出國報告（出國類別：國際會議）

「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」研討會

服務機關：行政院環境保護署土壤及地下水污染整治基金管理會

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派赴國家：美國

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報告日期：104 年 2 月 9 日

摘要

本次赴美國聖地牙哥參加「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」（2014-Contaminated Site Management：Sustainable Remediation and Management of Soil）研討會。本研討會辦理日期爲 11 月 17 日至 11 月 20 日，爲期 4 天，以永續發展爲主軸，邀請美國環保署、各大專院校或研究機構研究人員及環境工程顧問公司專家，針對土壤及地下水污染調查技術、整治技術及場址管理策略發表演說，主要議題包括污染場址調查工具方法、污染場址整治復原技術及污染場址最適當管理措施，共 12 項子題，本次會議採同一空間，依序進行各子題演說之方式辦理，包括化學氧化整治法、污染範圍整治與管理、零價鐵整治法、同位素分析、場址調查技術、現地改善技術、生物整治及物理性整治等議題。

本會議邀請美國環保署專家進行第一場專題演說，探討過去數十年來土壤及地下水污染整治工法之演進與應注意事項，其中包括現地化學氧化法、土壤氣體抽除法以及生物處理法，在化學氧化法部分，地質條件成爲決定整治成效之重要因素之一，特別是注入後藥劑於地表下傳輸情形，傳輸過程決定與污染物接觸之時間，因此需依據不同的地質條件安排注入井分布；土壤氣體抽除法亦需要完整掌握地質條件，並且進行先導試驗及最終驗證工作；生物處理法屬於較爲先進之改善工法，且對環境衝擊較小，生物處理法成功要件有三大要件，工法施作彈性、工法施作適應性及工法施作之耐心。

第二場次專題演說邀請巴西環境工程顧問公司專家針對巴西土壤及地下水污染之整治管理措施歷程進行發表，藉由演說過程可瞭解巴西針對土壤及地下水之污染管理策略發展較晚，但與其先進他國家相似，鼓勵污染土地活化，並禁止工廠在農業區內設立，土地再利用須在進行詳細調查與風險評估後才會執行，另推動污染資訊公開與公眾參與，且若確認整治工法無成效，亦必須對民眾公開說明。

透過相關單位安排，於本研討會結束後，由美國加州環保署水質管

理部（Regional Water Quality Control Board）專家帶領至當地聖地牙哥海灣進行場址參訪及解說，聖地牙哥海灣底泥由於早期軍事工業及其他相關行業發展造成底泥累積大量重金屬、多環芳香烴（PAHs）及多氯聯苯（PCBs）等污染物，透過當地環保署評估已對環境及生物體造成危害，隨即依據相關規定對於污染場址進行改善工作。

本次藉由研討會中實際案例分享及場址參訪，除能夠提升我國土壤及地下水污染調查及整治技術能力，並以更成熟之技術辦理污染調查工作，更能達到及早發現潛在污染，完成污染改善工作，另亦能夠吸取先進國家污染場址管理經驗，有效進行我國土壤及地下水污染管理策略推動，健全完備法規制度，並強化行政管理體系，最終達成整合污染場址之污染改善及管理，配合社會、經濟及環境三面向，導入永續發展之觀念，以確保我國國土之土壤及地下水永續利用。

目錄

一、目的

近年來土壤與地下水污染之議題已成爲世界各先進國家關注的環保問題，我國推動環境保護工作發展歷程與歐美先進國家相仿，除水、空氣、廢棄物、與毒化物之管制法令建置完備外，隨著國內經濟發展與變遷，國人生活環境所面臨之污染負荷已漸趨嚴重，尤其土壤及地下水爲最終受體，在廢棄物或廢水未經妥善處理之情況下，所衍生土壤與地下水污染問題亟需積極面對會並著手解決。

土壤及地下水污染議題除污染調查技術與污染改善技術外，污染場址之管理亦爲重要課題，尤以我國土壤及地下水污染整治法施行以來，國內累積大量待整治之污染場址，搭配我國土地特性及近年來都市開發需求，可利用之土地面積有限，因此「永續管理」概念即被導入土壤及地下水污染場址管理策略。

本次赴美國聖地牙哥參加「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」(2014-Contaminated Site Management：Sustainable Remediation and Management of Soil）研討會，研討會自 11 月 17 日至 20 日，爲期 4 天，以永續發展爲主軸，邀請美國環保署、各大專院校或研究機構研究人員及環境工程顧問公司專家，針對土壤及地下水污染調查技術、整治技術及場址管理策略發表演說，主要議題包括污染場址調查工具方法、污染場址整治復原技術及污染場址最適當管理措施，另於研討會結束後，由美國加州環保署水質管理部（Regional Water Quality Control Board）專家帶領至當地聖地牙哥海灣進行場址參訪及解說，瞭解當地環保署對於污染場址所採行之管理及改善措施，研討會資料如附件 1，本次行程如表 1-1。

參加本次研討會可達下列效益：

（一） 藉由會議中實際案例分享與技術成果，提升我國土壤及地下水污染調查及整治技術能力，以更成熟之技術辦理污染調查工作，及早發現潛在污染，並完成污染改善。

（二） 吸取先進國家污染場址管理經驗，有效進行我國土壤及地下水污染管理策略推動，健全完備法規制度，並強化行政管理體系。

（三） 整合污染場址之污染改善及管理，配合社會、經濟及環境三面向，導入永續發展之概念，以確保我國國土之土壤及地下水永續利用。

表 1-1　本次行程

日期		工作內容
月	日	
11	17	出席「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」國際研討會
11	18	出席「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」國際研討會
11	19	出席「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」國際研討會
11	20	出席「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」國際研討會
11	21	聖地牙哥海灣進行場址參訪

二、過程

（一）研討會

本次「2014 年污染場址管理：土壤、底泥及水之永續整治及管理」（2014-Contaminated Site Management：Sustainable Remediation and Management of Soil）研討會是由 Redox Technologies, Inc.主辦，並由美及歐洲數個顧問公司及學術單位專家籌組委員會辦理。本研討會於美國聖地牙哥舉行，會議時間自 11 月 17 日至 20 日，採同一會議室依序進行各子題演說之方式辦理，共計 12 項子題，63 場次演說，內容涉及土壤及地下水污染場址調查工具方法、土壤及地下水污染場址整治復原技術及土壤及地下水污染場址最適當管理措施，包括化學氧化整治法、污染範圍整治與管理、零價鐵整治法、同位素分析、場址調查技術、現地改善技術、生物整治及物理性整治等議題，完整之 12 項子題如下（各演說內容詳附件 2）：

Session 1：Keynote Lecture

Session 2：Advanced Oxidation Processes for Contaminants Removal

Session 3：Remediation and Management of Large Plumes

Session 4：Molecular Diagnostic Tools

Session 5：In-Situ Chemical Oxidation for Treatment of Contaminants

Session 6：Zero Valent Iron in Remediation

Session 7：Applications of Compound-Specific Isotope Analysis (CSIA)

Session 8：High Resolution Site Characterization

Session 9：In-Situ Reduction

Session 10：Combining Remedial Technologies

Session 11：In-Situ Bioremediation- Putting the Microbe to Work

Session 12：Physical Removal of Contaminants

由會議名稱可了解本研討會以永續發展爲主軸，邀請美國環保署、各大專院校或研究機構及環境工程顧問公司專家與會發表演說，第一場專題演說邀請美國環保署專家針對過去數十年來整治工法之演進與應注意事項進行，過去三十年間，發現了許多重大污染的場址，因此包括聯邦及州政府逐步建立相關清除法規，改善工法亦有相關大的演進，能夠針對危害廢棄場址進行調查及污染移除，各種技術均有其限制與適用範圍，對於特定污染場址，不同類別之技術的可行性與適用性亦有差異，選取改善工法之邏輯包括：建立場址特徵、確認整治範圍、建立整治目標、界定整治污染物數量、評估可能性之技術及其可行性、評估整治技術之有效性及經費預估、決定所需資料並進行調查工作及評估技術合併之可行性等，目前我國污染場址僅有土壤污染時，主要以土壤氣體抽除法（Soil Vapor Extraction, SVT）及開挖法換土爲主，若有地下水污染時，則另搭配空氣注入法（Air Sparging）及現地化學氧化法（In-situ Chemical Oxidation），若污染情況更嚴重而有浮油時，則搭配浮油回收技術及抽出處理法。

第一場專題演說中針對現地化學氧化法、土壤氣體抽除法以及生物處理法進行更進一步之說明。現地化學氧化法係利用各種化學氧化劑，注入土壤或地下水污染層中，氧化油品污染所造成環境中存在之各項化合物，使其成爲二氧化碳及水，相關氧化劑曾被廣泛應用於廢水處理程序，目前逐漸被利用於土壤及地下水污染之現地處理。現地化學氧化法之特點爲處理時間較快，相對於生物整治法而言，需要的反應時間較短。惟地質條件限制及各種氧化劑的特性，均會限制氧化的時間以及效果，需根據實際情形進行選擇，部分氧化劑雖然反應較慢，但可以緩慢持續與污染物接觸反應，提供較長的接觸時間，因此在氧化劑的選擇上須加以評估。現地化學氧化法最主要的考量因子爲土壤與氧化劑的反應性，假設土壤中含有大量的其他有機質，那麼有可能會消耗大量的化學藥劑，造成成本支出增加，因此如何擇定氧化劑與注入方式即成爲一關鍵課題。地質條件亦爲決定整治成效之重要因素之一，特別是注入後藥劑於地表下傳輸情形，傳輸過程決定與污染物接觸之時間，必須依據不

同的地質條件設計注入井分布，因此包括場址在進行改善前之細密調查結果、水文地質參數，以及化學藥劑接觸的時間以及成效，皆需要於整治工法正式施行前完全掌握，才有辦法提升整治成效。本次會議中另名專家以一處美國加州軍事設施作爲研究對象，該處由於有乾洗設施及設備，導致四氯乙烯污染至地下水，該場址選擇以現地化學氧化法爲改善工法，在調查工作階段即針對地質狀況進行分析，依據分析結果該場址地質組成以坋土及黏土組成，另依據地質調查結果得到該場址滲透率、水力梯度及水流方向，因此得以估計污染物單位流量，經由各種繁複調查工作後，即著手設計與進行測試，由此可見即使是使用現地化學氧化法此類使用廣泛之改善工法，施作前之各項前置作業仍須小心與謹慎，另整治工法設計考量時，人員安全及交通安全亦須納入考量因素。

土壤氣體抽除法係針對不飽和層或通氣層土壤中揮發性污染物進行整治之方法，主要爲利用真空抽氣，使存在於土壤中之污染物產生揮發作用，污染物由固相或液相轉移爲氣相，並因抽氣井使污染區土壤產生負壓，使污染物隨土壤氣體往抽氣井方向移動，而被抽出，被抽除土壤氣體可進行回收或經處理後排放。土壤氣體抽除法於施作時須避免產生短流現象，避免影響抽氣井影響半徑而導致降低處理效率，土壤氣體抽除法主要可運用於在處理中透氣性及高透氣性土壤中含有揮發性污染物成分之場址，包括油品類及含氯溶劑之污染。與現地化學氧化法類似，在改善工法於施作前須進行一連串繁複之調查工作，首先需完全掌握場址之地質條件，土壤氣體抽除法能否有效施作之要件之一爲土壤孔隙介質滲透性，若於地質調查階段發現滲透性相當低，則代表該場址簿適合土壤氣體抽除法，需評估以其他工法替代；另地質條件符合施作要件時，接下來必須進行污染物之調查，除評估其污染物深度及範圍外，亦須了解污染物是否屬高揮發性污染物。地質條件及污染物特性都掌握後，則必須進行先導試驗，瞭解抽氣範圍分布，並且進行最終驗證工作。

目前處理土壤及地下水污染之生物整治法主要包括生物通氣法、生物堆法及生物曝氣法等，土壤中原本即可能存在現地微生物，部分微生物本身能夠利用有機污染物做爲生長基質，而產生代謝污染物的作用，

進而分解污染物質，達到總污染量下降進而移除污染物之目的，但生物分解作用有其必要及合適的環境限制條件，例如溫度、濕度、氧氣、污染物與生物接觸途徑等，若沒有適當的環境，微生物可能無法直接利用，亦無法有效利用有機污染物做爲分解基質，其中一項重要的影響因子就是營養鹽，由於微生物生長所必須之碳源，能夠由有機污染物提供，但是其他生長代謝所需的物質，例如氮、磷、微量元素等，就必須從外界提供足夠的量，否則土壤層環境中並不會存在足量的這些物質，也會降低整治工法成效。生物處理法屬於較爲先進之改善工法，且對環境衝擊較小，而經由幾十年之施作經驗，生物處理法成功要件包括工法彈性、工法適應性及施作時之耐心。

近年來針對地下水污染場址，滲透性反應牆（Permeable Reactive Barrier, PRB）亦爲一相關重要之改善工法，其概念爲在發現污染源或污染團之地下水流向下游位置的地表下，建構一道具有可滲透性的阻隔牆，類似一般土木建築工程施工時所挖掘設置的地下水阻水牆，惟其不同之處在於其具有可滲透性，因此不會完全阻斷地下水使其地下水流繞道，因而改變地下水流向以及流速，通常於滲透性的阻牆內，必須填充會降解污染物的材料或物質，流經反應牆之地下水，經過所填充之反應物質後，污染物即被吸附、固定於阻牆內，或是經由化學性、生物性反應降解成無害物質，而處理過的地下水，則持續流往下游，但污染物濃度已降至不會危害人體健康之低風險濃度，因此達成整治成效，滲透性反應牆所使用之填充物相當多元化，因應不同的目標污染物，會有不同的填充物以及反應降解機制產生，其中常用的物質包括活性碳、鐵粉、鋅粉、皂土、有機物、沸石等，其中又以鐵粉運用較爲廣泛。在美國及歐洲滲透性反應牆使用最多的填充介質爲零價鐵（ZVI, Zero-Valent Iron）或與之混合的反應介質，本次研討會其中一場針對零價鐵之演說中，美國內華達州一處工廠使用含鉻原料，在生產製造加工過程中，鉻滲透至淺層地下水中，造成地下水污染物濃度超過法規值，針對本場址特性及污染物，於 2013 年 10 月選用滲透性反應牆進行改善工法，並選用零價鐵作爲其中之反應物，反應牆之位置位於水流相對下游處，除可

