

出國報告（出國類別：實習）

## 赴美國 ATL 公司學習放射性廢棄物及 環境復育之政策制訂與處理技術

服務機關：核能研究所

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## 摘 要

赴 ATL 公司並學習該公司的相關計畫管理與執行經驗，除此之外，並聯絡有關放射性廢棄物處理之相關廠商，針對各種放射性廢棄物的處理方法、檢驗技術與處理經驗，與負責人聯絡並安排與其討論該公司於此領域之經驗。另安排行程到美國 NRC 總部學習環境復育法規之政策制訂與法規規範等，以期回國後可以檢視國內應用到廢料處理場、核能電廠或其他廢棄物處理單位之法規。另一重要目的是要拓展與美國核能界之人際關係，多認識 contractors 及儀器設備廠商等，回國後有較多人際關係資源可以應用。

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## 壹、目的

此次公差行程主要是以 ATL(Advanced Technologies and Laboratories)公司為據點，盡其所能學習該公司之接洽能源部(DOE)的相關計畫管理與執行經驗外，並聯絡有關放射性廢棄物處理之相關廠商，針對如廢土或廢液等之各種處理方法、檢驗技術與處理經驗，與負責人聯絡並安排與其討論該公司於此領域之經驗。並且安排行程到 NRC(Nuclear Regulatory Commission)總部學習環境復育法規之政策制訂與法規規範等，除了拓展人際關係外，更期待回國後可以應用到廢料處理場廢土及其他廢棄物之處理。

此次實習之另外重要目的之一，是要拓展與美國核能界之人際關係，多認識政府人員、contractors 及儀器設備廠商，以便回國後有較多人際資源可以應用於所內相關的研發工作。



## 貳、過 程

### 一、公差行程(台灣時間)

10 月 19 日 台灣出發

10 月 20 日 抵達(飛抵西雅圖國際機場，轉機至公差地點 Pasco)

10 月 21 日~12 月 2 日 於 ATL 公司學習放射性廢棄物及環境復育之  
政策制訂與處理技術，並聯絡相關廠商

12 月 3~11 日 至 Washington DC 參訪 ATL 公司總部及 NRC 總  
部並討論法規

12 月 12~13 日 整理研習資料，撰寫報告

12 月 14~16 日 回程

### 二、公差研習記錄

於 10/21(US time)第一次到黃博士公司-ATL，首先設定電腦使用權限並介紹同事認識，由 Tom Harper 先生及 Tracy 小姐(兩位主要負責工作為該公司各種計畫案之管理)接見，討論我方的需求及想要學的技術，首先由 Tom Harper 先生介紹 ATL 公司，主要工作是接洽 Hanford Site 的計畫，並且說明安全是公司的第一守則，進出公司都要登記等注意事項，之後開始討論我方有關土壤復育及廢棄物處理的議題，對方強調基於安全考量無法提供公司內任何有關 Hanford 的計畫內容或技術性文件，可接觸的文件都可從 DOE 網站或是 Google 等搜尋到，該公司可以針對我方提供的相關資料與我方討論細節，著實瞭解對方對於安全的重視。

與 ATL 老闆黃博士討論很多議題，包括：(1)土壤除污(2)吸附劑(3)含氫廢水排放等。對於土壤除污，黃博士建議使用  $\gamma$  偵檢器先行篩檢

各太空包的活度後，再依自己訂定的處理標準判斷此包是否需要處理或是貯存掩埋，依此原則將土壤分成兩部分後再行處理低劑量的部分。美國有許多偵檢器的廠商(如 Canberra 或 ORTEC 等公司，黃博士原本答應幫忙接洽認識人員並與其討論，但後來因黃博士太忙而自行尋找)都有設計及製作，整組設備費用可能高達 300 萬美金，但如果由 ATL 幫忙設計組裝並將軟體特製化後，費用將可減少許多，設計的主要原則是將土壤中的 Cs-137 核種找出，等移除熱點(Hot spot)後其他土壤則可以不用處理或是依低放射性廢棄物處置。偵檢器大小需要可將一噸重的太空包放入為主，而偵檢器最少需四面，並由軟體模擬算出並標示出 3D 空間中的熱點，經初步判斷，只有高活度的土壤才經過水處理，將 Cs-137 核種清洗到水中，並加入 Cl 離子，可形成 CsCl<sub>2</sub> 等化合物後沈澱，連吸附劑都不用就可將核種去除。美國處理污染土壤的單位很多，也試過很多方法，包括水洗，加熱，掩埋等，但現在各個處理單位(如國家實驗室等)經費不足，許多較耗能或複雜的程序漸漸不被採用，而對於核研所想要採取的加熱至高溫後將 Cs-137 趕走的方法並不贊成，他認為變成氣體後的核種最為棘手，需要考慮密閉等問題，一旦發生洩漏則會很麻煩。

美國現在處理土壤有土地廣大的優勢，只要將掩埋場(landfill)蓋好，就可將土壤倒入保存 50 年以上，故漸漸也不處理而以貯存代替。吸附劑部分黃博士並不清楚，因其接觸的都是計畫管理等，因此並沒有認識的廠商。而氙的排放黃博士也認為與水混合後排放即可，但是排放的總量及限值需要注意。

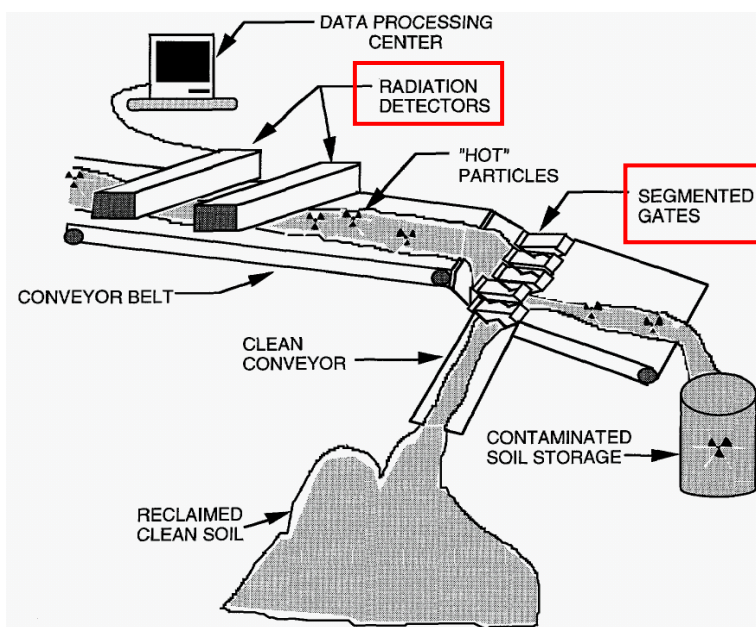
### (一) 公差學習標的

出差到美國前已經先行收集想要學習的相關資料，到達美國後持

續查詢資料，並將想要學習的內容條列如下，希望可以較快與相關的廠商接觸，而與 Tom 及 Tracy 討論後，他們答應就我方要學的內容聯絡認識的相關人員，請求給予相關資訊或是技術，透過電話或是見面進行交流。而 Jou Hwang 也提供認識的廠商名片數個，希望透過 email 先與對方聯絡，並告知我方的要求，從而得到資訊或是相關技術聯絡人等。以下是此次公差擬學習的項目：

## 1. Soil Remediation

We plan to deal with our contaminated soil of nearly 16,000 m<sup>3</sup> by the method shown below that Los Alamos National Laboratory did, and the red blocks are the most important parts that we want to learn and communicate with related contractors that had similar experience nearby. Here are the companies that we know and want to contact with:



Radiation Detector:

Canberra (1-800-243-4422 or (203)238-2351)  
CH2M Hill Plateau Remediation Company (dealt with 200-MG-1 and BC Control Area in Hanford Site)

Others?

Segmented Gates:

Eberline (headquarter in New Mexico and office in Richland, Washington)

**Table 2. SNAP™ Experience**

Client	Location	Experience
Los Alamos National Laboratory	Los Alamos, NM	Providing radiological characterization services for low-level/TRU waste segregation since 1994; also provided SNAP™ software to multiple LANL clients
Kaiser-Hill Company, LLC	Golden, CO	Providing radiological characterization services using SNAP™ in support of decommissioning projects since 1999
Fluor Hanford, Inc.	Richland, WA	Provided radiological characterization services using SNAP™ in support of 233-S Process Building decommissioning
Bechtel BWXT Idaho, LLC	Idaho Falls, ID	Providing mobile NDA services for low-level/TRU waste segregation
Lovelace Respiratory Research Institute	Albuquerque, NM	Provided services using SNAP™ for characterization of waste <i>in situ</i> and in drums for shipment and disposal
BWXT of Ohio	Miamisburg, OH	Provided radiological characterization and low-level/TRU segregation of more than 300 miscellaneous and irregularly shaped items
Battelle Memorial Institute	Columbus, OH	Provided radiological characterization of 68 waste drums and boxes, including B-25 boxes, 55- and 30-gallon drums, and very large specialty boxes; data used to make low-level/TRU determinations for some of the waste items
ICF Kaiser	Colonie, NY	Performed NDA of 1,600 yd <sup>3</sup> of uranium-contaminated wood chips in 96-ft <sup>3</sup> waste boxes to determine whether the material met the criteria for free release, release on site, or offsite disposal
AWE Aldermaston	United Kingdom	Provided training and SNAP™ software
Sandia National Laboratories	Albuquerque, NM	Provided training and SNAP™ software

RWE NUKEM GmbH (branch in Danbury, CT, phone: +1 203-778-9420)

Savannah River Site used it to treat 800 tons soil

LANL

Sandia National Laboratories, ER Site 16 and 228 & TA-II C&D Equipment (crushing and screening equipment in

Florida, [www.aggregatepros.com](http://www.aggregatepros.com) , 型錄如附件一所示)

Terex (in Spokane, Valley Equipment Company, Inc., )

If the radioactivity of soil is too high, we need to use washing method to treat that soil.

Soil Washing: ORNL

ART Inc. (Tampa, Florida, lead by Hanford Westinghouse Company)

Earthline Technologies

Roy F. Weston

New Mellenium

Brice Environmental Services Corp.  
Paulson Constrution(California)  
Others?

## **2. Nitrate Ion Treatment**

Using chemical reducing reagent, such as active metals, borohydride, formic acid, hydrazine or hydrogen, to reduce nitrate ion in waste water below the level of 10 ppm.

