Independent Technical Review Report: Nevada Test Site

Review of Disposal Practices at the Nevada Test Site

By Craig H. Benson, PhD, PE; William H. Albright, PhD; David P. Ray, PE; and John Smegal

Sponsored by:

The Office of Engineering and Technology (EM-20)

15 July 2008

TABLE OF CONTENTS

1. INTRODUCTION

The Nevada Test Site (NTS) is part of the Nevada Site Office (NSO) of the U.S. Department of Energy's (DOE) National Nuclear Security Administration (NNSA). NTS extends over approximately 356,000 ha in the Great Basin desert, and is located approximately 105 km north of Las Vegas. Radioactively contaminated materials from the NTS, other DOE facilities, and other federal agencies are disposed at NTS at two low-level radioactive waste (LLRW) management sites: Area 3 and Area 5. Disposal operations at Area 3 have been discontinued since 2006, but the facility is available for future disposal. The anticipated closure date for Area 3 is 2027. Area 5 is still operating and will be expanded to accept future wastes. This report focuses on Area 5. However, many of the issues related to final cover also apply to Area 3.

Area 5 is a 300 ha facility north of Frenchman Flat in the southeast corner of NTS that commenced operations in 1961 and began accepting off-site waste in 1976. LLRW and mixed low-level radioactive waste (MLLW) are disposed in Area 5 in shallow (3-15 m deep) unlined trenches and pits (Fig. 1). The MLLW unit will be closed in 2011 or when the capacity (20,000 m^3) is reached (whichever comes first). An entirely new facility will need to be permitted and constructed if mixed wastes are to be disposed at NTS after 2011.

A schematic of the disposal areas in Area 5 is shown in Fig. 2. More than 400,000 m^3 of LLRW and 8,600 m^3 of MLLW have been disposed in the existing (65 ha) developed area. Nearly 3 million m^3 of capacity remains within the 300 ha footprint of Area 5.

Waste generators undergo a certification and acceptance process before being approved for disposal of waste at NTS. This process includes demonstration of compliance with the NTS Waste Acceptance Criteria (NTSWAC). These criteria provide requirements for waste characterization, waste form, traceability, packaging, and transfer.

2. OBJECTIVE AND SCOPE

DOE requested that an Independent Technical Review (ITR) team provide input on several lines of inquiry related to the disposal operations at NTS. The ITR team, which was comprised of Craig H. Benson, PhD, PE (University of Wisconsin; Madison, WI), William H. Albright, PhD (Desert Research Institute; Reno, NV), David P. Ray, PE (U.S. Army Corps of Engineers; Omaha, NE), and John Smegal (Legin Group; Washington, DC), has expertise in waste containment, civil engineering, geotechnical engineering, and project management. The ITR team was requested to address the following lines of inquiry (LOI):

1. Do any issues exist with the landfill design, operations, and management that could impact its ability to meet performance objectives? Are there potential issues in the landfill program that could lead to problems similar to those identified at Hanford's ERDF? If yes, have preventive and mitigative measures been taken to remedy the situation?

2. Are there cost-effective lessons learned from reviews of other DOE disposal operations that may improve the reliability and effectiveness of operations and management of NTS landfills?

3. Are there good practices at NTS landfills that may benefit other EM sites?

4. How can NSO apply experience gained at other sites that have installed RCRA disposal cells for MLLW?

5. What lessons have been learned from closures of disposal cells at other DOE sites?

These LOI were addressed by conducting a site visit on 29 April 2008, reviewing documents provided by DOE personnel from NSO, and based on the experience of the ITR team. Findings of the ITR team for each of the LOI are described in the following sections.

3. LINE OF INQUIRY NO. 1

Do any issues exist with the landfill design, operations, and management that could impact its ability to meet performance objectives? Are there potential issues in the landfill program that could lead to problems similar to those identified at Hanford's ERDF? If yes, have preventive and mitigative measures been taken to remedy the situation?