進行污染改善作業外，亦能夠防堵地下水污染持續向外擴散，在三種不同之反應牆類型中（不連續型反應牆、連續型反應牆，漏斗與門反應牆），挑選不連續反應牆進行施作，只要係依據出其調查結果以及整治經費考量，反應牆之設計必須考慮污染團捕捉範圍、改善效率以及反應牆之生命週期，水流經過反應牆之時間必須足以使受污染之地下水與零價鐵進行完整反應，如此才能確保水流經過反應牆後，地下水之污染濃度低於法規標準，因此反應速率亦爲設計時之重要因子。另外由於反應過程中可能產生多餘礦物質，礦物質有可能會累積於滲透性反應牆，因此如何能增加反應牆使用壽命，對於整治成效有絕對影響，因此在施作過程中，必須針對多項參數例如：酸鹼值、溶氧、氧化還原電位、導電度、污染物濃度等項目進行定期監測，該場址目前仍持續進行整治作業。


US Marine Corp, Recruit Depot, Parris Island, S.C.
Active military facility
The Problem
Former dry cleaner facility
Multiple releases of PCE on-site (sanitary sewer)
Ground water contamination
Discharge to wetlands (?)
Site Characterization
ISCO remedial approach, design, deployment, and treatment performance evaluation


Domestic
Other
Wastewater

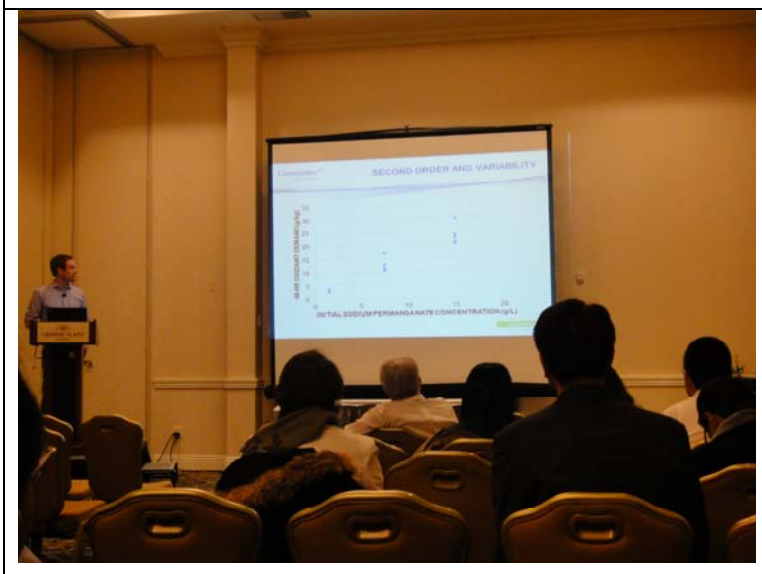
SECOND ORDER AND VARIABILITY

圖 2-1　　研討會現況


SITE BACKGROUND
CROWNE PLAZA


Evolution of Groundwater Remediation
CROWNE PLAZA


CROWNE PLAZA


Nanoscale Zero-Valent Iron (nZVI, nano-Fe⁰)
CROWNE PLAZA


EXIT


EXIT

圖 2-1　　研討會現況（續）

本次會議主辦單位於同一會議場地，共安排三場次不同主題之研討會，除污染管理研討會之外，另兩場爲半導體催化及太陽能轉換研討會議與水、空氣及土壤之養化技術研討會，三場研討會分屬不同會議室，惟會議室外屬共用空間，主辦單位於公用空間亦安排研究海報陳設及廠商攤位，研討會議場外現況如圖 2-2。本次廠商攤位中，Accelerated Remediation Technology, Inc.主要從事地下水改善整治井之設計，其設計概念爲將各整治工法包括氣提法、注氣法及土壤氣體抽除法等，整合至同一口井中，藉由不同操作設計搭配，增加其處理半徑，與傳統工法相比，能夠節省改善工法支出成本，並同步加強整治成效，與該公司人員簡單對談過程中，瞭解該公司曾拜訪台灣，相關技術將來亦可能利用於我國地下水污染場址中，相關資料如附件 2，廠商攤位如圖 2-3。

本研討會除針對土壤及地下水污染調查及整治技術安排實際案例分享外，亦針對其他國家場址管理及策略推動安排專題，第二場次專題演說邀請巴西環境工程顧問公司專家針對巴西土壤及地下水污染之整治管理措施歷程進行發表，巴西爲拉丁美洲最大國家，亦爲世界上第五大國家，巴西經濟發展快速，其中包括大量傳統工業，自 1980 年代後相關工廠移至專屬工業區後，原工廠舊址欲進行商業發展，在開發過程中即遇到土壤及地下水污染問題，因此巴西政府針對遭受土壤及地下水污染之區域，逐步展開污染調查、改善及管理，巴西對於土壤及地下水污染管理策略雖發展較其他先進國家晚，但整體概念相似，以環境永續爲主體，鼓勵污染土地活化，並禁止工廠在農業區內設立，納入風險概念，污染土地再利用須進行詳細調查與風險評估後才會判定是否適合執行，另推動污染資訊公開與公眾參與，且若確認整治工法無成效，亦必須對民眾公開說明。透過專題演說，能夠更了解美國及巴西土壤及地下水污染整治管理之發展進程，雖法規規定均不盡相同，惟環境保護及環境友善之目的並無不同。

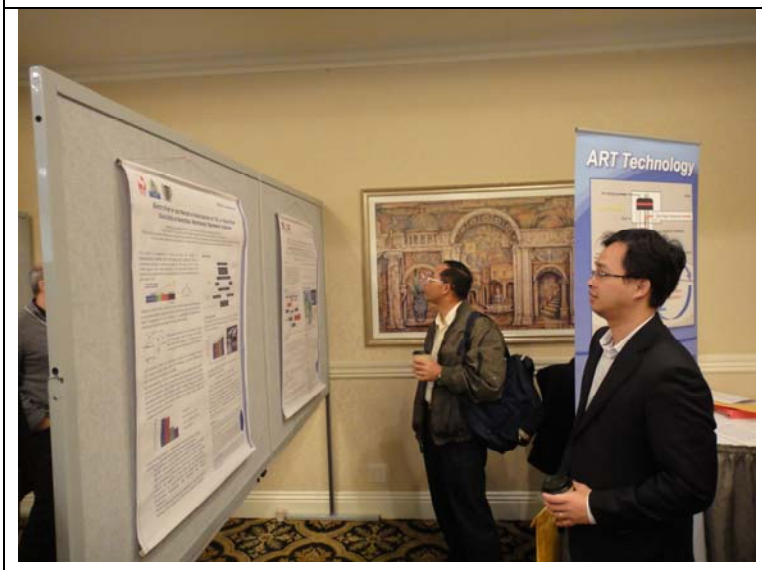

圖 2-2　　研討會議場外現況


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圖 2-3　　參展廠商攤位

（二）場址參訪

本研討會雖以土壤、地下水及底泥爲研討會命名，惟多數案例僅包括土壤及地下水，透過相關單位安排，於會議結束後，由美國加州環保署水質管理部（Regional Water Quality Control Board, California Environmental Protection Agency）之程博士（Charles Cheng）帶領至當地聖地牙哥海灣進行場址參訪及解說，如圖 2-4。

首先至 Shelter Island 港口早年停放大量遊艇，在進行遊艇船身保養及防鏽工程時，所使用之塗料直接接觸湖水，因此導致塗料中之重金屬污染致湖水，導致其水體中銅濃度超過美國環保署標準，另船體進行清除保養工程時，常將船體塗料直接刮除，並排放於湖水中，此舉亦爲污染來源之一，美國環保署發現該區域湖水及底泥遭受污染後，即要求此港口之主管機關採取採取適當管理措施（BMP, Best Management Practices），主要措施有二：（1）船身防鏽塗料成分全面改換爲不含銅及其他污染物之塗料（2）船體進行清潔保樣工程時，所刮除之物質需於水體中完整蒐集，並於地面上妥善處理，不得直接排入湖水中。經由上述主要措施，該區域之水體品質與污染情形逐步好轉，此外，該區域除有遊艇停靠之外，周邊亦有多家旅館經營，旅館之廢污水經由地下管道排放進入水體，旅館業產生之廢污水雖無重金屬危害，惟其細菌含量偏高，大量累積湖水中，亦會造成植物體及生物體之危害，有鑑於此，美國環保署針對旅館業產生之廢污水，要求各家旅館採用每日最大承載量（TMDL, Total Maximum Daily Load）進行管控，限制每日可排放水量，並要求各旅館業者在排放前先進行初步過濾程序，以有效降低細菌含量，除此之外，經由美國環保署調查，發現周圍居民於遛狗時，狗隻所排之糞便亦爲細菌主要來源，因此要求遛狗之民眾需隨手撿起狗隻糞便，以減少細菌來源。

在參訪完 Shelter Island 後，前往聖地牙哥國際機場旁之港口，該港口之污染主要爲多氯聯苯（PCBs），其來源係由於早期周邊工業發展，工業區廢水透過雨水管道直接排放進入港口，由於主要爲航空工業，因

此廢水中含有大量多氯聯苯，進而污染水體及底泥，美國環保署針對本區域之污染，先進行詳細之污染範圍調查，了解污染範圍及深度後，即著手進行底泥挖掘工程，針對污染之底泥及水體進行處理，另以風險阻隔角度，針對港口底層之鵝卵石，於上方覆蓋一層人工薄模，並於薄膜上層再覆蓋一層乾淨砂土，以避免生物體將底泥污染物食入體內，再藉由食物鏈之影響擴及更多生物。

在鄰近之海岸線港口，亦曾遭受重金屬、多環芳香烴（PAHs）及多氯聯苯（PCBs）等污染物之污染，來源包括從事渦輪機及挖土機等大型機具之造之機械公司、城市廢水、污水處理場未妥善處理之廢水及軍事造船維修廠等，由於污染皆爲早期工業發展或環保法規尚未健全時所造成，且聖地牙哥海灣爲一重要之軍事基地，僅採取單一改善工作恐無法有效完成整治，美國環保署採取每日最大承載量先行進行管制，避免污染情況持續加重，另在行政作爲上，依據相關資料追出相關污染責任主體，要求共同負起污染整治及改善責任。參訪照片如圖 2-5 至圖 2-9。

經由參訪過程能夠了解，聖地牙哥海灣區域由於早期軍事工業及其他相關行業發展造成底泥累積大量重金屬、多環芳香烴及多氯聯苯等污染物，透過當地環保署評估已對環境及生物體造成危害，隨即依據相關規定對於污染場址進行改善工作，經由多年努力，聖地牙哥海灣目前已成爲著名觀光休憩景點。

圖 2-4　　本次參訪地點分布

圖 2-5　聖地牙哥海灣（1）

圖 2-6　聖地牙哥海灣（2）

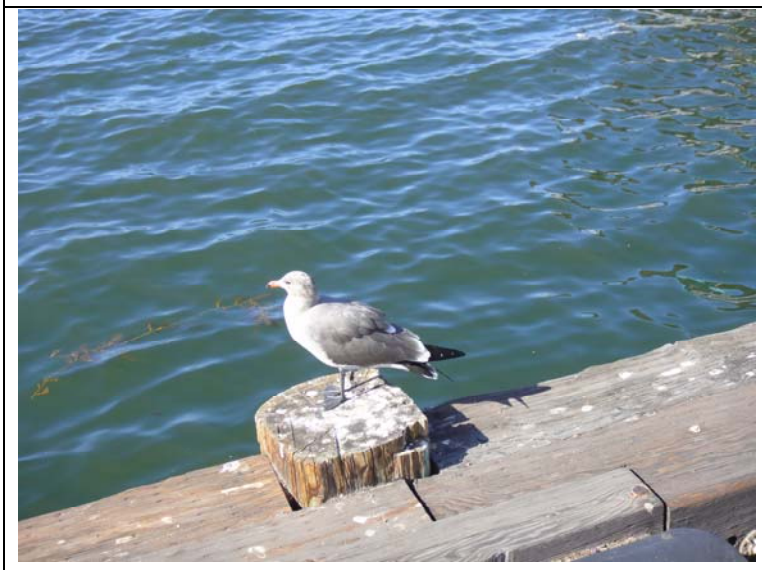
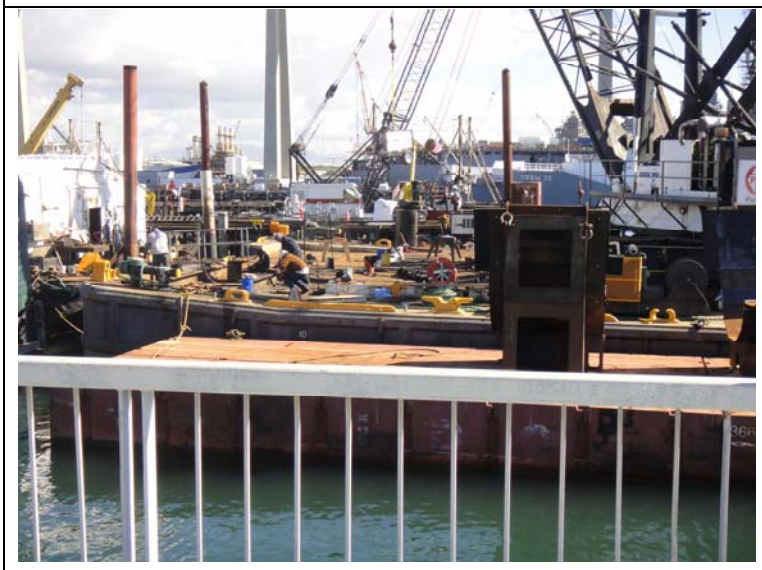