## **3. TRU Treatment**

## **4. Other Radioactive Liquid Waste Treatment**

### **(1)Mercury Treatment:**

Perma-Fix Northwest, Inc. (PFNW)(also has experience in Low Level Waste Treatment, locate in 2025 Battelle Blvd.Richland, WA 99354, (509) 375-5160)

### **(2)Absorbent:**

For Cs-137 and Sr-90 (IONSIVE in Tennessee)

### **(3)Tritium Discharge**

### **(4)Organic Radioactive waste water**

## **5. Final Disposal and Low Level Waste Disposal**

### (二) 污染土壤處理文獻及廠商資料

於 10/24(US time)開始到公差結束期間，持續上網查詢 DOE Scientific and Technical Information 資料庫及 Google 等公開網路資源，找出相關的污染土壤處理文獻或公司，並經由文獻整理出土壤水洗的廠商，相關的文獻及污染土壤處理廠商整理如下：

1. Suer, Ahmet, "Soil washing technology evaluation", Report number: WSRC-TR--95-0183, Westinghouse Savannah River Co., Aiken, SC (United States), 1995

土壤除污的評估流程如下：

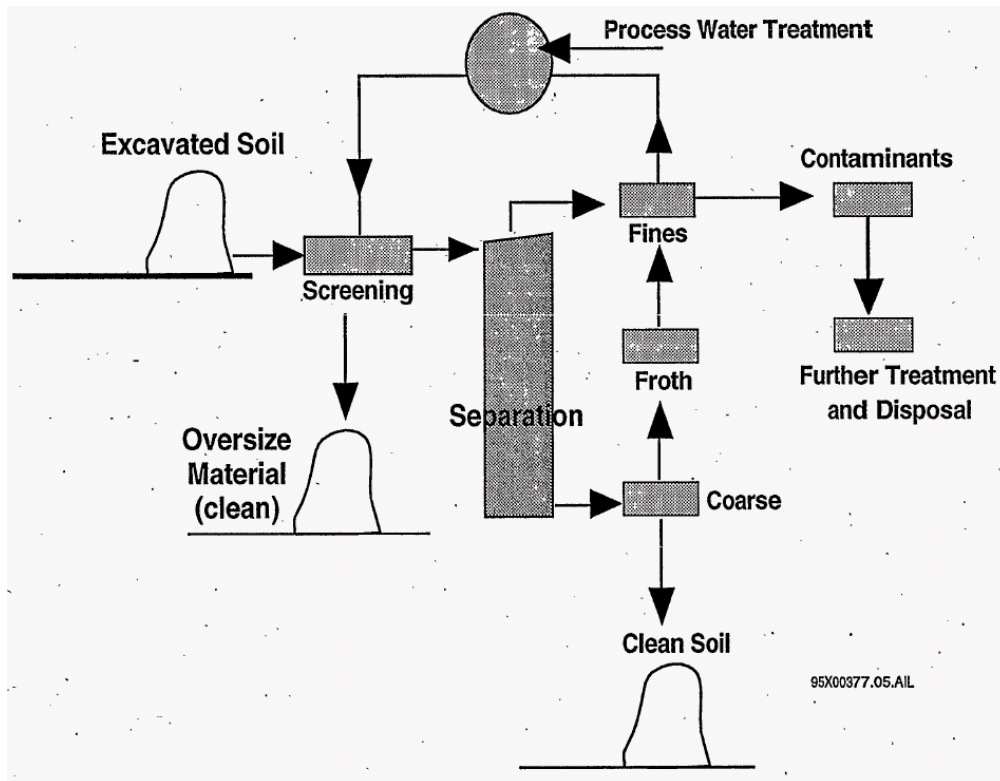


圖 2.1 土壤除污之評估流程(Ahmet, 1995)

並於報告中詳列各執行過土壤除污的廠址及各個 contractors，名單如下(底線表示該 Contractor 在國家實驗室做過土壤清洗)：

- (1) ART, Inc.
- (2) AWC/Lockhead
- (3) Biogenesis
- (4) Bergmann USA
- (5) Canonie Environmental Services
- (6) Cognis Inc.
- (7) Ecova
- (8) Genesis Eco System
- (9) Interra
- (10) OI-IM
- (11) SEG (Westinghouse)
- (12) Tuboscope Vitco International Environmental Services
- (13) Waste Management/Rust

## (14) Westinghouse Remediation Services

2. U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office, “Proceedings from the remediation of radioactive surface soils workshop”, DOENV--798, USA, 2001

文中列出許多處理廠商的基本資料、擁有之處理經驗及處理土壤種類的資訊，如下表 2.1 所示，因此，針對表 2.1 整理出參與廠商之公司網址、聯絡人資訊等，並寫信與其聯絡是否可提供土壤除污等相關資料，當中有許多公司已經不存在(使用刪除線——表示)或是當事人已經離開該公司，故條列可聯絡到之資料如下：

- (1) MT2(Metal Treatment Technologies), <http://www.metalstt.com/>,  
地址: 14045 West 66th Avenue • Arvada, CO80004  
電話: 888-435-6645 Toll-free, 303-456-6977  
聯絡人: PeJames F. Uhlinger, PG, *REMEDIATION SERVICES / FIRING RANGE SERVICES*, [juhlinger@mt2.com](mailto:juhlinger@mt2.com) 或  
Mark Peters, 303-456-6977, [mpeters@metalstt.com](mailto:mpeters@metalstt.com)(無法通信)
- (2) Oak Ridge National Laboratory, <http://www.ornl.gov/>
- ~~(3) University of Nevada Reno (UNR), <http://www.unr.edu/>(公司已不存在)~~
- (4) Brice Environmental Services Corporation,  
<http://www.briceinc.com/>  
聯絡人: Craig Jones, phone: 907-456-1955, [craigj@briceinc.com](mailto:craigj@briceinc.com)  
或公司信箱 [albab@briceinc.com](mailto:albab@briceinc.com)
- ~~(5) Earthline Technologies, <http://www.earthlinetech.com/>(公司已不~~

存在)

(6) Eberline Services, <http://www.eberlineservices.com/>(可聯絡上)

(7) ~~JVI Companies, <http://www.jvicompanies.com/top.htm>(公司已不  
存在)~~

(8) URS Corp and ZYIC, LLC, <http://www.urscorp.com/main.htm>(台  
灣有分公司)

總部地址: 600 Montgomery Street, 26th Floor, San Francisco, CA  
94111-2728 USA

總部電話:+1.415.774.2700

聯絡人: Ye Yi, 801-904-4000, [ye\\_yi@urscorp.com](mailto:ye_yi@urscorp.com)(無法通信), 756  
East Winchester Street, Suite 400, Salt Lake City, UT,  
84107-7560

台灣分公司電話: 02-2916-0061

(9) Roy F. Weston, Inc.(改名為 Weston Solutions, Inc., 台灣有分公司),  
<http://www.westonsolutions.com/>

總公司地址: 1400 Weston Way, PO Box 2653, West Chester, PA  
19380

總公司電話: Toll Free: 1-800-7WESTON, Phone: 610-701-3000

聯絡信箱: [info@westonsolutions.com](mailto:info@westonsolutions.com),

台灣分公司電話: 02-2721-0231

(10) Brookhaven National Laboratory, <http://www.bnl.gov/>

(11) MacTec(改名為 Amec), <http://www.mactec.com>

總公司地址: 1105 Lakewood Parkway, Suite 300, Alpharetta, GA  
30009

總公司電話: 770-360-0600

聯絡信箱: MacTec 網站內留言



(12) IT Corporation, <http://www.theitgroup.com>(公司倒閉)

(13) Knelson Concentrators, <http://www.knelson.com>

總公司地址: 19855 98 Ave., Langley, British Columbia, Canada

V1M 2X5

總公司電話: +604-888-4015

聯絡信箱: [knelson@knelson.com](mailto:knelson@knelson.com)

表 2.1 污染土壤各處理廠商資料(DOE et al., 2001)

**Vendor Technologies Survey Summary**

(Page 1 of 6)

Company	UNR	Earthline Technologies	Roy F. Weston
<b>Contact Information</b>	Rajendra Mehta University of Nevada, Reno OSPA/Mail Stop 325 Reno, Nevada 89557 775-784-4040 mehta@mines.unr.edu	Jeff Kulpa Earthline Technologies 1800 East 21st Street Ashtabula, OH 44004 440-993-2804 jeff_kulpa@earthlinetech.com	Sayan Chakraborti Roy F. Weston, Inc. 1400 Weston Way, Bldg. 5-2 West Chester, PA 19380 610-701-3022 chakrabs@mail.rfweston.com
<b>Technology</b>	Centrifugal Gravo-magnetic Concentration	Soil Washing	Soil Washing
<b>Technology Description</b>	centrifugal gravomagnetic separation and flotation processes	smart physical separation + chemical extraction soil washing	Physical separation based on mining engineering principles combined with Segmented Gate System at the back-end
<b>Maturity</b>	Bench (3 inch) to Full Scale Capability	Bench to Full Scale Capability	Bench to Full Scale Capability
<b>Amount Required for Bench Scale Demo</b>	kg amounts	kg amounts	kg amounts
<b>Radionuclides</b>	U, Pu, Th at the bench	U, ?? At bench through FS	Currently used for U, Ra. Can be applied to Pu by adjusting process operating parameters
<b>pCi/gm</b>	22-28870	100	Input: U - ~1100 pCi/g, Ra - ~600 pCi/g Output: U - <22 pCi/g, Ra - <7.2 pCi/g
<b>Volume Reduction</b>	70-99%	70-97%	Up to -95% achievable by the process. Current process operates at 55-60% based on the life cycle economics of transportation and disposal cost at Envirocare <sup>a</sup> .
<b>Removal Efficiency</b>	25-95%	≥50%	Not Applicable
<b>Soil Sources</b>	INEL, LANL, Fernald, NTS, JA	Ashtabula	Any soil within the range of sandy to moderately clay will work
<b>Full scale throughput</b>	40-50 tph	20-40 tph	80 tph
<b>Portable?</b>	Yes	Yes	Yes
<b>Water Consumption</b>	High, but can probably be recycled	Moderate, but can be recycled	Moderate, but can be recycled
<b>Secondary Wastes</b>	Spent water	<3% of the feed volume	Minimal
<b>Treatment Costs</b>	\$1.21/ton	\$75-300/ton	\$7-10/ft <sup>3</sup>
<b>Potential for HW/MW/TRU generation?</b>	Possible TRU in rich soil fraction	Possible TRU in concentrate	No TRU wastes are generated in the current project, and none are expected for application to NTS soils

<sup>a</sup> If there is a hike in these costs in the future, then it will make sense to increase volume reduction up 95% or to the extent needed to offset increase in the transportation and disposal cost per cubic foot.

**Vendor Technologies Survey Summary**  
(Page 2 of 6)

Company	URS	ART	Retech
<b>Contact Information</b>	Ye Yi URS Corporation 756 East Winchester Street, # 400 Salt Lake City, Utah 84107 801-904-4000 ye_yi@urscorp.com	Carl Seward Art Engineering, LLC 12526 Leatherleaf Drive Tampa, FL 813-855-9852 cseward@tampabay.rr.com	Ronald K. Womack Retech Systems, LLC 100 Henry Station Road Ukiah, CA 95482 707-467-1721 ronald.k.womack@retechsystemsllc.com
<b>Technology</b>	Flotation	Soil Washing	Vitrification
<b>Technology Description</b>	Air-Sparged Hydrocyclone Flotation	Physical/Chemical Separation	Plasma Arc Centrifugal Treatment (PACT)
<b>Maturity</b>	Bench to Full Scale Capability	Bench to Full Scale Capability	Bench to Full Scale Capability
<b>Amount Required for Bench Scale Demo</b>	g to kg amounts	2-30 kg	kg amounts
<b>Radionuclides</b>	Pu	U, TH, Ra	Pu
<b>pCi/gm</b>	Unknown	??	1500-2500
<b>Volume Reduction</b>	80-90%	??	60-70% volume decrease of soil upon vitrification
<b>Removal Efficiency</b>	Unknown	Unknown	Not Applicable
<b>Soil Sources</b>	NTS	Hanford, Maywood, Ashtabula, numerous others	INEEL
<b>Full scale throughput</b>	10 tph per unit	10-100 tph	12 kg/hr pilot 500 - 1,000 kg/hr full scale (6,000 - 10,000 tpy)
<b>Portable?</b>	Yes	??	Yes?
<b>Water Consumption</b>	High, but can be recycled	Moderate, but can be recycled?	Minimal/none?
<b>Secondary Wastes</b>	Minimal	Minimal	None except for equipment components. Minor volatilization of radionuclides can occur.
<b>Treatment Costs</b>	\$10-13/ft <sup>3</sup>	<18 ft <sup>3</sup>	Unknown
<b>Potential for HW/MW/TRU generation?</b>	Possible TRU in concentrate	Possible TRU in concentrate	No

