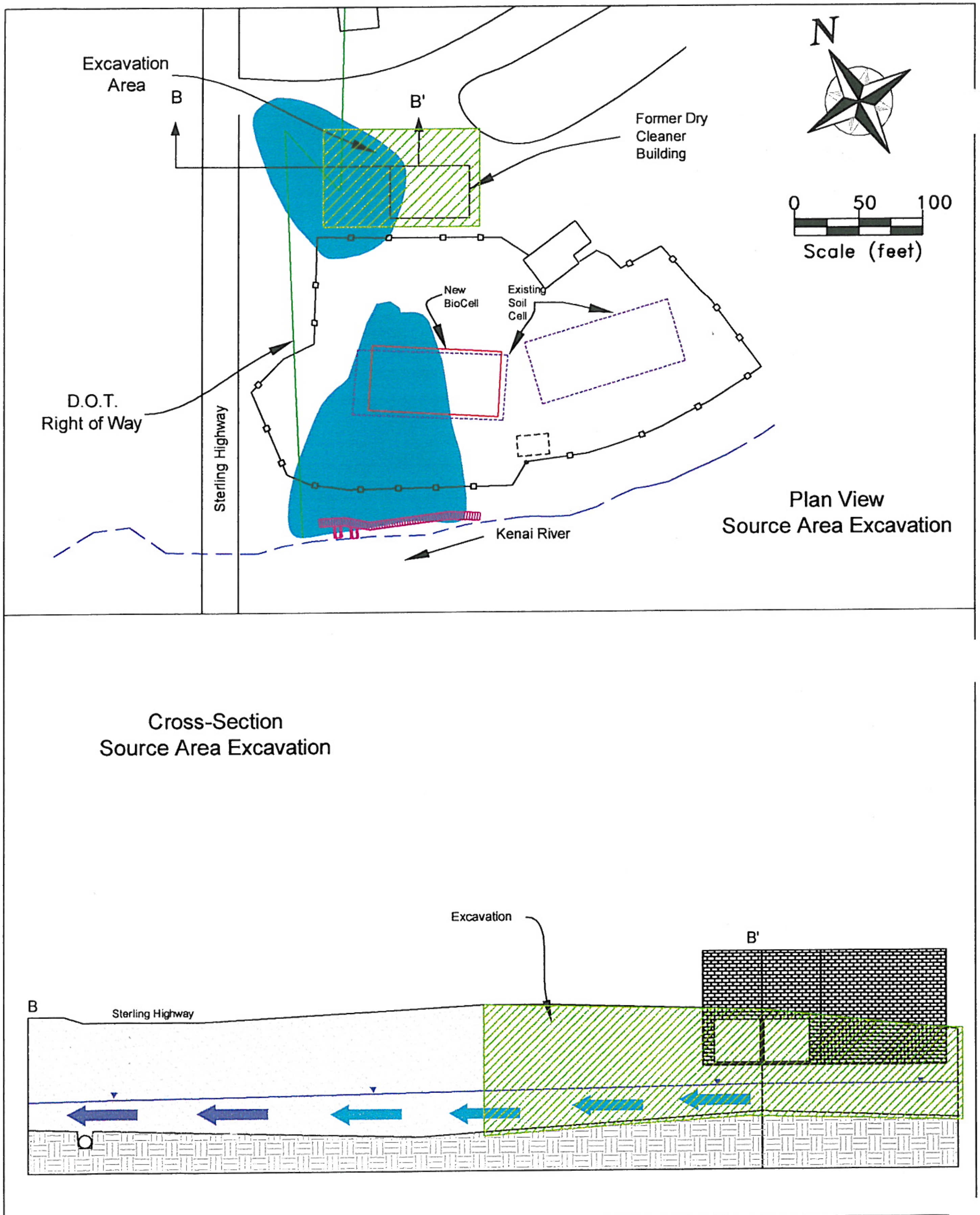
System Installation

- The former dry cleaner building will be demolished prior to excavation. No costs for building demolition are included in this estimate.
- Excavation dimensions will be 75 feet by 120 feet by 35 feet deep. Resulting in the excavation of approximately 9,500 CY of uncontaminated soil and 5,700 CY of contaminated soil. Contaminated soil will be transported about 200 feet to a remediation cell.
- Soils above the water table (estimated at 18 feet below ground surface) are considered clean and will be used as backfill.
- The excavation will be sloped at a 1:1 grade from the ground surface to the top of the glacial-till layer. The glacial-till layer is cohesive enough to allow for more vertical slopes. Safety fencing will be placed around the excavated area.
- Dewatering of the excavation will be necessary. The water will be treated on-site with a portable air stripper. The water will be discharged to the local sewer after on-site treatment.
- No utilities cross the planned excavation area.
- Confirmation soil samples will be collected from the excavation floor at a frequency of one per every 150 SF. Confirmation soil samples will be collected from the excavation sidewalls at a frequency of every 25 feet. These samples will be analyzed by EPA method 8260.
- Contaminated soils can be treated on-site under the existing contained-in determination.
- The contaminated soils will be placed into four soil treatment cells located on the site. Each treatment cell is capable of containing approximately 1,500 CY of contaminated soil.
- One large connex will house the soil treatment system controls and blowers for all treatment cells.

System O&M

- Continual operation and maintenance of the treatment cells will be required. Electrical costs for blower operation, heating, and lights are expected for up to 5 years.
- There will be no requirements for off-gas control or treatment.
- After treatment, confirmation soil samples will be collected at a frequency of 30 samples per cell. These samples will be analyzed by EPA method 8260.
- Fifteen wells will be sampled periodically for 5 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