圖 2-7　聖地牙哥海灣（3）



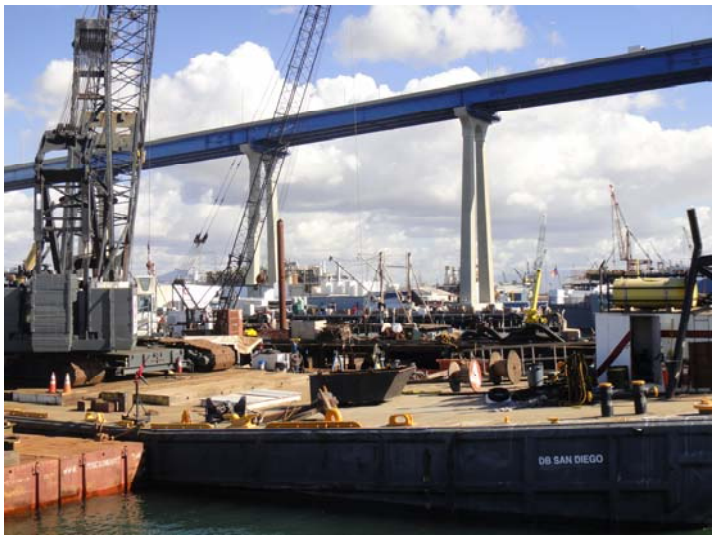


圖 2-8　聖地牙哥海灣（4）

圖 2-9　聖地牙哥海灣（5）

三、心得與建議

我國現行列管場址約 2,000 餘處，概分爲六大類別，依照現行土壤及地下水污染整治法規定，污染場址改善應由污染行爲人負責，依據不同列管形態提出控制計畫、污染調查及評估計畫或整治計畫，計畫之審查由所在地主管機關負責，整體架構與國外場址管理架構類似，經由會議中各專家實際案例可發現，針對一特定場址要進行改善前，事前準備工作非常繁複，從資料蒐集、補充調查、確認污染範圍及選定工法等，均須以嚴謹之態度面對，另包括水文地質條件亦爲重要因素，且在工法施行前，亦須進行先導試驗，在各項工作項目完成確認後，才會正式施作改善工法，通常工作項目越繁複，經費亦愈高，目前國內多數污染行爲人心態爲欲儘速完成改善解除列管，且成本需控制在一定範圍內，有時會由於未完整掌握場址資訊，導致改善工法無效，更嚴重的是會造成污染持續擴散及濃度升高，此時如欲再做改善控制，成本恐會比預期更高，因此應將國外對於場址改善之觀念及方法帶入國內，儘速完成污染

改善固然爲首要目的，更近一步應將永續觀念導入場址改善中，並選擇對於環境衝擊較小之改善工法。

經由場址參訪過程，可以了解美國對於污染場址管理之目的及方式，我國由於早年環保法規並不完善，配合工商經濟快速發展，導致土壤及地下水遭受污染，此狀況與聖地牙哥海灣遭受污染之情形類似，聖地牙哥海灣污染來源爲早期軍事工業、造船業、旅館業及其他機械工業，發現污染造成環境及生物體危害後，美國環保署及採取相關措施，除被動地移除污染外，採取適當管理措施針對污染源管制亦爲重要關鍵，包括限定排放量、改用不含污染物質原料及避免污染物直接進入海灣等，採用治標且治本之改善工法，國內可將相關管理架構帶入污染場址策略，並以健康風險爲主軸，達成保護環境及各生物體之目地。另聖地牙哥海灣經由一連串適當管理措施後，逐步完成污染改善工作，近年來當地政府極力發展觀光，聖地牙哥海灣搭配其他著名景點即成爲當地特色，觀光業之蓬勃發展亦帶動當地經濟，對於政府及民間爲一雙贏之局面，亦爲我國學習之標的之一。

附件一
研討會資訊

2014 - Contaminated Site Management:
Sustainable Remediation & Management of Soil, Sediment and Water
(CSM-2014)

Crowne Plaza, San Diego, California, USA
November 17-20, 2014

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Who Are The Organizers?

Dr. Hussain Al-Ekabi, President of Redox Technologies, Inc., has been organizing international conferences since 1992, on various areas of Environmental Science and Technology, in Canada, USA, Europe (Belgium, France, Germany, Netherlands, Poland, and Switzerland), Asia (Japan & Korea) and Latin America (Colombia). He always chooses, distinguished professors from universities/research institutions and recognized experts from environmental remediation firms from around the world, to speak at these conferences. In doing so he recognizes the important roles of the speakers as without their excellent contributions these conferences wouldn't have been successfully organized. Dr. Al-Ekabi can be reached by phone: 519 858 5055, Fax: 519 858 5056 or by **e-mail: hussain@alekabi.com**.

The Structure of the Program

The program consists of keynote lectures (30 min), invited presentations (25 min), platform presentations (15 min) and poster sessions. We have chosen excellent keynote and invited speakers from U.S.EPA, universities/ research institutions and environmental consulting and technology firms. This surely sets the stage for the construction of an outstanding technical program. Abstracts that will be received until **Friday, July 18, 2014** based on "Call for Papers" will be chosen for platform presentations and some for poster presentations. The merit of the abstract coupled with the preference of the author determines whether an abstract will be selected for a platform or a poster presentation.

Keynote Speakers

Jim Cummings, Technology Innovation and Field Services Division OSWER/USEPA

- **Developments and Trends in Hazardous Waste Site Remediation**

Michael Kavanaugh, Geosyntec Consultants, USA ..... We are waiting for confirmation.

- **Management of Chlorinated Solvent Source Zone**

We are in the process of inviting a third keynote speaker.

Partial List of Invited Presentations (Alphabetical Order)

In addition to the invited presentations (listed below) we are still waiting for the confirmations of more invited presenters mainly from the environmental consulting and technology firms.

Isaac M. Aboulafia, MEC^{X}, USA

- **Engineered Application of In-Situ Chemical Oxidation...More than 'Pumping and Dumping'**

Yoon-Seok Chang (Co-author: Jae-Hwan Kim), POSTECH, Korea

- **Exposure of *Arabidopsis Thaliana* to Fe Nanoparticles Induces the Enhancement of Root Elongation and Stomatal Opening**

Gary Cronk, JAG Consulting Group, Inc., USA

- **Destruction of Chlorinated and Petroleum Hydrocarbons using Caustic Activated Sodium Persulfate**

Hilde Decuyper[1], N. Vermeiren[2], J. Gemoets[3], R. Lookman[3], I. Van Keer[3], L. Bastiaens[3] ([1] A+E Consult bvba, Belgium; [2] Smet F&C N.V., Belgium; [3] VITO , Belgium)

- **Implementation of Zero Valent Iron for Source Zone Treatment via Soil Mixing**

Patrick Evans, CDM Smith, USA
- **Slow-Release Chemical Oxidants for In Situ Treatment of Dioxane and Chlorinated Solvents**

Malcolm Fabiyi, Praxair Inc., USA
- **From the Lab to the Field - A Decade of Commercializing Advanced Oxidation Technologies in Biological Wastewater Treatment**

Steven Gaito, ARCADIS, USA
- **Title Is Being Received Soon**

Jay Hodny, Amplified Geochemical Imaging, LLC, USA
- **High Resolution Site Characterization**

Scott G. Huling, U.S.EPA, USA
- **ISCO and CVOCs: Oxidant Delivery and Deployment Optimization, and Comprehensive Performance Evaluation**

Vladimir Jirku, Institute of Chemical Technology, Czech Republic
- **Mitigating the Biostatic Effect of Zero Valent Iron Nanoparticles**

Stephen Koenigsberg (Brown and Caldwell), **Joseph Guarnaccia** (BASF), **Kevin O'Driscoll, Robert M. DiFilippo, Paul Piccillo** (Thermocyclomics) and **Raymond Sambrotto** (Columbia University)
- **Degradation of Persistent PCBs in Soil during Incubations with a Thermophilic Bacterium**

Laurie LaPat-Polasko, ENVIRON, USA
- **In-Situ Bioremediation of Chlorinated Solvents using Bio-stimulation and Bio-augmentation**

Hope Lee, Pacific Northwest National Laboratory, USA
- **Use of Molecular Biological Tools and CSIA to Assess Microbial Activity and Contaminant Degradation in Environmental Systems**

Tamzen Macbeth, CDM Smith, USA
- **Overview of Mass Flux and Mass Discharge as Compliance Metrics for DNAPL Cleanup**

Bruce K. Marvin, **Ehsan Rasa and Ryan Fimmen,** Geosyntec Consultants, USA
- **Reaction Kinetics in the Design of In Situ Chemical Oxidation Systems**

Denis M. O'Carroll and Chris Kocur, Western University, Canada
- **Pilot Scale Demonstration of a Coupled Abiotic and Biotic Remediation using nZVI**

Jane Piper, Piper Environmental Group, USA
- **Ozone Process Advances for Groundwater and Soil Remediation**

Felicity Roddick, Royal Melbourne Institute of Technology, Australia
- **Impact of Advanced Oxidation Processes on Reverse Osmosis Concentrate from Municipal Wastewater**

Refugio Rodríguez Vázquez, Biotechnology and Bioengineering Research Centre and Advances Studies of the National Polytechnic Institute (CINVESTAV-IPN), Mexico

- **Full-Scale Application of an Accelerated Bioremediation Technology on Hydrocarbon and Pesticide Contaminated Soils**

Lars Rosén, Chalmers University of Technology, Sweden

- **SCORE: A Multi-Criteria Decision Analysis Method for Assessing the Sustainability of Remediation at Contaminated Sites**

Devon Rowe, ENVIRON, USA

- **Evolution of Conceptual Site Model Using Multimedia CSIA**

Alan G. Seech, PeroxyChem, USA

- **A New Approach to Fixation of Heavy Metals in Soil, Sediment, and Groundwater using MetaFix™ Reagents**

Jack Sheldon, Antea™Group, USA

- **Lessons Learned from an Aerobic Bioremediation Program**

Kent S. Sorenson, Jr., CDM Smith, USA

- **Costs and Benefits of Multicomponent Remedies for Complex Groundwater Cleanups**

Elizabeth Schawrtz, TRC Solutions, USA

- **Fate and Transport of Methane and Vinyl Chloride at a Site Undergoing In Situ Bioremediation**

Avelino Eduardo Saez, University of Arizona, USA

- **Matrix Effects in the Treatment of Trace Organics in Wastewater Effluent by Hydrogen Peroxide Photolysis**

Orfan Shouakar-Stash, University of Waterloo, Canada

- **Advancement in the Application of Compound-Specific Isotope Analysis (CSIA) in Assessing the Fate of Chlorinated Solvents in the Subsurface**

Shane A. Snyder, University of Arizona, USA

- **Evaluation of Bioactivity Attenuation/Formation in Recycled Water Using UV and Ozone AOPs**

Ricardo A. Torres Palma, Universidad de Antioquia Medellin, Colombia

- **Effect of Organic and Inorganic Water Matrix Components During the Application of Advanced Oxidation Processes for Water Remediation**

Omer Uppal & Co-authors, LANGAN, USA

- **Full-Scale Implementation of an Air Sparge System for Treatment of VOCs, SVOCs, and Arsenic**

Amy Wilson, TRC Solution, USA

- **A Multi-Year Evaluation of Natural Attenuation of Chlorinated Ethenes and Methanes using CSIA**

Ryan Wymore, Theodore Kuehster, Garry Stanley, Jeff Kurtz, and David Folkes, Geosyntec Consultants, USA

- **Long-term Remediation and Management for a Co-mingled Chlorinated Solvent and 1,4-Dioxane Source Area and Plume**

Julio Zimbron, Colorado State University, USA
- **Estimation of Rates of Petroleum Biodegradation in Soils using Passive CO2 Flux Traps**

Preliminary List of Platform Presentations (Alphabetical Order)

Some of the invited presenters have also offered platform presentations cited in this section. However, much more platform presentations will be chosen from abstracts that will be submitted on **Friday, July 18, 2014** in response to "Call for Abstracts".