**Vendor Technologies Survey Summary**  
(Page 3 of 6)

Company	IT	New Mellenium	Electropetroleum
<b>Contact Information</b>	Ed Alperin IT Corporation 304 Directors Drive Knoxville, TN 37923 865-694-7335 ealperin@theitgroup.com	Sue Aggarwal New Millennium Nuclear Technology 900 E. Copeland, Suite 210 Arlington, TX 76011 817-277-2427 saggarwal@nmg.org	J. Kenneth Wittle, Ph.D., Vice Pres. Electro-Petroleum, Inc. 996 Old Eagle School Rd. Wayne, PA 19087 (610) 687-9070 kwittle@electropetroleum.com
<b>Technology</b>	Bioremediation	Soil Washing	Electrokinetic
<b>Technology Description</b>	biologically-mediated removal and treatment of plutonium (Pu), other radionuclides, and heavy metals in soil	Physical/Chemical Separation	Electrophoresis, electro osmosis, ion migration
<b>Maturity</b>	Bench to Full Scale Capability	Bench to Full Scale Capability	Unknown
<b>Amount Required for Bench Scale Demo</b>	kg amounts	kg amounts	kg amounts
<b>Radionuclides</b>	Pu, Am	NORM	Unknown
<b>pCi/gm</b>	35	Unknown	Unknown
<b>Volume Reduction</b>	95-99%	Unknown	Unknown
<b>Removal Efficiency</b>	80%	Unknown	Unknown
<b>Soil Sources</b>	NTS	Unknown	Unknown
<b>Full scale throughput</b>	up to 70,000 yd <sup>3</sup> per biopile. 14 months duration	Unknown	Unknown
<b>Portable?</b>	Yes	Unknown	Unknown
<b>Water Consumption</b>	High (about 60 gal/yd <sup>3</sup> ), but can be recycled?	Unknown	Unknown
<b>Secondary Wastes</b>	Minimal	Unknown	Unknown
<b>Treatment Costs</b>	\$150/yd <sup>3</sup>	Unknown	\$30/yd <sup>3</sup> for >100,000yd <sup>3</sup> of HW
<b>Potential for HW/MW/TRU generation?</b>	Possible TRU in concentrate	Unknown	Possible TRU in concentrate

**Vendor Technologies Survey Summary**  
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Company	Brookhaven National Laboratory	Brice Environmental Services Corp.	Knelson Concentrators
<b>Contact Information</b>	Paul Kalb, Division Head Environ. Research & Tech. Division Environ. Sciences Department Brookhaven National Laboratory Upton NY, 11973 kalb@bnl.gov	Craig Jones Brice Environmental Services Corp. 3200 Shell Street Fairbanks, Ak 99707 907-456-1955 craigj@briceinc.com	Knelson Concentrators 19855-98 Avenue Langley, BC Canada V1M 2X5 604-888-4015 knelson@knelson.com
<b>Technology</b>	Sulfur Polymer Stabilization/Solidification	Soil Washing (Physical Separation)	Centrifugal Gravity Concentrator
<b>Technology Description</b>	chemically stabilizes and physically encapsulates the mercury in a solid matrix.	Physical Sizing, Density Sepn, Classification/Attrition, Magnetic Separation, Water Treatment/Dewatering	Centrifugal Gravity Concentrator using Continuous Variable Discharge
<b>Maturity</b>	Bench and Pilot capability	Bench to Full Scale Capability	Bench to Full-Scale Capability
<b>Amount Required for Bench Scale Demo</b>	kg amounts	kg amounts	kg amounts
<b>Radionuclides</b>	Cs-137, Co-60, Sr-90, Am-241	Cs, Sr, U	Unknown
<b>pCi/gm</b>	Tested up to 10,000 pi/gm Am-241	Unknown	Unknown
<b>Volume Reduction</b>	Volume of final product = volume of soil prior to treatment (i.e., no volume increase)	Variable, depending on the particular site. Based on past experience ranging from 75 - 95%	Unknown
<b>Removal Efficiency</b>	Not Applicable	Up to 98%	Unknown
<b>Soil Sources</b>	Mixed waste contaminated soil from remediation of BNL Chemical Holes	Depleted uranium firing ranges, spill sites	Unknown
<b>Full scale throughput</b>	Can be scaled to meet the waste demand. Production-scale process vessels up to 350 cu ft capacity are available.	4.2 tph pilot scale, 30 tph full scale	50-70 tonnes per hour
<b>Portable?</b>	Yes. This technology can be skid mounted and deployed in a portable mode.	Yes	Yes
<b>Water Consumption</b>	None	Moderate, but can be recycled?	High, but can be recycled
<b>Secondary Wastes</b>	PPE, off-gas residuals (which can be reprocessed by the system)	Residual soil volume in some cases (deleted spent water is treated as part of the process)	Spent water
<b>Treatment Costs</b>	Variable, depending on the specific waste stream, level of contaminants, etc.	Variable, based on soil quantity and treatment requirements. Treatment costs decrease with increasing soil quantity on a per-ton basis.	Unknown, expected to be low
<b>Potential for HW/MW/TRU generation?</b>	Yes	Possible TRU in concentrate	Possible TRU in concentrate

**Vendor Technologies Survey Summary**  
(Page 5 of 6)

Company	Eberline Services	Metal Treatment Technologies, Inc.	Normex
<b>Contact Information</b>	Joseph Kimbrell Eberline Services 4501 Indian School Road NE, #105 Albuquerque, NM 87110 505-262-2694 jkimbrell@eberlineservices.com	Mark Peters Metal Treatment Technologies, Inc. 303-456-6977 mpeters@metalstt.com	Jullien Louis Normex International 281-242-7277 kdgni@cs.com
<b>Technology</b>	Segmented Gate System	Solidification/Stabilization	Same as Knelson??
<b>Technology Description</b>	Physical separation of soil based on activity levels. Soil moisture content must be <20%	EcoBond™	Unknown
<b>Maturity</b>	Full Scale	Unknown	Unknown
<b>Amount Required for Bench Scale Demo</b>	N/A	kg amounts	Unknown
<b>Radionuclides</b>	Cs, Co, Ra, Th, U, Am, Pu	Cs, Sr	Unknown
<b>pCi/gm</b>	Unknown	Unknown	Unknown
<b>Volume Reduction</b>	4 - 99%	None	Unknown
<b>Removal Efficiency</b>	N/A	N/A	Unknown
<b>Soil Sources</b>	15 DOE sites	Rocky Flats	Unknown
<b>Full scale throughput</b>	50-200 yd <sup>3</sup> /day	Unknown	Unknown
<b>Portable?</b>	Yes	Yes	Unknown
<b>Water Consumption</b>	Minimal	Moderate	Unknown
<b>Secondary Wastes</b>	None	None	Unknown
<b>Treatment Costs</b>	\$50-1000/yd <sup>3</sup>	Typically 30% to 50% less expensive than traditional methods	Unknown
<b>Potential for HW/MW/TRU generation?</b>	No	No	Unknown

**Vendor Technologies Survey Summary**  
(Page 6 of 6)

Company	JVI Companies	Ground Environmental Services, Inc.
<b>Contact Information</b>	Joseph Messana JVI Companies 13535 S. Torrence Ave, Bldg. T, Chicago, IL 60633 773- 646-2227 Joe@JVI.Net JVIcompanies.com	Joe Kauschinger Ground Environmental Services, Inc. 770-993-3538 dkauschinger@earthlink.net OR Roger Spence Oak Ridge National Laboratory 865-574-6782 spencerd@ornl.gov
<b>Technology</b>	Vacuum Auger Scarification Technology.	<i>In situ</i> implementation technique
<b>Technology Description</b>	Precision excavation of soil surface layers. Online analysis/ measurement and data logging.	Multipoint Injection (MPI™). <i>In situ</i> implementation technique using multiple interactive jets for hydraulic mixing of soil with a variety of treatment agents to stabilize/fix in place or remove (extract/excavate). Demonstrated for shallow land burials and tanks.
<b>Maturity</b>	Design stage, with some pilot scale experience	Ready for field deployment
<b>Amount Required for Bench Scale Demo</b>	N/A, pilot is minimum scale	Not Applicable
<b>Radionuclides</b>	Primary: Plutonium Secondary: Undefined	This implementation technique can be combined with a variety of treatment agents for treating most, if not all, radionuclides identified as contaminants of concern by DOE. These include the actinides, transuranics, fission products and activated species most often listed, as well as the mobile species that generally create plumes (Cs-137, Sr-90, Tc-99). In addition the technique can be used to create the hydraulic barriers at targeted depths and locations to hydraulically isolate the contaminated area. This is not only a general containment strategy, but is key to most strategies attempting to contain or isolate tritium.
<b>pCi/gm</b>	Undefined: Online analysis/ measurement	Unknown
<b>Volume Reduction</b>	70+% possible	None
<b>Removal Efficiency</b>	Not Applicable	Not Applicable
<b>Soil Sources</b>	N/A	Unknown
<b>Full scale throughput</b>	88 LFM	40-ton monolith created with 8 minutes of actual injection time. Site preparation can be done prior to bringing high pressure pumps on site for the actual injection. Actual injection time exceeds field time (including site preparation, mixing injection fluid (aqueous solutions, slurries, grouts), opening/closing valves (that activates or inactivates sets of jet lances), with relative difference depending on job size.
<b>Portable?</b>	Yes, as conceptualized	Yes
<b>Water Consumption</b>	None	Moderate
<b>Secondary Wastes</b>	None	Minimal or none
<b>Treatment Costs</b>	\$1.5 M to fabricate	\$500,000 to treat a small underground storage tank, 20-40% of which is fixed cost
<b>Potential for HW/MW/TRU generation?</b>	None	No

<sup>a</sup> If there is a hike in these costs in the future, then it will make sense to increase volume reduction up 95% or to the extent needed to offset increase in the transportation and disposal cost per cubic foot.

寫信到各公司詢問是否有技術服務或相關處理經驗，信件內容大致如下：

It's nice to have your information on the internet. Your company has been listed as the vendor of DOE and had experience in contaminated soil treatment. I am from Taiwan and will be stay in ATL company in Richland, WA for my internship from now to December 14. It's an opportunity for me to stay in ATL and learn some techniques and experience from them and from other companies in nuclear field.

Our institute back in Taiwan is urgent to deal with contaminated soil as soon as possible and need to discuss with companies that manufacture nuclides detector and screening, segmented gate system, or have soil washing experience. Our soil is mainly contaminated by Cs-137 and part with Co-60. The volume is about 16,000 cubic meter. If you have information or technique service about this topic, please feel free to let me know who I can contact with (by phone or by email) and where I can meet them, etc. By the way, I will be in Washington DC and Gaithersburg, Maryland in the period of Dec. 3-11 and I can arrange to meet you in your branches there.

Thanks for your patient and look forward to your response and cooperating with you in the future. Any clue is very useful for me.