Area 5 of NTS is in an arid and remote location where ground water is very deep. These conditions are ideal for containment and isolation of waste. The review by the ITR team found no issues at Area 5 that could pose immediate problems comparable to those that occurred at ERDF in 2007.

The relationship between waste placement methods and disposal operations, stability of the final cover, and long-term performance is an issue that is common to all of the DOE on-site disposal facilities, including those at NTS. Waste placement methods and modes can directly influence the potential for differential settlement, which may ultimately affect the integrity of the final cover and the rate of percolation into the waste. Most of the waste disposed at NTS is in containers. Thus, long-term disintegration of the containers, and the subsequent subsidence, may affect the integrity of the final cover and long-term isolation of the waste. Erosion and seismic deformation may also be important.

Integrity of the final cover is important to minimize the amount of water that enters the waste. The relatively thick cover profile proposed for Area 5 and the hydrology of the vadose zone at NTS make this issue less important than at other sites. Additionally, NSO has selected a conceptual design for the final cover based on natural principles. This design is more flexible than conventional covers with barrier layers, and therefore is less susceptible to formation of defects in response to distortion caused by settlement or seismic events. However, if defects do form in the cover, they can serve as preferential flow paths that permit a greater amount of water to enter the waste than anticipated.

A recent PA (Bechtel Nevada 2006) for Area 5 states that "the cover integrity and thickness are assumed to be unaffected by subsidence. Cracks formed as waste subsides are assumed to be filled in by the natural flow of unconsolidated cover material. Although the Area 5 RWMS closure cover is assumed to subside over time, natural process and maintenance during the institutional control period are assumed to reduce or eliminate all potential impacts of subsidence on cover performance." A plan should ultimately be developed that details the frequency of inspection, methods that will be used to identify defects, and procedures that will be followed to repair defects that are encountered. A plan should also exist to document that unconsolidated materials fill defects as assumed in the PA, and that filled defects provide the level of isolation that is anticipated.

Compaction of waste and soil-waste mixing ratios have been significant issues at other DOE disposal facilities. This issue is less important at NTS because of the widespread use of containers and the small amount of soil used for waste placement during disposal. Moreover, previous studies have addressed the importance of these issues at NTS (e.g., Shott et al. 1998). However, when new MLLW units or LLRW units are proposed for NTS, these issues may arise during the review process. Thus, the ITR team encourages NSO to revisit these previous investigations, and to confirm that the past findings are consistent with the knowledgebase that has evolved in the last decade.

The use of unlined landfills at NTS is a different containment strategy than employed at most other DOE on-site disposal facilities. Performance assessments published by DOE indicate that unlined landfills at NTS are protective of the environment in the context of DOE Order 435.1. Arguments can also be made that unlined landfills at NTS may be superior to lined landfills (e.g., elimination of a "bathtub effect," an upward gradient through waste is possible, the hydrology is consistent with the natural setting, etc.). However, when new facilities are proposed, the adequacy of unlined landfills may become an issue. Accordingly, the ITR recommends that NSO take a proactive approach and review the scientific underpinnings of unlined landfills for waste containment before embarking on new facilities. The findings from this review could be compiled in an authoritative document that substantiates a particular containment strategy. The review might weigh the pros and cons of both lined and unlined facilities in a quantitative and unbiased assessment in the context of DOE Order 435.1 and other relevant regulations (e.g., regulations pertinent to mixed waste disposal). For example, the review might consider that a liner system may interfere with the natural hydrology on site and therefore have an adverse long-term impact, but also permits the collection and treatment of contaminated liquids that might otherwise be discharged to the subsurface, and can be used to detect adverse performance of the final cover. Regardless of the issues considered, such a review would need to consider the most recent scientific information relevant to both unlined and lined landfills, and should involve technical experts with a background in radioactive waste disposal as well as non-radioactive hazardous waste disposal. Involving experts with and without DOE experience would also provide a broader perspective and make the review more authoritative.

