Attachment J

Alternatives Assessment for Open Detonation Activities at Los Alamos National Laboratory

Included in LA-UR-11- 03642

Alternatives Assessment for Open Detonation Waste Treatment Activities at Los Alamos National Laboratory

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Introduction

The purpose of this assessment is to discuss the feasibility of alternatives to explosives hazardous waste treatment through open detonation (OD) at the Los Alamos National Laboratory (LANL) and present justification for maintaining this capacity. The United States Environmental Protection Agency (EPA) provided options within the regulations for the safe destruction of excess, obsolete or unserviceable (EOU) military munitions and energetic materials through open burning (OB) and/or OD. The EPA provides rules for OB and OD operations in Title 40 of the Code of Federal Regulations Section 265.382 (40 CFR §265.382). These rules state that,

> "open burning of hazardous waste is prohibited *except* for the open burning and open detonation of waste explosives. Waste explosives include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment".

The EPA also provided guidance for the operations at OD units in the EPA OB/OD Permitting Guidelines document (EPA, 2002). In the guidelines, the EPA acknowledges,

> "Because of safety hazards, as well as the site-specific feasibility factors for alternative treatment technologies, there are certain circumstances and energetic wastes that necessitate the use of OB/OD treatment. Thus, OB/OD treatment is not expected to be totally replaced by alternative technologies in the near future".

This alternatives assessment will focus on explosives waste streams that are treated by OD and the two OD units used to treat hazardous waste at LANL. These treatment units are dual use and support other testing and explosives operations and research important to the missions at LANL. EPA guidelines for the operations of OD hazardous waste treatment units state that the selection and appropriateness of OD treatment must also be based upon the following (EPA, 2002):

- site specific safety,
- transportation hazard potential,
- offsite treatment options, and
- feasibility of alternative technology considerations.

This assessment will evaluate the feasibility of using technologies other than OD for treatment of LANL's explosives waste streams. The applicability of alternative treatment methodologies will be evaluated based upon safety, transportation hazard potential, offsite treatment options, percentages of the total amount of waste per waste stream the technology will treat and the feasibility of alternative technologies that may be identified for each of these waste streams. This assessment also outlines other important factors used for developing the conclusion that onsite treatment by OD is the safest and most feasible option to treat certain explosives hazardous wastes.

Facility and Unit Descriptions

LANL is located in Los Alamos County, an incorporated county, in north-central New Mexico; approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (see Figure 1). LANL is divided into technical areas (TAs) and occupies approximately 40 square miles. LANL and the associated residential and commercial areas of Los Alamos County, which occupy an area of approximately 109 square miles, are situated on the Pajarito Plateau. The plateau consists of a series of finger-like mesas separated by deep east-west trending canyons. Ephemeral, interrupted, or intermittent streams lie at the bottoms of all the canyons. The mesa tops range in elevation from approximately 7,800 feet above mean sea level (AMSL) at the flank of the Jemez Mountains, located to the west of Los Alamos, to about 6,200 ft AMSL at their eastern extent, where they terminate above the Rio Grande.

LANL's central mission is to develop and apply science and technology to ensure the safety, security, and reliability of the US nuclear deterrent; reduce global threats; and address other emerging national security challenges. This central mission is supported by research that also contributes to conventional defense, civilian, and industrial needs. Programs include nuclear, medium energy, and space physics; hydrodynamics; conventional explosives; chemistry; metallurgy; radiochemistry; space nuclear systems; controlled thermonuclear fusion; laser research; environmental technology; geothermal, solar, and fossil energy research; nuclear safeguards; biomedicine; health and biotechnology; and industrial partnerships. LANL is owned by the United States Department of Energy (DOE) and is operated jointly by the DOE National Nuclear Security Administration (NNSA) and Los Alamos National Security, LLC. Hazardous waste is treated by OD at two firing sites at LANL located at two TAs; TA-36 and TA-39. Both OD units are located within the LANL-Facility perimeter boundaries and away from public access areas.

TA-36 is located in the east-central portion of LANL and is spread over several mesa tops between a branch of Pajarito Canyon to the north and Water Canyon to the south. The TA-36-8 OD Unit (also known as "Minie Site") is located near control building 8 in the southern portion of TA-36. The firing site consists of an irregularly-shaped sand and grass covered area that measures approximately 500 feet east to west and 300 feet north to south.

TA-39 is located in the southern portion of LANL and includes much of the mesa between Water Canyon to the north and Ancho Canyon to the south. The TA-39-6 OD Unit (also known as Point 6) is located near control building 6 and is a relatively flat, sand-covered area that measures approximately 40 feet by 40 feet in a canyon bottom. Steep canyon walls rise to heights of 100 feet or more in the immediate vicinity of the OD unit, forming a rough semi-circle around the unit.

Waste Streams Treated Through Open Detonation

The waste streams treated at the OD units consist of the following:

- Excess explosives: This waste stream includes large, laboratory sized, or small amounts of excess conventional explosives, developmental energetic materials, or novel formulations. Explosives may be in the form of flakes, granules, crystals, powders, pressings, plastic bonded, putties, rubberized solids, extrudable solids, or liquids. Developmental energetic materials are synthesized in small quantities in high explosives chemical labs. Explosives infrequently contain barium or ammonium nitrate mixed with more than 0.2% combustible substances. Approximately 3 to 7% of the explosives in this waste stream contain depleted uranium. Other materials that may be present in this waste stream include plastic bags, wrapping, and casings; cardboard and paper; and fiberboard containers. A fraction of the waste stream may contain metals such as aluminum, brass, steel, stainless steel, and copper. This waste stream represents 50% to 90% of explosives waste treated by OD.
- Detonators, initiators, mild detonating fuses, and blasting caps: This waste stream includes detonators, initiators, mild detonating fuses, and blasting caps containing conventional explosives. Explosives may be in metal or plastic casings and may contain lead based primaries or be in metal sheaths. This waste stream includes manufactured articles (detonators) removed from fire protection systems. Other materials that may be present in this waste stream include plastic bags and wrapping; cardboard and paper; and fiberboard containers. This waste stream may include metals such as aluminum, lead, brass, stainless steel, steel, nickel, and copper. This waste stream represents 1% to 2% of all explosives waste treated by OD.

- Shaped charges and test assemblies: This waste stream includes shaped charges consisting of cores of explosives with metal sheaths or metal liners, or high explosives test assemblies consisting of explosives in plastic or metal holders. Assemblies may contain metal including lead, aluminum, copper, brass, steel, tantalum, glass and stainless steel. Other materials that may be present in this waste stream include plastic components, bags, or wrapping; cardboard or paper; and fiberboard containers. This waste stream represents 1% to 2% of the explosives waste treated by OD.
- Projectiles and munitions larger than 50 caliber: This waste stream includes military munitions such as projectiles and munitions larger than 50 caliber. A fraction of this waste stream includes materials bonded to depleted uranium. Other materials that may be present in this waste stream include plastic bags and wrapping; cardboard and paper; fiberboard drums; and metal such as lead, brass, steel, stainless steel, copper, and aluminum. This waste stream represents 1% to 2% of the explosives waste treated by OD.
- Pressing molds: This waste stream includes urethane (Adiprene) pressing molds contaminated with detonable quantities of explosives. Other materials that may be present in this waste stream include plastic bags, plastic wrapping, cardboard, and paper. This waste stream is treated infrequently and represents 1% to 2% of the explosives waste treated by OD at LANL.
- Explosives-contaminated debris: This waste stream includes detonable explosives-contaminated debris generated in laboratories and prep rooms. Debris may include filters removed from laboratory equipment or may contain solvents. Very rarely, this waste stream may also include depleted uranium. Other materials that may be present in this waste stream include plastic pieces, bags, wrapping and tubing; weigh boats; latex or nitrile gloves; glass or plastic vials; cardboard and paper; fiberboard containers; kimwipes, rags, and swabs; glassware; and metal. Metal constituents may include aluminum, stainless steel, steel, brass, and copper. Solvents in the waste stream may include trace quantities of ethanol, acetone, methanol, ethyl acetate, toluene, cyclohexanone, benzene, chloroform, 1,2-dichloroethane, 1,2-dichloroethylene, methyl ethyl ketone, fluor-inerts or trichloroethylene. This waste stream represents less than 1% of all of the explosives hazardous waste treated at the OD Units.
- Small caliber ammunition: This waste stream is rarely treated and includes small caliber munitions (less than 50 caliber) that have unknown properties as a result of testing activities or damage. These materials are managed as explosives which pose a special risk in storage and transportation in accordance with the DOE Explosives Safety Manual (DOE, 2006). Other materials that may be present in this waste stream include plastic bags and wrapping; cardboard and paper; and metal such as steel, brass, copper, lead and zinc. This waste stream represents less than 1% of explosives treated by OD.
- Black powder or gunpowder: This waste stream is rarely treated and includes standard commercial and military grades of black powder or gunpowder. These powders are typically potassium or sodium nitrate based. Other materials that may be present in this waste stream include plastic bags, wrapping, and containers; cardboard and paper; tin and fiberboard containers. This waste stream represents less than 1% of the explosives waste treated by OD.