此篇文獻中提到之廠商有回應的如下各節所示，大部分公司都音訊全無，信件如石沈大海般沒有回應。

### 3. CH2M Hill Plateau Remediation Company (<http://www.plateauremediation.hanford.gov/>)

Hanford Site 的 contractors 之一，該公司主要是執行 Central Plateau 環境清理及廢棄物廠址及污染地下水之清理，減少污染地下水排放到 Columbia River 的機會。該公司工作範圍包括固體及液體之廢棄物處理與處置、土壤及地下水復育、Plutonium Finishing Plant 的結束 (closure) 及高放射性污泥之處理等。下圖 2.2 為 CH2M HILL 用挖土機將位於 Hanford Site 內的 200-MG-1 廢棄

物廠址內的土壤移除並裝載到卡車上，該 200-MG-1 位址主要受到丟棄或是燃燒各種殘骸或化學藥品所污染。圖 2.3 顯示挖土機移除 BC Control Area 內的 Zone A 土壤，該 BC Control Area 有 13 平方英里大，此復育工作是由 Recovery Act 經費資助。

結果：該公司並無回應。



圖 2.2 CH2M Hill 公司針對 Hanford Site 內 600-40 waste site 的 Remediation



圖 2.3 CH2M Hill 公司在 Hanford Site 內的 BC Control Area 做土壤復育

除了移除污染土壤外，該公司還利用噴撒種子在土壤上，讓其重新生長植物來進行土壤環境復育，如下圖 2.4 所示。



圖 2.4 在 Hanford Site 內的 BC Control Area 噴撒種子




#### 4. RWE NUKEM GmbH

該公司為德國公司(NUKEM GmbH Industriestr. 13, 63755 Alzenau Germany, Tel.: +49 6023-9106, E-Mail: info@nukem.de), 在美國有分部(NUKEM, Inc., 39 Old Ridgebury Road, Section B-1, Box #9, Danbury, CT06810-5100, USA, Tel.: +1 203-778-9420, E-Mail: info@nukeminc.com)可以聯繫, 該公司處理經驗如下圖 2.5 所示:

### Decommissioning / Site Remediation


#### SITE MONITORING SYSTEM

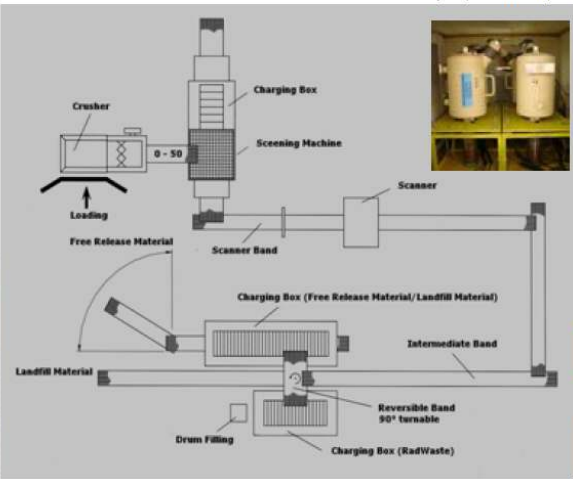


#### Automatic Soil Sorting & Measuring Equipment

*high resolution  $\gamma$ -spectroscopie*

- 10,000 m<sup>2</sup>
- 20,000 tons
- U-234, Th-232 (relevant)
- U-235, Ac-228 (measured)
  
- Length 30m
- Width 40m
- Height 7m





The diagram illustrates the workflow of the soil sorting equipment. It starts with 'Loading' into a 'Crusher', followed by a '0-50' size separator. Material then goes to a 'Charging Box' and a 'Scanning Machine'. A 'Scanner Band' leads to a 'Scanner'. From there, material is directed to a 'Charging Box (Free Release Material/Landfill Material)', an 'Intermediate Band', a 'Reversible Band 90° turnable', and finally to 'Drum Filling' and a 'Charging Box (RadWaste)'. An inset photo shows two large white drums.


RWE NUKEM GmbH

圖 2.5 RWE NUKEM 公司之土壤篩分及量測設備

10/11 從該公司網站寫信留言詢問有關污染土壤處理之經驗及接洽人, 內容大致如下:

I am from Taiwan and stay in ATL in Richland for less than 2 months and I will back to Taiwan on December 14. I studied about your experience in treating contaminated soil and that's what exactly what we need: the sorting and washing etc. soil treatment techniques back in our institute in Taiwan. Please tell me who I can contact with by phone or

email.Thank a lot and look forward to your response.

結果：該公司並無回應。

#### 5.ORTEC Company

由台灣克馬公司陳晉輝老闆幫忙聯絡位於 Tennessee 的人員，但沒有進一步消息。

10/26(US time)起開始陸續寫信給 Jou Hwang 博士介紹的廠商，信件內容大致如下：

Dear SIR,

It's nice to have your information from Jou Hwang in ATL, WA. I am from Taiwan and will be stay in ATL in Richland for my internship to December 14. It's an opportunity for me to stay in ATL and learn some techniques and experience from them and from other companies in nuclear field.

Our institute back in Taiwan is urgent to deal with contaminated soil as soon as possible and need to discuss with companies that manufacture nuclide detector, segmented gate system or have soil washing experience. Attached file is a short brief about our need. If you have information about that, let me know who I can contact with and where I can meet them, etc. By the way, I will be in Washington DC and Maryland in the period of Dec. 4-10 and I maybe can arrange to meet you. But the date has not been determined yet. I'll let you know as the date settling down.

Thanks for your patient and look forward to your response. Any clue is very useful for me.

其中有幾家公司回應，並將其細節整理如下各小節中。

(三) Valley Equipment Company Inc.

於 10/25 寄信到 Valley Equipment Company Inc.詢問土壤篩分裝備等事宜，對方於 10/27 回覆如下內容，並同時檢送該公司之生產機械型錄如附件二所示。

Thank you for your interest in our screening equipment. We have a lot of options for screening equipment. We are a TEREX|Finlay dealer, so I have attached a brochure on the Finlay screen plants we carry. We can also do custom screening equipment to suite your specific needs. I would need to have some more information on what you were looking to do with it. You mentioned you needed to screen 2 tons per hour, which is very little. Our screens we inventory are usually good for around 300 tons per hour screening around 1-1/2" opening. The opening size will greatly effect the capacity of a screen. It takes a lot more screening area to screen on 1/4" opening then it does 1-1/2" opening.

Please let me know if I can be of further assistance.

Sincerely,  
Joe Jensen  
General Manager

***V*alley *E*quipment** Company, Inc.

3730 E Trent Ave. Spokane, WA 99202

Cell: 509-979-6710, Toll Free:1-855-321-5001, Phone: 509-321-5000,  
Fax: 509-321-5007, Email: [joe@valleyequip.com](mailto:joe@valleyequip.com), Web:  
[www.valleyequip.com](http://www.valleyequip.com)

該公司只生產製造土壤篩分之機器，用以將土壤分成不同大小粒徑後分堆，於台灣也有許多此類型之製造公司，因此不需要用到美國之廠商，徒然增加製造處理設備之麻煩，但該型錄詳列許多機器之明細

可以做為日後設計之重要參數。

#### (四) Eberline Services

10/27(US time) Eberline Services 回應如下：

Thank you for your message and please pass my thanks on to Dr. Hwang for his referral. I greatly appreciate his confidence.

Eberline Services offers soil segregation (segmented gate systems) and radiological characterization/mapping tools that have proven very effective in identifying and addressing radiologically contaminated soil. As a matter of fact, I would bet the soil segregation system described by the graphic in your attachment is our system. Also, much of the detection of radiologically contaminated soils performed by CH2M Hill Plateau Remediation Company is done by our staff or with equipment we first developed at Hanford. I have attached a detailed presentation that provides an overview of these capabilities.

After you have reviewed the attached, I would be very happy to meet with or talk to you. I may be in Richland the week of November 14 but, if not, we can talk by phone. Thank you for your interest and I look forward to hearing from you.

Bill Niemeyer, Program Manager, Eberline Services, Inc.  
601Scarboro Road, Oak Ridge, TN37830, 865-291-8930  
bill.niemeyer@eberlineservices.com

並提供檔案如附件三所示。於 11/7 寫信與其聯絡見面等相關事宜，於 11/10 再次電話聯絡並留言是否到 Richland，其回覆表示因為工作忙碌，沒有時間安排到 Richland，但可以安排電話會議討論，並請其提供有關污染土壤處理的技術及經驗，但 Bill 於 11/16 回信如下：

Eberline Services does not provide soil treatment technologies. Our soil segregation system is a waste minimization and waste characterization tool and we pursue opportunities in those two markets. We do not perform treatment.

Concerning companies that treat soil, I assume you are interested in technologies or systems that could be exported to Taiwan as opposed to companies with fixed facilities in the US that perform those services. I understand ARCADIS does soil washing, generally to address halogenated semi-volatiles and PCBs. However, I do not know anyone at ARCADIS. Dr. Wu might. As for soil burning, that is generally performed at a fixed facility with an incinerator and generally to address organic contaminants as opposed to radioactive. Solidification and stabilization are the two techniques used for on-site treatment of soil with radioactive contamination. If Taiwan is interested in sending its radioactively contaminated soil to the US (which is not easy or quick), I can put you in touch with 2 firms that would be interested in discussing that opportunity.

I would be happy to speak with you by phone tomorrow (at 1.00 p.m. eastern time) or, if you would like to explore the soil treatment options more fully before we talk, we can schedule a call for the week of November 28. Please let me know your preference.

信中表示該公司沒有做污染土壤處理技術服務，只有利用 SGS 系統作廢棄物減廢及特徵標定等用途，並推薦 ARCADIS (<http://www.arcadis-us.com/>, Suthan Suthersan, Chief Technical Officer, AUSInternet@arcadis-us.com, 866 287 7373，email 聯絡但是沒有回應)

這家有做污染土壤水洗經驗廠商，表示可以與其聯絡。並約定 11/17 進行電話訪問，電話中 Bill 表示此 SGS 系統與核種 mapping 系統是分開的兩個不同系統，SGS 系統主要是將土壤減量，mapping 系統則可應用在各種場地並找出此場地的核種分佈以確認該地區是否有受到污染，並經由 GPS 定位及傳送資料。該公司的 SGS 系統可處理速度約為 25~30yd<sup>3</sup>/hr，且是可攜式的(portable)，而目前各個國家實驗室已經都結束污染土壤處理計畫，所以沒有實際機器可以看，且該公司現也沒有執行的建造案。並詢問其是否可以將設備賣到台灣，Bill 表示需要雙方洽談後瞭解我方之需求，才可由其經理決定，不管是技術支援、技術授權、建造操作或是建造後才運送至台灣等，都需要更深入的討論，該公司也可以派人到所內詳細說明該系統，以便確認可以應用於本所。後續 Bill 也來信確認回台灣之後的聯絡方法，並保持聯絡確認所內是否採用該公司之系統及對其之評價。

表 2.2 Eberline 應用 SGS 系統處理廢土經驗

**Table 2. SNAP™ Experience**

<b>Client</b>	<b>Location</b>	<b>Experience</b>
Los Alamos National Laboratory	Los Alamos, NM	Providing radiological characterization services for low-level/TRU waste segregation since 1994; also provided SNAP™ software to multiple LANL clients
Kaiser-Hill Company, LLC	Golden, CO	Providing radiological characterization services using SNAP™ in support of decommissioning projects since 1999
Fluor Hanford, Inc.	Richland, WA	Provided radiological characterization services using SNAP™ in support of 233-S Process Building decommissioning
Bechtel BWXT Idaho, LLC	Idaho Falls, ID	Providing mobile NDA services for low-level/TRU waste segregation
Lovelace Respiratory Research Institute	Albuquerque, NM	Provided services using SNAP™ for characterization of waste <i>in situ</i> and in drums for shipment and disposal
BWXT of Ohio	Miamisburg, OH	Provided radiological characterization and low-level/TRU segregation of more than 300 miscellaneous and irregularly shaped items
Battelle Memorial Institute	Columbus, OH	Provided radiological characterization of 68 waste drums and boxes, including B-25 boxes, 55- and 30-gallon drums, and very large specialty boxes; data used to make low-level/TRU determinations for some of the waste items
ICF Kaiser	Colonie, NY	Performed NDA of 1,600 yd <sup>3</sup> of uranium-contaminated wood chips in 96-ft <sup>3</sup> waste boxes to determine whether the material met the criteria for free release, release on site, or offsite disposal
AWE Aldermaston	United Kingdom	Provided training and SNAP™ software
Sandia National Laboratories	Albuquerque, NM	Provided training and SNAP™ software