4. LINE OF INQUIRY NO. 2

Are there cost-effective lessons learned from reviews of other DOE disposal operations that may improve the reliability and effectiveness of operations and management of NTS landfills?

As discussed in the response to LOI No. 1, an important lesson learned from all of the DOE disposal facilities reviewed by the ITR team is the effect of waste placement operations on the long-term stability of the final cover. Issues relevant to NSO include the impacts of void space inside and between containers, container lifespan, and the influence that containers may have on the plant ecosystem that controls the hydrology of the cover. The issue of void space has been addressed by a previous workshop conducted by DOE (U.S. DOE 1998). The ITR recommends that NSO review the findings of this workshop, and determine if they are consistent with the knowledgebase that has evolved in the decade since it was conducted, as well as the experience of other DOE disposal facilities. Other recommendations relevant to waste placement are noted under LOI No. 1

Automation of processes, monitoring, and record keeping have also been found to reduce costs and improve quality. For example, electronic monitoring and control technologies can be used to monitor and track waste packages prior to and during shipment, and to control entry to the disposal facility, thereby minimizing the likelihood that unacceptable wastes are buried. Automated processes can also provide data streams that are immediately recorded and archived, providing unambiguous records that can be audited by third parties. Systems of this type are being deployed for waste tracking at OR's EMWMF, and could be considered at NTS.

Field testing has also proven to be a cost-effective means to collect data to demonstrate the efficacy of a technology or to obtain full-scale parameters for prediction. For example, a field testing program at ERDF was used to evaluate new waste compaction methods and to assess compressibility of the existing waste. As a result, several lingering concerns of the regulatory authorities were solved in an authoritative manner. NSO has employed this approach to assess cover effectiveness. Results of the lysimeter study at Area 5 have shown that a cover system employing natural principles can limit flow into underlying waste to very small amounts. This test has also shown that plants are necessary to maintain a favorable water balance. The ITR team recommends that NSO consider a similar field program to evaluate potential subsidence of the waste, and its impact on performance of the final cover. This field program could build on the evidence in Shott et al. (1998) and the findings of the 1998 workshop, and provide a definitive assessment of the impacts of subsidence on the performance of final covers in arid environments. This type of study would be beneficial to others in the DOE complex that operate disposal facilities in arid regions.

Developing reliable forecasts of waste volumes, and how waste volumes affect air space requirements and expansion plans, has been found to be important when sites interact with their stakeholders including oversight agencies outside of DOE. Even at sites that are not constrained by the availability of land, accurate forecasting can be useful for conducting an informed assessment of existing capacity, and the need for expansion. Consequently, technical issues associated with an expansion can be resolved and regulatory interactions can be initiated in a timely manner. This could be especially important if the volume of off-site waste delivered to NTS should increase substantially.

5. LINE OF INQUIRY NO. 3

Are there good practices at NTS landfills that may benefit other EM sites?

The long-term testing NSO has conducted to validate the final cover design is a forward-thinking approach that should be adopted by other DOE sites operating on-site disposal facilities. Tests to evaluate covers should be initiated before closure, as done at NTS, to ensure that a long-term data set is available to demonstrate the efficacy of the cover design to DOE and its stakeholders (regulators, public).

Lessons learned from the historical interaction between NSO and its stakeholders could be particularly valuable to other DOE sites. NSO's success in operating LLRW and MLLW disposal facilities with the Yucca Mountain debate in the background is a testament to the importance of this long-term relationship. NSO should consider developing a lessons-learned document or webinar on good practices for stakeholder interaction that could be shared with other DOE site managers.

6. LINE OF INQUIRY NO. 4

How can NSO apply experience gained at other sites that have installed RCRA disposal cells for MLLW?