Detailed information for these waste streams is provided in the permit modification request for the OD Units at LANL. Figure 2 illustrates waste treatment quantities for the past five years. The majority (50% to 90%) of the waste treated onsite consists of excess explosives. The other waste streams are treated less frequently and in smaller quantities.

Safety and Security Concerns

Safety and security are important concerns in the decision to treat waste onsite or ship waste offsite. Both have separate but equal concerns that result in the conclusion that onsite treatment is the best choice for certain explosives wastes. While human safety is paramount in all explosives handling operations, security classification issues can also add to the complexity of handling, transport, and treatment of explosives wastes generated at LANL.

The most important aspect when dealing with explosives waste streams is to minimize or eliminate, if possible, the danger and exposure to workers and the public from accidental detonation of the waste. At LANL, work activities associated with explosives and other energetic materials are carefully controlled and explosives safety is maintained in all operations within DOE through the requirements outlined in the DOE Explosives Safety Manual (DOE, 2006). This manual provides directives for safe explosives operations, facility configuration, maintenance, and other activities. At DOE Facilities, human safety is paramount during all operations with explosives, including waste management activities.

Safety presents the most significant consideration when evaluating alternative methods of treatment for energetic waste. Similar to handling radioactive, toxic and other hazardous wastes, safety is fundamental to minimizing or eliminating exposure to workers and the public from explosives wastes. As energetic materials age or are subjected to testing, the resulting energetic waste can develop properties that are unpredictable. Even minor damage to an explosives part that may introduce cracks can increase the sensitivity of that material significantly. Explosives wastes such as these are prohibited from transportation on public highways and roads in accordance with United States Department of Transportation (DOT) regulations (49 CFR Part 173, Subpart C).

DOE has an active role in research and development of explosives formulations, explosives synthesis, charge geometry, and explosives assemblies. DOE and operating organizations maintain explosives safety standards that fully address potential risks. LANL explosives operations have integrated the following rule for safety: Limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of explosives consistent with safe, reliable and efficient operations.

The presence of depleted uranium and/or security considerations can also complicate the ability to treat an explosive hazardous waste offsite. Approximately 5% of all of the explosives waste treated by OD over the past five years contained depleted uranium, which is not accepted at the offsite facilities described later within this assessment and; therefore, cannot be sent offsite. Additionally, security-related considerations may significantly delay or prohibit the acceptance by, or transport to, an offsite treatment facility. Both of these concerns affect the decision to treat waste onsite.

Each waste detonation is carefully planned to minimize worker exposure and handling of explosives. Personnel who have been trained in explosives handling and are familiar with the explosives' characteristics conduct onsite waste treatment operations which reduces the potential for compromise of the energetic material and the likelihood of serious injury or death. LANL explosives waste streams vary widely in form and constituents. Onsite explosives professionals are familiar with the specific types of explosives waste generated at LANL and the processes that generate them. Therefore, it is often safer to treat these wastes onsite rather than to ship them offsite.

Alternatives Assessment Approach

Methods for reducing the amount of waste treated by OD onsite at LANL over the past several years have followed a hierarchy of consideration.

- The first consideration is pollution prevention and waste minimization. This involves reducing or eliminating the wastes that must be treated by OD.
- The second consideration is alternative technologies. Alternative technology assessments are developed to evaluate the ability to treat LANL-generated waste streams using techniques or methodologies that are different from OD. Several factors are considered, including: applicability of the technology to LANL's waste streams; the availability of those technologies offsite; onsite construction feasibility; time considerations for permitting and construction; and potential public response. LANL cautiously approaches consideration of some alternative technologies because of previous negative public response to the operation of incinerators and air curtain destructors.
- The final consideration is the feasibility of offsite transport to facilities that can treat explosives hazardous waste.

This alternatives assessment will discuss each of the considerations mentioned above and summarize the path forward on how and where treatment of explosives hazardous waste will occur at LANL.

Pollution Prevention and Waste Minimization

Waste minimization requires implementation of processes, practices, and procedures to reduce the volume of explosives and explosives-contaminated waste that must be ultimately managed as hazardous wastes. Considerable effort has been made to eliminate, minimize, or reuse wastes. Operations and waste management personnel rigorously apply waste minimization principles to "green" the processes and significantly reduce the quantity of high explosives wastes treated by OD. Figure 2 illustrates the volume and types of waste treated at LANL by OD over the past five years. As shown in Figure 2, there has been a dramatic decrease in the volume of the most commonly treated explosives waste stream (Excess Explosives) during that time. Waste generators and waste professionals continuously work at improving the management of regulated and non-regulated wastes generated by implementing the following waste minimization practices:

- All new programs, modifications to existing programs, or work execution with potential waste management impacts are evaluated during the planning phase to look for waste minimization opportunities.
- Personnel at LANL emphasize waste management practices, waste minimization, and material recycling/reuse opportunities during each pre-job briefing.
- Evaluation of explosives synthesis, processing, production, and testing operations is conducted to identify opportunities to reduce the volume of, or eliminate altogether, explosives waste streams.
- Evaluation of explosives research, processing, and production operations is conducted to identify "green" opportunities, such as use of fewer solvents, use of less toxic materials, and implementation of cleaner synthesis operations.
- Separation and segregation practices are applied to explosives waste streams to reduce the volume and toxicity of detonable hazardous wastes.
- When possible, excess explosives are transferred from original owners to other experimental groups for onsite reuse and recycling.
- Excess explosives can also be transferred from original owners to offsite facilities for experimental use.

- Implementation of a centralized explosive inventory system that is available to all explosives custodians provides the opportunity for owners and users to search a common inventory system for in-stock explosives materials before ordering new materials.
- Explosives-contaminated laboratory glassware is now washed in dedicated dishwashers to remove residual high explosives. Cleaned glassware may be discarded as non-hazardous waste.
- Coordination of waste treatment detonations is conducted to pair wastes that require the use of more fuel with wastes that require less fuel. This optimizes waste treatment efficiency and reduces the number of waste treatment detonations required.
- Where possible, excess explosives are used as fuel for waste treatment detonations.
- Bulk propellants and munitions containing propellants are shipped to an offsite facility for treatment and disposal when possible and practical.

In addition, LANL has systematically and successfully applied pollution prevention principles to reduce the toxicity of the explosives waste streams and the amounts of excess explosives and explosives-contaminated waste treated onsite as demonstrated by the following examples.