River Terrace RV Park Alternative UT-F Source Area Excavation Upper Contaminant Plume						
					Total Cost	Total Cost
Function	Unit	Quantity	Cost Per Unit	Total Cost	(- 30%)	(+ 50%)
1. Base Construction Estimate						
1.1. Excavate, Backfill, and Transport						
1.1.1. Excavate uncontaminated soil above water table and backfill	CY	9500	$10	$95,000		
1.1.2. Excavate contaminated material below water table and transport	CY	5700	$75	$427,500		
1.1.3. Furnish and place new backfill	TON	9700	$14	$135,800		
1.1.4. Fencing	LF	630	$20	$12,600		
1.1.5. Confirmation Sampling	EA	52	$250	$13,000		
Total for Excavate, Backfill, and Transport				**$683,900**		
1.2. Dewatering/Waste Management						
1.2.1. Pump and Stripping System	LS	1	$40,000	$40,000		
1.2.2. Holding Tank Rental	MO	1	$3,000	$3,000		
1.2.3. Decontamination Operations	LS	1	$10,000	$10,000		
Total for Dewatering/Waste Management				**$53,000**		
1.3 Construct Remediation Cells						
1.3.1. Soil Cell Structure	LS	4	$30,000	$120,000		
1.3.2. Cell Liner and Cover	SF	48,000	$0.50	$24,000		
1.3.3. Piping	LF	2,400	$2.00	$4,800		
1.3.4. Blower Building w/equip.	EA	1	$35,000	$35,000		
1.3.5. Installation Labor	MH	1,200	$40	$48,000		
1.3.6. Confirmation Sampling	EA	120	$250	$30,000		
Total for Construct Remediation Cells				**$261,800**		
Construction Cost Subtotal				**$998,700**	**$699,090**	**$1,498,050**
2. Mobilization / Demobilization	%	1	15%	$149,805		
3. Construction Contingency	%	1	20%	$199,740		
4. Administrative Charge	%	1	15%	$149,805		
5. Engineering and Design	%	1	20%	$199,740		
Capital Cost Total				**$1,697,790**	**$1,188,453**	**$2,546,685**
Annual O&M Costs						
Mobilization and General Requirements	%	1	15%	$4,127		
Maintenance Support (2 hrs per week)	HR	104	$65	$6,760		
Operating Power	LS	1	$20,000	$20,000		
Routine Equip. Replacement and Repair	LS	1	$750	$750		
Annual O&M Cost Total				**$31,637**		
Present Worth Analysis						
O&M Cost for Years 1 - 5 @ 7%				$129,716		
Monitoring Cost for Years 1 - 5 @ 7%				$220,037		
Total O&M Cost (Present Worth - 5 yrs)				**$349,753**	**$244,827**	**$524,629**
Total Present Worth Cost (5 Yrs @ 7%)				**$2,047,543**	**$1,433,280**	**$3,071,314**