Several RCRA disposal cells have been constructed at DOE sites (e.g., Fernald, Hanford, Idaho, Oak Ridge). Although some lessons learned from these facilities are site specific, others may apply generally to operating and future on-site disposal facilities in the DOE complex. DOE should consider offering a workshop where site managers and staff can share lessons learned at DOE facilities. Workshop facilitators could include staff from DOE facilities with RCRA disposal cells.

Experience at DOE RCRA-style disposal facilities has shown that filling practices and timing can affect the design requirements and construction sequence for a disposal facility. For example, compaction methods and criteria can affect the requirements for the final cover, criteria regarding soil-debris ratio can influence the construction schedule for new cells (e.g., if a lined area is needed for staging or stockpiling mixing components), and the sequencing of waste streams can affect the availability of mixing soils and air space usage. A key lesson learned is that filling practices need to be identified and the timing for waste streams considered when computing air space requirements for the facility and when defining construction sequencing.

Experience has also shown that regulators should be involved as partners in each step of the design process. If regulators are well informed, decisions can be made more quickly and complicated issues are more readily resolved. This approach has been used successfully by the Corps of Engineers in closing disposal facilities operated by the U.S. Navy and U.S. Air Force.

Installation of RCRA disposal cells has become standard practice in most regions of the U.S. Thus, many lessons learned have been complied into continuing education courses offered by organizations such as the American Society of Civil Engineers. NSO staff are encouraged to participate in continuing education courses before embarking on design and construction of a new RCRA disposal cell. Documents available from U.S. EPA can also be particularly helpful (e.g., Bonaparte et al. 2002).

7. LINE OF INQUIRY NO. 5

What lessons have been learned from closures of disposal cells at other DOE sites?

Final closure of RCRA-C style disposal facilities has occurred at Fernald and Mound. A non-RCRA MLLW facility was closed at Sandia, and a collection of mill tailings facilities (RCRA and non-RCRA style) have been closed as part of DOE's UMTRA program.

Common themes at each of these sites have been long-term performance, sustainability with minimal maintenance and/or intervention, the level of monitoring, and the importance of long-term stewardship. Each of these issues may be important when closing non-RCRA and RCRA-style disposal facilities at NTS. The ability to document that the facility has been designed to function for the 1,000-yr design period will be important to regulators and other stakeholders. The monitoring and surveillance program during the institutional control period may also be an important issue. Stakeholders will need to be convinced that the monitoring and surveillance program will provide for continuous assessment of the containment system, as well as monitoring of adjacent pathways and receptors (ground water, air, and biota). Benson et al. (2003) describe a remote monitoring and surveillance system that was evaluated as a prototype for the Fernald on-site disposal facility. This type of approach might be applicable to NTS.

DOE's UMTRA program provides one of the longest records on the performance of disposal facilities. DOE's experience in maintaining UMTRA facilities should be incorporated when EM designs on-site disposal facilities and their monitoring and surveillance programs. UMTRA has shown that disposal facilities must be designed to be congruent with the natural surrounding environment if they are to be sustainable and require minimal maintenance. Native vegetation should be used in cover profiles that mimic the natural soil profile. Sharp edges and linear features should also be avoided, as nature will alter these features until they become consistent with local conditions. Geomorphologists and ecologists can play an important role in understanding these processes, and can provide insights into designing a disposal facility that must persist for at least 1,000 years.

Basic construction issues can have a significant effect on the cost and schedule of a closure operation. For example, availability of materials should be verified before a final design is accepted for construction. This would include the availability of cost-effective borrow sources for construction of liner, cover, and drainage systems, which can have a dramatic effect on construction cost and long-term performance. Construction details should also be verified and checked against similar details used at other DOE on-site disposal facilities to ensure that they are practical, provide acceptable performance, and will be accepted by the regulatory authority. In additional to LFRG oversight, experts from other DOE sites involved in construction of on-site disposal facilities could be recruited to review final designs and to share lessons learned.