<u>Treatability study of mercury/explosives separation technology</u>

Several vital processes in the LANL explosives laboratories generate waste streams that contain both mercury, principally as metal, and high explosives. Because of the combination of toxicity and reactivity, these waste streams are nearly impossible to ship offsite for disposal. The purpose of the study was to evaluate solvent extraction technology to separate the wastes into streams with established disposition paths. The successful technology required repeated steps of solvent extraction, air agitation, centrifugation, precipitation, filtering, and washing. The resulting waste streams were explosives; explosives-contaminated filters; solvents containing less than 1percent high explosives; mercury and non-detonable contaminated combustibles; and concentrated nitric acid. The solvents containing less than one percent high explosives, mercury and non-detonable contaminated combustibles, and concentrated nitric acid are shipped offsite for disposal. The explosives and the explosives-contaminated filters are treated onsite through OD or OB. The recovered elemental mercury is reused in the processes that originally generated it. This technology has potential application for treating explosives-contaminated mercury recovered from traps and piping in former high explosives processing buildings undergoing demolition.

<u>Recognition of Pollution Prevention Program</u>

LANL organizations responsible for explosives engineering, synthesis, processing, and production received Green Zia awards in 2000, 2001, and 2002. These awards are recognition from NMED's Green Zia Environmental Excellence Program for noteworthy performance in developing and implementing a successful systematic pollution prevention program.

<u>Implementation of Environmental Management System (EMS)</u>

In 2005, LANL's EMS was implemented in accordance with DOE Order 450.1A and was independently verified as compliant with the International Organization for Standardization (ISO) Standard for EMS (ISO 14001). EMS involves workers and managers at all levels evaluating their activities for potential environmental impacts; identifying actions to mitigate negative interactions and foster positive interactions; developing plans to implement those actions; and documenting and reporting their progress.

Pollution Prevention Awards for developing "green" explosives

The following Improvements in explosives and explosives syntheses were recognized with LANL P2 Awards including:

- Invention of a new class of primary explosives that do not contain toxic metals and are safer to handle (2006 LANL Environmental Stewardship P2 Award, 2007 NNSA Best in Class P2 Award).
- Development of a new production method for the explosive DAAF that eliminates the use of sulfuric acid and organic solvents and produces only non-hazardous by-products (2008 LANL P2 Award).
- Development of a new production method for producing a high thermally stable explosive known as DAAzF that produces only water, salt, and sodium bicarbonate as by-products (2009 LANL P2 Award).
- Development of an environmentally-friendly method for producing the precursor chemicals used in production of an insensitive high explosive (2010 LANL P2 Award).

Onsite/offsite transfers for alternative use

EMS Environmental Action Plans (EAPs) for FY07 through FY10 included actions to review explosives inventories and transfer or dispose of excess explosives. Transferring excess explosives from explosives owners to other onsite groups for alternative uses removed a total of 30,141 pounds from this waste stream from 2007 through 2010. Transferring excess explosives offsite to Naval Air Systems Command (NAVAIR) at China Lake, California in 2008 removed an additional 10,654 pounds from the waste stream. Transfer of approximately 5,000 pounds of bulk explosives to other DOE and United States Department of Defense (DoD) facilities is pending.

Material segregation and separation

Applying the principles of material segregation and separation increased the volume of explosives-contaminated combustible waste managed as non-hazardous waste and sent to a commercial facility for treatment and disposal. The quantity of hazardous explosives-contaminated debris treated onsite by OD/OB has correspondingly decreased. Figure 3 illustrates this trend.

Offsite treatment and disposal

Bulk propellants and munitions containing propellants are shipped to an offsite facility for treatment and disposal when the waste meets DOT requirements, the waste meets the facility's waste acceptance criteria, and the waste can be safely and securely transported and disposed. During recent initiatives to dispose of excess explosives, personnel identified excess rocket motors containing nitrocellulose, nitroglycerin, lead based primaries, and perchlorate propellants. Offsite treatment was the preferred alternative due to the size of the items and aggregate quantity of perchlorate propellants. A commercial facility was identified that could meet the Resource Conservation and Recovery Act (RCRA) treatment requirements as well as ensure destruction of the rocket motors in accordance with DOE and DoD regulations. The rocket motors were shipped to this facility, located in Colfax, Louisiana for safe, secure, and compliant disposal in April, 2007. The "Disposition of Excess Rocket Motors" project received a 2008 LANL P2 Award.

These pollution prevention and waste minimization practices described above have demonstrated success by increasing the quantity of excess explosives transferred offsite to other users (over 10,000 pounds), increasing utilization onsite by different programs (in excess of 30,000 pounds),decreasing the quantities of explosives treated by OD, and increasing the volume of non-detonable explosives-contaminated waste sent offsite for disposal. The cumulative effect of these pollution prevention and waste minimization practices is that the amount of explosives treated onsite by OD has been a decreasing trend since 2006 (Figure 2).

Alternative Technologies

Alternatives to OD treatment have been researched in support of demilitarization efforts for over a decade. Most research for alternative technologies has been oriented toward the disposition of excess munitions due to the volume of munition stockpiles at DoD facilities. These munitions are primarily encased weapons including rockets, missiles, bombs, mortar rounds, artillery ammunitions, grenades, cluster munitions, and land mines. Weapons may be subject to material recovery activities to disassemble, reclaim, and recover the explosives for waste treatment.

In contrast, most of the waste treated by OD at LANL is waste excess explosives that are not encased and do not require extensive preparation prior to treatment. Damaged small arms ammunition, munitions, and encased test assemblies are a small fraction of the LANL waste streams. Additionally, most alternative technologies are designed to treat larger quantities of waste at one time which is not typical of LANL practices. The following description of alternative technologies includes material recovery activities, mitigation, and treatment.

Description of Alternative Technologies

Briefly described below are technologies that have been used at other DOE and DoD facilities as alternatives to OD. Each of the technologies has been assessed as individual alternative technologies to the onsite treatment of explosives waste streams by OD at LANL. These descriptions were garnered from the following documents: *Literature Review on Demilitarization of Munitions (Poulin, 2010)* and *Evaluation of Alternative Technologies to Open Detonation for Treatment of Energetic Wastes at the Naval Air Weapons Station, China Lake, California (NAWCWD, 2004)*.

- Base hydrolysis oxidation heats waste to mild temperatures (90 to 150 degrees Celsius) and usually elevated pressures (200 pounds per square inch gauge) with a strong base (pH>12). The explosive waste is converted to water-soluble, non-energetic products. The resulting solution is hazardous and must be further treated using bio-remediation or supercritical water oxidation.
- Bioremediation technology uses cultures shown to break down explosives. This technology is most amenable for use on contaminated soils. This technology has been demonstrated to degrade explosive to non-energetic compounds directly. The time to accomplish the degradation is rather lengthy.
- Chemical conversion of recovered explosives and propellants to form other products is used in processes such as solvent extraction and solvolytic extraction. This technology can only treat specific types of explosives waste based upon the specific chemical makeup of the explosive. Extraction technologies frequently create a secondary hazardous waste stream comprised of organic solvents.
- Co-firing in boilers can be utilized when explosives are desensitized so that they can be co-fired with traditional fuels in commercial boilers for heat. The explosive must be soluble in fuel oil #2.
- Contained burning in a confined burn facility consists of treating the explosives waste in blast-reinforced chambers. In some cases fuel must be added to the waste stream (such as kerosene). The combustion gases are contained, and filtered prior to release in the atmosphere. This treatment is most amenable to small caliber ammunition and bulk explosives.