Darren Burgett, Environmental Resource Management, USA – Prefers Poster
- **Utilizing Variations in Tidal Cycle and Hydrated "Quick" Lim as Catalysts for Persulfate Activation**

Grace Chen & **Kershu Tan**, CDM Smith, Edison, NJ; **Frank Tsang**, CDM Smith, Fairfax, VA; **Tamzen Macbeth**, CDM Smith, Helena, MT, **Ian Bowen**, USACE, Kansas City, MO
- **Performance of a Vegetable Oil Biobarrier in a Geochemically Complex Glauconite Aquifer**

Patrick Evans, CDM Smith, USA
- **Biogeochemical Transformation for In Situ Remediation of Chlorinated Solvents**

Stephen Koenigsberg (Brown and Caldwell), **Sandy Britt** (ProHydro), **Lawra Dodge, Ron Harwood** (Excel), **Gregg Gustafson** (INW), **Bob Kelley** (ARS), **Mark Kram** (Groundswell), **Fayez Lakhwala** (PeroxyChem), **Frank Loeffler** (UT Knoxville), **Dora Ogles** (Microbial Insights), **Bob Pirkle** (Microseeps) and **John Sohl** (Columbia Technologies)
- **A Multivariate Diagnostic Strategy to Examine Product Performance Claims**

Tamzen Macbeth, CDM Smith, USA
- **Thermally-Enhanced In Situ Reduction for Cleanup of Chlorinated Benzene and Ethene DNAPL**

Bruce Marvin, **Mary DeFlaun and Ryan Wymore,** Geosyntec Consultants, USA
- **Push-Pull Testing for Evaluation In-Situ Chemical and Biological Remediation Processes – Platform Presentation**

Kent Sorenson, Jr. **and Nathan Smith,** CDM Smith, USA
- **Bioremediation for Full-Scale Remediation of a TCE-Contaminated Source Area and Large, Dilute Plume**

Omer Uppal & Co-authors, LANGAN, USA
- **Performance Evaluation of a Pump and Treat System for Containment of a Large PCE Plume**
- **An Integrated Hydraulic Fracturing and Push-Pull ISCO Approach for Crystalline Bedrock Aquifer**
- **Innovative Vapor Intrusion Mitigation Designs for Complex Building Foundations**

Ryan Wymore, Bob Mueller and Lesley Hay-Wilson, Geosyntec Consultants, USA
- **ITRC's Environmental Molecular Diagnostics: New Tools for Better Decisions**

Julio Zimbron, Colorado State University, USA

- **Processes and Solutions for The Surface Water Discharge of LNAPL from Contaminated Groundwater**

The Scope of the Conference

The **CSM-2014** covers the following themes:

A. Tools for Defining Impacts and Liabilities to Soil, Sediment and Water

1. Tools and Methods for Defining Contaminants Distributions such as MIPs, Waterloo Profilers, etc.
2. Understanding Matrix Diffusion
3. Contaminant Transport in Complex lithologies
4. Using the Triad Approaches for Effective Site Characterization
5. High Resolution Characterization Techniques
6. Data Management and Graphical Tools for Contaminant Distribution and Transport
7. Sampling and Monitoring—Analytical Methods, Technologies, and Strategies
8. Molecular/ Biological Tools for Understanding Contaminant Transportations
9. Human and Ecological Risk Determination
10. Remediation and Risk Management at Fractured Bedrock Sites
11. Developing Effective Conceptual Models
12. Emerging Contaminants Issues

B. Tools for Mitigating Impacts to Soil, Sediment and Water

1. Biological Methods of Contaminant Treatment
   - *i. In- Situ Bioremediation*
   - *ii. Enhanced Bioremediation Strategies*
   - *iii. New Approaches for Enhanced Bioremediation of Hydrocarbons and PAHs*
   - *iv. Enhanced Bioremediation of Chloromethane and Chlorinated Aromatics*
   - *v. New Concepts for Enhanced Bioremediation of Chlorinated Ethenes*
2. ISCO and ISCR Methods for Contaminant Treatment
   - *i. In-Situ Chemical Oxidation*
   - *ii. New Concepts of In-Situ Chemical Oxidation*
   - *iii. In-Situ Chemical Reduction*
   - *iv. Coupling of ISCO with Bioremediation*
3. Applications of Zero Valent Iron (ZVI)
4. In-Situ and On-Site Thermal Remediation
5. Contaminant Stabilization and Fixation
6. Permeable Reactive Barriers
7. Phytoremediation
8. Natural attenuation Processes Including Abiotic and Biotic Processes
9. Advances in Natural Attenuation
10. Innovative Delivery Techniques
11. Extraction Technologies using Air, Water, Heat or Energy
12. Use of Technical Impracticality
13. Plume Management and Treatment
14. Source Treatment Technologies

C. Strategies for Managing Contaminated Soil, Sediment and Water

1. Green and Sustainable Remediation
2. Sustainable Sediment Management
3. Integrated DNAPL Remediation Approaches
4. Integrating Remediation with Development (brownfields)
5. Regulatory Initiative Impacting Contaminated Sites
6. Managing Natural Resource Damages
7. The Economics of Remediation
8. Effective Portfolio Management for Contaminated Properties
9. Control versus Treatment
10. Managing Third Party Liabilities

D. Wastewater Treatment

E. Management of Water Systems

F. Vapor Intrusion Assessment and/or Mitigation

Call for Abstracts

Scientists, Engineers, and business professionals who are interested in Remediation and Management of Soil, Sediment and Groundwater are strongly encouraged to submit abstracts of up to 500 words in MS word format describing their work. All abstracts are due by **Friday, July 18, 2014**. Authors who need few more days to get the approval of their management and/or clients should write to Hussain Al-Ekabi (hussain@alekabi.com) informing him about the extra days they need.

In addition to the invited speakers, a large number of abstracts that will be submitted based on "Call for Abstracts" will be chosen for platform presentations. The rest of the abstracts will be presented in the poster sessions. Although the program will be constructed on the merit of the contributions (abstracts), authors are advised to indicate their preference of presentations (Platform or Poster). Each poster will have 1.2 m x 1.2 m of display space.

Guidelines to Prepare Abstracts

Please follow the following guidelines in preparing your abstract(s):

- Type single space Using, if possible, Times New Roman 12-point font (preferred);
- Keep all material within a one-inch margin on all sides;
- The title should be typed in boldface (Title Case, 14- points) centered at the top of the page;
- Leave a double space between the title and the names of the author(s);
- The names of the authors should be typed in boldface in single space, followed the addresses of the authors in single space; Underline the name of the presenting author;
- Leave a double space between the end of the addresses and the opening paragraphs;
- Abstracts should be sent, in Microsoft Word format, to Dr. Hussain Al-Ekabi (E-mail: hussain@alekabi.com).

Call for Exhibits

Companies involved in soil, Sediment and groundwater are invited to exhibit their products and/or services. Exhibits will be displayed throughout the conferences in a central area near the registration desks, coffee breaks, poster sessions and lecture rooms. The cost of an 8-ft x 10-ft exhibiting space is **$1750.00** if payment is received

on or before **Friday, July 18, 2014** and **$2000.00** if payment is received after that date. The exhibition fee includes two free registrations to attend all lectures, lunch, coffee breaks, reception and the banquet dinner. Thus, with two free registrations, the cost of the exhibition is essentially nominal. We lowered the cost in order to encourage environmental consulting and technology firms to exhibit their products/services. Please, reserve early, as space is limited, and will be served on a first come first serve basis.

Registration

The deadline for the early registration is **Friday, July 18, 2014.** The on-site registration starts on **Sunday, November 16, 2014 at 2:00 – 7:00pm** and will be resumed on **Monday morning at 7:30am.**

Meeting Site and Accommodation

CSM-2014 will be held at the Crowne Plaza of San Diego, California, USA. A block of rooms with discounted conference rates has been reserved for the participants until **Friday, October 17, 2014.** The block is reserved under **Redox Technologies, Inc.** The rate is **$105** for a single-bed or double bed rooms. For online reservation please click on the link: https://resweb.passkey.com/go/RedoxTechnologiesInc. It will take you directly to the block of **Redox Technologies, Inc.** You can also make a reservation by phone: **1-888-233-9527** and then ask to be booked at the conference rate of **Redox Technologies, Inc.**

Dates to Remember

Friday, July 18, 2014		Deadline for receiving abstracts
Friday, July 18, 2014		Deadline for receiving payments of early registration
Friday, August 15, 2014		Notification of the authors regarding their abstracts
Sunday, Nov. 16, 2014	2:00 – 7:00pm	On-site registration
Monday, Nov. 17, 2014	8:30am – 5:30pm	Technical sessions
Tuesday, Nov. 18, 2014	8:30am – 5:30pm	Technical sessions
Wednesday, Nov. 19, 2014	8:30am – 5:30pm	Technical sessions
Wednesday, Nov. 19, 2014	7:00 – 9:00pm	Reception & Banquet Dinner
Thursday, Nov. 20, 2014	8:30am – 4:00pm	Technical Sessions
Thursday, Nov. 20, 2014	4:00pm	Adjourn

附件二

研討會細部議程

2014 - Contaminated Site Management: Sustainable Remediation & Management of Soil, Sediment and Water (CSM-2014)

Crowne Plaza, San Diego, California, USA
November 17-20, 2014

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The Organizers

Dr. Hussain Al-Ekabi, President of Redox Technologies, Inc., has been organizing international conferences since 1992, on various areas of Environmental Science and Technology, in Canada, USA, Europe (Belgium, France, Germany, Netherlands, Poland, and Switzerland), Asia (Japan & Korea) and Latin America (Colombia). He always chooses distinguished professors from universities/research institutions and recognized experts from environmental remediation firms from around the world, to speak at these conferences. In doing so he recognizes the important roles of the invited speakers as without their excellent contributions these conferences wouldn't have been successfully organized. He often consults with many of them, thus, they are considered members of the International Advisory Committee of the conference. Dr. Al-Ekabi can be reached by phone: 519 858 5055, Fax: 519 858 5056 or by **e-mail: hussain@alekabi.com**.

International Advisory Committee

Conference Correspondence

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e-mail: hussain@alekabi.com; Website: www.redoxtech.com

Monday, November 17, 2014

Session 1: Keynote Lectures

(Combined Session for CSM-2014 & AOTs-20)

8:30 – 9:00am **Developments and Trends in Hazardous Waste Site Remediation**
Jim Cummings
Technology Innovation and Field Services Division OSWER/USEPA, Washington, D.C., USA

9:00 – 9:30am **The Evolution of Brazilian Remediation Regulations and Standards**
Ana Paula Queiroz, Giovanna Setti, Thiago Gomes
Brazilian Association of Environmental Engineering and Consulting Companies/Waterloo Brasil Ltda., São Paulo, SP, Brazil

9:30 – 10:00am **Role of Advanced Oxidation in Potable Water Reuse**
Shane A. Snyder, Tarun Anumol, Xuhao Nie, and Shimin Wu
University of Arizona, Tucson, AZ, USA

10:00 – 10:20am **Coffee Break**

Session 2: Advanced Oxidation Processes for Contaminants Removal

(Combined Session for CSM-2014 & AOTs-20)

10:20 – 10:40am **Impact of Advanced Oxidation Processes on Reverse Osmosis Concentrate from Municipal Wastewater**
Felicity Roddick, Muhammad Umar, Thang Nguyen and Linhua Fan
Royal Melbourne Institute of Technology, Melbourne, Victoria, Australia

10:40 – 11:00am **Is Advanced Chemical Oxidation a Viable Treatment for Micropollutants in Sewage Sludge?**
I. Akmehmet Balcıoğlu and N. Bilgin Öncü
Bogazici University, Bebek-Istanbul, Turkey

11:00 – 11:20am **Effect of Organic and Inorganic Water Matrix Components during the Application of Advanced Oxidation Processes for Water Remediation**
Paola Villegas-Guzman, Javier Silva-Agredo, Oscar Florez, Ana L. Giraldo-Aguirre, Efraim A. Serna-Galvis, Ricardo A. Torres-Palma
Universidad de Antioquia, Medellín, Colombia

11:20 – 11:40am **In-situ Chemical Oxidation (ISCO) and CVOCs: Design, Deployment, and Comprehensive Performance Evaluation**
Scott Huling and Ken Jewell
U.S.EPA, Ada, OK, USA

11:40 – 12:00n **Reaction Kinetics in the Design of In-Situ Chemical Oxidation Systems**
Bruce K. Marvin, Ehsan Rasa and Ryan Fimmen
Geosyntec Consultants, Oakland, CA, USA

12:00 – 12:20pm **From the Lab to the Field - A Decade of Commercializing Advanced Oxidation Technologies in Wastewater Treatment**
Malcolm Fabiyi
Praxair Inc., Burr Ridge, IL, USA

12:20 – 1:30pm **Lunch**

Session 3: Remediation and Management of Large Plumes

1:30 – 1:55pm **Overview of Contaminant Mass Discharge as a Compliance Metric for DNAPL Cleanup**
Tamzen W. Macbeth[1], Randa Chichakli[2], Dominic Giaudrone[3], Mark Murphy[4], Kira Lynch[5], Howard Orlean[5], and Tamara Langdon[5]
[1]CDM Smith, Helena, MT, USA
[2]CDM Smith, San Diego,CA, USA
[3]CDM Smith, Bellevue, WA, USA
[4]USACE Seattle District, Seattle, WA, USA
[5]USEPA Region 10, Seattle, WA, USA

1:55 – 2:20pm **Bioremediation for Full-Scale Remediation of a TCE-Contaminated Source Area and Large, Dilute Plume**
Kent Sorenson, Jr. and Nathan Smith
CDM Smith, Denver, CO, USA

2:20 – 2:45pm **Long-term Remediation and Management for a Co-mingled Chlorinated Solvent and 1,4-Dioxane Source Area and Plume**
Ryan Wymore, Theodore Kuehster, Garry Stanley, Jeff Kurtz, and David Folkes
Geosyntec Consultants, Greenwood Village, CO, USA

2:45 – 3:10pm **Performance Evaluation of a Pump and Treat System for Containment of a Large PCE Plume**
Omer J. Uppal [1], Mathew Wenrick[2], Imtiyaz Khan[2], Stewart H. Abrams[2] and Jeffery Smith[3]
[1]Langan, Elmwood Park, New Jersey, USA
[2]Langan, Lawrenceville, New Jersey, USA
[3]Langan, Philadelphia, Pennsylvania, USA

3:10 – 3:30pm **Coffee Break**

3:30 – 3:55pm **LNAPL Sheen Impacts to Surface Water: Development of Multiphase Flow Process-Based Sheen Remedies**

Julio Zimbron
E-Flux, LLC, Fort Collins, CO, USA

3:55 – 4:20pm **Large Diffuse Plume Alternative Approach to Pump & Treat/ MCLs: A Sustainable Plume Management Approach Using the Arizona WQARF Model**

Scott Zachary[1], Eric Pigati[2], Paula R. Chang[3]
[1]Haley & Aldrich, Inc., San Diego, California, USA
[2]Haley & Aldrich, Inc., Tucson, Arizona, USA
[3]Haley & Aldrich, Inc., Phoenix, Arizona, USA

4:20 – 4:45pm **Advances in Surfactant Selection for LNAPL Remediation**

David F. Alden[1], Gary M. Birk[1] and John Sankey[2]
[1]Tersus Environmental, Wake Forest, North Carolina, USA
[2]True Blue Technologies, Long Beach, CA, USA

Session 4: Molecular Diagnostic Tools

4:45 – 5:10pm **SCORE: A Multi-Criteria Decision Analysis Method for Assessing the Sustainability of Remediation at Contaminated Sites**