Bill 更提供兩家可以處理污染土壤之廠商: (1) Perma-Fix

Environmental Services, Richard Macon, 575 Oak Ridge Turnpike, Suite 200, Oak Ridge, TN37830, 865-216-4361, rmacon@perma-fix.com , 及(2) EnergySolutions, Steve Priest, 1009 Commerce Park Drive, Suite 100, Oak Ridge, TN37830, 865-771-3975 (cell), slpriest@energysolutions.com , 可與其聯絡得到更多資訊。

#### (五) Perma-Fix Environmental Services

寫信給上述兩家土壤處理廠商，內容大致如下：

It's nice to have your information from Bill Niemeyer, Eberline and he

said you have services on contaminated soil treatment. I am from Taiwan and our institute back in Taiwan is urgent to deal with contaminated soil as soon as possible and need to discuss with companies that manufacture nuclides detector and screening, segmented gate system, or have soil washing or burning experience. Our soil is mainly contaminated by Cs-137 and part with Co-60. The volume is about 16,000 cubic meter. If you have information or technique service about this topic, please feel free to let me know what you can do for us or your brochure of your experience and services. I will stay in ATL company in Richland, WA for my internship from now to December 14. It's an opportunity for me to stay in ATL and learn some techniques and experience from them and from other companies in nuclear field. By the way, I will be in Washington DC and Gaithersburg, Maryland in the period of Dec. 3-11 and I can arrange to meet you if you will be in nearby regions during that time. If not, I can discuss with you through email or I can call you.

Thanks for your patient and look forward to your response and maybe have an opportunity to cooperate with you in the future. Any clue is very useful for me.

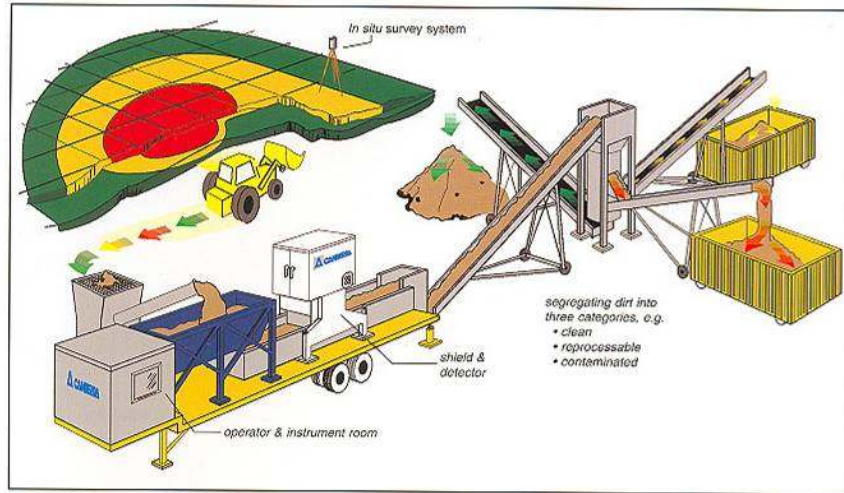
其中只有 Perma-Fix Environmental Services 的 Richard Macon 回應表示該公司有土壤篩分及水洗的技術，先將土壤減量之後再予以處理(如果還需要的話)，可以減少處理的麻煩及成本，該想法與我們一致，並表示 Cs-137 核種可以很容易地清洗下來，該公司也提供相關之經驗資料如附件四所示。



## (六) Canberra

經由台灣資佳公司王啓勝老闆(Victor C Wang，手機:0935-518-206，電話:02-2662-6941)與美國代理商 Canberra 聯絡，Bruce Gillespie(辦公室電話: 509-371-1857)馬上與我方聯絡希望於 11/15 見面事宜，於 Richland 辦公室見面討論如圖 2.6 所示之該公司環境復育 (environmental remediation)設備，見面地點為 Bruce 辦公室(AREVA Fuel plant on Horn Rapids Rd., Richland, WA 99352)，他表示該圖是一種設計概念，該公司主要製造的是偵檢器(detector)及屏蔽(shielding)部分，其餘的過篩及輸送等機械設備需要與偵檢器做電腦系統各方面的整合，才可以使整套系統運作。

# Canberra... Solutions for Environmental Remediation



If you have a contaminated soil problem, we have a *New, Innovative, Integrated* solution

*In situ*  
high resolution  
field gamma  
spectroscopy

+

Nuclide-specific  
automatic  
conveyor  
dirt sorting

=

• Less radioactive waste  
• Lower project cost  
• Earlier project completion  
• Better project documentation

The *In situ* Soil System provides the preliminary characterization to guide the excavation. Canberra's Automated Conveyor Soil Monitor can then be used to characterize and segregate clean from contaminated dirt.

- Reduces contaminated volume from 25 to over 75%
- Reduces false alarms with nuclide-specific results and release levels

- Separates waste into three output streams
  - "clean", for low cost disposal
  - "somewhat contaminated", but perhaps suitable for volume reduction schemes, such as soil washing
  - "contaminated", for disposal as radioactive

Contact us for more information...

**CANBERRA** Canberra Industries, 800 Research Parkway, Meriden, CT 06450 U.S.A.  
Tel: 203-238-2351 Toll Free: 1-800-243-4422 FAX: 203-235-1347 <http://www.canberra.com>

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SYSTEM  
CERTIFIED

With Offices In: Australia, Austria, Belgium, Canada, Central Europe, Denmark, France, Germany, Italy, Netherlands, Russia, United Kingdom.

圖 2.6 Canberra 公司環境復育服務及設備

Bruce 並簡報該公司偵檢器應用於實際土壤處理時的操作情形，如附件五所示，該公司的偵檢器可偵測範圍大約半徑 1 公尺、深度 15 公分的土壤，於附件中呈現的幾個實際操作可知將偵檢器吊起後逐步量測並標示測量地點，再由數據分析找出有污染的範圍，他並表示該公司的純鍺偵檢器對於 Cs-137 及 Co-60 核種之偵測非常靈敏，因此

可以很快的偵檢出該地區哪些地方受到污染，並透過軟體內的 GPS 定位器將其位置記錄起來，供操作人員及規劃者規劃下一步的處理。Bruce 並表示如在台灣要購買儀器都需透過該公司在台灣的代理商進行，美國部分只針對客戶要求做出客製化之偵檢器賣出，許多的操作細節代理商如果不會，還是得透過美國總公司調整或設定。會後與 Bruce 合影於辦公室外，如圖 2.7 所示。



圖 2.7 與 Canberra 公司 Bruce 先生合影

### (七) Chesapeake Nuclear Services

Chesapeake Nuclear Services 的 J. Stewart Bland(mail: [jsbland@chesnuc.com](mailto:jsbland@chesnuc.com), phone: 410-266-9174)回信表示可以到 Washington DC 時安排時間到他辦公室討論相關細節，並傳來該公司研發設計的型錄如下圖 2.8 及圖 2.9 所示。


# CRATER™

*This field-ruggedized radiation detection system with integrated analytical methods provides unique solutions for difficult radiation detection problems encountered during site decommissioning and remediation.*


**COMPTON RATIO ANALYSIS FOR TESTING ENVIRONMENTAL RADIOACTIVITY**

Multiple CRATER™ systems are currently in use at DOE's Hanford Site for remediation of waste burial trenches. Used to identify high dose rate items and locate spent fuel fragments in an excavator-mounted monitoring system, CRATER™ has been credited with saving millions of dollars in project costs.

*Photo at right shows CRATER™ system mounted on an excavator bucket.*



- Supports large area soil remediation and bulk material scanning projects
- Allows sorting and segregating in varying background levels and material compositions
- Real-time data collection, analysis, and Bluetooth communication
- Supports automated material processing and handling mechanisms
- Offers significant throughput improvements and reduced personnel exposures
- Customized spectral analytical methodology
- Rugged and weather-tight
- Data can be integrated with real-time GPS and incorporated into mapping applications like ArcPad



**Chesapeake Nuclear Services**  
www.chesnuc.com



**Radiation Safety Associates**  
www.radpro.com

**FOR MORE INFORMATION:**  
J. Stewart Bland, Certified Health Physicist  
**phone** 410-266-9174 **email** jsbland@chesnuc.com

圖 2.8 Chesapeake Nuclear Services 的 CRATER™ 系統

我方也回應會安排時間與其討論並看是否可提供實際工作照片以茲判斷是否適合本所使用。於 10/27 回應表示可以到 Washington DC 附近位於 Annapolis, Maryland 的辦公室與其見面，並討論相關的議題，且隨信提供該公司 CRATER 系統的實際應用照片如圖 2.10 所示，該系統應用於 Washington Closure 計畫內，針對 Hanford Site 的處置壕溝進行復育的工作，現共有 7 個偵檢器系統應用於場內。並將其發表有關此系統的文章(如附件六)檢附於信中，其回信說明此系統之應用如下：

# RES-Q™

## RADIOACTIVE ENVIRONMENTAL SURVEY AND QUANTIFICATION



Chesapeake Nuclear Services



Radiation Safety Associates

A field-ruggedized radiation detection system with gamma spectrometry and integrated shielding design for enhanced detection capability in varying backgrounds and challenging environmental conditions. Scan areas and material for screening. Collect static measurements for quantifying. User-configurable field-of-view and shield geometry for enhanced capability in a wide range of environmental conditions.

### Technological Approach

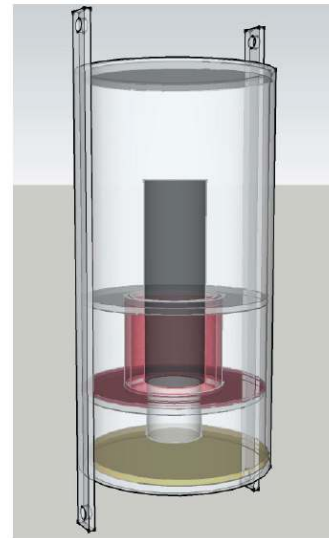
- Portable, field-ruggedized gamma spectrometry
- Scanning and static modes of operation to support screening and quantification assessments
- Built-in, user-fillable, copper-lined shielding chamber (unfilled eases transport and handling)
- Attachable collimator for high dose rate applications
- Data can be integrated with real-time GPS to support mapping applications like ArcPad™ and Google Earth
- Automated gain stabilization with continual QA checks for ensuring quality data
- Quantification of radionuclide concentrations/activity for user-defined sample geometries
- Detector retractable/extendable within shield for user-defined field-of-view, reducing background and focusing measurement
- Full-spectra mode or user-defined Region of Interest (ROI), Library, and peak-based analyses
- Compton Continuum subtract methodology for enhanced detection in varying backgrounds

### Design Specifications

- 8-inch diameter aluminum casing with universal mounting bracket
- 2x2 inch NaI(Tl) detector – reliable, rugged, and readily available
- 512-channel gamma spectrometry
- User-defined ALERT and ALARM levels by specific ROIs and/or gross mode
- External and internal power supply with up to 12 hours operation without external source
- Remote operation with Trimble Recon™ and Bluetooth™ communication
- Optional long-range Bluetooth for up to 1 km line-of-sight operation

### Applications

- Site characterization and remediation
- Excavator mounted for soil screening
- Vehicle mounted for drive-over surveys
- Emergency response and recovery assessments
- Robotic deployment for radiation assessments in uninhabitable areas
- In-field sample screening with built-in standard geometries



ABOVE: Simplified drawing showing integrated shielding with adjustable detector positioning for changing field-of-view

BELOW: Integrated mounting bracket and remotely operable for equipment application (ATV mount shown)



For information, contact J. Stewart Bland 410.266.9174; email: JSBland@chesnuc.com

圖 2.9 Chesapeake Nuclear Services 的放射性核種偵測系統



圖 2.10 CRATER 系統實際應用照片

Attached is a presentation that was given at the Waste Management Symposium a few years ago. The system described in the paper is specific for the application at Hanford. CRATER can be configured with different scintillation detectors to better support the intended application. Larger detectors (example 2X2 NaI or 3X3 NaI) would improve low level detection.