- Contained burn for explosives-contaminated wastes involves burning in a facility designed for wastes contaminated with small amounts of explosive material. This technology is similar to a contained burning, but is more conducive to burning combustible wastes contaminated with explosives rather than ammunition or bulk explosives. It is used mostly for combustible wastes (e.g., rags, gloves, wipes, plastic, etc) that are contaminated with small amounts of explosives. There is no controlled fuel supply for this burn technology, as then it would be considered an incinerator.
- Cryogenic cutting uses liquid nitrogen that is pressurized and then ejected through a small orifice at high velocities. The system includes a cryogenic fluid supply system, a pressurization system, a temperature control system, a nozzle system, a recovery system, and a manipulation system. This treatment is effective as a pretreatment to cut through casings for the purpose of removing the casing from the explosive prior to treatment; however a static charge can build up under certain circumstances and is a safety concern. Secondary materials spray is an additional waste stream.
- Contained detonation involves the detonation of explosive wastes inside a steel chamber constructed to dampen the blast. After-burning reactions are suppressed to protect the integrity of the chamber. Particulates are filtered from the detonation gases. This technology best suited for small pieces of explosives, and may provide residence time for contaminants to transform into toxic or more complex compounds than those created when detonating in open air.
- Fluidized bed incineration is an enclosed incinerator that utilizes the injection of explosives waste into a turbulent bed of hot sand, created by forced air. Emissions are filtered to prior release to the environment. This process is limited to liquids, slurries, and powders with low organic content. The powders must be homogeneous in size.
- Foam technology encases the explosives waste as they are detonated in order to prevent the dispersion of material and dampen noise. This technology can be applied to OD activities for sound mitigation and fragment dispersion reduction, but not as an individual treatment technology to destroy the explosive.
- Hydromilling of explosive waste uses high pressure water jets to “cut” through the material. This is a pretreatment technology that is not conducive for experimental explosive waste streams. A secondary hazardous waste stream of water and explosives is created by this process.
- Liquid ammonia extraction uses propellant, explosive fuel and oxidizer ingredients to extract, separate and recover the explosive using liquid ammonia. This treatment method can treat explosive wastes that have a plastic binder associated with the waste in a limited capacity.
- OB of explosives waste destroys waste by self-sustained combustion after being ignited or by controlled burning in an open environment. This technology best serves waste generated during machining of explosives, excess explosive powders and pieces, explosive contaminated combustible wastes, laboratory samples of experimental explosives and large pieces of equipment that must be flashed prior to shipment offsite for recycle or disposal.
- Molten salt oxidation technology consists of introducing the explosives waste and oxidizing air into a vessel containing a bed of molten salts. The salt oxidizes the organic components of the waste stream to carbon dioxide and steam. The inorganic portion of the waste stream is contained in a molten bed of salt. The molten salt technology must be maintained at 500-1100 degrees Celsius. This technology requires a pre-treatment step of size reduction (e.g., shredding,

milling, grinding, sizing) prior to molten salt treatment and a homogeneous waste stream for the feed.

- Rotary kiln incineration is an enclosed incinerator treatment technology. The rotary kiln slowly moves waste from one end to the other and waste detonates or combusts within the chamber, Therefore, only small amounts of explosive waste can be treated at one time. Emissions are filtered prior to release to the atmosphere. Small explosive items with casings (<40 grams energetic material) can also be treated with this technology. Uniform explosive waste streams are treated most efficiently.
- Plasma arc incineration uses molten slag (soil with iron fluxing agent) which destroys inorganic compounds. The technology encapsulates inorganic toxic solid wastes in the molten slag and when hardened, is disposed. Emissions are filtered prior to release to the atmosphere. This is an enclosed alternative to incineration that can be utilized for explosive wastes that are high in organic compounds (e.g., paint, solvents).
- Super critical water oxidation uses the outcome of the base hydrolysis treatment and treats the solution in a high pressure high temperature tubular flowing reactor. The pressure and temperature exceed the critical point of water where extreme oxidation occurs resulting in a breakdown of the waste solution into nitrogen, carbon dioxide and carbon and carbon/nitrogen products. This treatment method can treat organic waste streams that contain no plastic materials. The feed materials must be flowable such as base hydrolysate.

Applicability of Alternative Technologies to Open Detonation

The treatment technologies described above have been evaluated for the purpose of finding a safe and viable alternative to the current method of OD for explosives and explosives-contaminated wastes. Through this evaluation, it has been determined that three of the alternatives technologies may be used to treat the varied and unique explosives waste streams. These technologies are: contained burn in a confined burn facility, contained detonation and OB. There is no single alternative technology that encompasses the breadth of explosives waste streams that exist at LANL. The alternative technologies used for the evaluation are summarized in Table 1.

The alternative technology evaluation was completed to determine if there was a viable alternative technology to current OD operations. The following criteria were used in the alternative technology evaluation:

- Is the technology a pre-treatment, mitigation, or in-situ technology?
- Does the technology have the versatility to treat all of LANL's hazardous explosives waste streams?
- What are the limitations to the technology with regards to current hazardous explosives waste streams treated by OD (e.g., size, weight limitations, multi-step process, safety issues, and production of a secondary hazardous waste stream)?
- Does the alternative technology need a RCRA permit and if so, what type?

After the assessment, a determination on whether the technology would be a viable alternative to current OD operations was made. Those treatment technologies that are identified as pre-treatment, mitigation or in-situ were not considered viable alternatives to the OD treatment process for the following reasons:

- Pre-treatment technologies are a multi-step processes and are usually conducted for destruction of waste such as military munitions in order to separate an explosive from casings.

LANL does not remove the casings (should there be one) from its explosives waste as this would put the safety of personnel at risk. The explosives waste streams consisting of explosives encased in metal or plastic compromises approximately 1-2% of LANL's explosives waste stream. In situations where no casing is present, LANL's explosives waste stream have, in most situations, been "insulted" or changed from a pristine state to an unknown stability. Applying a pre-treatment technology to an explosive whose properties are not completely known, poses an unnecessary risk to the employee.

- Mitigation technologies do not destroy the explosive, but rather mitigate the treatment activity that initially must take place. Foam prevents fragment dispersal and mitigates the sound of the destruction technology. Foam mitigation technology research is ongoing, however, there is a chance that the foam may produce an electrical charge putting the employee at risk should the explosive detonate prematurely.
- In-situ technologies need a known constant waste stream for the biodegradation process to occur. This degradation process happens over a long period of time (compared to other treatment technologies) and the biological cultures need constant monitoring for optimal conditions to ensure degradation. Some LANL explosives waste streams have properties that are unknown because the explosive has been changed during research and development; therefore, in-situ remediation is not an option.

Experimental formulations of explosives by their very nature do not lend themselves to treatment technologies that do not involve a detonation. Evaluation and qualification for treatment using alternative technologies would require larger quantities of the experimental materials to be produced than would be reasonable or allowable. The formulations are not produced in large quantities for each experiment. It has been determined that these types of explosives waste would only be amenable to treatment by OD or confined detonation in the small quantities that they are produced at LANL.

After screening to remove pre-treatment, mitigation, and in-situ technologies from the list for consideration, a comparison of the remaining alternatives technologies to OD was conducted. This comparison is detailed in Table 1. It was determined that contained detonation, contained burn in a confined burn facility, and OB are able to treat at least 50% of LANL's explosives waste streams, which would make these technologies a potentially viable alternative to OD. Then a focused evaluation of these three alternative technologies as compared to OD was conducted. The results of the focused evaluation are included in Table 2. These technologies were evaluated for the following:

- the percentage of LANL's OD hazardous energetic waste stream each technology is capable of treating;
- industry proven technology;
- potential secondary hazardous waste streams created from the treatment technology;
- public acceptance of the technology;
- reliability and maintenance of treatment equipment;
- personnel safety; and
- whether the technology meets RCRA regulatory guidelines.

Based on this evaluation, none of the three alternatives technologies evaluated are capable of treating all of the explosives waste streams generated at LANL currently treated by OD. All technologies considered viable alternatives require a RCRA hazardous waste permit (in accordance with the requirements of 40 CFR Part 264, Subpart X) in place prior to construction of the facilities, installation of the equipment, and treatment of the explosive wastes.

Offsite Waste Treatment and Disposal

Elimination of all waste streams at LANL that require OD treatment is not a likely scenario; however, some waste streams may have a path forward for offsite disposal. This option is not considered waste minimization because it does not reduce the volume or toxicity of materials that must be managed as explosive hazardous waste. Offsite treatment is not an alternative to OD treatment, because in most cases wastes that are shipped offsite are treated by OB or OD at other hazardous waste treatment facilities. Nevertheless, it is important to explore the option of offsite shipment and treatment of explosives and explosives-contaminated waste generated at LANL.