Lars Rosén[1], Pär-Erik Back[2], Tore Söderqvist[3], Jenny Norrman[1], Petra Brinkhoff[4], Tommy Norberg[1], Yevheniya Volchko[1], Malin Norin[4], Magnus Bergknut[5], Gernot Döberl[6]
[1]Chalmers University of Technology, Sweden
[2]Swedish Geotechnical Institute, Sweden
[3]Enveco Environmental Economics Consultancy, Sweden
[4]NCC Construction, Sweden
[5]Umeå University, Sweden
[6]Umweltbundesamt, Austria

5:10 – 5:35pm **A Multivariate Diagnostic Strategy to Examine Product Performance Claims**

Stephen Koenigsberg[1], Sandy Britt[2], Lawra Dodge[3], Ron Harwood[3], Gregg Gustafson[4], Bob Kelley[5], Mark Kram[6], Fayez Lakhwala[7], Frank Loeffler[8], Dora Ogles[9], Bob Pirkle[10] and John Sohl[11]
[1]Brown and Caldwell; [2]ProHydro; [3]Excel; [4]INW; [5]ARS; [6]Groundswell; [7]PeroxyChem; [8]UT Knoxville; [9]Microbial Insights; [10]Microseeps; [11]Columbia Technologies

5:35 – 6:00pm **Environmental Molecular Diagnostics (EMDs): New Tools for Better Decisions**

Ryan A. Wymore, Lesley Hay Wilson[2], Bob Mueller[3]
[1]Geosyntec, Greenwood Village, CO, USA
[2]Sage Risk Solutions LLC, Austin, TX, USA,

[3]New Jersey DEP, Trenton, NJ, USA

Tuesday, November 18, 2014

Session 5: In-Situ Chemical Oxidation for Treatment of Contaminants

8:30 – 8:55am **Engineering Design and Injection Considerations When Using Caustic Activated Sodium Persulfate: A Case Study Review and Lessons Learned**

Gary Cronk[1], Nicole Persaud[2], and Jack Sheldon[3]
[1]JAG Consulting Group, Inc. Santa Ana, CA, USA
[2]Antea Group, San Jose, CA, USA
[3]Antea Group, West Des Moines, IA, USA

8:55 – 9:20am **An Integrated Hydraulic Fracturing and Push-Pull ISCO Approach for Crystalline Bedrock Aquifer**

Omer J. Uppal[1], Erica Sterzinar[1], Annie Lee[2], Brian Blum[1], Stewart H. Abrams[1]
[1]Langan, Elmwood Park, New Jersey, USA
[2]Langan, San Francisco, CA, USA

9:20 – 9:45am **Engineered Application of In-Situ Chemical Oxidation...More than 'Pumping and Dumping'**

Isaac Aboulafia[1], Doug Carvel[1], Larry Rader[2]
[1]MEC[X], Houston, TX, USA
[2]MEC[X], Chicago, IL, USA

9:45 – 10:10am **Slow-Release Chemical Oxidants for In Situ Treatment of Dioxane and Chlorinated Solvents**

Patrick J. Evans[1], Pamela Dugan[2], and Michelle Crimi[3]
[1]CDM Smith, Bellevue, WA, USA
[2]Carus Corporation, LaSalle, IL, USA
[3]Clarkson University, Potsdam, NY, USA

10:10 – 10:30pm **Coffee Break**

Session 6: Zero Valent Iron in Remediation

10:30 – 10:55am **Mitigating the Biostatic Effect of Zero Valent Iron Nanoparticles**

Vladimir Jirku, Karolina Padrova, Richard Ježdík, Alena Cejkova and Jan Masak
Institute of Chemical Technology, Prague, Czech Republic

10:55 – 11:20am **Exposure of *Arabidopsis Thaliana* to Fe Nanoparticles Induces the Enhancement of Root Elongation and Stomatal Opening**

Jae-Hwan Kim and Yoon-Seok Chang
School of Environmental Science and Engineering, POSTECH, Pohang, Korea

11:20 – 11:45pm **Pilot Scale Demonstration of a Coupled Abiotic and Biotic Remediation using nZVI**
Denis M. O'Carroll and Chris Kocur
Western University, London, ON, Canada

11:45 – 12:10pm **Implementation of Zero Valent Iron for Source Zone Treatment via Soil Mixing**
Hilde Decuyper[1], N. Vermeiren[2], J. Gemoets[3], R. Lookman[3], I. Van Keer[3], L. Bastiaens[3]
[1] A+E Consult bvba, Lauwe, Belgium
[2] Smet F&C N.V., Dessel, Belgium
[3] VITO, Mol, Belgium

12:10 – 1:30pm **Lunch**

1:30 – 1:55pm **Design, Construction, and Monitoring of a Field-Scale Discontinuous Permeable Reactive Barrier for Chromium Removal**
Patrick Hsieh, Natasya Gray, and Miao Zhang
AMEC Environment & Infrastructure, Inc., Seattle, WA, USA

Session 7: Applications of Compound-Specific Isotope Analysis (CSIA)

1:55 – 2:20pm **Advancement in the Application of Compound-Specific Isotope Analysis (CSIA) in Assessing the Fate of Chlorinated Solvents in the Subsurface**
Orfan Shouakar-Stash
University of Waterloo, Waterloo, ON, Canada

2:20 – 2:45pm **Evolution of a Conceptual Site Model Using Multimedia CSIA**
Devon Rowe[1], Carol Serlin[2], Tom Chandler[2], Steve Luis[2], Farshad Razmdjoo[2], and Seema Turner[3]
[1]ENVIRON International Corporation, Clackamas, OR, USA
[2]ENVIRON International Corporation, Irvine, CA, USA
[3]ENVIRON International Corporation, Los Angeles, CA, USA

2:45 – 3:10pm **Use of Molecular Biological Tools and CSIA to Assess Microbial Activity and Contaminant Degradation in Environmental Systems**
Hope Lee and Brady Lee
Pacific Northwest National Laboratory, Richland, WA, USA

3:10 – 3:30pm **Coffee Break**

3:30 – 3:55pm **A Multi-Year Evaluation of Natural Attenuation of Chlorinated Ethenes and Methanes Using CSIA**
Amy M. Wilson and Elizabeth Schwartz
TRC Companies, Inc., Concord, CA, USA

Session 8: High Resolution Site Characterization

3:55 – 4:20pm **3D Subsurface Characterization and 4D Monitoring of Remediation-Induced Changes in Bulk Electrical Conductivity Using High-Performance Time-Lapse Electrical Resistivity Imaging**
Timothy C. Johnson, Mike Truex, Dawn Wellman, Lee D. Slater[2], Frederick D. Day-Lewis[3] , Roelof J. Versteeg[4]
[1]Pacific Northwest National Laboratory, Richland, WA, USA
[2]Rutgers University, Newark, NJ, USA
[3]US Geological Survey, Storrs, CT, USA
[4]Subsurface Insights, LLC. Hannover, NH, USA

4:20 – 4:45pm **High Resolution Site Characterization in Brazil Using Resistivity Piezocone Test (RCPTu) for Hydrostratigraphic Profile**
Marcos Tanaka Riyis, Rafael Muraro Derrite and Mauro Tanaka Riyis
ECD Sondagens Ambientais, Sorocaba, SP, Brazil

4:45 – 5:10pm **Data Visualization in a Bid Data World - Utilizing 2-Dimensional and 3-Dimensional Data Analysis to Evaluate Complex Environmental Data Sets**
Jason C. Ruf
S2C2 Inc, Raritan, NJ, USA

5:10 – 5:35pm **Reserved -TBA**

5:35 – 6:00pm **TBA**

Wednesday, November 19, 2014

Session 9: In-Situ Reduction

8:30 – 8:55am **Thermally-Enhanced In Situ Reduction for Cleanup of Chlorinated Benzene and Ethene DNAPL**
Hamide Kayaci[1], Tamzen W. Macbeth[2], Keith Forman[1] and Melanie Kito[1]
[1]U.S. Navy, NAVFAC SW Division, San Diego, CA, USA
[2]CDM, Pocatello, ID, USA

8:55 – 9:20 **Optimizing Chemical Reduction Strategies to Achieve Treatment Standards for Chlorinated Compounds at Two Industrial Sites in Brazil**
Jack Sheldon
Antea Group, West Des Moines, IA, USA

9:20 – 9:45am **A Full-Scale, Eight Year Study of the Remediation of Chlorinated Solvents and Heavy Metals Through In-situ Reduction**
Brian Hitchens and Sam Williams
Geosyntec Consultants, San Diego, CA, USA

9:45 – 10:10am **Evaluation of In Situ Chemical Reduction to Treat Chlorinated Ethenes in High Sulfate Aquifers**
Daniel Leigh[1], Daniel E. Johnson[2] and Keith L. Etchells[2]
[1]PeroxyChem LLC, Philadelphia, PA, USA
[2]SCS Engineers, San Diego, CA, USA

10:10 – 10:30am **Coffee Break**

Session 10: Combining Remedial Technologies

10:30 – 10:55am **Combining In Situ Remediation Technologies for Optimal Treatment Performance**
Jeremy Birnstingl
REGENESIS, Bath, UK

10:55 – 11:20am **Costs and Benefits of Multicomponent Remedies for Complex Groundwater Cleanups**
Kent S. Sorenson, Jr., Tamzen Macbeth, Nathan Smith
CDM Smith, Denver, CO, USA

11:20 – 11:45am **Multi-Component Remediation of Petroleum and Metals at an Industrial Site in San Francisco, California**
Belinda Butler-Veytia[1], Jim Warner[2], Arun Chemburkar[2], Katie Wolf[2], Marcelo Germani[2], and Gina Sperinde[2]
[1]ERM, Greenwood Village, CO, USA
[2]ERM, Walnut Creek, CA, USA

11:45 – 12:10am **Push-Pull Testing for Evaluation In-Situ Chemical and Biological Remediation Processes**
Bruce Marvin, Mary DeFlaun and Ryan Wymore
Geosyntec Consultants, Oakland, CA, USA

12:10 – 1:30pm **Lunch**

1:30 – 1:55pm **In-Situ Bioremediation of Chlorinated Solvents using Bio-stimulation and Bio-augmentation**
Laurie LaPat-Polasko
ENVIRON International, Phoenix, AR, USA

1:55 – 2:20pm **The ART-Jection Technologies, Combining Physical Removal, Chemical Treatment and Biodegradation to Remedy Impacted Soils and Groundwater Effectively and Cost-efficiently**
Mohamed Odah
Accelerated Remediation Technologies, Inc., Overland Park, Kansas, USA

2:20 – 2:45pm **Combining Abiotic and Biotic Processes for Aggressive Treatment of Chlorinated Ethenes**
Daniel Leigh
Peroxychem LLC, Philadelphia, PA, USA

2:45 – 3:10pm **Coupling Technologies to Facilitate Rapid Remediation – Synergies, Challenges, and Lessons Learned**
Christopher Gale[1] and Brian Hitchens[1], Doug Riddle[2]
[1]Geosyntec Consultants, San Diego, CA, USA
[2]RELLC, Mountain Center, CA, USA

3:10 – 3:30pm **Coffee Break**

3:30 – 3:55pm **Successful In Situ Bioremediation Following In Situ Chemical Oxidation for PCE Remediation**
Richard J. Hirsch
Hirsch Gibney, Inc., Parker, CO, USA

Session 11: In-Situ Bioremediation- Putting the Microbe to Work

3:55 – 4:20pm **Natural Attenuation Promoted by Microbial Phosphorus Cycling**
Patricia A. Sobecky[1], Martial Taillefert[2], Robert J. Martinez[1], and Melanie Beazley[1]
[1]University of Alabama, Tuscaloosa, AL, USA
[2]Georgia Institute of Technology, Atlanta, GA, USA

4:20 – 4:45pm **Degradation of Persistent PCBs in Soil during Incubations with a Thermophilic Bacterium**
Stephen Koenigsberg[1], Joseph Guarnaccia[2], Kevin O'Driscoll[3], Robert M. DiFilippo[3], Paul Piccillo[3] and Raymond Sambrotto[4]
[1]Brown and Caldwell; [2]BASF; [3]Thermocyclomics; [4]Columbia University

4:45 – 5:10pm **Fate and Transport of Methane and Vinyl Chloride at a Site Undergoing In-Situ Bioremediation**
Elizabeth Schwartz, Jessica Barros, and Gary Gunderson

TRC Companies, Inc., Concord, CA, USA

5:10 – 5:35pm **Soil Bioremediation with Low Levels of Organic Residues in a Former Refinery**
Rodríguez-Vázquez Refugio, Alejandro Islas –García, Juan Manuel Arce-Ortega
Depto. de Biotecnología y Bioingeniería, CINVESTAV-IPN
Departamento de Biotecnología y Bioingeniería, Centro de Investigación y de Estudios Avanzados del IPN, Av. Instituto Politécnico Nacional No. 2508, Col. San Pedro Zacatenco, México, D.F., México

Thursday, November 20, 2014

Session 11: In-Situ Bioremediation: Putting the Microbe to Work
Continued ....