The CRATER system is detector system that is mounted on an excavator to monitor bucket content. It incorporates gamma spectral analysis techniques that can be configured to the radionuclides of concern. It communicates by Bluetooth to a handheld pda-type device (Trimble RECON). It has very user-friendly user interfaces for operation. It does not require a full computer and is field-rugged. Its best application is for bulk soil screening – in other words screening soil in the excavator bucket. While we have not configured it as a conveyor system, it is readily adaptable.

Written by J Stewart Bland, CHP (jsbland@chesnuc.com)

11/8(US time)其回信確認見面時間可以安排在 12/5 或 12/6 期間，他也可以到 ATL 總公司說明與討論，省去了我方交通的時間，又可以方便讓吳博士等相關人員參與討論。故我方回信表示可以在 12/5 (US time)與 J. Stewart 先生見面，主要討論此系統及土壤處理經驗。

12/5 在 ATL 公司位於 Gaithersburg 的總部與 J. Stewart、Dr. Wu、總裁 Alice 見面，並與 Stewart 先生進行討論，他提到 CRATER 系統主要是針對 Hanford Site 的需求量身定做的，全部都是符合 Hanford 要求量測用過核燃料碎片(spent fuel fragments)用，主要是利用 NaI 偵檢器來偵測每次挖土機挖出來一杓的廢土是否含有強放射性核種 Cs-137，再用 PDA 等遠端連線儀器顯示該批土壤是否受到污染，由操作或地面人員決定此批廢土是否被污染，及其污染程度如何。偵測

的時間長短由現場決定，如果土壤具有強放射性，則偵測時間可短至 2 秒鐘，如果需要量測極低污染的土壤，量測時間需增加到 10 分鐘之久，端看應用層面及污染程度而定；有此設計製造經驗後，該公司利用該原型更改為較容易操作的型號：RES-Q，如下圖 2.11 所示，該設備可以手動調整位於中間的偵檢器高低，藉此來調整所欲量測之範圍，偵檢器越高，越會被旁邊的鉛屏蔽所阻擋，因此可偵測的面積就越小，而增加整個偵檢器與待測物體的距離也是有相同的效果，Stewart 並藉由投影片資料解釋該公司發展此設備的經過及該儀器之應用範圍，資料如附件七所示，首先先確認 Hanford 所需處理的廢土種類及其污染程度，建立處理設備原型，並經評估及數次實驗測試後，改良並真正運用在處理上，改善了原本使用純鍺偵檢器的開挖、平鋪及長時間偵測的缺點；最後，Stewart 表示該設備初略估計大約為 20,000~50,000 美元之間，依照客戶的要求進行評估並建造符合要求之設備，而我方也陳述立場，如要合作，該公司需透過台灣立案的公司或是該公司設置於台灣的分公司進行投標等程序才符合採購法之要求；圖 2.12 為與 Stewart 先生於討論後合照。

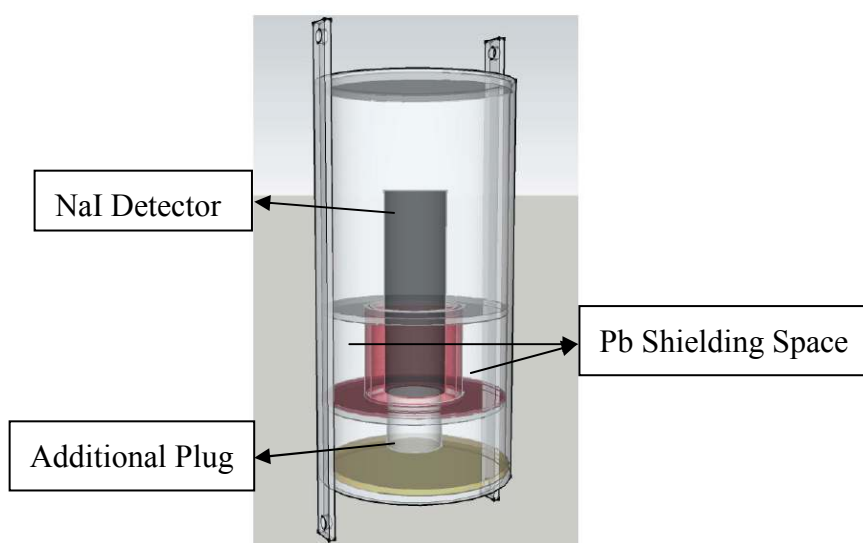


圖 2.11 Chesapeake 公司的 RES-Q Model





圖 2.12 與 Chesapeake 公司的 Stewart 先生於 ATL 公司總部合照

#### (八) Nuclear Regulatory Commission (NRC)

1.NRC 簡介：美國原子能委員會是美國國會在二戰以後立法設立的政府機構，目的是提倡、管理原子能在科學及科技上的和平用途。1946 年原子能法案通過後，國會賦予原子能委員會特殊的獨立職權：委員會可以自由任用專家學者，不適用一般文官體制的規定；為了安全考量，美國所有的核生產設備、核反應爐、相關技術資訊及研究結果都由該委員會掌控。美國國家實驗室系統(National Laboratory system)就是建立在曼哈頓計劃的基礎上。1954 年美國國會通過了原子能法案修正案，賦予原子能委員會促進並管制核能的使用的職權，使得商用核能的發展

變成可行。於是原子能委員會必須訂定管制標準保護一般民眾的安全，同時又要避免訂定太嚴格的標準限制工業的發展，這是一件很困難的事。而在 1960 年代許多核管制標準被批評太弱，包括輻射劑量標準、輻射保護標準(radiation protection standards)、核反應爐安全(reactor safety)、電廠位址(plant siting)及環境保護標準(environmental protection)等。1974 年國會終於決定將原子能委員會的業務一分為二，根據當年能源組織改組法(Energy Reorganization Act)，核管制業務交由在核能管理委員會(Nuclear Regulatory Commission)會執行(1975 年 1 月 19 日開始運作)，而促進核能利用的業務交由能源研究與發展局(Energy Research and Development Administration，後來併入能源部)執行。(資料來自 Wikipedia 及 NRC 網站)。NRC 的主要任務是確保大眾健康、防衛及核子物料在美國本土使用之安全可以受到足夠的保護，責任範圍包括:商用核子反應器法規、非電力研究(non-power research)、反應器的測試及訓練、核燃料循環設施、醫用、研究用及商用核子物料、放射性物料及廢料的運輸、貯存及處置等。

- 2.行程安排：由原能會駐美國之趙衛武博士(Wei-Wu Chao, Taiwan Atomic Energy Council Representative in DC, Deputy Director of Science and Technology Division, TECRO., 4201 Wisconsin Ave.

NW Washington DC 10062, Cell: 240-393-9320, Tel: 202-895-1932)負責聯絡 NRC 內之相關人員及 DOE 官員 (Christine Martin, responsible for the coordination/integration of AIT-TECRO cooperation activities), 對於到訪 NRC 做預先準備, 但因趙博士需於 11 月 25 日~12 月 12 日期間返台參加台美合作會議, 故交代 Dr. Casper Sun(Health Physicist, Radiation Protection Branch, Division of System Analysis, Office of Nuclear Regulatory Research, MS CSB 3C-07, U.S.. Nuclear Regulatory Commission, Washington, D.C. 20555 Office: 301-251-7912)為後續聯絡人, 而 Dr. Wu (Chuan-Fu Wu)也協助後續聯絡。孫博士隨即告知可以到 NRC 的 Public Meeting Site(<http://www.nrc.gov/public-involve/public-meetings/index.cfm>)查詢預約的時間、地點及討論事項等。由於孫博士於 11 月中後至 12 月初因為私事不在美國, 所以將聯絡工作交由 Jeff Dehn (International Relations Specialist, Office of Nuclear Regulatory Research (RES), Phone: 301-251-7672, [jeff.dehn@nrc.gov](mailto:jeff.dehn@nrc.gov))幫忙安排見面討論等事宜, 並提供給他我方需要討論的議題請其協助安排相關人員。我方訂定 12 月 3 日到 12 月 11 日期間到 Washington DC 參訪 NRC、ATL 公司總部及洽談相關廠商, 故與 Jeff 商討並請其安排到 NRC 總部參觀之時間。於 11/10 Jeff 先生及趙博士 email 聯絡需要明確的討論題目, 這樣才好安排

整個 NRC 參與之人員，因此條列討論議題如下：

- (1) Regulation or guidance for radiation detection after the soil remediation from decontamination (discuss with Dr. Sun).
- (2) Final disposal limitation of contaminated soil stored in drums.
- (3) Discharge limitation of nitrate- and mercury-contained waste water.
- (4) Packaging, transportation and storage regulation of TRU solid waste.
- (5) Emission of tritium to surrounding area(air or river).

針對議題，Dr. Wu 亦建議如下：

I suggest you focus on the topic of "U.S. Regulations and Policies Related to Contaminated Soil Remediation/Cleanup."

Currently NRC does not have regulations that provide detailed standards for soil cleanup. Subpart E of NRC regulation 10 CFR 20 "Standards for Protection Against Radiation" sets some requirements for termination of nuclear facilities (you may visit Website <http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/> to see 10 CFR 20). The requirements in 10 CFR 20 are very general. Some states have established more specific guidelines, New York is an example. There are also technical studies that established cleanup goals (see attachments). Your questions for Jeff (and other NRC staff he arranges to meet with you) may include:

- (1) What does NRC think about the state-level guidelines?
- (2) What are NRC's involvements in the state's efforts in establishing

those guidelines?

(3) Does NRC plan to establish more detailed standards for the entire nation?