Offsite Treatment Options

Options for waste treatment offsite are limited, but are considered for both existing waste streams and new explosives waste that are characterized. There are three facilities capable of accepting and/or treating some of the explosives waste streams generated at LANL, as follows:

- Veolia ES Technical Solutions-Trade Waste Incineration (Veolia-TWI);
- General Dynamics Ordnance and Tactical Systems, Joplin Operations; and
- Clean Harbors, Colfax Facility.

At this time, contracts exist with Veolia-TWI and Clean Harbors, Colfax Facility. Offsite treatment and disposal options for explosives-contaminated combustible debris as well as other explosives waste streams are being explored.

The Clean Harbors, Colfax Facility consists of twenty separate treatment units (40 CFR Part 264,Subpart X, Thermal Treatment Units) with the capability of treating reactive (D003) characteristic hazardous wastes through OB processes. The facility is capable of treating up to 480,000 pounds of explosives waste annually and has the capability of storing up to 50,000 pounds of explosives (Clean Harbors, 2011).

Veolia-TWI consists of three permitted treatment units (two fixed hearth thermal treatment units and one rotary kiln thermal treatment unit) with the capability of treating explosives waste that has been properly characterized; provided that the waste does not contain any prohibited wastes as listed within the facility permit (Veolia Environmental Services, 2009). The facility includes a magazine that is used to store up to 100,000 pounds Bureau of Alcohol, Tobacco, Firearms and explosives (BATF) low explosives; however, the facility has no capability to store BATF high explosives or detonators.

All energetic wastes sent to offsite commercial treatment facilities must meet the following requirements:

- DOT transportation requirements,
- the treatment facilities’ waste acceptance criteria (WAC), and
- federal requirements for transfer to commercial facilities.

Bulk propellants, munitions containing propellants, and excess explosives are shipped to an offsite facility for treatment and disposal when the waste meets the facility’s waste acceptance criteria, offsite disposal is economically feasible, and the waste can be safely transported. Offsite shipments in the last five years include the following:

- 3,200 pounds of rocket motors containing perchlorate based propellants, and
- 1,570 pounds of prilled ammonium nitrate (managed offsite as chemical waste).

Offsite Treatment Limitations

Offsite disposal would result in a decrease in the overall quantity of explosives waste treated onsite and the potential closure of two more OD treatment units at LANL. However, all of the wastes that would be shipped offsite for treatment and disposal would still be thermally treated in some form. The waste may be treated by OD, OB, or incineration. Additionally, prior to transportation of waste offsite, LANL must obtain an explosives identification number (Ex ID No.) or interim hazard classification in order to transport explosives wastes on public roads or highways. The process for obtaining an EX ID No. is lengthy (several years depending upon DOT response) and may be unattainable based on the waste characterization of the small amounts of explosive formulations created at LANL. A new EX ID No. is required for each waste stream and for each change in a waste stream.

Waste would have to accumulate onsite prior to shipment offsite, rather than the current practice of treating explosives waste streams as soon as practicable.

Public and Worker Safety

Each of the offsite facilities are some distance away; Veolia-TWI is located 1,084 miles northeast of LANL and Clean Harbors, Colfax Facility is located 842 miles east of LANL. Transportation of this waste from LANL to either of these facilities would be via motor carrier over public roads. Transportation of explosives by motor carrier occurs nationwide on a daily basis, but not without risk to the public. In contrast, the public has limited contact with or access to explosives transported for onsite treatment by OD at LANL. OD treatment of waste onsite decreases the potential for the public to be exposed to these wastes. Onsite treatment also decreases the handling of waste required by workers. Packaging and transport for onsite treatment is conducted by explosives personnel that have experience handling wastes that are not in pristine condition, have been subjected to insult, or are generated from unique processes. Shipment offsite places these wastes in the hands of personnel who are less knowledgeable and experienced with these particular waste streams. The distances transported also increase the risk of transportation incidents, theft, or diversion. Transporting waste for hundreds of miles via motor carrier also increases the overall emissions from vehicles that transport the waste to treatment and/or disposal facilities.

Accumulation of Waste Onsite

Most treatment/disposal facilities require a minimum volume per shipment, as specified in their waste acceptance criteria. Quantities of excess explosives and explosive-contaminated wastes generated at LANL have been decreasing, but are not consistent because they are based on programmatic activities. Wastes treated onsite are currently treated within days or weeks of being generated. If onsite treatment capabilities are not maintained, these wastes would be accumulated until the minimum volume accepted by the offsite treatment facility was reached or a lesser quantity for transport can be brokered with the receiving facility.

Offsite Transport Restrictions and Prohibitions

Shipments on public roads pose hazards and risks for both public and worker safety as discussed above. In addition, there are restrictions and prohibitions on transport of explosives and explosives-contaminated wastes. Security considerations may also prohibit the transport of certain types of explosives. During times of heightened security risk, LANL has prohibited the shipment of explosives waste for security reasons. As previously mentioned, offsite shipment increases the potential risk of transportation-related incidents, theft, or diversion.

Offsite commercial treatment, storage, and disposal facilities (TSDFs) establish criteria to ensure that explosive waste accepted for disposition meets their individual RCRA permit requirements, including EPA Hazardous Waste Numbers (EPA HW No.), and can be safely handled by the facility. Requests for treatment and disposal submitted to these facilities must include documentation that confirms compliance with their waste acceptance criteria including a description of the physical form, chemical constituents, EPA HW No., DOT Proper Shipping Name (PSN), and EX ID No. Developmental explosives and novel formulations may be characterized by EPA HW No. in addition to D003 (reactive). If these EPA HW No. are not included in the offsite facility's RCRA permit, the waste does not meet the applicable acceptance criteria for treatment. Shipments of explosive wastes offsite for disposal are subject to the availability of appropriate storage and treatment capacity at the receiving commercial facilities. Wastes cannot be transported until shipments are approved by these facilities. Elapsed time between request for transport and authorization to ship can be significant (six months). Explosives may deteriorate or become unsuitable for transport while waiting for disposal approval. Inability to promptly remove and dispose of excess, aging, or insulted explosives unnecessarily exposes workers to greater hazards.

There are waste streams generated at LANL that cannot be legally or safely transported on public roadways to offsite commercial facilities. DOT addresses explosives transportation approval requirements at 49 CFR § 173.54 "Forbidden Explosives". The list of explosives forbidden from being offered for transport or transported, include:

- new explosives that have not been examined, classed and approved for transport;
- explosives containing chlorates and either an ammonium salt or an acidic substance;
- damaged packages or articles;
- propellants that are unstable, condemned or deteriorated;
- explosives specifically forbidden in the Table of Hazardous Materials; and
- explosives that fail to pass specified sensitivity, stability and burning tests.

New explosives must be tested, classed, and assigned proper shipping names and EX ID No. by the DOT Associate Administrator in accordance with DOT requirements in 49 CFR §§ 173.56 through173.58. Any explosives that fail the required testing series cannot be assigned these numbers and cannot be transported to commercial facilities. There is currently a substantial backlog of document packages pending review by the DOT Associate Administrator's office; review of new requests may take several years. New explosives pending review that do not yet have proper shipping names and EX ID No. cannot be transported until these are assigned. An Interim Hazard Classification (IHC) valid for up to one year could be issued for the DOE in lieu of an EX-number if the commercial facility was willing to accept the waste transported under this condition.

LANL supports threat reduction and enhanced surety missions through research, development and testing of energetic materials. These energetic materials include novel formulations, developmental explosives, and test assemblies that cannot pass required sensitivity, stability, and burn testing for transport on public roads and are therefore forbidden from public transport. Propellants of any quantity that are deteriorated cannot be transported offsite. Required sensitivity, stability, and burning tests must be performed on the materials as generated; therefore, it is impossible to know if a waste will pass testing for offsite transport until it has been produced. It is necessary to maintain onsite waste treatment capability to safely disposition those materials which are forbidden from transport.