8:30 – 8:55am **Measurement of Hydrocarbon Natural Attenuation Rates in Soils Using Passive CO_2 Flux Traps**
Julio Zimbron
E-Flux, LLC, Fort Collins, CO, USA

8:55 – 9:20pm **Lessons Learned from an Aerobic Bioremediation Program**
Jack Sheldon
Antea™Group, West Des Moines, IA, USA

9:20 – 9:45am **Microbially-Mediated Treatment of Oil Well Drill Cuttings**
M. S. Showell[1], J. J. P. Roberts[1], R.S. Carpenter[1], N. Pal[2], and Y. Nelson[2]
[1]BiOWiSH Technologies, Inc., Cincinnati, OH, USA
[2]California Polytechnic State University, San Luis Obispo, CA, USA

9:45 – 10:10am **Performance of a Vegetable Oil Biobarrier in a Geochemically Complex Glauconite Aquifer**
Grace Chen[1], Kershu Tan[1], Frank Tsang[2], Tamzen Macbeth[3] and Ian Bowen[4]
[1]CDM Smith, Edison, NJ, USA
[2]CDM Smith, Fairfax, VA, USA
[3]CDM Smith, Helena, MT, USA
[4]USACE, Kansas City, MO, USA

10:10 – 10:30am **Coffee Break**

10:30 – 10:55am **Biogeochemical Transformation for In Situ Remediation of Chlorinated Solvents**
Patrick Evans
CDM Smith, Bellevue, WA, USA

10:55 – 11:20am **Bioaugmentation of Non-Ligninolytic Fungi for Degradation of PAHs in Contaminated Soil**

Diana V. Cortés-Espinosa, Angel E. Absalón, Anaisell Reyes Cesar, Germán Zafra and Sergio Moreno
Instituto Politécnico Nacional, Tlaxcala, México

11:20 – 11:45am **Selection of Optimal Culture Conditions for PAH Removal in Soils by Mixed Microbial Consortia**

German Zafra[1], Angel E. Absalón[1], Miguel A. Anducho-Reyes[2], Diana V. Cortés-Espinosa[1]
[1] Instituto Politécnico Nacional, Tlaxcala, México;
[2] Universidad Politécnica de Pachuca, Zempoala, Hidalgo, México

Session 12: Physical Removal of Contaminants

11:45 – 12:10pm **MetaFix™ Reagents for Chemical Fixation of Heavy Metals in Soil and Groundwater**

Alan Seech[1] and Daniel Leigh[2]
[1]PeroxyChem Environmental Solutions, Corona Del Mar, CA, USA
[2]PeroxyChem Environmental Solutions, Walnut Creek, CA, USA

12:10 -1:30pm **Lunch**

1:30 – 1:55am **Results of First Full Scale 1,4-Dioxane Synthetic Media Groundwater Remediation System**

Steve Woodard[1] and Louis Burkhardt[2]
[1]Emerging Compounds Treatment Technologies - ECT2, USA
[2]Raytheon Company, USA

1:55 – 2:20pm **Full-Scale Implementation of a Pulsed Air Sparge System for Treatment of VOCs, SVOCs, and Arsenic**

Omer J. Uppal [1], Annie Lee[2] Matthew Ambrusch[1], Nadira Najib[1], Steve Ciambruschini[1] Stewart H. Abrams[3]
[1]Langan, Elmwood Park, New Jersey, USA
[2]Langan, San Francisco, California, USA
[3]Langan, Lawrenceville, New Jersey, USA

2:20 – 2:45pm **Column Tests to Assess Feasibility of Flushing Perchlorate from Soil**

Cindy G. Schreier[1], Deni Chambers[2] and Mark Gage[2]
[1]PRIMA Environmental, Inc., El Dorado Hills, CA, USA
[2]Northgate Environmental Management, Oakland, CA, USA

2:45 – 3:10pm **Optimization of Remedial Action of Arsenic in Groundwater Vineland Chemical Company Superfund Site, New Jersey Part II:**

Column Tests Results Vineland Chemical Company Superfund Site, New Jersey

Lily Sehayek[1], Nica Klaber[2] Juan Corona[1], Tricia North[1], Loeper Joseph[1], Mark Chamberlain[1], Laura Bittner[1]
[1]US Army Corps of Engineers, Philadelphia, PA, USA,
[2]U.S.EPA Region II, New York, NY, USA

3:10 – 3:35 **Innovative Vapor Intrusion Mitigation Design for Complex Building Foundations**

Omer J. Uppal[1], Matthew Ambrusch[1], Steven Ciambruschini[1], Nadira Najib[1], Stewart H. Abrams[2] and Matthew Wenrick[2]
[1]Langan, Elmwood Park, NJ, USA
[2]Langan, Lawrenceville, NJ, USA

3:35pm **Adjourn**

附件三

參展廠商資

ACCELERATED REMEDIATION TECHNOLOGIES, INC. (ART)
INTEGRATED REMEDIATION SYSTEM

1.0 Introduction

Numerous technologies have been implemented at sites worldwide to remediate contaminated groundwater. Some of the most commonly used technologies such as air sparging, soil vapor extraction and ex-situ (above-ground) air-stripping are based on the physical removal of contaminants; however, significant shortcomings are inherent with each method. A remediation technology that combines the advantages of air sparging, soil vapor extraction and air-stripping plus in-situ active treatment would be more effective. This technology would compensate for shortcomings associated with pump-and-treat such as long project life and costs of water disposal and the deficiencies related to air sparging such as a limited radius of influence and removal rate.

2.0 ART Integrated Remediation System

Accelerated Remediation Technologies, Inc (*ART*) has developed innovative, proprietary remediation technologies that are based on well-proven and established concepts. The systems are designed to fit in four inch wells (minimum) and be very cost effective when compared with other remediation technologies.

2.1 Technical Description

The ART Technologies combine in-situ air stripping, air sparging, soil vapor extraction and enhanced bioremediation/oxidation – plus, dynamic subsurface circulation in an innovative wellhead system. Figure 1 (below) illustrates a dual screened well casing and the combined remediation concepts and their effects in the subsurface.

The air sparging component results in reduced water density and lifting (mounding) of the water table in the vicinity of the well. This in turn causes a net negative pressure gradient to the well resulting in water flowing back towards the well. This upwelling force created by the sparging results in an in-well "packer" concept resulting in a pressure gradient from the lower screened interval to the upper screened interval that assists in driving the dynamic subsurface circulation forces.

Vacuum pressure (the vapor extraction component) is applied atop of the well point to extract vapor from the subsurface. The negative pressure from vacuum extraction creates additional water mounding, boosts the net gradient back towards the well and removes vapors from the unsaturated vadose zone and well annulus. The SVE and sparging technologies combined in the same well further enlarge the radius of influence.

A submersible pump is placed at the bottom of the well to re-circulate water to the top for downward discharge through a spray head. The water cascades down the interior of the well and system piping, providing multiple wetted surfaces for volatile

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mass transfer - similar to what occurs in a packed-column air-stripping tower. Enhanced stripping via air sparging near the bottom of the well occurs simultaneously. In essence, the well will act as a subsurface air-stripping tower. In addition to the air stripping resulting from the pumping/cascading, the pumped, stripped, highly oxygenated water will flow down the well annulus and over the mounded water back into the aquifer and vadose zone – hydraulically enhancing the radius of influence. These combined synergistic technologies effects will set up a circulation zone surrounding the well that will further enhance cleanup.

In summary, contaminants are stripped from the water as a result of the combined effects of in-well air stripping and in-well air sparging. The "radius of results", or dynamic subsurface circulation cleaning zone, is created by a combination of a negative hydraulic pressure gradient as a result of air sparging, additional negative gradient resulting from the application of vacuum extraction, and subsurface water circulation induced by a submersible pump. All of these different components can be integrated and installed in a four-inch or larger groundwater well.

3.0 ART-Jection Remediation Technologies Option

As part of our continued efforts to improve the ART Technologies and increase efficacy, the ART-Jection Technologies alternative has been developed. This technology builds on the proven ART Integrated design and allows for the addition of amendments (gas or liquid) directly into the formation as part of the in-well processes. Amendments may include ozone, nitrogen and other chemical or biological amendments (gas or liquid). Chemicals added into the saturated zone via the injection point will be mixed further by the subsurface circulation to be delivered throughout the sphere of influence. This innovative design, detailed in Figure 2, will provide clients a wider range of options to maximize the chances of success. The injection process and pumping may occur alternately depending on site specifics and to minimize the potential of extracting some of the chemicals into the well prior to dispersion into subsurface.

The ART In-Well Integrated Technologies have proven capabilities at very challenging sites for remediation of chlorinated solvents, hydrocarbons and recalcitrant compounds. The ART design can be retrofitted to existing legacy systems or can be employed as a new site-wide solution. The addition of the ART-Jection alternative provides for increased flexibility and confidence for our clients to remedy even the most difficult sites.

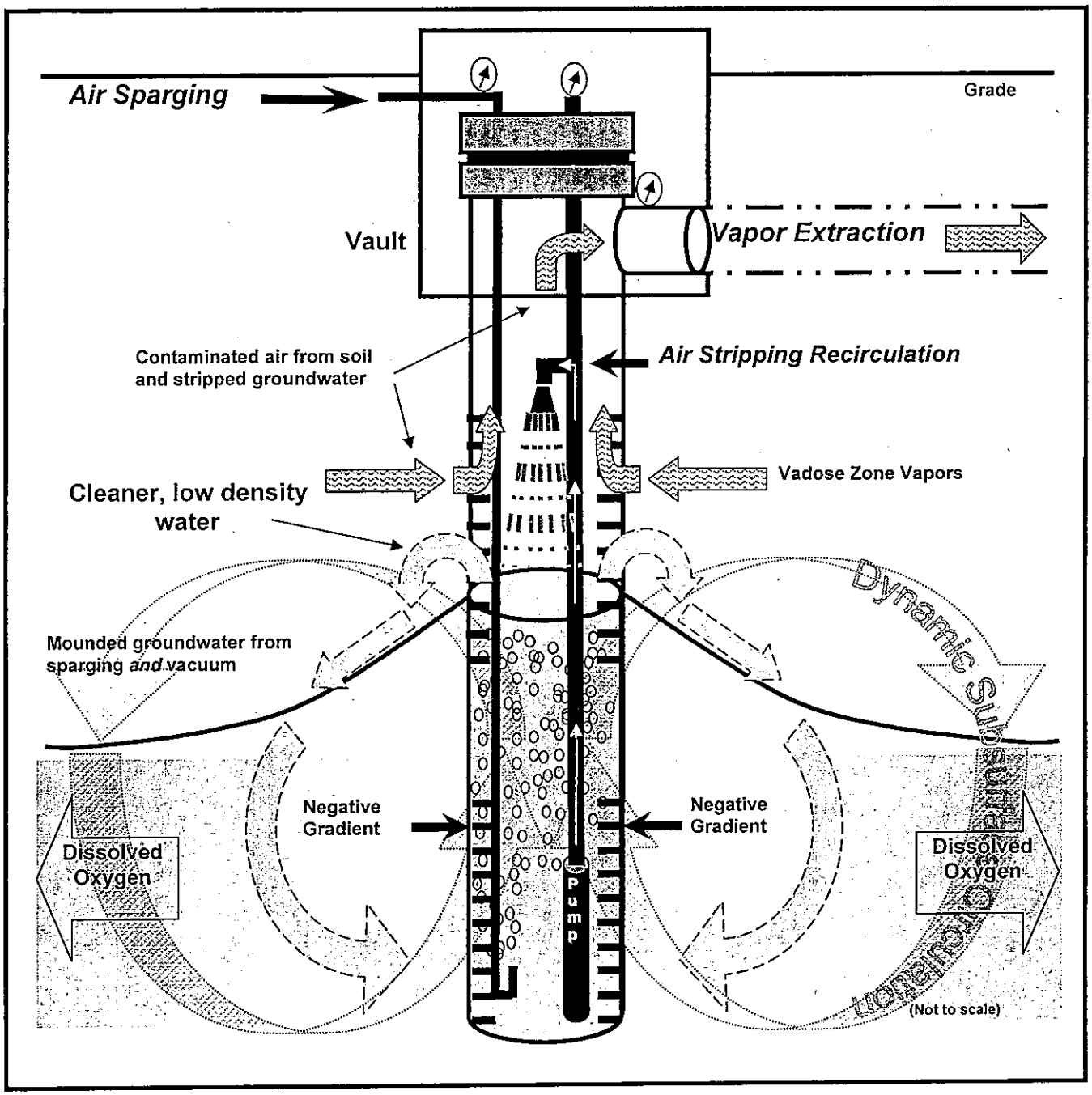

FIGURE 1

ART Integrated Technologies

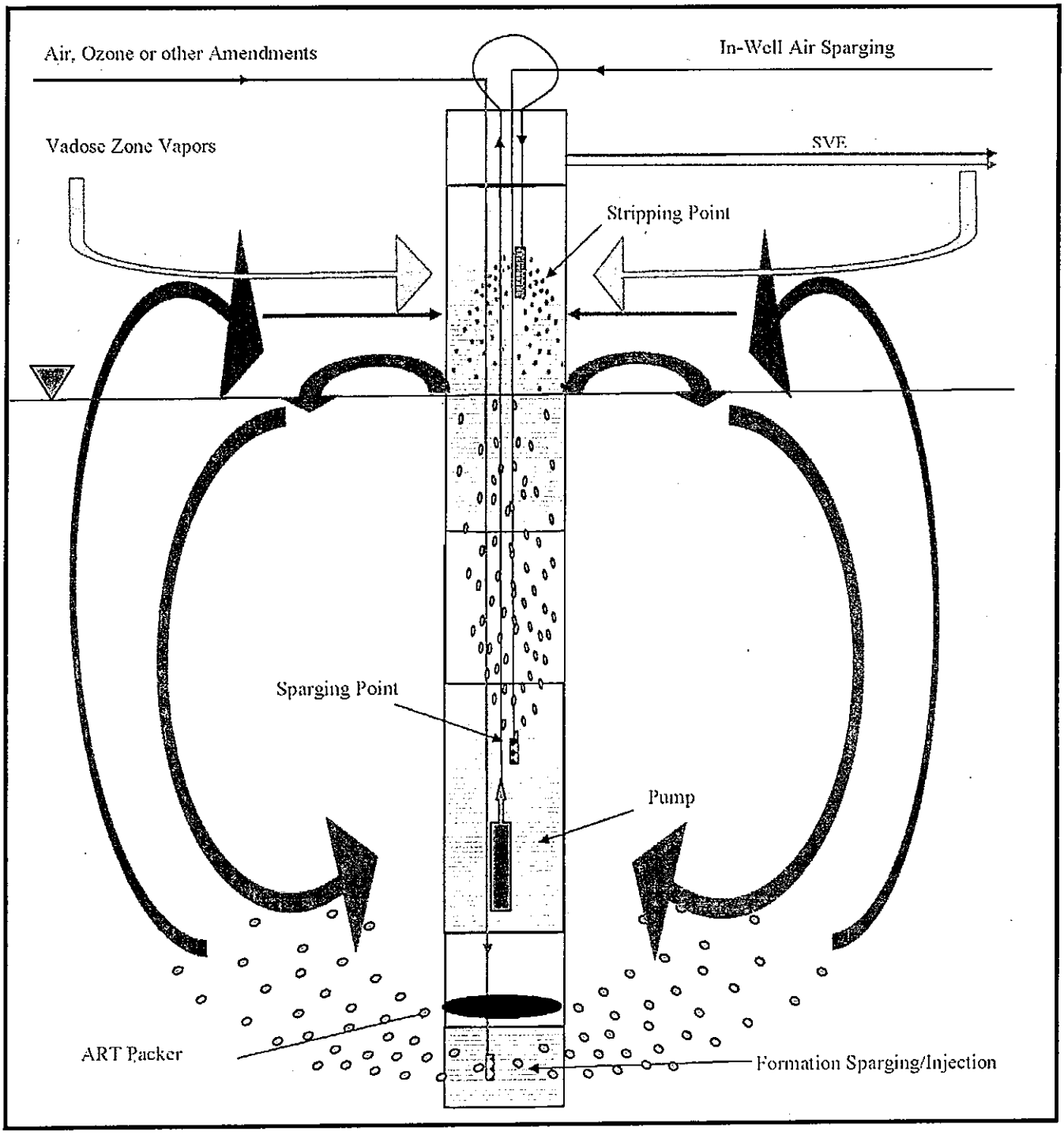

FIGURE 2

ART-Jection Technologies

VOC and 1,4 Dioxane Case History
ART In-well Remediation Technology

Accelerated Remediation Technologies, LLC (*ART*) was secured by a major aerospace company to implement the *ART* In-Well Technology at a 1,4-dioxane impacted site in North Carolina. The client and consultant elected to install the *ART* In-Well Technology in a single well in the source area to evaluate its ability to treat VOCs and 1,4-dioxane. *ART* worked closely with the client's consultant to configure and install the *ART* Technology in a saprolitic soil over fractured bedrock.