OASIS/BRISTOL JV	Conceptual Drawing River Terrace RV Park Feasibility Study Soldotna, Alaska	Date: Jan 2000	**Figure Q-9**
ADEC Contract No: 18-2-12-12		Drawn By: JAS Checked By: ASN	Project No: 20019

ALTERNATIVE UT-G

REDUCTIVE ANAEROBIC BIOLOGICAL IN-SITU TREATMENT TECHNOLOGY (RABBIT)

(UPPER CONTAMINANT PLUME)

Capital Cost:	$194,000 to $415,000
O&M Costs (Present Worth @ 10 years):	$408,000 to $874,000
Total Present-Worth Cost:	$602,000 to $1,290,000

Description:

This alternative consists of in situ injection of Hydrogen Release Compound (HRC) through approximately 100 injection wells. HRC injection results in anaerobic bioremediation of chlorinated solvents such as PCE and TCE. HRC offers a passive, and possibly low-cost approach to in-situ remediation. HRC is a moderately flowable material that can be injected under pressure into an aquifer using various drilling and direct push technologies. It can maintain dechlorinating conditions in the aquifer for six months to one year or more, depending on site characteristics. HRC provides time-release hydrogen source to accelerate the reduction of anaerobically degradable contaminants.

Advantages of this technology include the elimination of aboveground treatment and processing equipment, and reduced disruption to the site. Since chlorinated hydrocarbon sources are difficult to locate, a large number of injection wells, placed in a grid pattern, will most likely be required to address the entire source area. It is expected that annual replacement of the HRC will be required to maintain reductive anaerobic biological treatment conditions.

To promote enhanced remediation of the PCE contamination underneath the building, injections of sodium lactate or liquid HRC will be conducted. The solution will be prepared in a large tank and pumped through a hose to the sumps or other injection points placed in the floor of the building. Two injections are planned for the first year with annual injections being performed each year after that.

Because this alternative includes aggressive treatment of the contaminant source area, it is estimated that the RAOs can be achieved in ten years. Ten years was assumed due to the unknown size and volume of contaminant source material. The potential for contaminant source material underneath the building and the possibility of PCE penetrating the till material may extend the required treatment time.

Implementation of this alternative will also involve groundwater and surface water monitoring and institutional controls to ensure that the dissolved-phase PCE is not causing risk to human health or the environment. It is estimated that this monitoring will be required for a period of 10 years, but the actual monitoring period may vary depending on how soon the remedial action objectives are met. Although some variations in monitoring techniques may occur between alternatives, the costs will not vary much between the options.

Assumptions:

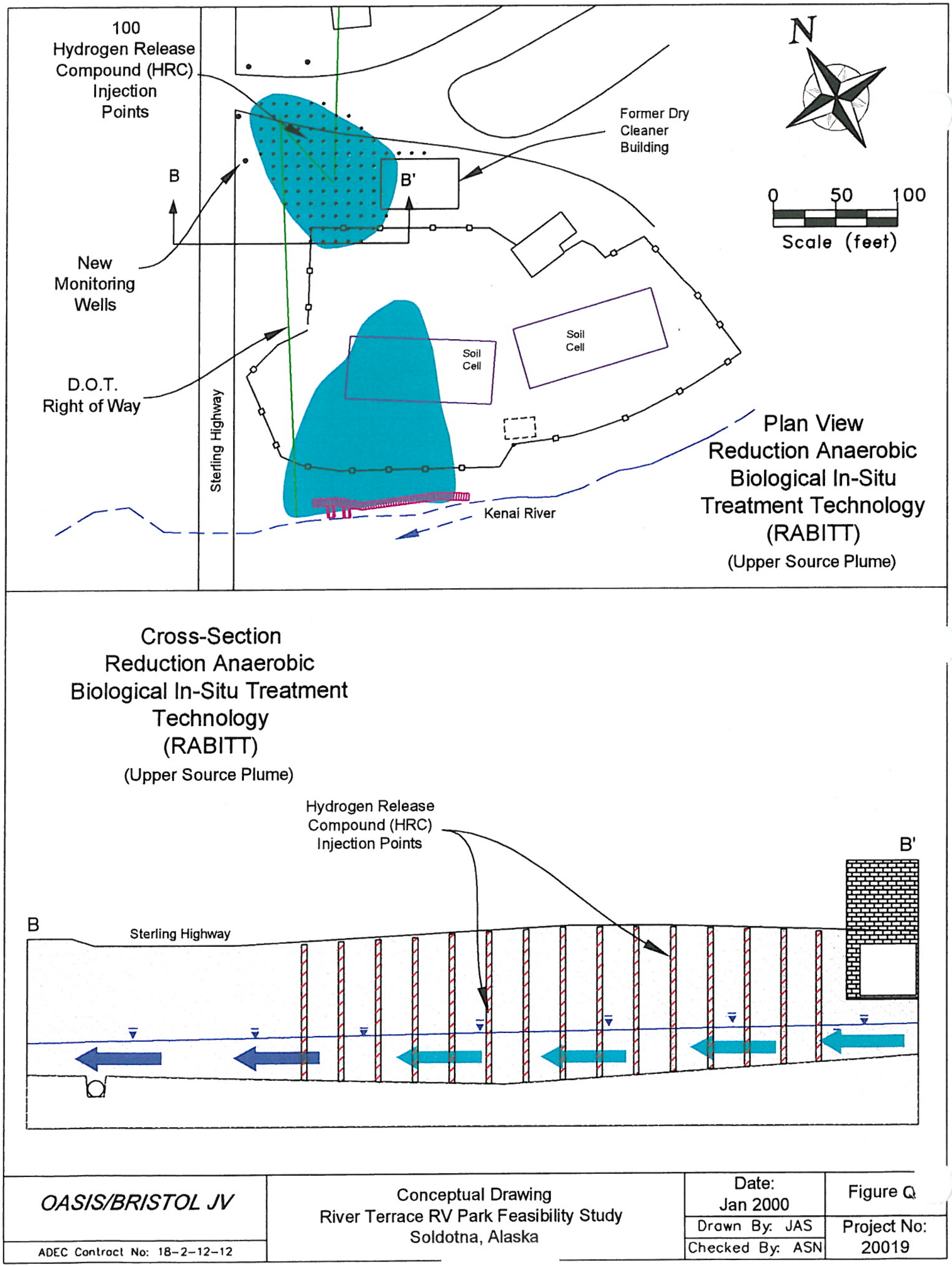
System Installation

- One hundred 2-inch diameter injection wells will be drilled to a depth of 20 to 25 feet below ground surface. Each injection point will receive approximately 20.3 lbs of HRC in the bottom six feet of the boring.
- Liquid batches of HRC or sodium lactate will be prepared and injected underneath the floor of the building to promote remediation of PCE contamination underneath the building. These injections would be conducted twice a year the first year and then annually for the next ten years or until PCE contamination is reduced below the ACL.
- Appropriate method of injection will be determined by design engineer.
- HRC injection is a proprietary treatment method that requires a contract with Regenesis Corporation of California.