Commercial facilities may not be able to accept certain wastes for treatment. For example; explosives, explosive assemblies, and explosives-contaminated wastes which are classified or secret restricted data (CRD or SRD) or that contain radioactive or source nuclear material are problematic for transport to offsite facilities. Ownership of these materials cannot be transferred to commercial waste treatment facilities without adequate and approved safeguards and security in place. In the case of radioactive wastes, ownership of the materials cannot be transferred to commercial waste treatment facilities without appropriate licenses for radioactive materials, a RCRA permit for mixed wastes, and adequate and approved safeguards and security in place.

Necessity of Open Detonation Waste Treatment

The capability of treating explosives and explosives-contaminated wastes by OD at the TA-36-8 and TA-39-6 OD Units must remain in place to avoid significant impacts to LANL missions and greater safety risks to workers and the public. The following support the necessity to treat explosives by OD:

- Waste minimization practices have been applied at LANL to reduce the volume of explosive hazardous wastes that must be treated by OD.
- Bulk propellants and munitions containing propellants are currently shipped to offsite facilities for treatment and disposal when possible.
- Explosive waste streams are generated at LANL that cannot be safely transported or securely disposed at offsite facilities.
- Explosive waste streams are generated at LANL for which there are no offsite commercial facilities available for treatment.
- OD is the single treatment that can safely and compliantly treat all of LANL's OD explosives waste streams without pretreatment.

Impacts from Loss of Open Detonation Units

The impacts associated with the loss of the OD Units at LANL include the following:

- reduction and/or loss of current missions,
- inability to obtain new missions,
- inability to repair or upgrade existing explosives processing buildings, and
- inability to proceed with demolition of former explosives processing buildings.

Inability to fully support current missions or fulfill new missions significantly impacts national security and global threat reduction. These missions may be diverted to other DOE sites, however, this would result in delays as diversions are planned or put in place.

The inability to treat demolition wastes impact facility maintenance and removal of vacated structures that processed explosives. Repairs and upgrades of existing explosives processing buildings and demolition of vacated explosives processing buildings will produce contaminated debris waste streams that cannot be shipped offsite for treatment. There are approximately 50 buildings with expected explosives-contamination at LANL (over 155,000 sq. ft.) that have been identified for demolition in the next five years. Leaving these structures untouched may produce an even more undesirable situation as they continue to weather and age. Pipes, drains, and sumps will continue to corrode and potentially leak explosives-contaminated liquids into the ground and the high explosives materials themselves may develop greater sensitivity or less stability with age.

There are no technically viable alternatives to OD for several explosives waste streams generated at LANL. The Clean Harbors facility in Colfax, Louisiana has RCRA permitted miscellaneous units in accordance with 40 CFR Part 264, Subpart X. These units use the same process (OD) that is utilized onsite for treatment of these wastes because it is the safest, most efficient, and most economical treatment method. The other two commercial facilities (General Dynamics Ordnance and Veolia-TTWI) have RCRA permitted incinerators in accordance with 40 CFR Part 264, Subpart O.

Conclusion

This alternatives assessment discusses waste minimization efforts, operational practice changes, and process efficiencies that decrease the amount and types of explosives waste requiring treatment by OD. Waste minimization and process efficiency efforts have decreased the overall volume of waste that is generated at LANL during routine operations. These efforts are effective and continual at LANL, but will not eliminate the need for continued onsite OD treatment in the foreseeable future.

In addition, this assessment outlines alternatives treatment technologies to OD and the restrictions and safety considerations for offsite transport of explosives waste streams. The primary aspect of explosives waste treatment that this assessment considers is worker and public safety. Overall, the alternatives assessment concludes that there is no other single treatment technology that can treat all of the explosives wastes streams generated at LANL and currently treated onsite by OD; therefore, multiple treatment technologies would have to be employed onsite. These treatment technologies require RCRA permits in accordance with 40 CFR Part 264, Subpart O (incinerators) or Subpart X (miscellaneous units) prior to construction. OD is the safest treatment method for certain explosives waste streams and these treatment activities cannot be eliminated.

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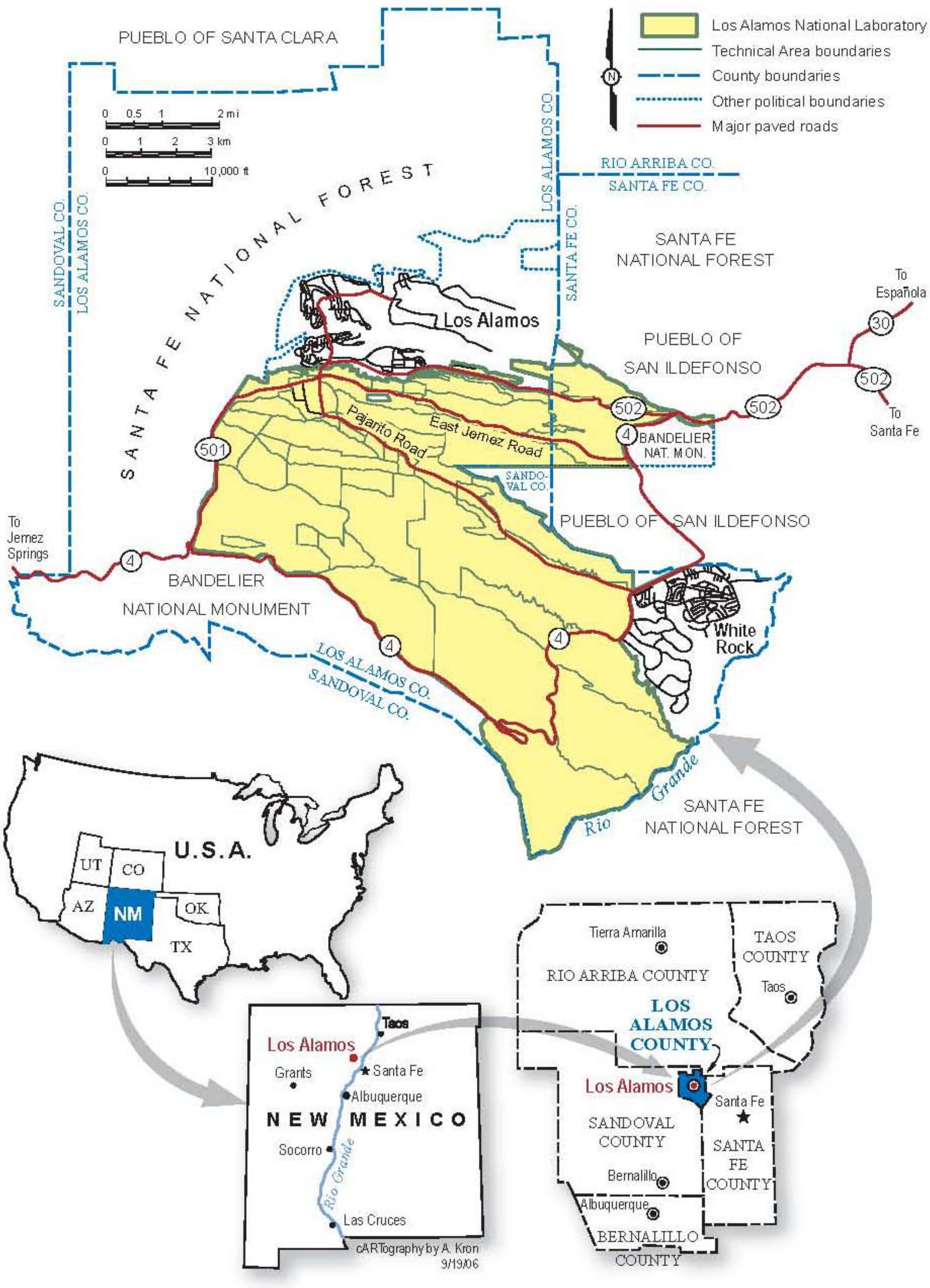