The *ART* Demonstration Well was installed in the source area where 1,4-dioxane concentrations exceeded 43,000 µ/L. Two monitoring wells were positioned 10 and 20 feet downgradient from the *ART* well. The 1,4-dioxane concentrations in the adjacent groundwater monitoring wells and in extracted vapors were analyzed. Groundwater results for 1,4 dioxane are listed below. Analytical testing of the vapor stream indicated that significant amounts of 1,4-dioxane and other chlorinated compounds were being stripped from the subsurface.

	MW-1	MW-2	Vapor
Distance from *ART* Well	10 feet	20 feet	
Initial Concentrations (µg/L)	25,000	28,000	490
30 Days Concentrations (µg/L)	7,500	2,600	740
60 Days Concentrations (µg/L)*	27,000	7,700	ND
90 Days Concentrations (µg/L)	7,400	2,400	1,100

* Evaluation of sampling procedures indicates that results for this round may be inaccurate.

The integrated remediation concepts employed by the *ART* Technology result in multiple, in-situ stripping passes of each unit of water, flushing of the vadose zone and circulation within the soil/water column. Accordingly, it is believed that the flexibility of the *ART* design enabled the treatment of each unit of water several times to compensate for the low stripability of 1,4-dioxane. Further, for total VOC recovery, the single *ART* well outperformed a 10 SVE and 6 sparge point system that had been operating since 1994 (see below).

System	1,1,1-TCA	1,1-DCA	1,1-DCE	PCE	TOTAL (lbs.)
AS/SVE	0.06	0.07	0.06	0	**0.19**
ART Well*	8.06	0.37	0.58	0.38	**9.39**

*similar time period as AS/SVE system

Summary: The *ART* Technology proved that it effectively and cost efficiently reduced 1,4-dioxane concentrations in surrounding wells by more than 90% in a few weeks. At this site, the *ART* approach has been deemed to be more cost efficient than groundwater extraction and surface treatment technologies and has outperformed the existing AS/SVE system. The *ART* Technology has now been approved by the state as the primary remediation method for the site.

For Additional Information Contact:

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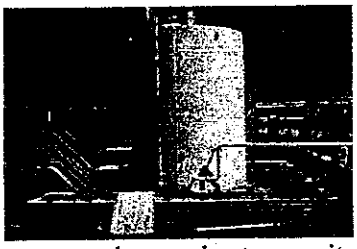
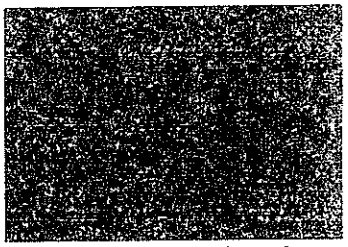
Chlorinated Solvent Plume Remediation

Midwest United States





ERM was contracted by a confidential client to implement a remedial action program to address groundwater impacted by chlorinated solvents. The site is a former manufacturing facility, which used an underground storage tank for waste oil generated by manufacturing operations and cleaning activities. During excavation of the tank, it was determined the feeder line was leaking waste oil containing chlorinated solvents, including PCE and 1,1,1-TCA.

The site is located in the river deposits of a Midwestern United States river characterized by interbedded silts and sands to a depth of about 12 feet, and medium to fine grained sands below 12 feet. Groundwater was encountered at a depth of approximately 30 to 35 feet.

ERM's Approach

ERM evaluated several different remedial technologies including air sparge and soil vapor extraction, pump and treat, and in-situ chemical oxidation oxidation. When evaluating these alternatives, ERM considered several different factors, including:

- Stratigraphy
- Short term capital investment and operating costs
- Impact to current operations and neighbors
- Potential longer term costs to closure

ERM identified the ART In-Well Stripping System as the preferred technology at this site. ERM designed an approach that initially included one ART well with a mechanical system capable of manifolding up to three wells, if required. The ART well was installed to a depth of 65 feet, with the pump installed at a depth of 50 feet. ERM worked closely with ART to establish the optimum operating parameters and observe the impact of the system on the aquifer system. ERM operated the system in different configurations to establish the efficacy of each component of the system, as well as assessing where the majorette of mass was expected to be recovered. ERM recorded water levels and vacuum reading in observation wells and existing monitoring wells, collected frequent groundwater samples, collected frequent air samples from the system piping, while varying the flow and pumping rates within the system, and dissolved oxygen levels in observation points and groundwater monitoring wells to assess the sphere of influence from the system

After reviewing the data obtained from the pilot study and establishing the longer term operating parameters, ERM implemented the system on a full scale basis.

Results

Induced vacuum was detected in wells located up to about 40 feet from the ART well, while the water levels showed impacts approximately 30 feet away from the ART well. The analytical results from groundwater samples collected over time showed that the concentrations of constituents of concern (primarily PCE) decreased from approximately 200 micrograms/liter (µg/L) to less than the MCL (5 µg/L) in the source area in about 8 months.

The system was operated for approximately 14 months total, and then shut down. Rebound sampling showed very little rebound in groundwater concentrations at the source area. Site is pursuing a No Further Action conclusion from the regulatory authority.

Conclusions

The installation of the ART In-Well system achieved the remedial cleanup objective at the source in a time frame that was faster than anticipated with other traditional remedial technologies at a cost estimated to be approximately 20 to 30 percent less than other technologies, including installation and power costs. Importantly though, the ART system did not require above ground treatment of groundwater or wasting of water to the sewer, thus providing a sustainable approach to the remediation of the impacted groundwater.

For additional information, please contact:
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(610) 524 3644
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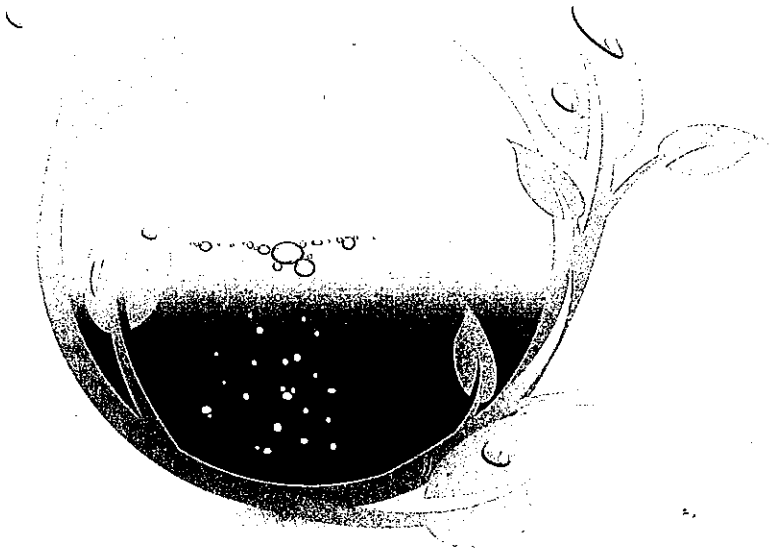
ART

Accelerated Remediation Technologies, Inc.

Soil and groundwater remediation is our "art"



Remediation Services

Effective

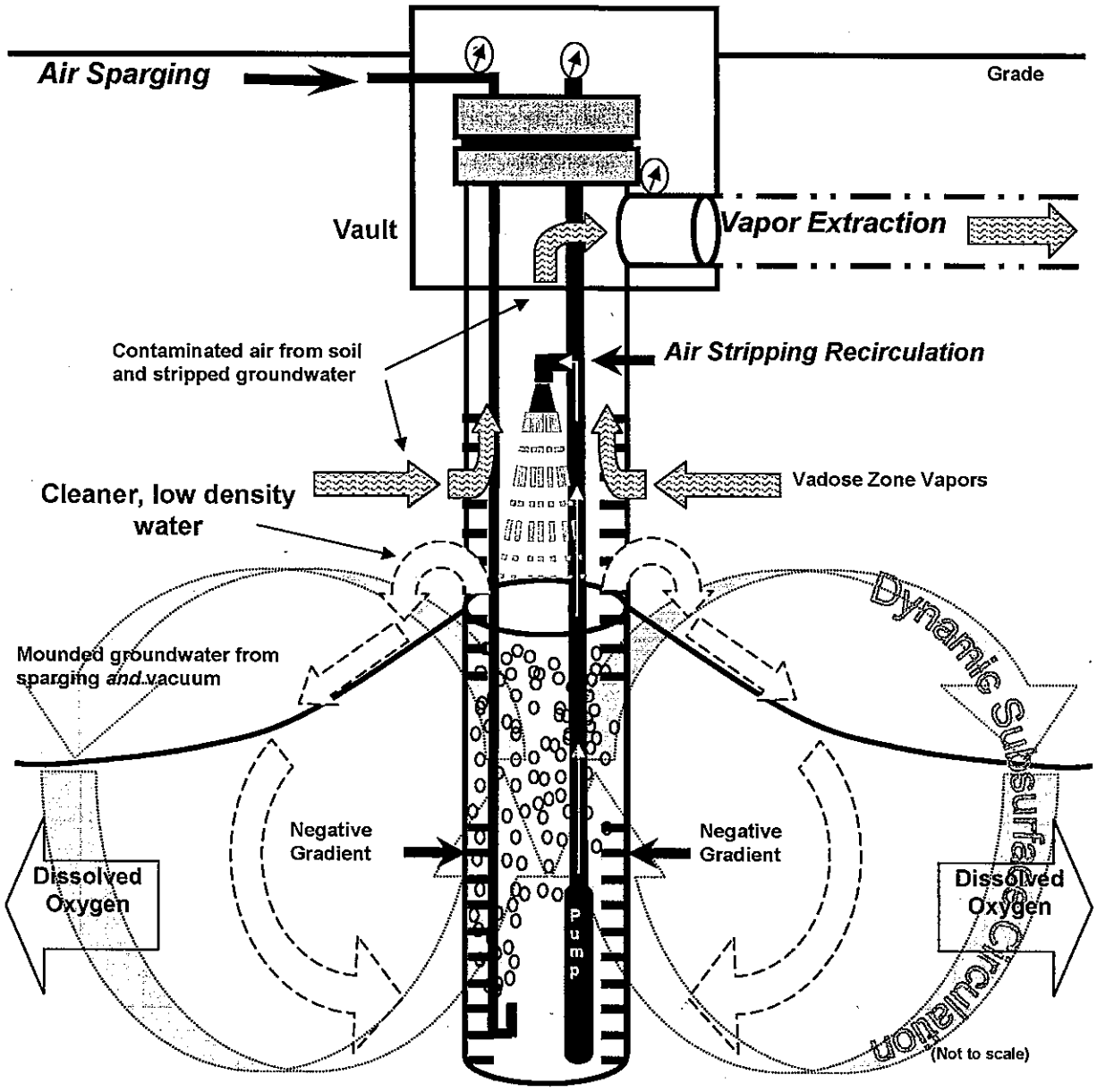
Efficient

Proven

Technologies that make sense...