8. RECOMMENDATIONS FOR NTS

The following recommendations are made by the ITR team regarding disposal practices at NTS:

- Waste placement methods and disposal operations can affect the long-term stability of a final cover. This issue is common to all DOE on-site disposal facilities, including those at NTS. The impacts of differential settlement, extreme precipitation events, and seismic activity on the final cover proposed for Area 5 at NTS have been addressed in previous studies and workshops (e.g., Shott et al. 1998, U.S. DOE 1998). The ITR recommends that these studies be reviewed in the context of the knowledgebase that has evolved since these studies were conducted and be sure that the conclusions that were drawn are consistent with current scientific thinking within and external to DOE.

- The use of unlined landfills at NTS is a different containment strategy than employed at most other DOE on-site disposal facilities. The ITR recommends that NSO carefully review the merits of unlined and lined landfills through an unbiased comparative expert assessment prior to embarking on developing new facilities. Experts with and without DOE experience might be involved in this assessment.

- Automation of processes, monitoring, and record keeping can reduce costs and improve quality. NSO should explore where automation can be applied as part of waste acceptance, landfilling operations, and record keeping.

  Lessons learned from the historical interaction between NSO and its stakeholders could be particularly valuable to other DOE sites. NSO should consider developing a lessons-learned document or webinar on good practices for stakeholder interaction that could be shared with other DOE site managers.

  DOE should consider offering a workshop where site managers and staff from facilities can share lessons learned regarding on-site disposal. Workshop instructors and facilitators could include staff from DOE facilities with RCRA and non-RCRA disposal cells.

- Common themes during closure of other DOE disposal facilities include long-term performance, sustainability with minimal maintenance and/or intervention, monitoring, and long-term stewardship. Each of these issues should be considered when preparing closure plans for non-RCRA and RCRA-style disposal facilities at NTS. DOE experience in maintaining UMTRA facilities should be applied when designing closures (as well as new cells) to ensure the designs are congruent with the natural setting.

These recommendations should be considered in the context of NTS' Radioactive Waste Management Basis and Disposal Authorization Statement and the associated conditions imposed by the Low-Level Waste Disposal Facility Federal Review Group. If necessary, an Unreviewed Disposal Question Evaluation might be conducted or a recommendation could be addressed through appropriate PA Maintenance Plan activities.

9. ACKNOWLEDGEMENT

This technical review was supported by Mark Gilbertson (DOE-HQ), Dinesh Gupta (DOE-HQ), and Jhon Carilli (DOE-NSO). Owen Robertson (DOE-RL) participated in the site visit and the review. The ITR thanks those individuals with DOE who provided information and input during the review.

10. REFERENCES

Benson, C., Tipton, R., Kumthekar, U., and Chiou, J. (2003). Web-Based Remote Monitoring System for Long-Term Stewardship of a Low-Level Radioactive Waste Landfill, *Proc. Ninth International Conference on Radioactive Waste Management and Environmental Remediation*, ASME, S16, 1-6.

Bonaparte, R., Daniel, D., and Koerner, R. (2002). Assessment and Recommendations for Improving the Performance of Waste Containment Systems, Report No. EPA/600/R-02/099, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH.

Shott, G., Barker, L., Rawlinson, S., Sully, M., and Moore, B. (1998). *Performance Assessment of the Area 5 RWMS at the NTS, Nye County, Nevada,* Revision 2.1, DOE/NV/11718—176, Bechtel Nevada, Las Vegas, Nevada.

U.S. DOE (1998). *Consequences of Subsidence for the Area 3 and Area 5 Radioactive Waste Management Sites, Nevada Test Site (Working Group Report).* DOE/NV—502 UC-600. U.S. Department of Energy, Nevada Operations Office, Waste Management Division, March 1998.

U.S. DOE (2001), Radioactive Waste Management Manual, DOE M 435.1-1, Office of Environmental Management, U.S. Department of Energy, Washington, DC.