Figure 1

Regional Location Map of Los Alamos National Laboratory

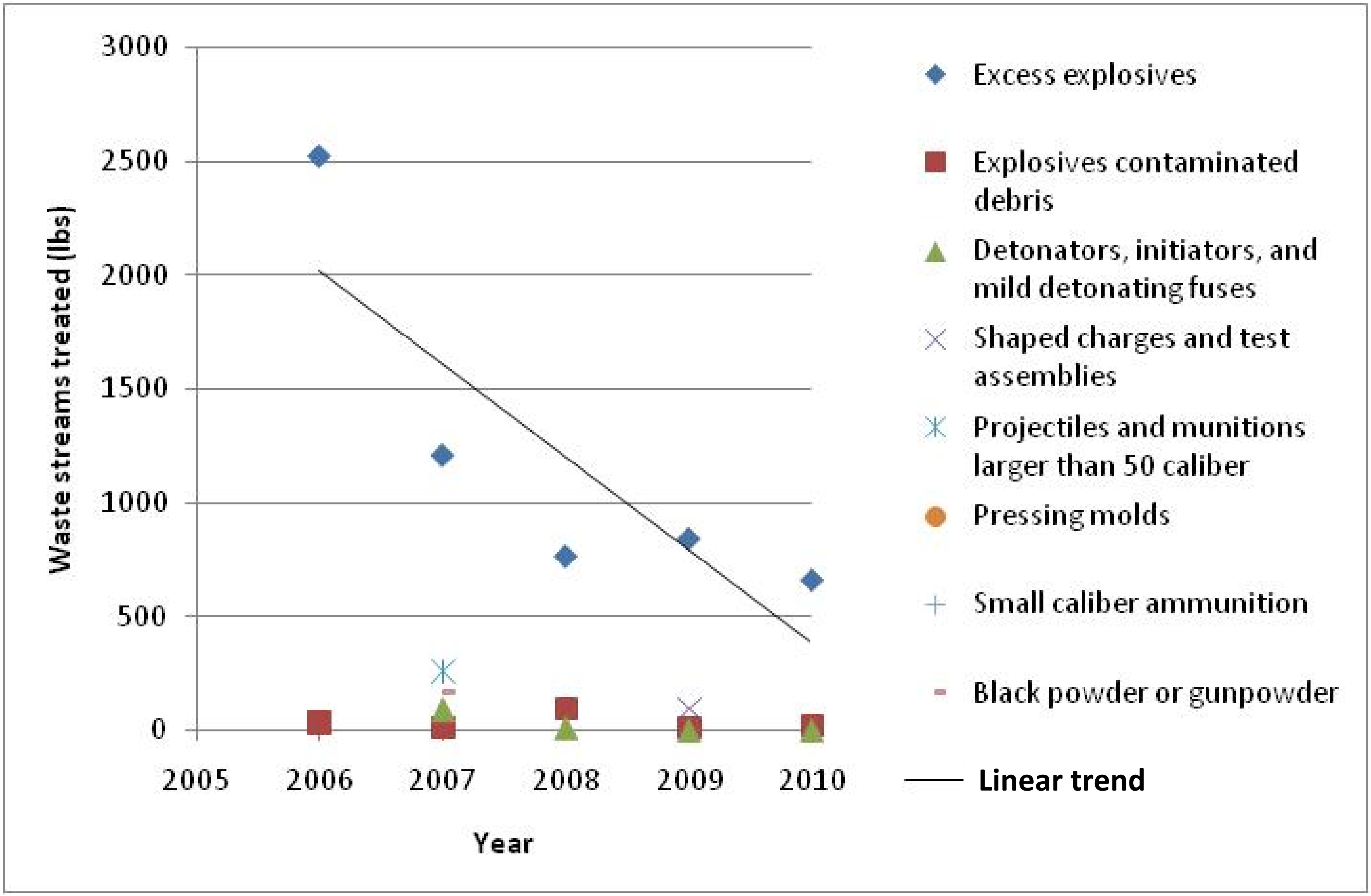

Figure 2. Onsite Waste Treatment through Open Detonation at Los Alamos National Laboratory

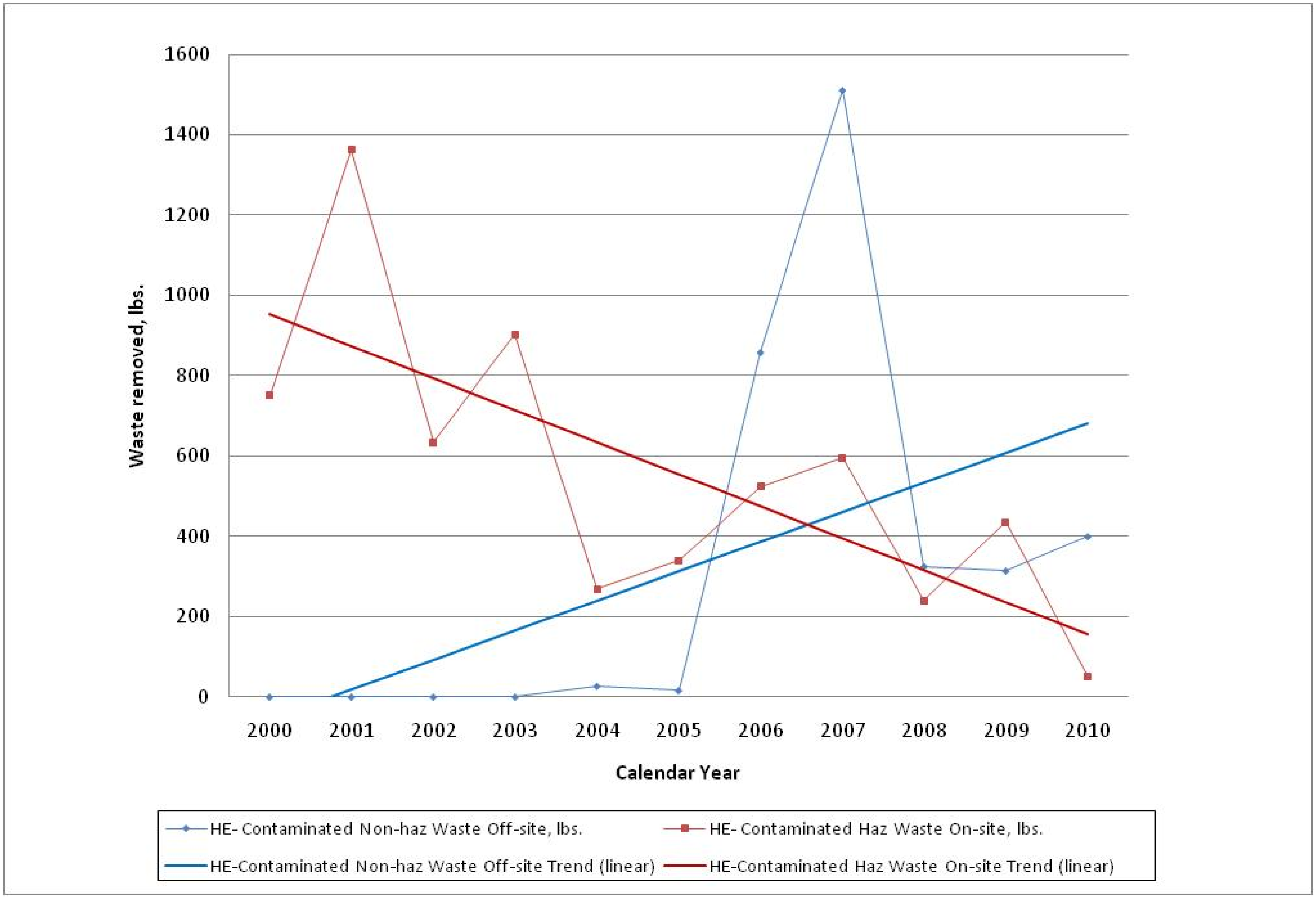

Figure 3. Comparison of Onsite Waste Treatment and Offsite Waste Treatment for Explosives-Contaminated Combustibles