ART Integrated Technologies

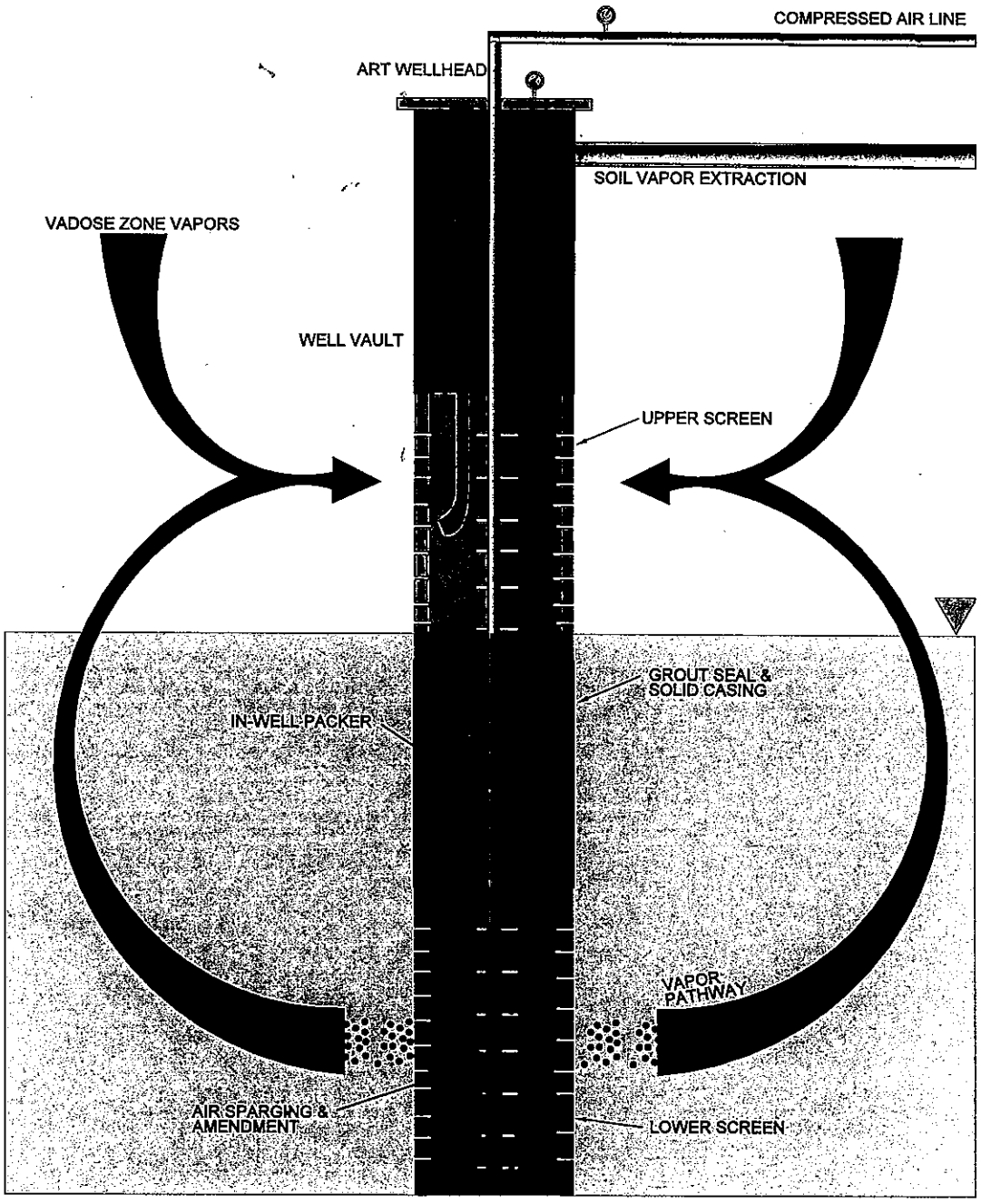
Accelerated Remediation Technologies, Inc. (ART) continues to provide our clients the most effect site closure in months, not years. We made it happen at sites where other technologies did not del



The ART Technologies combine in-well air stripping, air sparging, vapor extraction, flushing, bioremediation/oxidation and other processes acting simultaneously in an innovative re-circulation well design. The ART Technologies proved effective at a wide range of subsurface conditions including fractured bedrock formations at sites worldwide. The ART Technologies have been impressive in treating a myriad of contaminants including chlorinated and petroleum compounds, MTBE and 1,4 dioxane.

Single-Point AS/VE Technologies

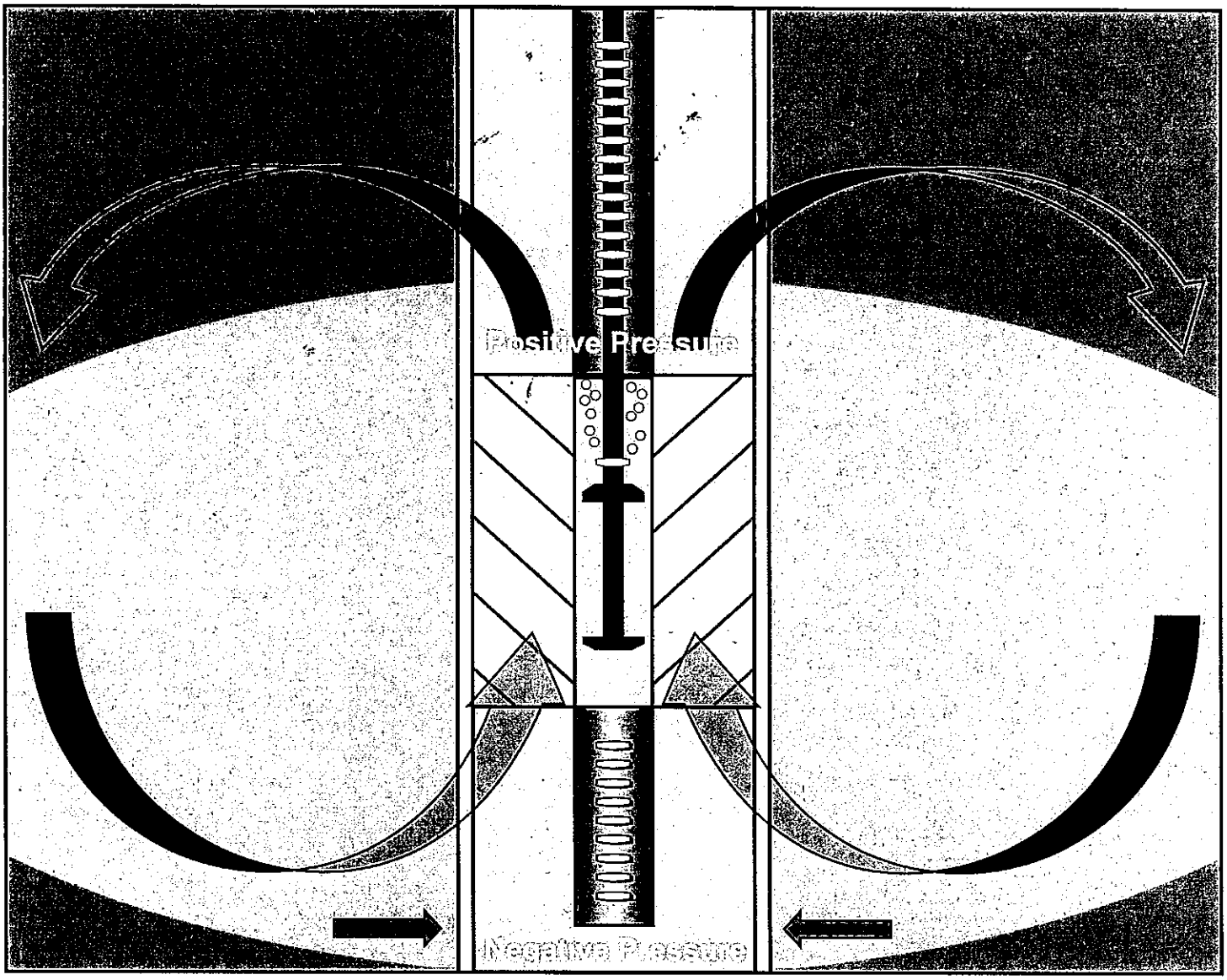
ost efficient in-situ remedial technologies. The ART Technologies consist of eight proven concepts working sy
clients range from governmental agencies and Fortune 500 companies to small single operations, worldwide



The ART Single-Point AS/VE Technologies combine advantages of air sparging, vapor extraction and aerobic degradation while it minimizes vapor intrusion and flow channeling potentials. The design is based on utilizing separate screens in the same well to sparge and extract vapors, reducing the number of sparging and extracting points and associated piping, trenching and waste generation. Amendments

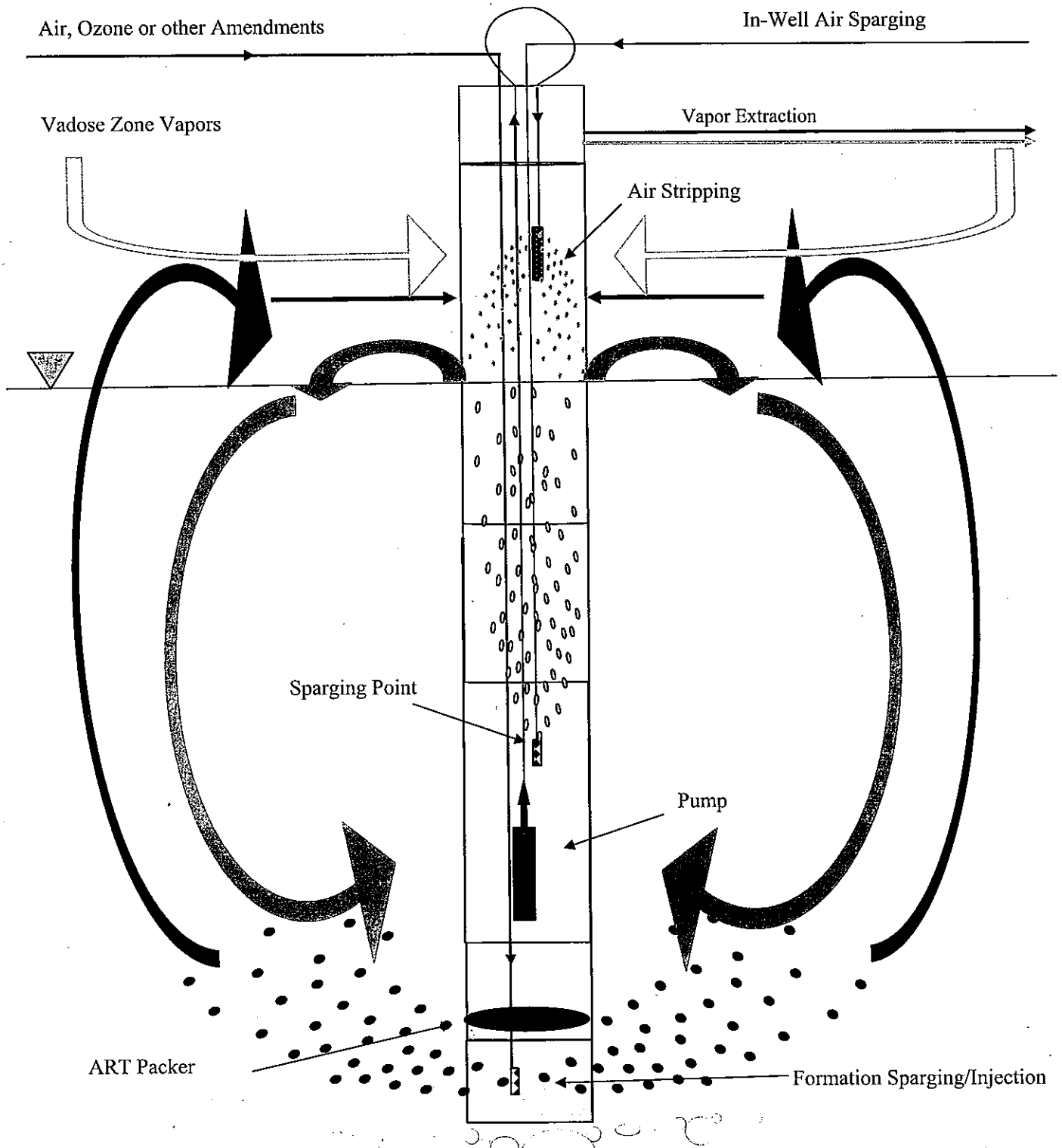
LowPerma Technologies

ically to remedy soil and groundwater. Our goal at every installation is to exceed expectations and achieve



ART developed the Low Perma Technologies to remedy soil and groundwater in low permeability formation impacted with volatile, semi-volatile and other compounds. The technologies are based on well-proven and established concepts including in-well air stripping, flushing, vapor extraction and bioremediation. Contaminated water extracted from the lower screen under high vacuum is treated [illegible] through the upper screen back into the formation. Amendments may also be injected

ART-Jection Technologies



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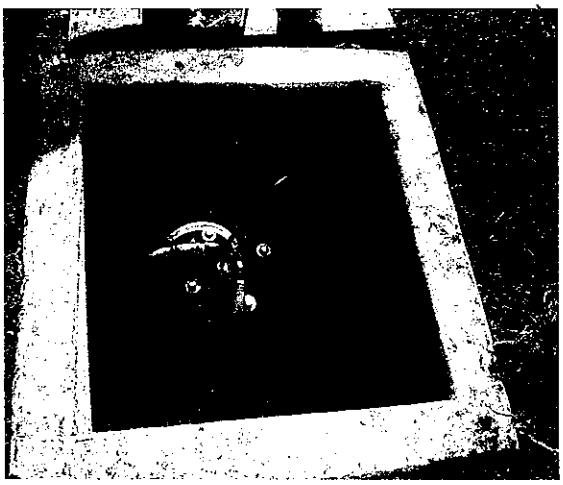
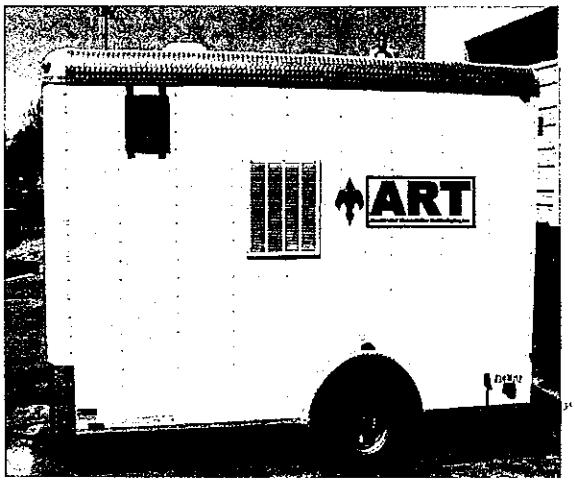
Consulting • Design • Installation



Flexibility is an inherent part of the ART design. Well heads may be completed above or below grade depending on site specific needs.



Our demonstration units may be leased to pilot test and evaluate performance of the ART Technologies at any site. The mobile units contain air compressors and regenerative blowers with process controls similar to full scale systems. These units provide clients a low cost option to determine the feasibility and effectiveness of the ART Technologies at sites prior to a full-scale implementation. The ART demonstration option simplifies the decision on the next remediation step.