提供的附檔(如附件八)為紐約州環境保育部(New York State Department of Environmental Conservation)自己訂定的放射性廢棄物指導文件。

### 3.見面與討論

訂於 12 月 7 日上午 9 點至 NRC 總部的 Church Street Building (21 Church Street, Rockville, MD 20852)進行討論。本次參與討論人員計有：Program Management, Policy Development & Analysis Staff 的 Wendy Eisenberg (International Programs Team)、Office of Federal and State Materials and Environmental Management Programs 的 Rateb Abu-Eid(Boby)及 Dr. Sun Casper(Radiation Protection Branch)，開始由孫博士報告 NRC 的組織架構及其所屬單位(Radiation Protection Branch)，並介紹其參與的 Regulatory Guides 介紹與法規修訂，並以假設美國的 Yucca Mountain 高放射性廢棄物處置場發生核種洩漏為題來闡述核種洩漏對於環境及人類的影響，主要管制的核種與 EPA 針對飲用水(Drinking Water)的管制種類相同，共計 8 種：C-14、Tc-99、I-129、Ra-228、Ra-226、Np-237、Pu-239 及 Am-241，探討其一萬年後對環境的影響，而

選擇一萬年的原因是：1.超過一萬年後的不確定性(uncertainty)變的很大而無法接受、2.經過一萬年後地質不會有特殊的改變及 3.如果少於一萬年就無法和有潛力的場址(potential site)做比較。並計算以上八種核種經過一萬年後的有效劑量率(effective dose rates)只有 Pu-239 經過一萬年後其有效劑量率是無法接受的，其他都符合 EPA 的要求，其劑量率隨時間之變化如圖 2.13 所示。

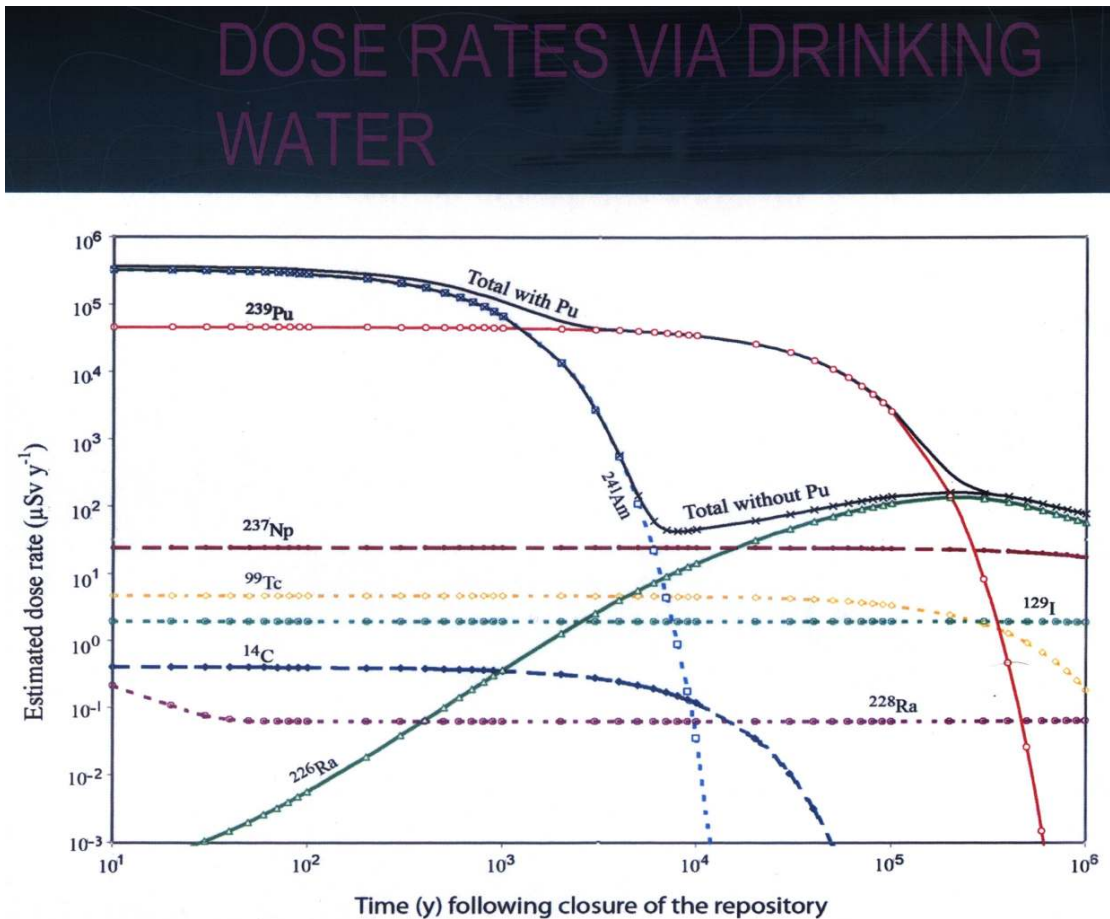


圖 2.13 八種元素其劑量率隨時間之變化

之後，主要用討論的方式，針對我方的問題由 NRC 專家回答，於會後整理提問的問題加上 NRC 的回答條列如下：

(1)U.S. Regulations and Policies Related to Contaminated Soil Remediation/Cleanup

ANS: Most of the regulations are stated in 10CFR20 Subpart E. Tolerance radioactivity for adults is 25 mrem/yr according to NRC but value would be changed to 15 mrem/yr under regulations of EPA.

(2)What does NRC think about the state-level guidelines?

ANS: Every state has their own guidelines that would match up to their environment and policies, but must meet the standard of NRC's guidelines. NRC has the responsibility to review the regulations every three years to make sure regulations of every state meet the standard to NRC's.

(3)What are NRC's involvements in the state's efforts in establishing those guidelines?

ANS: NRC doesn't involve in establishing guidelines of every state but has the responsibility to review them. Mr. Bobby mentioned that the clearance has the limitation of 1mrem per year total waste discharge and the release is 25 mrem. There is a very big difference between each other.

(3)Does NRC plan to establish more detailed standards for the entire nation?

ANS: No. 10CFR20 sub E is the standard. If it is changed, lots of regulations need to be changed.

(4)Discuss with Dr. Sun about Series Regulatory Guidance.

ANS: Dr. Sun reported his research and details are mentioned above.

(5)Final disposal limitation of contaminated soil stored in drums.

ANS: 10CFR60 is the regulation of high level waste and 10CFR61 is the regulation of low level waste. According to final disposal limitations of every different plant, limitation of drums is different.

(6) Discharge limitation of nitrate- and mercury-contained waste water.

ANS: It's the responsibility of EPA, not NRC.

(7) Packaging, transportation and storage regulation of TRU solid waste.

ANS: Dr. Wu is the expert of TRU (transuranic radioactive) waste treatment and according to his opinions, RCRA (resource conservation recovery act) gives EPA the authority to deal with hazardous materials, includes the generation, transportation, treatment, storage, and disposal of hazardous waste in USA. WIPP (waste isolation pilot plant) is a deep geological repository licensed to permanently dispose of TRU waste for 10,000 years. WIPP Land Withdrawal Act (LWA) sets aside the land for developing and building a transuranic radioactive waste repository. It also requires EPA to set disposal standards, establish compliance criteria and a process to certify that the WIPP facility is technically able to meet the standards. EPA must reevaluate the WIPP every five years during its 35-year operation to determine if it continues to meet the standards and should be recertified. Packaging of TRU waste needs to be certified by NRC.

(8) Emission of tritium to surrounding area (air or river).



ANS: Limitation of H-3 discharge is 5 Curie/year in USA. No other useful methods to treat it.

於會後互相交換名片以便日後可以互相交流，也使得核研所在 NRC 多了一個窗口可供諮詢，而這也是孫博士於會面前告知此行最主要目的：認識並結交朋友。會後將以上的回答寄給與會人員確認，但沒有回音。



圖 2. 14 左起為 Dr. Sun Casper、Rateb Abu-Eid(Boby)及 Wendy Eisenberg

## (九) 其他

### 1.EVMS 評估

EVMS(Earned Value Management Systems)是剛好吳博士在研習期間針對 ATL 公司做的分析報告，其主要根據 ANSI 的 GEIA Standard 裡面的 Earned Value Management Systems 的規範逐條檢視 ATL 公司是否有達到各種 Guideline 的要求，其中 EVMS 的 Guideline 包含：

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## 2.1 Organization

- a) Define the authorized work elements for the program. A work breakdown structure (WBS), tailored for effective internal management control, is commonly used in this process.
- b) Identify the program organizational structure including the major subcontractors responsible for accomplishing the authorized work, and define the organizational elements in which work will be planned and controlled.
- c) Provide for the integration of the planning, scheduling, budgeting, work authorization and cost accumulation processes with each other, and as appropriate, the program work breakdown structure and the program organizational structure.
- d) Identify the organization or function responsible for controlling overhead (indirect costs).
- e) Provide for integration of the program work breakdown structure and the program organizational structure in a manner that permits cost and schedule performance measurement by elements of either or both structures as needed.

## 2.2 Planning, Scheduling, and Budgeting

- a) Schedule the authorized work in a manner which describes the sequence of work and identifies significant task interdependencies required to meet the requirements of the program.
- b) Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress.
- c) Establish and maintain a time-phased budget baseline, at the control account level, against which program performance can be measured. Initial budgets established for performance measurement will be based on either internal management goals

or the external customer negotiated target cost including estimates for authorized but undefinitized work. Budget for far-term efforts may be held in higher level accounts until an appropriate time for allocation at the control account level. If an over-target baseline is used for performance measurement reporting purposes, prior notification must be provided to the customer.

- d) Establish budgets for authorized work with identification of significant cost elements (labor, material, etc.) as needed for internal management and for control of subcontractors.
- e) To the extent it is practicable to identify the authorized work in discrete work packages, establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire control account is not subdivided into work packages, identify the far-term effort in larger planning packages for budget and scheduling purposes.
- f) Provide that the sum of all work package budgets plus planning package budgets within a control account equals the control account budget.
- g) Identify and control level of effort activity by time-phased budgets established for this purpose. Only that effort which is not measurable or for which measurement is impracticable may be classified as level-of-effort.
- h) Establish overhead budgets for each significant organizational component for expenses that will become indirect costs. Reflect in the program budgets, at the appropriate level, the amounts in overhead pools that are planned to be allocated to the program as indirect costs.
- i) Identify management reserves and undistributed budget.
- j) Provide that the program target cost goal is reconciled with the

sum of all internal program budgets and management reserves.

### 2.3 Accounting Considerations

- a) Record direct costs in a manner consistent with the budgets in a formal system controlled by the general books of account.
- b) When a work breakdown structure is used, summarize direct costs from control accounts into the work breakdown structure without allocation of a single control account to two or more work breakdown structure elements.
- c) Summarize direct costs from the control accounts into the organizational elements without allocation of a single control account to two or more organizational elements.
- d) Record all indirect costs that will be allocated to the program consistent with the overhead budgets.
- e) Identify unit costs, equivalent unit costs, or lot costs when needed.
- f) For EVMS, the material accounting system will provide for:
  - 1) Accurate cost accumulation and assignment of costs to control accounts in a manner consistent with the budgets using recognized, acceptable, costing techniques.
  - 2) Cost recorded for accomplishing work performed in the same period that earned value is measured and at the point in time most suitable for the category of material involved, but no earlier than the time of actual receipt of material.
  - 3) Full accountability of all material purchased for the program including the residual inventory.

### 2.4 Analysis and Management Reports

- a) At least on a monthly basis, generate the following information at the control account and other levels as necessary for management control using actual cost data from, or reconcilable with, the accounting system:

- 1) Comparison of the amount of planned budget and the amount of budget earned for work accomplished. This comparison provides the schedule variance.
  - 2) Comparison of the amount of the budget earned and the actual (applied where appropriate) direct costs for the same work. This comparison provides the cost variance.
- b) Identify, at least monthly, the significant differences between both planned and actual schedule performance and planned and actual cost performance, and provide the reasons for the variances in the detail needed by program management.
  - c) Identify budgeted and applied (or actual) indirect costs at the level and frequency needed by management for effective control, along with the reasons for any significant variances.
  - d) Summarize the data elements and associated variances through the program organization and/or work breakdown structure to support management needs and any customer reporting specified in the contract.
  - e) Implement managerial action taken as the result of earned value information.
  - f) Develop revised estimates of cost at completion based on performance to date, commitment values for material, and estimates of future conditions. Compare this information with the performance measurement baseline to identify variances at completion important to company management and any applicable customer reporting requirements including statements of funding requirements.

## 2.5 Revisions and Data Maintenance

- a) Incorporate authorized changes in a timely manner, recording the effects of such changes in budgets and schedules. In the directed

effort prior to negotiation of a change, base such revisions on the amount estimated and budgeted to the program organizations.