System O&M

- Replacement of the HRC will be required on an annual basis. It was assumed that 25 borings would be installed each year to replace the HRC.
- Annual injection of sodium lactate or liquid HRC underneath the building floor will be required on an annual basis. It was assumed that the equivalent of 1,000 lbs of HRC would be used during each injection.
- Fifteen wells will be sampled periodically for 10 years. Sampling will be quarterly for the first 3 years, semiannually for the next two years, and annually thereafter. Water samples will be analyzed for VOCs (8260) during each sampling event and annually for geochemical indicator parameters. The geochemical indicator parameters include pH, redox potential (Eh), alkalinity, dissolved oxygen, ferrous iron, sulfate or sulfide, chloride, and potentially, dissolved hydrogen.
- Annual reporting and data analysis will include a discussion on system O&M, groundwater monitoring results, and air monitoring results.

River Terrace RV Park						
Alternative UT-G Reductive Anaerobic Biological In-Situ Treatment Technology (RABITT)						
Upper Contaminant Plume						
Function	Unit	Quantity	Cost Per Unit	Total Cost	Total Cost (- 30%)	Total Cost (+ 50%)
1. Base Construction Estimate						
1.1. HRC Injection						
1.1.1. Drill Injection Points	EA	100	$750	$75,000		
1.1.2. Hydrogen Release Compound	LBS	2032	$7	$14,224		
1.1.3. Installaltion Equip and Labor	LS	1	$10,000	$10,000		
Total for HRC Injection Wells				**$99,224**		
1.2. HRC Injection Under Building						
1.1.1. Sodium Lactate or HRC	LBS	2000	$7	$14,000		
1.1.2. Installation Equip and Labor	LS	1	$10,000	$10,000		
Total for Injection Under Building				**$24,000**		
1.2. Dewatering/Waste Management	LS	1	$5,000	**$5,000**		
1.3. Pilot Study	LS	1	$30,000	**$30,000**		
Construction Cost Subtotal				**$158,224**	**$110,757**	**$237,336**
2. Mobilization / Demobilization	%	1	10%	$15,822		
3. Construction Contingency	%	1	20%	$31,645		
4. Administrative Charge	%	1	15%	$23,734		
6. Engineering and Design	%	1	30%	$47,467		
Capital Cost Total				**$276,892**	**$193,824**	**$415,338**
Annual O&M Costs						
Replacement of HRC (25 borings)	LS	1	$25,000	$25,000		
Reinjection of HRC under Building	LS	1	$12,000	$12,000		
Mobilization and General Requirements	%	1	15%	$5,550		
Annual O&M Cost Total				**$42,550**		
Present Worth Analysis						
O&M Cost for Years 1 - 10 @ 7%				$298,853		
Monitoring Cost for Years 1 - 10 @ 7%				$284,075		
Total O&M Cost (Present Worth - 10 yrs)				**$582,928**	**$408,050**	**$874,393**
Total Present Worth Cost (10 Yrs @ 7%)				**$859,820**	**$601,874**	**$1,289,731**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100
Scale (feet)
New
Monitoring
Wells
Soil
Cell
Soil
Cell
D.O.T.
Right of Way
Sterling Highway
Kenai River
Plan View
Reduction Anaerobic
Biological In-Situ
Treatment Technology
(RABITT)
(Upper Source Plume)
Cross-Section
Reduction Anaerobic
Biological In-Situ Treatment
Technology
(RABITT)
(Upper Source Plume)
Hydrogen Release
Compound (HRC)
Injection Points
B'
B
Sterling Highway
OASIS/BRISTOL JV
ADEC Contract No: 18-2-12-12
Conceptual Drawing
River Terrace RV Park Feasibility Study
Soldotna, Alaska
Date:
Jan 2000
Drawn By: JAS
Checked By: ASN
Figure Q
Project No:
20019
I:\Jobs\OASIS_Bristol_JV\River_Terrace Data Reports\RIFS - January\Figures\COSTING ANALYSIS FIGURES\UT-E.dwg, 03/09/00 02:47:00 PM