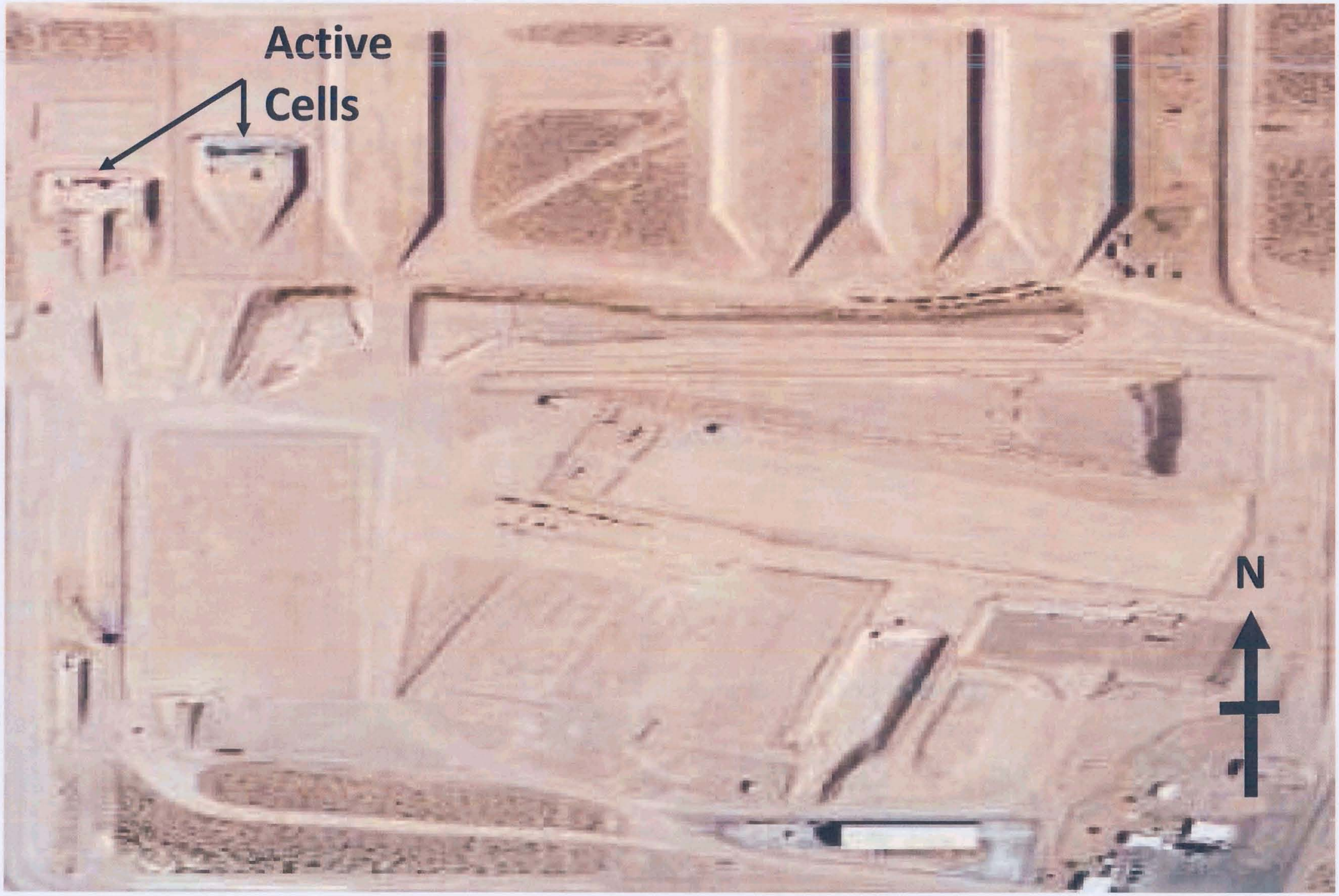

Fig. 1. Aerial view of Area 5 showing open and closed disposal trenches (see Fig. 2 for layout details).