- b) Reconcile current budgets to prior budgets in terms of changes to the authorized work and internal replanning in the detail needed by management for effective control.
- c) Control retroactive changes to records pertaining to work performed that would change previously reported amounts for actual costs, earned value, or budgets. Adjustments should be made only for correction of errors, routine accounting adjustments, effects of customer or management directed changes, or to improve the baseline integrity and accuracy of performance measurement data.
- d) Prevent revisions to the program budget except for authorized changes.
- e) Document changes to the performance measurement baseline.

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吳博士的分析報告非常複雜，英文的書寫方式也很難懂，吳博士強調要瞭解此份報告，需對該公司三個主要的預算管制系統及會計系統非常瞭解才有辦法讀懂，並且根據這些電腦管理系統的統計資料與 Guideline 中的項目逐條核對，才可分析出 ATL 公司是否有符合 EVMS 的標準。

## 2.Consolidated Information Center

11/8(US time) 調查並知道附近有 Hanford Site 的 Public Information Center，開放給一般民眾參觀及查詢相關資料，於是選了離 ATL 公司最近、在 Washington State University 內的 Consolidated Information Center (DOE-RL Public Reading Room, Washington State University Consolidated Information Center, Room

101L,2770 University Drive Richland, WA 99352)查詢相關資料，裡面各種資料相關完整，可以透過 Catalog (<http://reading-room.labworks.org/Catalog/Search.aspx>) 搜尋該 Public Room 所收藏的資料，多半都是各種環境影響評估及規劃等資料，針對技術性的文件部分則較少收藏，但透過館內小姐的說明，可以在許多的 DOE 或其 Contractor 建構之網站搜尋到技術文獻並下載 PDF 全文檔，其常用資料庫大致如下：

- (1) DOE Information Bridge (<http://www.osti.gov/bridge/>)
- (2) The Energy Citations Database (<http://www.osti.gov/energycitations/>)
- (3) Hanford Home Page (<http://hanford.gov>)

對於此閱覽室的設置深感佩服，雖然使用的人數不多，但是集結了許多文件，且都公開給社會大眾，可以讓有疑惑的民眾充分瞭解核能設施在地方的影響及近年來做的事情，減低其疑慮。



圖 2.15 Consolidated Information Center of DOE-RL in Richland

### 三、ATL 公司簡介

ATL (Advanced Technologies and Laboratories International Inc.) 是 DOE-ORP(Office of River Protection)其中一個 contractor，主要參與 Hanford 清理計畫(cleanup mission)，其技術人員每年測試多達 25,000 個樣品。ATL 在 200 West Area of the Site 有一個實驗室(Laboratory 222)，主要是接收、處理、測試及貯存許多來自 Hanford Site 內不同計畫的樣品，所以 ATL 是一個技術及環境管理的技術提供者，以下是 ATL 公司檔案：

- 創立於 1989 年
- 總部設立於 Maryland, 並有許多辦公室分別為於：Washington DC, Ohio, South Carolina, Illinois, Mississippi, and Washington State
- 主要工作：Environmental management and planning, occupational safety and health, information technology, training, and public outreach service.
- 廢棄物管理(Waste Management)
  - Radioactive and Hazardous Waste Management
  - Radioanalytical Laboratory Services
  - Planning and Policy Analysis





圖 2.16 ATL 公司辦公室分佈

- 主要客戶摘錄如下：
  - Department of Energy (DOE)
    - Office of Environmental Management
    - Office of Management, Budget, and Evaluation
    - Office of Defense Programs
    - Office of Environment, Safety, and Health
    - Richland Operations Office
    - Idaho Operations Office
    - Oak Ridge Operations Office
    - Savannah River Operations Office
    - Office of River Protection
    - National Energy Technology Laboratory, Morgantown , WV
  - National Nuclear Security Administration, NNSA-HQ
    - Office of Emergency Management
    - Office of Nuclear Safeguards and Security Programs
    - Oakland Operations Office
    - Albuquerque Operations Office
  - National Laboratories (Los Alamos, Sandia, Pacific Northwestern, Argonne, Oak Ridge)
  - Nuclear Regulatory Commission (NRC)
    - NMSS
    - NRR
    - RES
  - Housing and Urban Development (HUD)
  - Environmental Protection Agency (EPA)
  - Occupational Safety and Health Administration (OSHA)
  - National Institute of Occupational Safety and Health (NIOSH)
  - Center for Disease Control and Prevention (CDC)
  - Department of Homeland Security
    - Office of Security
    - Immigration and Naturalization Services
  - Department of Transportation

- Universities and Hospitals
- 聯絡資訊：

**Gaithersburg, Maryland**

Address: 555 Quince Orchard Road, Suite 500, Gaithersburg,  
MD20878

Phone: (301) 515-6786, Fax: (301) 972-6904

Email: [mcdougall@atlintl.com](mailto:mcdougall@atlintl.com)

**Richland, Washington**

Address: 1979 Snyder Street, Suite 130, Richland, WA 99354

Phone: (509) 375-4200

Email: [jhwang@atlintl.com](mailto:jhwang@atlintl.com)

#### 四、Richland 及 Hanford Site 介紹

Richland 座落在華盛頓洲(Washington State)的東南方，位於 Columbia River 及 Yakima River 交界處，與周圍的兩個城市：Pasco 及 Kennewick 並稱為 Tri-Cities，每個城市都有其特色：Richland 自從美國政府在 Hanford Site 設置核子反應器後，人口迅速增加，且此舉也使得 Richland 對於 Tri-Cities 的經濟貢獻良多，也使此區域成為科學及技術的社區；Kennewick 是三個城市中最大也是最有發展性的，腹地包含了 Columbia Park 綠地，常舉辦各種戶外活動如高爾夫等；Pasco 是華盛頓洲成長最快的城市之一，周遭被自然環境包圍，機場、鐵路及公路運輸都在此城市中。而 Tri-Cities 中最有名的就是釀酒廠 (Winery)，多達 160 家，其葡萄酒品質優秀，很值得到當地酒莊品嚐，另外也可到眾多分佈的高爾夫球場揮杆。



圖 2.17 Richland 周邊(包含 Pasco 及 Kennewick)



圖 2.18 酒莊及高爾夫運動是 Richland 兩大特色

Hanford Site 位於華盛頓州的東南方，接近 Richland，緊鄰 Columbia River，其地理位置圖及小檔案介紹如圖 2.19 及圖 2.20 所示，其面積

大約為 1500 平方公里，大約為一個新竹縣(1428 平方公里)大小，現由三個單位負責該地點之營運：PNNL(Pacific Northwest National Laboratory)由 DOE 的 SC (Office of Science)監督管理，該實驗室主要負責 DOE(Department of Energy)、國土安全局(Department of Homeland Security)、國家原子安全委員會(National Nuclear Security Administration)等各單位有關能源、化學及環境等相關的研究，員工共有約四千九百多人。另一單位為 DOE-RL(Richland operations office)，由 DOE 的 EM(Office of Environmental Science)負責預算分配及計畫管理等，此單位主要負責反應器、土壤、地下水及固體廢棄物掩埋場地的清理計畫，同時也管理老舊設施的破壞和殘留的銻物料的處理。第三個單位為 DOE-ORP(Office of River Protection)，同樣也是由 DOE 內的 EM 部門管理，主要任務是處理液體及半固體(semi-solid)的核子及化學廢棄物，這些廢棄物現都貯藏在 177 個地下桶槽內。同時 ORP 也負責建造廢棄物處理場(Waste Treatment Plant)，此場位於 Hanford Site 的中央，主要將桶槽內的廢棄物與製造玻璃的材料結合，透過玻璃化技術(vitrification)將廢棄物安定化並可將此廢棄物安全地存放在最終處置場內。

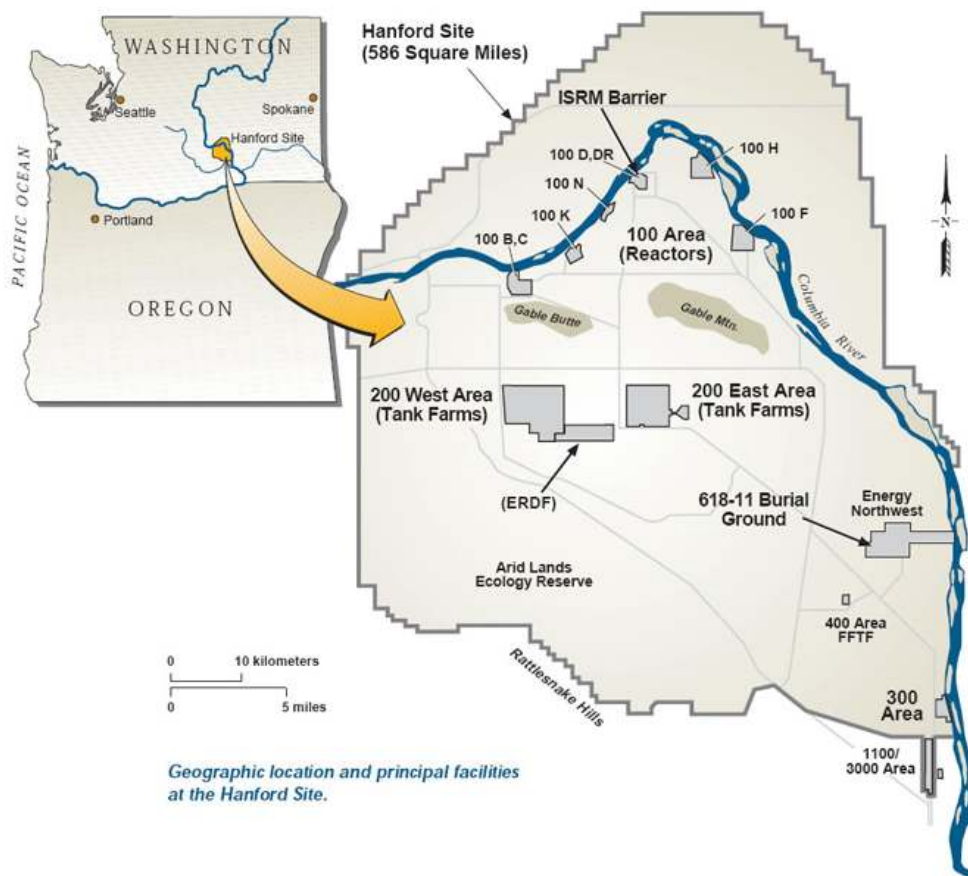


圖 2.19 Hanford Site 的地理位置及設施分佈圖

HANFORD SITE AT A GLANCE	
<b>Location</b>	The U.S. Department of Energy's Hanford Site is located in southeastern Washington State near the city of Richland.
<b>Dominant Features</b>	Rattlesnake Mountain on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit of the Hanford Reach National Monument rises 3,525 feet above sea level, and the Columbia River flows through the northern and eastern part of the site.
<b>Size</b>	The site covers approximately 586 square miles.
<b>Employees</b>	DOE and its contractors employed approximately 15,558 workers in 2009.
<b>Mission</b>	The Hanford Site mission is to safely clean up and manage the site's facilities and waste, and reduce the size of the site by releasing the land for other uses.
<b>Site Management</b>	DOE's Richland Operations Office and Office of River Protection jointly manage the central portion of the Hanford Site through several contractors and their subcontractors. DOE, U.S. Fish and Wildlife Service, and Washington Department of Fish and Wildlife each manage units of the Hanford Reach National Monument.

圖 2.20 Hanford Site 小檔案(from summary of the hanford site environmental report 2009)