Table 1. Comparison of Alternative Technologies for Open Detonation Waste Treatment

Treatment Technology	LANL Waste Stream Applicability	Limitations	Viable Alternative to OD	RCRA Permit needed?[1]
Chemical Conversion	None	This technology creates a secondary hazardous waste during the solvent extraction necessary for chemical conversion of the explosive. This technology is not suitable for explosives that have been "insulted" because the extent of change to the energetic is unknown.	NO	YES (Subpart X)
Open Burning	~50%	A secondary waste stream is created from the burn and must be analyzed for hazardous constituents and disposed of.	YES	YES (Subpart X)
Molten Salt Oxidation	None	This process requires pre-treatment by shredding, grinding or sizing the explosives waste prior to utilizing the molten salt technology.	NO	YES (Subpart X)
Contained Detonation	~50%	This technology is limited by the amount and size of the explosives waste stream that can be treated at one time. Fragments from the detonation may damage the chamber. Limited lifetime on number of detonations the chamber can treat. Current contained detonation chambers are limited to <100 pounds (net weight explosive). LANL has unique and varied waste streams with unknown energetic properties and items that may be >100 pounds.	YES	YES (Subpart X)
Contained Burn Facility	~50%	This technology is limited by the amount and size of the explosives waste stream that can be treated at one time. Secondary waste streams created are scrubber waste and bag house dust.	YES	YES (Subpart X)
Contained Burn for Explosives-Contaminated Wastes	<1%	This technology is limited by the types of explosives waste streams and the amount of waste that can be treated at one time. The amount and size of the accepted explosives-contaminated debris make this technology more applicable to combustible wastes. This technology can treat LANL's contaminated debris waste stream which is <1% of the total waste treated onsite. The secondary waste stream created is burn residue.	YES	YES (Subpart X)

Table 1. Comparison of Alternative Technologies for Open Detonation Waste Treatment (continued)

Treatment Technology	LANL Waste Stream Applicability	Limitations	Viable Alternative to OD	RCRA Permit needed?[1]
Incineration, Rotary Kiln	<1%	This technology is limited by the types and amount of explosives that can be treated at one time. This technology can treat LANL's contaminated debris waste stream which is <1% of the total waste treated onsite. The secondary waste streams created after applying this technology are ash and scrubber residues.	NO	YES (Subpart O)
Incineration, Fluidized Bed	<1%	This technology is limited to treating powders, liquids and slurries. LANL's waste stream is <1% for black powder or gunpowder. Secondary wastes streams include ash and scrubber residues.	NO	YES (Subpart O)
Incineration, Plasma Arc	~50%	This technology can treat approximately 50% of LANL's waste streams which include bulk explosives and small cased munitions and some excess explosives. The water cooled torch must be replaced periodically. The secondary waste streams created are ash, scrubber residue and slag.	NO	YES (Subpart O)
Supercritical Water Oxidation,	~25%	This technology is a secondary process after base hydrolysis. Base hydrolysis was not considered because it is a pre-treatment technology. The secondary hazardous waste stream created by base hydrolysis can be treated utilizing water oxidation. This process creates another waste stream consisting of inorganic acids, salts and sludge.	NO	YES (Subpart X)
Liquid Ammonia Extraction (Chemical Conversion)	None	This technology is not suitable for explosives that have been "insulted" because the extent of change to the energetic is unknown. This technology is also limited in the types of plastic binders that can be treated.	NO	YES (Subpart X)
Co-Firing in Boilers	None	This technology is not suitable for explosives that have been "insulted" because the extent of change to the energetic is unknown. This technology is limited to explosives that are soluble in Fuel Oil #2 and that will not erode or plug fuel injectors.	NO	YES (Subpart X)

[1] EPA Region 4 Types of Thermal Units Included Under 40 CFR Part 264, Subpart X

Table 2. Focused Comparison of Applicable Waste Treatment Technologies to Open Detonation[1]

Criteria	Open Detonation	Contained Detonation	Contained Burn in a confined burn facility	Open Burning
Percentage of LANL's OD hazardous explosives waste stream treatable by the technology	100%	~50%	~50%	~50%
Proven technology	Yes	Yes – although size limits are a consideration. Treatment of explosive wastes greater than 100 pounds may be an issue. Larger pieces of explosives and odd-sized equipment cannot be treated in a contained detonation as fragments or the pressure from a large explosion will damage the chamber. Waste contaminated with small amounts of depleted uranium (DU) could be treated but have the potential to produce fragments which damage or destroy the chamber.	Yes- although types and amounts of wastes are still unknown for LANL's variable and unique explosive waste streams. May require a burn study to thoroughly evaluate treatment of LANL waste explosive waste streams. Larger pieces of debris contaminated with DU are not amenable for treatment by this technology.	Yes- LANL would not burn some encased explosives wastes or wastes contaminated with DU for personnel safety issues.
Public acceptance	Limited- Public concerns about contamination and opposition to noise have been voiced	Unknown	Mixed- Previous public opposition to operation of incinerators. Support of confined burn facilities during open burning permit process.	Limited- Public opposition has been voiced concerning open burning
Process effluents	Metal fragments, CO_2, H_2O, and N_2.	Metal fragments; pulverized gravel; air pollution control unit residue; major burn emissions including CO, CO_2, H_2O, NO_x N_2; and secondary combustion products from residence time.	Emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters.	Ash that is further analyzed for hazardous constituents. CO, CO_2, H_2O, NO_x N_2, and little to no secondary combustion products

Table 2. Focused Comparison of Applicable Waste Treatment Technologies to Open Detonation (continued)

Criteria	Open Detonation	Contained Detonation	Contained Burn in a confined burn facility	Open Burning
				because of short residence time
Reliability and maintainability	Very reliable with virtually no maintenance	Smaller units have proven reliable. Larger units (100 pounds) experienced leaking seals, weld failures and weak points. Fragments may damage chamber and increase maintenance.	The reliability and maintainability are unknown at this time for LANL variable and unique explosive waste streams. Potential for catastrophic failure.	Very reliable and maintenance is minimal. Maintenance of burn tray, propane burners, and electronic matches are minimal.
Personnel Safety	Larger detonations for explosives pieces that are greater than the capacity of a confined detonation chamber. This requires less handling for workers. Also, the explosive would not have to be size-reduced prior to treatment by OD. LANL conducts detonations from a remote location inside the control building following specific operating procedures for OD to assure the safety of human health and the environment.	Large pieces of explosives may require size reduction prior to treatment in order to meet the operating capacity of the unit. This requires more handling by the worker and subsequent safety concerns. Potential for catastrophic failure.	With undetermined or insulted explosives waste, a contained burn is an unacceptable risk to personnel. There is no controlled flame to ensure complete detonation or burn of the explosive or a capability to view if the explosive has been fully treated prior to opening the chamber. Potential for catastrophic failure.	At LANL personnel have very specific training and are secured in a building removed from the tray. The burn is monitored remotely through cameras. Specific operating parameters are invoked for open burning to assure the safety of personnel and to protect human health and the environment.
Meet regulatory guidelines	Yes with applicable RCRA Hazardous waste permits for the facility.	Yes with applicable RCRA Hazardous waste permits for the facility.	Yes with applicable RCRA Hazardous waste permits for the facility.	Yes with applicable RCRA Hazardous waste permits for the facility.

[1] Guidance taken from Evaluation of Alternative technologies to Open Detonation for Treatment of Energetic Wastes at the Naval Air Weapons Station, China Lake, California