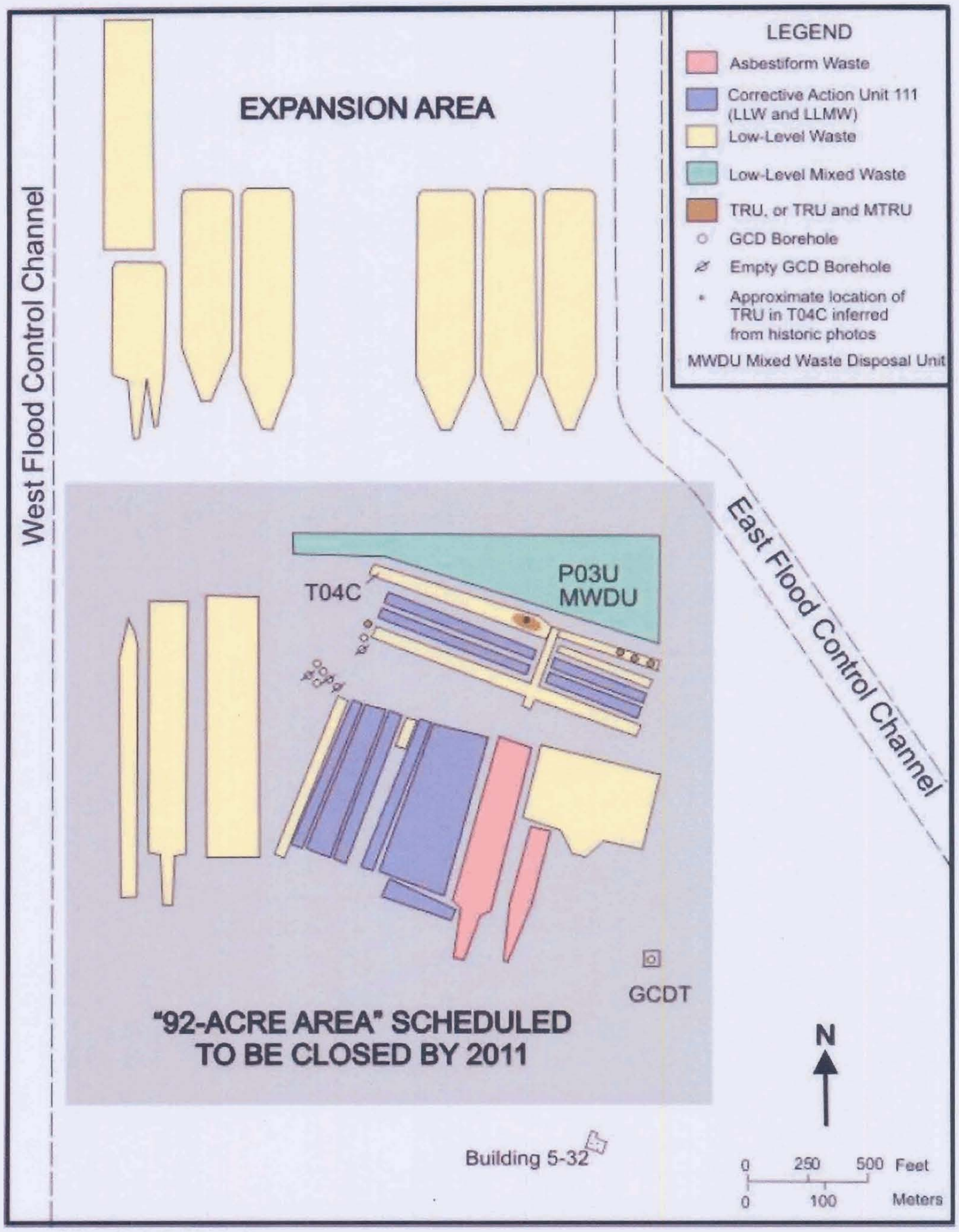

Fig. 2. Layout of trenches in Area 5.